SOIL SURVEY OF

Eddy County and Parts of Benson and Nelson Counties, North Dakota

United States Department of Agriculture
Soil Conservation Service
United States Department of the Interior
Bureau of Indian Affairs

In cooperation with
North Dakota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1959-69. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1971. This survey was made cooperatively by the Soil Conservation Service, the Bureau of Indian Affairs, and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Eddy, Nelson, and Benson County Soil Conservation Districts.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; 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 Eddy County and Parts of Benson and Nelson Counties are shown on the detailed soil 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 survey area 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 capability group and windbreak suitability 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, windbreak suitability groups, and the irrigation section.

Foresters and others can refer to the section "Woodland and Windbreaks," where the soils of the survey area are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife."

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 survey area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental Factors Affecting Soil Use."

Cover: Aerial view of a typical farmstead in Eddy County. In the background are soils of the Svea-Barnes-Hamerly association that are used for growing small grains, grass, and hay.

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SOIL SURVEY OF EDDY COUNTY AND PARTS OF BENSON AND NELSON COUNTIES, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, AND UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF INDIAN AFFAIRS, IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

EDDY COUNTY AND PARTS OF BENSON AND NELSON COUNTIES (called the survey area in this publication) are in the east-central part of North Dakota (fig. 1). The survey area includes 406,400 acres in Eddy County, 73,114 acres in Nelson County, and 45,636 acres in Benson County. The inclusion in this survey of the Warwick-McVille area, an irrigation survey area covering parts of three counties, accounts for the acreage in Nelson and Benson Counties. New Rockford is the county seat of Eddy County, Lakota is the county seat of Nelson County, and Minnewaukan is the county seat of Benson County.

These counties have a dry subhumid continental climate that is characterized by cold winters and warm summers. The physiography consists of glacial landforms, mainly ground moraines, recessional moraines, and outwash plains. The Sheyenne River, the James River, and their tributaries drain most of the area. In some areas most of the runoff collects in depressions and does not reach the rivers.

About 97 percent of the total land area is in farms or ranches, and about 70 percent is cultivated. Spring wheat is the main crop. Flax, barley, and oats are other important crops. The main livestock is beef and dairy cattle, hogs, and sheep.

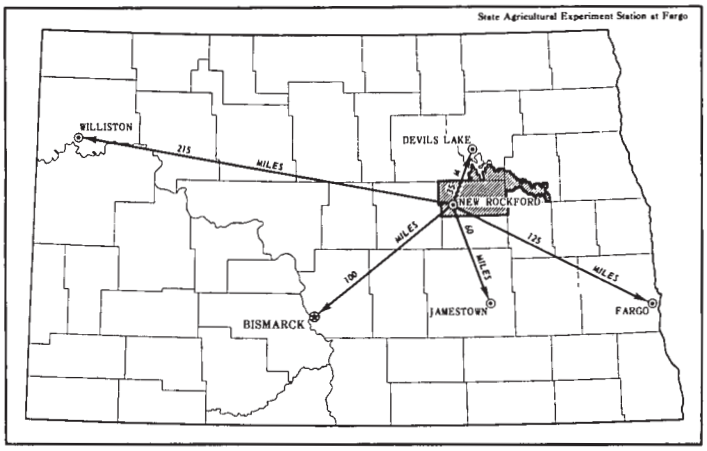

Figure 1.—Location of Eddy County and parts of Benson and Nelson Counties in North Dakota.

Two irrigation districts included in this survey area are the Warwick-McVille area and the New Rockford area. The soils in these areas are mainly suited to sprinkler-type irrigation. Crops such as sugar beets, potatoes, alfalfa, and truck crops should become more important with the further development of irrigation.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in this survey area, where they are located, and how they can be used. The soil scientists went into the counties knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and nature 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* 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. Most soil series are named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Hamar and Warsing, 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 charac-

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teristics that effect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer 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, Warsing loam is one of several phases within the Warsing 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 detailed soil map at the back of this publication was prepared from 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 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. Three such kinds of mapping units are shown on the soil map of the survey area: soil complexes, soil associations, 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. Ludden-Lamoure complex is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Towner-Dickey fine sandy loams 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." Fossum and Hamar sandy loams 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. Gravel pit is a land type in the survey area.

General Soil Map

The General Soil Map at the back of this survey shows, in color, the soil associations in Eddy County and the included parts of Benson and Nelson Counties. 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 the area, 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, recreation 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 or building or other structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

Adjoining soil associations in different survey areas may have some variations in name or composition of soils. These variations occur because the gradual changes in physiography, relief, or drainage patterns near survey boundaries require the inclusion of similar areas of limited acreage with larger associations. The names of some soils are unlike those appearing in recently published surveys of adjacent counties, because the concepts of the soil classification system have changed.

The soil associations in this survey have been grouped into 8 general kinds of landscapes for broad interpretative purposes. Each of the broad groups and 18 soil associations are described in the following pages. The texture mentioned in the descriptive title of an association is that of the surface layer. For example, in the Heimdal-Emrick-Fram association, "medium textured" refers to the texture of the surface layer.

Soils of the Glacial Till Plains

Soils of the glacial till plains are in all parts of the survey area. Some of these soils are on ground moraines that are nearly level and gently undulating. Other soils are on the recessional moraines that are gently undulating to steep.

These soils formed in calcareous loam or clay loam glacial till. Five soil associations are in this group. They make up about 38 percent of the survey area.

1. Heimdal-Emrick-Fram association

Nearly level and gently undulating, well drained, moderately well drained and somewhat poorly drained, deep, medium textured soils

This association is made up of soils that formed in glacial till and that consist of less than 18 percent clay. Most areas of these soils are nearly level, but next to drainageways and depressions they are gently undulating and gently sloping.

This association occupies about 17 percent of the survey area. It is about 40 percent Heimdal soils, 23 percent Emrick soils, 23 percent Fram soils, and 14 percent minor soils.

Heimdal soils are nearly level to gently undulating and are well drained. The surface layer is dark-gray loam about 7 inches thick. The subsoil is dark grayish-brown and pale-brown, friable loam about 9 inches thick. The substratum is mottled light-gray, light olive-brown, and light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Emrick soils are nearly level to gently undulating and are moderately well drained. The surface layer is very dark gray loam about 9 inches thick. The subsoil is dark-gray, friable loam about 8 inches thick. The substratum is mottled, light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Fram soils are nearly level and gently undulating and are somewhat poorly drained. They are calcareous. The surface layer is dark-gray loam about 6 inches thick. The upper part of the substratum is light-gray, friable loam about 16 inches thick, and it has an accumulation of lime. It is underlain by mottled, light yellowish-brown loam. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the Tonka, Parnell, Vallers, and Wyard series. The Tonka and Parnell soils are poorly drained and very poorly drained and are in depressions. The Vallers soils are poorly drained and are on the rims of depressions and along drainageways. The Wyard soils are somewhat poorly drained and are in shallow swales and depressions. Scattered throughout the area are claypan and saline soils.

Soils of this association are used mainly for cultivated crops. They are suited to all crops commonly grown in the survey area. The organic-matter content is high and fertility is medium in soils of this association. The main concerns of management are controlling soil blowing, improving drainage, and maintaining good tilth and fertility.

2. *Heimdal-Emrick association*

Nearly level to hilly, well drained and moderately well drained, deep, medium textured soils

This association consists of soils that formed in water-worked glacial till that has a clay content of less than 18 percent. Most areas of these soils are on gently undulating, nearly level, and hilly ground moraines. Steep recessional moraines are in small areas. Some large sloughs and potholes are scattered throughout the association.

This association occupies about 12 percent of the survey area. It is about 45 percent Heimdal soils, 25 percent Emrick soils, and 30 percent minor soils (fig. 2).

Heimdal soils are gently undulating to hilly and are well drained. The surface layer is dark-gray loam about 7 inches thick. It is thinner on the upper slopes and thicker on the lower slopes. The subsoil is dark

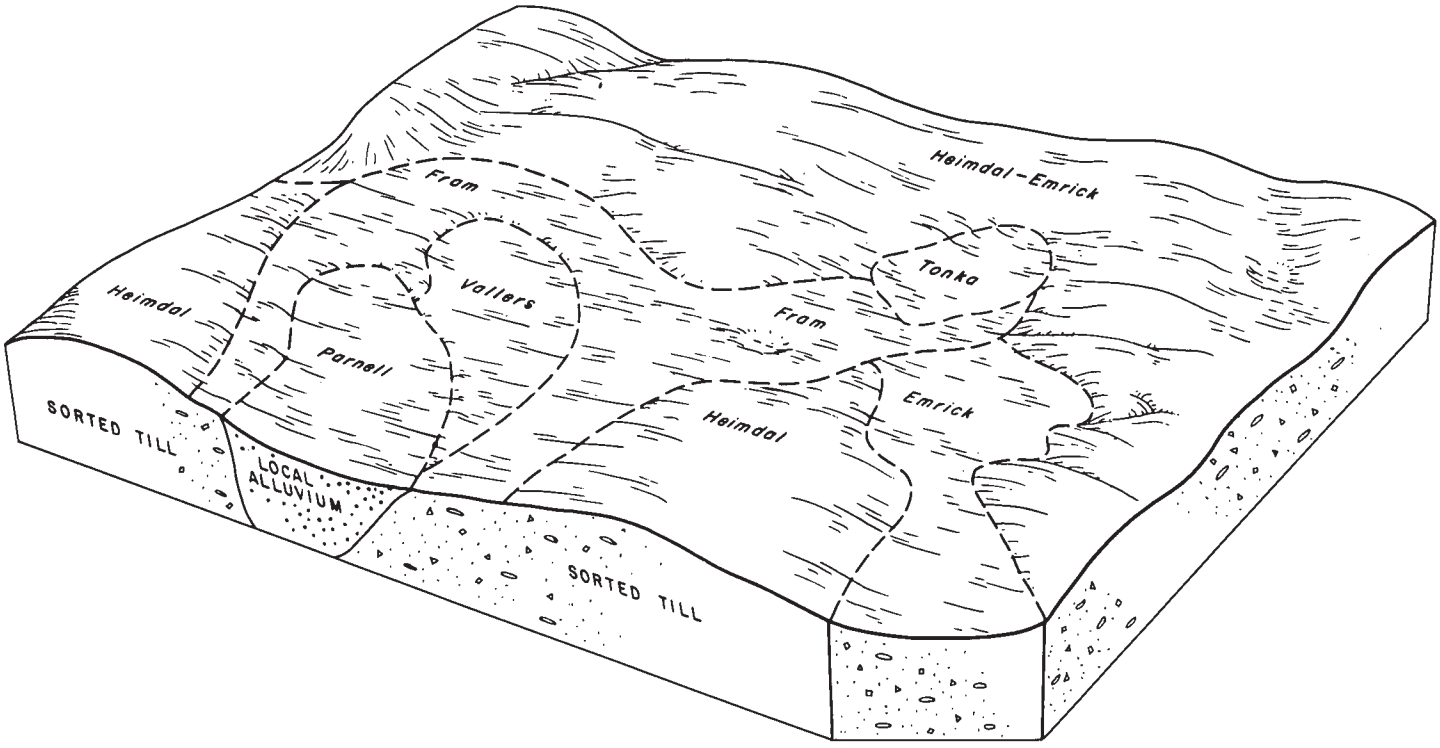

Figure 2.—**Topography, underlying materials, and typical pattern of soils in association 2.**

grayish-brown and pale-brown, friable loam about 9 inches thick. The substratum is mottled, light-gray, light olive-brown, and light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Emrick soils are nearly level to gently undulating and are moderately well drained. The surface layer is very dark gray loam about 9 inches thick. The subsoil is dark-gray, friable loam about 8 inches thick. The substratum is mottled, light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the Fram, Esmond, Tonka, Parnell, and Vallers series. The Fram soils are somewhat poorly drained, and the Vallers soils are poorly drained. Both soils are on rims around depressions. The Tonka soils are poorly drained, and the Parnell soils are very poorly drained. These soils are in depressions. The Esmond soils are well drained and are on shoulder slopes.

Soils of this association are used mainly for cultivated crops. Except for the soils on steep slopes that are in grass in many places, they are suited to all crops commonly grown in the survey area. The organic-matter content is high, and fertility is medium in all the soils. The main concerns of management are controlling soil blowing and water erosion and maintaining good tilth and fertility.

3. *Heimdal-Emrick-Esmond association*

Nearly level to steep, well drained and moderately well drained, deep, medium textured soils

This association consists of glacial till soils that have a clay content of less than 18 percent. Most areas of these soils are on gently rolling to steep recessional moraines. Large sloughs and potholes are scattered throughout the association.

This association occupies about 1 percent of the survey area. It is about 50 percent Heimdal soils, 20 percent Emrick soils, 15 percent Esmond soils, and 15 percent minor soils.

Heimdal soils are sloping to steep and are well drained. The surface layer is dark-gray loam about 7 inches thick. It is thinner on the upper slopes and thicker on the lower slopes. The subsoil is dark grayish-brown and pale-brown, friable loam about 9 inches thick. The substratum is mottled, light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Emrick soils are nearly level to gently sloping and are moderately well drained. The surface layer is very dark gray loam about 9 inches thick. The subsoil is dark-gray, friable loam about 8 inches thick. The substratum is mottled, light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Esmond soils are sloping to steep and are well drained. The surface layer is very dark gray loam about 5 inches thick. The next layer is dark-gray, friable, calcareous loam about 4 inches thick. The substratum is light brownish-gray, light-gray, and light yellowish-brown, calcareous, loam glacial till. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the Tonka, Parnell, and Vallers series. The Tonka soils are poorly drained, and the Parnell soils are very poorly drained. Both soils are in depressions. The Vallers soils are poorly drained and are on rims of depressions and along drainageways.

Soils of this association are used mainly for pasture. Some of the lower slopes and swales are used for hay. This association is well suited to wildlife habitat. The ridges and knolls are stony. The organic-matter content is high in Heimdal and Emrick soils and fertility is medium. The organic-matter content is moderate in Esmond soils, and fertility is low. The main concerns of management are overgrazing of pastures, controlling water erosion, and maintaining good fertility.

4. *Svea-Barnes-Hamerly association*

Nearly level and gently undulating, moderately well drained, well drained and somewhat poorly drained, deep, medium textured soils

This association consists of soils that formed in medium-textured glacial till that has a clay content of more than 18 percent. Most areas of these soils are nearly level, but next to drainageways and depressions the soils are gently undulating.

This association occupies about 6 percent of the survey area. It is about 38 percent Svea soils, 32 percent Barnes soils, 15 percent Hamerly soils, and 15 percent minor soils.

Svea soils are nearly level to gently undulating and are moderately well drained. The surface layer is very dark gray loam in the upper 6 inches and dark-gray silt loam in the lower 5 inches. The subsoil is dark grayish-brown and grayish-brown, friable silt loam and loam about 12 inches thick. The substratum is pale-yellow and mottled light-gray loam that has an accumulation of lime in the upper part. Permeability is moderate in the upper part and moderately slow in the lower part. The available water capacity is high.

Barnes soils are nearly level and gently undulating and are well drained. The surface layer is dark-gray loam about 6 inches thick. The subsoil is brown firm clay loam about 10 inches thick. The substratum is light-gray and light brownish-gray clay loam that has an accumulation of lime in the upper part. Permeability is moderate in the upper part and moderately slow in the lower part. The available water capacity is high.

Hamerly soils are nearly level and gently undulating and are somewhat poorly drained. They are calcareous. The surface layer is dark-gray loam about 7 inches thick. The upper 13 inches of the substratum is light-gray, friable loam that has an accumulation of lime. It is underlain by light brownish-gray calcareous loam glacial till that is mottled in the lower part. Permeability is moderately slow, and the available water capacity is high.

Minor soils of this association are in the Tonka, Parnell, and Vallers series. The Tonka soils are poorly drained, and the Parnell soils are very poorly drained. Both soils are in depressions. The Vallers soils are

poorly drained and are on the rims around the depressions. Claypan and saline soils are scattered throughout the association.

Soils of this association are used mainly for cultivated crops. They are suited to all crops commonly grown in the survey area. The organic-matter content is high, and fertility is medium in all the soils of this association, except for the Svea soil which has high fertility. The main concerns of management are controlling water erosion, improving drainage, and maintaining good tilth and fertility.

5. Barnes-Svea-Buse association

Gently undulating to hilly, well drained and moderately well drained, deep, medium textured soils

This association consists of soils that formed in glacial till that has a clay content of more than 18 percent. Most areas of these soils are gently undulating and hilly, but some areas are nearly level and steep.

This association occupies about 2 percent of the survey area. It is about 50 percent Barnes soils, 25 percent Svea soils, 15 percent Buse soils, and 10 percent minor soils.

Barnes soils are gently undulating to hilly and are well drained. The surface layer is dark-gray loam about 6 inches thick, and it is thinner on the steeper slopes. The subsoil is brown, firm clay loam about 10 inches thick. The substratum is light-gray and light brownish-gray clay loam that has an accumulation of lime in the upper part. Permeability is moderate in the upper part and moderately slow in the lower part. The available water capacity is high.

Svea soils are gently sloping and sloping and are moderately well drained. The surface layer is very dark gray loam about 6 inches thick. The next layer is dark-gray silt loam about 5 inches thick. The subsoil is dark grayish-brown, friable silt loam and loam about 12 inches thick. The substratum is pale-yellow and mottled light-gray loam that has an accumulation of lime in the upper part. Permeability is moderate in the upper part and moderately slow in the lower part. The available water capacity is high.

Buse soils are gently rolling and hilly and are well drained. The surface layer is loam about 7 inches thick. Colors are mixed. The substratum is mottled light brownish-gray loam that has an accumulation of lime in the upper 27 inches and is mottled light yellowish-brown loam in the lower part. Permeability is moderately slow, and the available water capacity is high.

Minor soils of this association are in the Tonka, Parnell, and Vallers series. Stony phases of Barnes, Svea, and Buse soils are also in the association. The Tonka soils are poorly drained, and the Parnell soils are very poorly drained. Both soils are in depressions. The Vallers soils are poorly drained and are on rims around the depressions.

The hilly soils in this association are used mainly for pasture for cattle and sheep. The less sloping areas are used for cultivated crops. These soils are suited to all close-growing crops commonly grown in the survey area. The organic-matter content is high in the Barnes and Svea soils and moderate in Buse soils. Fertility is high in the Svea soils, medium in the Barnes soils, and low in the Buse soils. The main concerns of management are overgrazing of pasture, controlling water erosion, and maintaining good fertility.

Soils of Dominantly Sand Mantled Glacial Till Plains

Soils of the sand mantled glacial till plains are nearly level to steep on glacial moraines. These are deep soils that formed in moderately coarse textured and coarse textured melt-water and wind-reworked sand deposits overlying loamy glacial till at variable depths. The sand mantle is about 7 to 50 inches thick, but it is thicker along foot slopes and swales. The underlying glacial till is sandy or silty in some areas.

There are three soil associations in this group. They make up about 10 percent of the survey area.

6. Towner-Heimdal-Swenoda association

Nearly level and gently undulating, moderately well drained and well drained, deep, moderately coarse textured and medium textured soils

This association consists of soils that formed in glacial melt-water deposits overlying loamy glacial till. These soils are nearly level and gently sloping, but they are steeper along drainageways, depressions, and large sloughs throughout the area.

This association occupies about 4 percent of the survey area. It is about 25 percent Towner soils, 25 percent Heimdal fine sandy loam soils, 15 percent Swenoda soils, and 35 percent minor soils.

Towner soils are nearly level to gently undulating and are moderately well drained. The surface layer is very dark gray fine sandy loam about 18 inches thick. The substratum is dark grayish brown, very friable loamy fine sand in the upper 9 inches. It is mottled light olive-brown and pale-yellow loam in the lower part. Permeability is rapid in the surface layer and moderately slow in the substratum. The available water capacity is moderate.

Heimdal soils are nearly level and gently undulating and are well drained. The surface layer is dark-gray sandy loam about 7 inches thick. The subsoil is dark grayish-brown and pale brown, friable loam 5 to 11 inches thick. The substratum is mottled light-gray, light olive-brown, and light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Swenoda soils are nearly level and gently undulating and are moderately well drained. The surface layer is very dark gray fine sandy loam in the upper 8 inches and very dark grayish brown sandy loam in the lower 10 inches. The subsoil is dark grayish-brown, mottled, very friable sandy loam about 10 inches thick. The upper part of the substratum is grayish-brown sandy loam about 2 inches thick, and the lower part is light-gray and light grayish-brown clay loam. Permeability is moderately rapid in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is moderate.

Minor soils of this association are in the Egeland, Embden, Dickey, Hecla, Cathay, and Larson series. The Egeland and Dickey soils are well drained and are on back slopes. The Embden and Hecla soils are

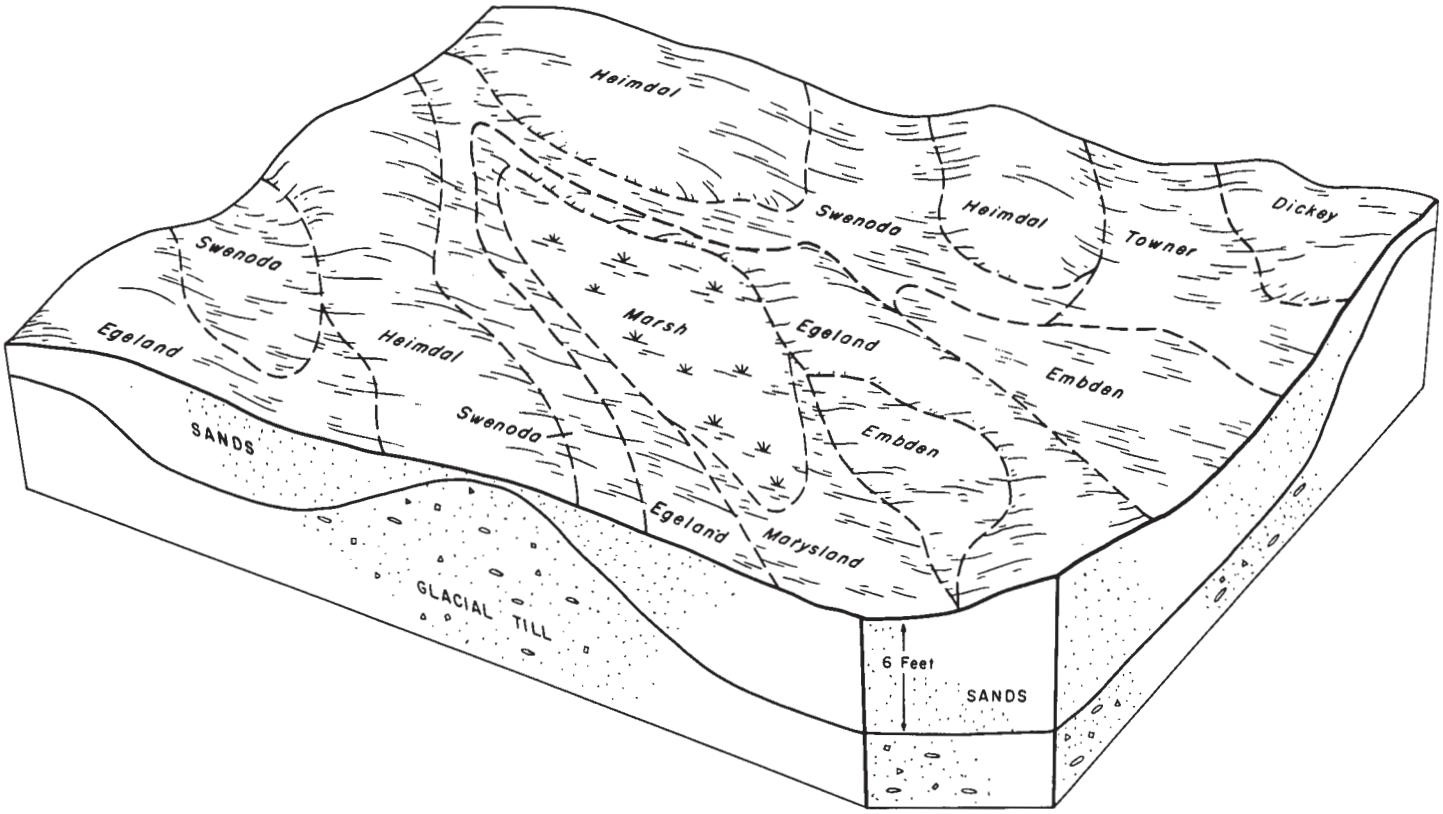

Figure 3.—**Topography, underlying materials, and typical pattern of soils in association 7.**

moderately well drained and are in swales. The Cathay and Larson soils are moderately well drained and somewhat poorly drained and are in swales.

Soils of this association are used mainly for cultivated crops. They are suited to all crops commonly grown in the survey area. A few steep areas and wet areas are used for pasture or wildlife habitat. The organic-matter content is high, and fertility is medium. The main concerns of management are controlling soil blowing and maintaining good tilth and fertility.

7. *Egeland-Heimdal-Swenoda association*

Gently sloping and hilly, well drained and moderately well drained, deep, moderately coarse textured and medium textured soils

This association consists of soils that formed in wind- and water-reworked sandy deposits overlying loamy glacial till. Most of the areas are gently sloping or hilly, but there are nearly level areas and steeper sloping areas along drainageways and depressions throughout the area. Some permanent lakes are in this association.

This association occupies about 4 percent of the survey area. It is about 25 percent Egeland soils, 25 percent Heimdal soils, 15 percent Swenoda soils, and 35 percent minor soils (fig. 3).

Egeland soils are gently sloping and hilly and are well drained. The surface layer is dark-gray sandy loam about 8 inches thick. The subsoil is dark grayish-brown and grayish-brown, very friable sandy loam about 12 inches thick. The upper part of the substratum is light brownish-gray loamy fine sand. In this association the substratum, below a depth of 40 inches, is loamy glacial till. Permeability is moderately rapid in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is moderate.

Heimdal soils are gently sloping and hilly and are well drained. The surface layer is dark-gray sandy loam about 7 inches thick. The subsoil is dark grayish-brown and pale-brown, friable loam about 9 inches thick. The substratum is mottled, light-gray, light olive-brown, and light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Swenoda soils are nearly level and gently sloping and are moderately well drained. The surface layer is very dark gray fine sandy loam in the upper 8 inches and very dark grayish-brown sandy loam in the lower 10 inches. The subsoil is dark grayish-brown, mottled, very friable sandy loam about 10 inches thick. The upper part of the substratum is grayish-brown sandy loam about 2 inches thick, and the lower part is light-gray and light grayish-brown clay loam. Permeability is moderately rapid in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is moderate.

Minor soils of this association are in the Embden, Towner, Dickey, Marysland, Cathay, and Larson series. The Dickey soils are well drained and are on back slopes. The Embden and Towner soils are moderately

well drained and are in swales. The Marysland soils are poorly drained and are on rims around depressions. The Cathay and Larson soils are moderately well drained and somewhat poorly drained and are in swales.

Soils of this association are used mainly for cultivated crops. The deep potholes, sloughs, and some of the hilly and steep areas are used for pasture, hay, or as wildlife habitat. The soils in cultivated areas are well suited to all crops commonly grown in the survey area, but sloping areas are suited only to close-growing crops. The organic-matter content is high in all the soils except Egeland soils, in which it is moderate. Fertility is medium. The main concerns of management are controlling soil blowing and water erosion and maintaining good tilth and fertility.

8. Heimdal-Embden-Serden association

Nearly level to steep, well drained, moderately well drained and excessively drained, deep, medium textured, moderately coarse textured and coarse textured soils

This association consists of soils that formed in wind- and water-reworked glaciofluvial sediments overlying glacial till. Most areas of these soils are on hilly and steeply sloping terminal moraines composed of lake sediments that have been deposited by glaciation. Some of the ridges are stony. There are nearly level and gently sloping areas, drainageways, deep depressions, and sloughs throughout this association.

This association occupies about 2 percent of the survey area. It is about 35 percent Heimdal soils, 20 percent Embden soils, 15 percent Serden soils, and 30 percent minor soils.

Heimdal soils are sloping to steep and are well drained. The surface layer is dark-gray sandy loam about 7 inches thick. The subsoil is dark grayish-brown and pale-brown, friable loam about 9 inches thick. The substratum is mottled, light-gray, light olive-brown, and light brownish-gray loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Embden soils are nearly level to gently sloping and are moderately well drained. The surface layer is dark gray and is 13 inches thick. The upper 5 inches is sandy loam and the next 8 inches is fine sandy loam. The subsoil is dark grayish-brown, very friable, fine sandy loam about 23 inches thick. The upper part of the substratum is dark-brown fine sandy loam, and the lower part is yellowish-brown and light yellowish-brown fine sand. Loamy glacial till is at a depth of about 40 inches in places. Permeability is moderately rapid, and the available water capacity is moderate.

Serden soils are nearly level to moderately steep and are excessively drained. The surface layer is dark-gray loamy fine sand about 2 inches thick. The substratum is grayish-brown loose fine sand and sand. Permeability is rapid, and the available water capacity is very low.

Minor soils of this association are in the Esmond, Egeland, Hecla, and Maddock series. The Esmond soils are well drained and are on shoulder slopes. The Egeland and Maddock soils are well drained and are on back slopes. The Hecla soils are moderately well drained and are in swales.

Soils of this association are used mainly for pasture. Some of the less sloping areas are used for hay or cultivated crops. The organic-matter content is high in the Heimdal and Embden soils and low in the Serden soils. Fertility is medium in the Heimdal and Embden soils and low in the Serden soils. The main concerns of management are controlling water erosion and soil blowing, preventing overgrazing of pasture, and maintaining good fertility.

Soils Dominantly of Glacial Outwash Plains and Sand Mantled Till Plains

Soils of the outwash plains and till plains are nearly level and gently undulating. These soils formed in moderately coarse textured and coarse textured meltwater or windblown deposits. Poorly drained and very poorly drained depressions and sloughs are common. The water table is within 5 feet of the surface over much of the area.

One soil association is in this group. It makes up about 6 percent of the survey area.

9. Hecla-Maddock-Hamar association

Nearly level and gently undulating, moderately well drained, well drained and somewhat poorly drained, deep, moderately coarse textured and coarse textured soils

This association consists of soils that formed in wind- and water-deposited sand. Most areas of these soils are nearly level, but some are gently undulating. There are poorly drained and very poorly drained depressions and sloughs.

This association occupies about 6 percent of the survey area. It is about 35 percent Hecla soils, 20 percent Maddock soils, 10 percent Hamar soils, and 35 percent minor soils.

Hecla soils are nearly level and gently undulating and are moderately well drained. The surface layer is very dark gray sandy loam about 16 inches thick. The subsoil is dark grayish-brown, very friable loamy sand about 16 inches thick. The substratum is mottled, grayish-brown loamy sand and fine sand. Permeability is rapid, and the available water capacity is low.

Maddock soils are nearly level and gently undulating and are well drained. The surface layer is dark-gray loamy sand or sandy loam about 7 inches thick. The subsoil is dark grayish-brown, very friable loamy sand about 13 inches thick. The substratum is brown, pale-brown, and grayish-brown loamy sand and sand. Permeability is rapid, and the available water capacity is low.

Hamar soils are nearly level and are somewhat poorly drained. The surface layer is loamy sand about 13 inches thick. It is very dark gray in the upper part and dark gray in the lower part. The substratum is mottled, light brownish-gray and grayish-brown sand. Permeability is rapid, and the available water capacity is low.

Minor soils of this association are in the Arveson, Marysland, Wyndmere, Clontarf, Stirum, and Totten series. The Arveson and Marysland soils are poorly

drained and are in swales and deep depressions. The Wyndmere soils are somewhat poorly drained, the Stirum soils are poorly drained, and the Totten soils are poorly drained and very poorly drained. They are in shallow depressions. The Clontarf soils are moderately well drained and are in shallow depressions.

Soils of this association have been used mainly for cultivated crops, except in the poorly drained and very poorly drained areas. Much of the area has been reseeded to grass. The moderately well drained and well drained soils are suited to all crops commonly grown in the survey area. All of the soils are suited to grasses and legumes. The organic-matter content is moderate, and fertility is medium in all the soils except Maddock soils, which have low fertility. The main concerns of management are controlling soil blowing and overgrazing, conserving moisture, and maintaining good tilth and fertility.

Soils of the Sandy Glacial Outwash Plains

Soils of the sandy outwash plains are nearly level and gently undulating. They formed in moderately coarse textured and coarse textured melt-water or windblown deposits. Most of the sand in these soils is coarse. In some areas there are hummocky sand dunes that are stabilized and some poorly drained and very poorly drained depressions and sloughs.

The one soil association in this group makes up about 7 percent of the survey area.

10. Claire-Lohnes-Hamar association

Nearly level or gently undulating, excessively drained, moderately well drained, and somewhat poorly drained, deep, coarse textured and moderately coarse textured soils

This association consists of soils that formed in wind- and water-deposited medium and coarse sands. Slopes are nearly level and gently undulating, but some areas are hummocky because of soil blowing. There are some poorly drained and very poorly drained depressions and sloughs.

This association occupies about 7 percent of the survey area. It is about 30 percent Claire soils, 25 percent Lohnes soils, 10 percent Hamar soils, and 35 percent minor soils (fig. 4).

Claire soils are nearly level and gently undulating and are excessively drained. The surface layer is dark-gray loamy coarse sand about 8 inches thick. The transitional layer is dark grayish-brown, very friable loamy coarse sand about 6 inches thick. The substratum is dark grayish-brown, grayish-brown, and light-gray coarse sand that has strata of fine sand. Permeability is rapid, and the available water capacity is very low.

Lohnes soils are nearly level and gently undulating and are moderately well drained. The surface layer is very dark gray loamy coarse sand about 16 inches thick. The next layer is dark grayish-brown, very friable, loamy coarse sand about 14 inches thick. The substratum is mottled brown and grayish-brown

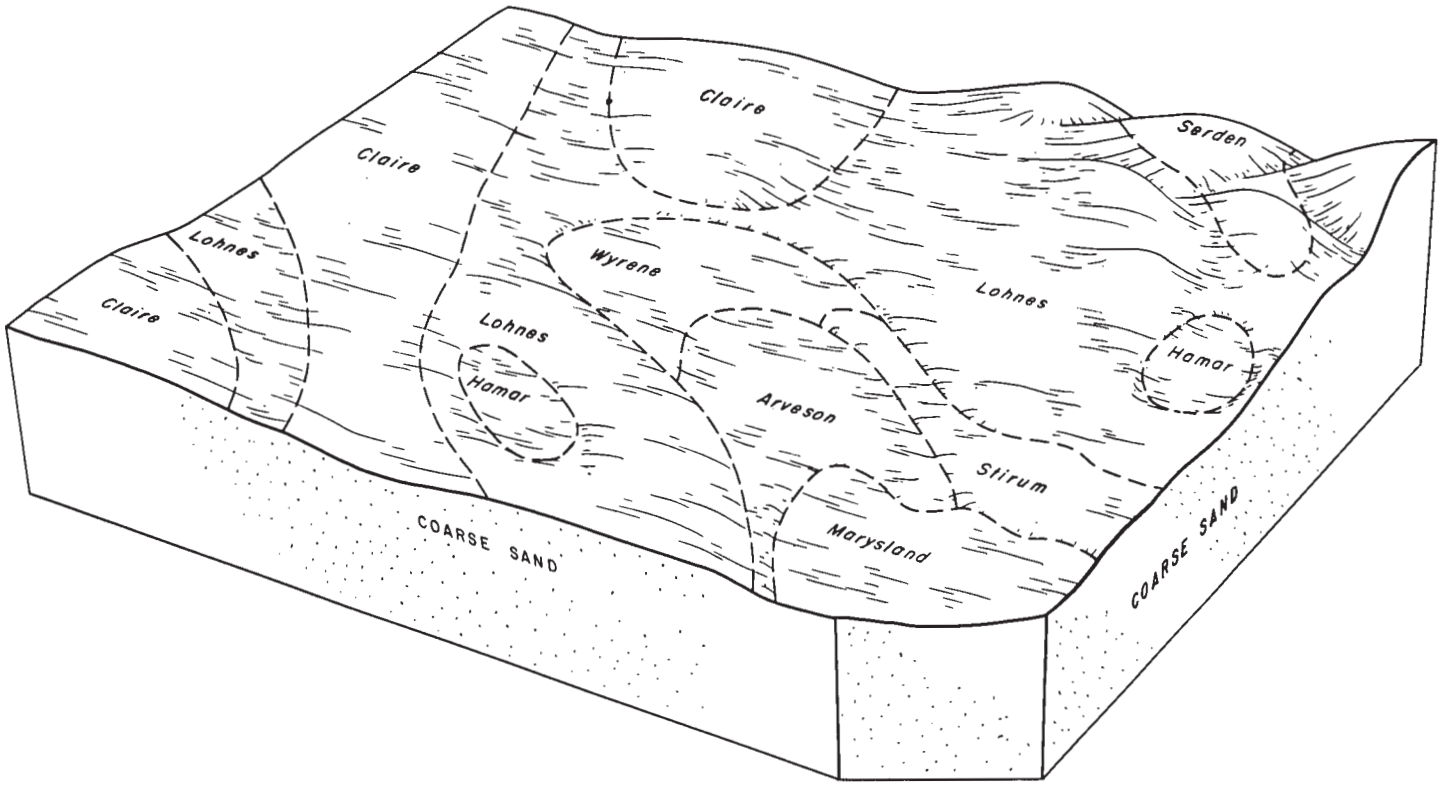

Figure 4.—Topography, underlying materials, and typical pattern of soils in association 10.

coarse sand. Permeability is rapid, and the available water capacity is low.

Hamar soils are nearly level and are somewhat poorly drained. The surface layer is loamy sand about 13 inches thick. It is very dark gray in the upper 7 inches and mottled dark gray in the lower 6 inches. The substratum is mottled, light brownish-gray and grayish-brown sand and loamy sand. In this association most of the sand particles are coarse. Permeability is rapid, and the available water capacity is low.

Minor soils of the association are in the Serden, Arveson, Wyrene, Marysland, Wyndmere, Fossum, and Stirum series. The Serden soils are excessively drained and are on shoulder slopes. The Wyrene and Wyndmere soils are somewhat poorly drained and are in positions similar to those of Hamar soils. The Marysland, Arveson, and Fossum soils are poorly drained and are in deep depressions. The Stirum soils are poorly drained and are in shallow depressions.

Some of the nearly level areas of this association are used for cultivated crops. Many of the gently undulating areas were cultivated but have been reseeded to grass. The soils are generally poorly suited to cultivated crops because of the hazard of soil blowing and the low and very low available water capacity. The soils, especially those that have a high water table, are well suited to grasses and legumes. The organic-matter content is low in Claire and Lohnes soils and moderate in Hamar soils. Fertility is medium in Hamar soils, low in Lohnes soils, and very low in Claire soils. The main concerns of management are conserving moisture, controlling soil blowing and overgrazing, and maintaining good fertility.

Soils of the Shaly Sandy and Gravelly Glacial Outwash Plains

Soils of the shaly outwash plains are mostly nearly level and gently undulating, but they are hilly to steep in pitted outwash areas. These are very shallow to moderately deep soils that formed in medium-textured and moderately coarse textured deposits overlying shaly sand and gravel.

Two soil associations are in this group. They make up about 16 percent of the survey area.

11. Brantford-Binford-Kensal association

Nearly level and gently undulating, well drained, somewhat excessively drained and moderately well drained, shallow and moderately deep, medium textured and moderately coarse textured soils

This association consists of shallow and moderately deep soils that formed in medium-textured and moderately coarse textured sediment overlying shaly sand and gravel. Most areas of these soils are on nearly level and gently undulating, smooth slopes. Steeper areas are near drainageways and depressions.

This association occupies about 12 percent of the survey area. It is about 30 percent Brantford soils, 15 percent Binford soils, 15 percent Kensal soils, and 40 percent minor soils (fig. 5).

Brantford soils are nearly level to gently undulating and are well drained. The surface layer is very dark gray and very dark grayish-brown loam about 9 inches thick. The subsoil is dark grayish-brown, friable loam about 6 inches thick. The substratum is grayish-brown and dark grayish-brown, stratified shaly sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Binford soils are nearly level and gently undulating and are somewhat excessively drained. The surface layer is very dark gray sandy loam about 6 inches thick. The subsoil is dark grayish-brown, friable sandy loam about 7 inches thick. The substratum is light olive-gray, stratified shaly sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Kensal soils are nearly level and are moderately well drained. The surface layer is very dark gray loam about 8 inches thick. The upper part of the subsoil is dark grayish-brown, friable loam about 6 inches thick. The lower parts of the subsoil are mottled, grayish-brown, friable loam 4 inches thick and mottled, grayish-brown heavy sandy loam 6 inches thick. The substratum is light brownish-gray, stratified shaly sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Minor soils of this association are in the Walum, Marysland, Borup, Tolna, and Divide series. The Walum soils are moderately well drained and are in a landscape position similar to that of Kensal soils. The Marysland and Borup soils are poorly drained and are in deep depressions. The Tolna soils are somewhat poorly drained and are in shallow depressions, and the Divide soils are somewhat poorly drained and are on the edges of deep depressions and in shallow depressions.

Soils of this association are used mainly for cultivated crops. They are suited to all crops commonly grown in the survey area. The organic-matter content is high in Brantford and Kensal soils and moderate in Binford soils. Fertility is medium. The main concerns of management are conserving moisture, controlling soil blowing and water erosion, and maintaining good tilth and fertility.

12. Brantford-Binford-Coe association

Gently undulating to hilly, well drained, somewhat excessively drained and excessively drained, very shallow and shallow, medium textured and moderately coarse textured soils

This association consists of shallow and very shallow soils that formed in medium-textured and moderately coarse textured sediment overlying shaly sand and gravel. These soils are mostly gently undulating to hilly, but they are nearly level and steeply sloping in places.

This association occupies about 4 percent of the survey area. It is about 25 percent Brantford soils, 25 percent Binford soils, 20 percent Coe soils, and 30 percent minor soils.

Brantford soils are gently undulating to hilly and are well drained. The surface layer is very dark gray and very dark grayish-brown loam about 9 inches thick. The subsoil is dark grayish-brown, friable loam about

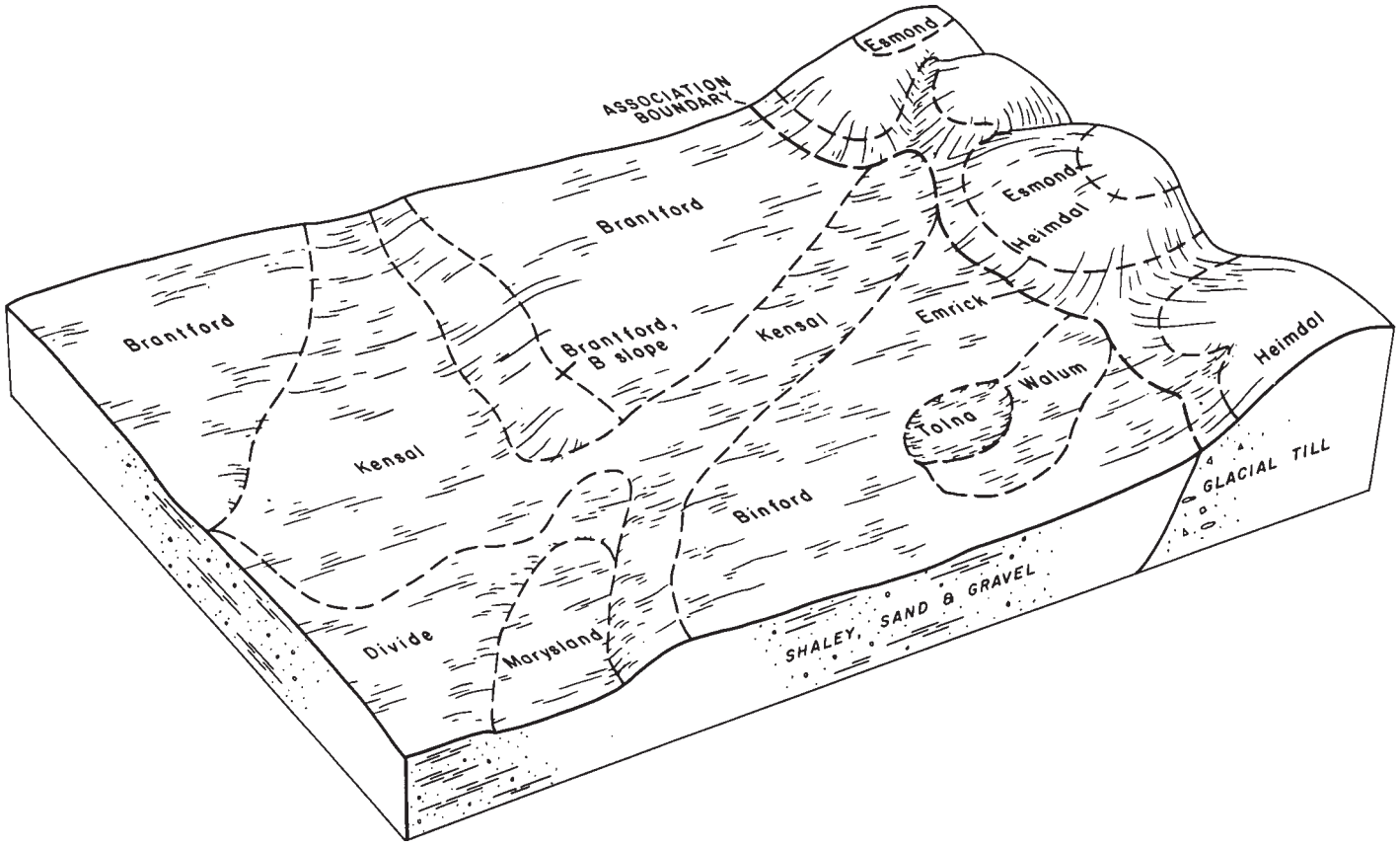

Figure 5.—**Topography, underlying materials, and typical pattern of soils in association 11.**

6 inches thick. The substratum is grayish-brown and dark grayish-brown, stratified shaly sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Binford soils are gently undulating to hilly and are somewhat excessively drained. The surface layer is very dark gray sandy loam about 6 inches thick. The substratum is light olive-gray, stratified shaly sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Coe soils are gently undulating to hilly and are excessively drained. The surface layer is dark-gray sandy loam about 6 inches thick. The substratum is light brownish-gray and gray, stratified shaly sand and gravel. Permeability is very rapid, and the available water capacity is very low.

Minor soils of this association are in the Borup, Marysland, Spottswood, and Vang series. The Borup and Marysland soils are poorly drained and are in deep depressions. The Spottswood soils are moderately well drained, and the Vang soils are well drained. Both of these soils are in swales and on foot slopes and toe slopes.

The gently undulating and gently rolling areas of this association are used for cultivated crops. The hilly, steep, and wet areas are used for pasture or hay. The organic-matter content is high in Brantford soils, moderate in Binford soils, and moderately low in Coe soils. Fertility is medium in Brantford and Binford soils and low in Coe soils. The main concerns of management are controlling soil blowing and water and fertility. Pasture management is necessary to prevent overgrazing.

Soils of the Sandy and Gravelly Glacial Outwash Plains

Soils of the sandy and gravelly outwash plains are mostly nearly level and gently undulating. These are medium textured and moderately coarse textured soils that formed in shallow, moderately deep, and deep deposits overlying sand and gravel. Four soil associations are in this group. They make up about 16 percent of the survey area.

13. Renshaw-Arvilla association

Nearly level and gently undulating, somewhat excessively drained, shallow, medium textured and moderately coarse textured soils

This association consists of soils that formed in medium textured and moderately coarse textured sediment overlying sand and gravel. Most areas of these soils are nearly level, but some are gently undulating.

Some areas are on high terraces along the Sheyenne River and James River.

This association occupies about 6 percent of the survey area. It is about 30 percent Renshaw soils, 30 percent Arvilla soils, and 40 percent minor soils.

Renshaw soils are nearly level and gently undulating and are somewhat excessively drained. The surface layer is dark-gray loam about 6 inches thick. The subsoil is dark grayish-brown and grayish-brown, friable loam about 9 inches thick. The substratum is brown and pale-brown stratified sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Arvilla soils are nearly level and gently undulating and are somewhat excessively drained. The surface layer is dark-gray sandy loam about 5 inches thick. The subsoil is dark-gray and grayish-brown, very friable sandy loam about 13 inches thick. The substratum is grayish-brown, yellowish-brown, brown, and light brownish-gray stratified sand and gravel. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low.

Minor soils of this association are in the Divide, Warsing, Fordville, and Osakis series. Several gravel pits are also in the association. The Divide soils are somewhat poorly drained and are in shallow depressions. The Fordville soils are well drained, and the Osakis soils are moderately well drained. These soils are in swales.

Soils of this association are used mainly for cultivated crops. They are suited to all crops commonly grown in the survey area. The organic-matter content is moderate and fertility is medium in both Renshaw and Arvilla soils. The main concerns of management are conserving moisture, controlling soil blowing and water erosion, and maintaining good tilth and fertility.

14. Divide-Glyndon association

Nearly level, somewhat poorly drained, moderately deep and deep, medium textured soils

This association consists of soils that formed in medium-textured sediment overlying sand and gravel. Most areas are nearly level, but some are gently undulating.

This association occupies about 3 percent of the survey area. It is about 40 percent Divide soils, 25 percent Glyndon soils, and 35 percent minor soils.

Divide soils are nearly level and are somewhat poorly drained. The surface layer is very dark gray loam about 11 inches thick. It is dark gray and light gray in the lower 4 inches. The upper part of the substratum is light-gray, calcareous, friable loam about 11 inches thick. The lower part is grayish-brown and light brownish-gray sand and gravel. Permeability is moderate in the surface layer and upper part of the substratum and is very rapid in the lower part of the substratum. The available water capacity is low.

Glyndon soils are nearly level and are somewhat poorly drained. The surface layer is dark gray and is about 10 inches thick. It is loam in the upper part and silt loam in the lower part. The substratum is 50 inches thick. The upper 20 inches is light-gray, friable silt loam that has an accumulation of lime. The next 12 inches is mottled, grayish-brown, very fine sandy loam. The lower 18 inches is light brownish-gray loamy fine sand. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the Borup, Marysland, Warsing, and Totten series. The Borup and Marysland soils are poorly drained and are in deep depressions. The Warsing soils are moderately well drained and are in slightly higher positions than Divide and Glyndon soils. The Totten soils are poorly drained and very poorly drained and are in positions similar to those of Divide and Glyndon soils.

Soils of this association are used for cultivated crops, hay, and pasture. The organic-matter content is high and fertility is medium in these soils. The main concerns of management are controlling wetness, controlling soil blowing in cultivated areas, and maintaining good tilth and fertility.

15. Marysland-Borup association

Nearly level, poorly drained, moderately deep and deep, medium textured soils

This association consists of soils that formed in lacustrine and outwash sediment. These areas are nearly level glacial outwash channels ⅓ to 1 mile wide and 3 to 10 miles long. Many seeps and small, better drained areas are along the channels.

This association occupies 3 percent of the survey area. It is about 30 percent Marysland soils, 30 percent Borup soils, and 40 percent minor soils.

Marysland soils are nearly level and are poorly drained or very poorly drained. The surface layer is about 12 inches thick. The upper part is very dark gray loam, and the lower part is gray silt loam that has an accumulation of lime. The next layer is friable silt loam about 12 inches thick that also has an accumulation of lime. It is gray in the upper part and light gray in the lower part. Below this is mottled dark-gray sandy clay loam about 5 inches thick. The underlying material is medium and coarse sand that is mottled light olive gray in the upper 11 inches and mottled gray in the lower part. Permeability is moderately rapid, and the available water capacity is moderate.

Borup soils are nearly level and are poorly drained. The surface layer is silt loam about 11 inches thick. It is dark gray. The upper part is dark gray, and the lower part is gray and has an accumulation of lime. The substratum is about 49 inches thick. The upper 23 inches is white, friable silt loam that has an accumulation of lime. The next 20 inches is silt loam that is light gray and white in the upper part and light yellowish brown and light gray in the lower part. Below this is light yellowish-brown sand and gravel. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the Colvin, Arveson, Totten, and Letcher series. The Colvin soils are poorly drained and very poorly drained, and the Arveson soils are poorly drained. These soils are in landscape positions similar to those of Marysland and Borup soils. The Letcher soils are somewhat poorly

drained, and the Totten soils are poorly drained and very poorly drained. These soils are in slightly higher positions than Marysland and Borup soils.

Soils of this association are used mainly for pasture and hay. The organic-matter content is high and fertility is medium in the Marysland and Borup soils. The main concerns of management are controlling wetness and overgrazing and maintaining good fertility.

16. Totten-Letcher association

Nearly level, poorly drained, very poorly drained and somewhat poorly drained, moderately deep and deep, moderately fine textured to moderately coarse textured claypan soils

This association consists of soils that formed in medium textured and moderately coarse textured sediment overlying sand and gravel and of deep soils that formed in moderately coarse textured glaciofluvial deposits. These soils are mostly nearly level, but they are gently undulating in places.

This association occupies about 4 percent of the survey area. It is about 50 percent Totten soils, 15 percent Letcher soils, and 35 percent minor soils.

Totten soils are nearly level and poorly drained or very poorly drained, and they have a claypan. The surface layer is very dark gray loam about 5 inches thick. The subsoil is about 21 inches thick. It is dark-gray, friable, sandy clay loam in the upper 5 inches; light-gray, friable, sandy clay loam in the next 7 inches; and mottled light-gray loam in the lower 9 inches. The upper 8 inches of the substratum is mottled, light yellowish-brown coarse sand. The next 6 inches is light yellowish-brown gravelly coarse sand. The lower part is light olive-brown and light yellowish-brown stratified coarse sand, gravelly coarse sand, and sandy gravel. Permeability is moderately slow in the surface layer and subsoil and rapid in the substratum. The available water capacity is low.

Letcher soils are nearly level and are somewhat poorly drained. The surface layer is very dark sandy loam about 7 inches thick. The subsurface layer is dark-gray sandy loam about 2 inches thick. The subsoil is dark grayish-brown and very dark grayish-brown, very firm sandy loam about 9 inches thick. The upper part of the substratum is light-gray, light olive-gray, and olive-gray sandy loam to loam that has an accumulation of lime. The underlying material is grayish-brown, light brownish-gray, and light-gray medium and coarse sands. Permeability is slow in the surface layer and subsoil and rapid in the substratum. The available water capacity is low.

Minor soils of this association are in the Osakis, Wyrene, Lemert, and Stirum series. The Osakis soils are moderately well drained and are in positions slightly higher than those of Totten and Letcher soils. The Wyrene soils are somewhat poorly drained and are in positions similar to those of Letcher soils. The Stirum soils are poorly drained, and the Lemert soils are poorly drained and somewhat poorly drained. These soils are in positions similar to those of Totten soils.

Soils of this association are used for cultivated crops, pasture, and hay. The organic-matter content is moderate and fertility is low in the Totten and Letcher soils. The main concerns of management are controlling soil blowing, improving drainage, and improving tilth and fertility.

Soils of the Bottom Lands and Side Slopes of the Sheyenne and James Rivers

Soils of the bottom lands and side slopes are deep, medium textured and moderately fine textured soils that formed in alluvial sediments, glacial till, and colluvial deposits of the Sheyenne and James River Valleys. One soil association is in this group. It makes up about 6 percent of the survey area.

17. Lamoure-Buse-Walsh association

Nearly level to steep, poorly drained, well drained, and moderately well drained, deep, moderately fine textured and medium textured soils

This association consists of soils that formed in alluvial deposits, glacial till, and colluvial deposits of the Sheyenne and James River Valleys. The soils on the bottom lands are nearly level, on the side slopes they are sloping to steep, and on the foot slopes and alluvial fans they are nearly level to sloping.

This association occupies about 6 percent of the survey area. It is about 15 percent Lamoure soils, 10 percent Buse soils, 10 percent Walsh soils, and 65 percent minor soils.

Lamoure soils are nearly level and are poorly drained. The surface layer is silty clay loam about 19 inches thick. It is very dark gray in the upper 7 inches and dark gray in the lower 12 inches. The subsoil is gray, firm clay loam about 27 inches thick. The substratum is dark-gray silty clay loam. Permeability is moderate, and the available water capacity is high.

Buse soils are sloping to steep and are well drained. The surface layer is loam about 7 inches thick. It has mixed colors. The upper 27 inches of the substratum is mottled, light brownish-gray, friable loam that contains an accumulation of lime, and the lower part is mottled light yellowish-brown loam. Permeability is moderately slow, and the available water capacity is high.

Walsh soils are nearly level to sloping and are moderately well drained and well drained. The surface layer is very dark gray loam about 19 inches thick. The subsoil is dark grayish-brown, friable loam about 11 inches thick. The substratum is light brownish-gray and white loam that has an accumulation of lime in the upper part. Permeability is moderate, and the available water capacity is high.

Minor soils of this association are in the La Prairie, Sioux, Coe, Kloten, Esmond, Edgeley, LaDelle, Ryan, Barnes, Heimdal, Borup, and Vallers series. Many areas are stony. The La Prairie and LaDelle soils are moderately well drained and are on bottom lands. The Sioux and Coe soils are excessively drained and are on steep side slopes. The Kloten and Edgeley soils are well drained and are on nearly level upper slopes and steep side slopes. The Esmond, Heimdal, and Barnes soils are well drained and are on side slopes. The Ryan soils are poorly drained and are on bottom lands. The Borup and Vallers soils are poorly drained and are on seep areas.

Soils of this association are used mainly for pasture. Some soils on bottom lands, foot slopes, and alluvial fans are suited to cultivated crops. Trees grow on the Sheyenne River bottom lands, and in places they cover the entire valley. The organic-matter content is high in Lamoure and Walsh soils and moderate in Buse soils. Fertility is medium in Lamoure and Walsh soils and low in Buse soils. The main concerns of management are controlling overgrazing and maintaining good tilth and fertility.

Soils of Dry Lake Basins

Soils of dry lake basins are around Stump Lake. One soil association is in this group. It makes up less than 1 percent of the survey area.

18. Lallie association

Nearly level, poorly drained and very poorly drained, deep, moderately fine textured soils

This association consists of soils that formed in fine-textured alluvial sediment. They are on nearly level lake basins that have dried up in the last 50 years.

This association occupies less than 1 percent of the survey area. It is about 90 percent Lallie soils and 10 percent minor soils.

Lallie soils are nearly level and are poorly drained or very poorly drained. The surface layer is dark-gray, calcareous silty clay loam about 2 inches thick. The upper 22 inches of the substratum is mottled, light-gray and gray, friable silty clay loam. The next 8 inches is very dark gray silty clay. The rest is mottled, light-gray and gray silty clay. Permeability is slow, and the available water capacity is moderate.

Minor soils of this association are in the Glyndon, Bearden, and Colvin series. Some areas are saline. The Colvin soils are poorly drained and very poorly drained and are in positions similar to those of Lallie soils. The Glyndon and Bearden soils are somewhat poorly drained and are in slightly higher positions than Lallie soils.

Soils of this association are used mainly for pasture and hay. Some of the soils in the higher, better drained areas are used for cultivated crops. These soils are suited to salt-tolerant grasses and grain crops. The organic-matter content is moderate, and fertility is low. The main concerns of management are controlling wetness and salinity and improving tilth and fertility.

Descriptions of the Soils

This section describes the soil series and mapping units in Eddy County and parts of Benson and Nelson Counties. A soil series is described in detail, and then, briefly, each mapping unit in that series is described. Unless specifically stated otherwise, what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Two descriptions of this profile are given for each series. The first is brief and in terms familiar to the layman. The second is detailed and is for those who need to make thorough and precise studies of soils. Color terms are for dry soil unless otherwise stated. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, the differences are stated in describing the mapping unit or they are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Made land and Peat, for example, do not belong to a soil series. Nevertheless, they are listed in alphabetic order along with the 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. Listed at the end of each description of a mapping unit is the capability unit and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit and windbreak suitability group can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the "Glossary" at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*8*).[2]

Aberdeen Series

The Aberdeen series consists of deep, nearly level, moderately well drained and somewhat poorly drained claypan soils that formed in moderately fine textured glaciofluvial deposits. These soils are in slight depressions on glacial outwash plains.

In a representative profile the surface layer is dark-gray loam about 7 inches thick. The subsurface layer is gray very fine sandy loam about 4 inches thick. The subsoil is grayish-brown and is about 14 inches thick. It is very firm, heavy clay loam in the upper 5 inches, firm heavy clay loam in the next 4 inches, and friable clay loam in the lower 5 inches. The substratum is 35 inches thick. The upper 10 inches is variegated light brownish-gray and white clay loam that contains an accumulation of lime, the 9 inches below that is mottled, light brownish-gray very fine sandy loam, the next 6 inches is mottled, light yellowish-brown very fine sandy loam, and the lower 10 inches is mottled, brown very fine sandy loam.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The dense subsoil and salts in the lower part of the subsoil limit root and water penetration. A water table is within 5 feet of the surface most of the year and is at or near the surface in spring and

[2] Italic numbers in parentheses refer to Literature Cited, p. 200.

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

Soil	Benson County	Eddy County	Nelson County	Total	Survey area
	Acres	*Acres*	*Acres*	*Acres*	*Percent*
Aberdeen loam	0	255	65	320	0.1
Aberdeen-Exline loams	0	226	0	226	(1)
Arveson sandy loam	0	860	0	860	.2
Arvilla sandy loam	105	542	268	915	.2
Arvilla sandy loam, gravelly substratum, 0 to 3 percent slopes	0	1,950	0	1,950	.4
Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes	3	1,760	154	1,917	.4
Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes	44	4,275	78	4,397	.8
Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes	4	1,175	0	1,179	.2
Arvilla-Sioux sandy loams, 6 to 9 percent slopes	55	930	135	1,120	.2
Barnes loam, 0 to 3 percent slopes	0	340	0	340	.1
Barnes loam, 3 to 6 percent slopes	0	830	500	1,330	.3
Barnes loam, 6 to 9 percent slopes	0	154	147	301	.1
Barnes-Svea loams, 0 to 3 percent slopes	0	2,050	0	2,050	.4
Barnes-Svea loams, 3 to 6 percent slopes	16	1,830	405	2,251	.4
Barnes-Svea stony loams, 3 to 6 percent slopes	0	535	0	535	.1
Barnes-Svea-Buse loams, 6 to 9 percent slopes	37	1,475	58	1,570	.3
Barnes-Svea-Buse stony loams, 6 to 9 percent slopes	0	1,050	0	1,050	.2
Bearden silt loam, saline	0	376	425	801	.2
Binford sandy loam	465	0	3,465	3,930	.7
Binford sandy loam, gravelly substratum, 0 to 3 percent slopes	0	301	0	301	.1
Binford sandy loam, gravelly substratum, 3 to 6 percent slopes	50	1,250	77	1,377	.3
Binford sandy loam, sandy substratum, 0 to 3 percent slopes	0	3,200	0	3,200	.6
Binford sandy loam, sandy substratum, 3 to 6 percent slopes	0	4,775	0	4,775	.9
Binford-Coe sandy loams, 6 to 9 percent slopes	0	2,075	60	2,135	.4
Binford-Coe sandy loams, 9 to 12 percent slopes	0	552	0	552	.1
Borup silt loam	360	4,980	570	5,910	1.1
Borup and Marysland silt loams, very wet	148	4,075	87	4,310	.8
Borup and Vallers loams, 3 to 6 percent slopes	0	1,625	0	1,625	.3
Brantford loam, 3 to 6 percent slopes	1,130	0	1,015	2,145	.4
Brantford loam, gravelly substratum, 0 to 3 percent slopes	5,203	1,050	0	6,253	1.2
Brantford loam, gravelly substratum, 3 to 6 percent slopes	2,155	1,510	0	3,665	.7
Brantford loam, sandy substratum, 0 to 3 percent slopes	16	1,000	0	1,016	.2
Brantford loam, sandy substratum, 3 to 6 percent slopes	76	940	0	1,016	.2
Brantford-Coe loams, 6 to 9 percent slopes	2,490	360	340	3,190	.6
Brantford-Kensal loams	7,812	0	7,150	14,962	2.8
Buse-Barnes loams, 9 to 30 percent slopes	170	700	1,125	1,995	.4
Buse-Edgeley loams, 9 to 30 percent slopes	0	0	2,245	2,245	.4
Buse and Kloten loams, 6 to 25 percent slopes	0	1,010	0	1,010	.2
Buse, Sioux, and Zell soils, 3 to 30 percent slopes	490	760	1,250	2,500	.5
Cathay loam	0	1,040	0	1,040	.2
Cathay-Heimdal loams, 0 to 3 percent slopes	0	1,010	0	1,010	.2
Cathay-Heimdal loams, 3 to 6 percent slopes	0	324	0	324	.1
Cathay-Larson loams	0	3,100	0	3,100	.6
Cavour-Cresbard loams	0	4	347	351	.1
Cavour and Vallers stony clay loams	0	414	0	414	.1
Cavour clay loam, shaly variant, 3 to 6 percent slopes	0	176	0	176	(1)
Claire loamy coarse sand, 0 to 3 percent slopes	1,220	5,375	127	6,722	1.3
Claire loamy coarse sand, 3 to 6 percent slopes	0	527	27	554	.1
Claire coarse sandy loam	0	515	0	515	.1
Claire-Lohnes-Hamar loamy coarse sands	370	3,075	235	3,680	.7
Clontarf sandy loam	140	1,190	0	1,330	.3
Coe sandy loam, 0 to 6 percent slopes	20	207	0	227	(1)
Coe sandy loam, 6 to 25 percent slopes	705	2,525	882	4,112	.8
Colvin silty clay loam	133	1,520	427	2,080	.4
Colvin silty clay loam, saline	64	13	563	640	.1
Colvin silty clay loam, very wet	358	1,250	327	1,935	.4
Cresbard-Cavour loams	158	0	412	570	.1
Divide loam, 0 to 3 percent slopes	257	131	1,412	1,800	.3
Divide loam, 3 to 6 percent slopes	0	279	0	279	(1)
Divide loam, saline	0	515	0	515	.1
Divide loam, gravelly substratum	0	3,640	0	3,640	.7
Divide loam, sandy substratum	177	7,335	110	7,622	1.4
Divide loam, till substratum	0	2,930	0	2,930	.6
Eckman loam, 0 to 3 percent slopes	0	396	0	396	.1
Eckman loam, 3 to 8 percent slopes	0	150	151	301	.1
Edgeley loam	0	0	790	790	.1
Edgeley and Cavour loams, 3 to 6 percent slopes	0	262	0	262	(1)
Edgeley loam, gravelly variant	0	0	482	482	.1
Egeland sandy loam, 0 to 3 percent slopes	0	288	0	288	.1
Egeland sandy loam, 6 to 12 percent slopes	22	381	0	403	.1
Egeland sandy loam, sandy substratum	0	268	0	268	(1)

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

Soil	Benson County	Eddy County	Nelson County	Total	Survey area
	Acres	*Acres*	*Acres*	*Acres*	*Percent*
Egeland fine sandy loam, till substratum, 0 to 3 percent slopes	0	980	0	980	.2
Egeland fine sandy loam, till substratum, 3 to 6 percent slopes	0	4,150	0	4,150	.8
Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes	0	1,600	0	1,600	.3
Embden sandy loam, 0 to 3 percent slopes	1,825	1,430	455	3,710	.7
Embden-Egeland sandy loams, 3 to 6 percent slopes	185	805	120	1,110	.2
Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes	0	2,400	0	2,400	.5
Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes	0	1,900	0	1,900	.4
Emrick sandy loam	0	600	0	600	.1
Emrick loam	0	5,800	0	5,800	1.1
Esmond, Coe, and Embden soils, 6 to 25 percent slopes	0	1,625	0	1,625	.3
Exline loam	0	379	298	677	.1
Fargo and Nutley silty clay loams	0	234	0	234	(1)
Fordville loam	90	1,050	495	1,635	.3
Fossum sandy loam	63	338	29	430	.1
Fossum loam	330	500	115	945	.2
Fossum and Hamar sandy loams	240	265	165	670	.1
Fram loam, 0 to 3 percent slopes	0	22,200	0	22,200	4.2
Fram loam, 3 to 6 percent slopes	0	940	0	940	.2
Fram loam, saline	0	640	0	640	.1
Fram and Wyndmere fine sandy loams	0	372	0	372	.1
Gardena loam, 0 to 3 percent slopes	1,044	1,150	866	3,060	.6
Gardena loam, 3 to 6 percent slopes	264	77	0	341	.1
Glyndon loam	2,180	2,880	475	5,535	1.0
Glyndon loam, saline	0	225	200	425	.1
Gravel pit	13	515	82	610	.1
Hamar loamy coarse sand	175	555	0	730	.1
Hamar loamy sand	286	1,115	144	1,545	.3
Hamar coarse sandy loam	0	280	426	706	.1
Hamar sandy loam	0	428	122	550	.1
Hamerly loam, 0 to 3 percent slopes	262	213	1,120	1,595	.3
Hamerly loam, 3 to 6 percent slopes	0	585	0	585	.1
Hamerly loam, saline	0	0	403	403	.1
Hamerly-Svea loams, 0 to 3 percent slopes	0	68	607	675	.1
Hamerly-Svea loams, 3 to 6 percent slopes	0	114	286	400	.1
Hecla loamy sand, 0 to 3 percent slopes	850	2,875	375	4,100	.8
Hecla loamy sand, 3 to 6 percent slopes	62	494	14	570	.1
Hecla sandy loam, 0 to 3 percent slopes	1,700	3,550	665	5,915	1.1
Hecla sandy loam, 3 to 6 percent slopes	139	1,300	46	1,485	.3
Hecla-Dickey fine sandy loams, 3 to 6 percent slopes	0	3,625	0	3,625	.7
Hecla-Hamar loamy sands	231	788	46	1,065	.2
Hecla-Maddock loamy sands, 0 to 3 percent slopes	0	528	0	528	.1
Hecla-Maddock loamy sands, 3 to 6 percent slopes	16	573	0	589	.1
Heimdal sandy loam, 0 to 3 percent slopes	69	1,290	0	1,359	.3
Heimdal sandy loam, 3 to 6 percent slopes	0	3,200	0	3,200	.6
Heimdal sandy loam, 6 to 9 percent slopes	0	1,270	0	1,270	.2
Heimdal loam, 0 to 3 percent slopes	0	5,100	0	5,100	1.0
Heimdal loam, 3 to 6 percent slopes	125	17,100	0	17,225	3.3
Heimdal loam, 6 to 9 percent slopes	0	2,675	0	2,675	.5
Heimdal-Embden fine sandy loams, 9 to 15 percent slopes	0	560	0	560	.1
Heimdal-Embden fine sandy loams, 15 to 25 percent slopes	0	7,900	0	7,900	1.5
Heimdal-Emrick loams, 0 to 3 percent slopes	91	35,600	0	35,691	6.8
Heimdal-Emrick loams, 3 to 6 percent slopes	114	15,150	0	15,264	2.9
Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes	123	7,900	0	8,023	1.5
Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes	160	2,950	0	3,110	.6
Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes	0	11,100	0	11,100	2.1
Kensal loam	0	760	0	760	.1
Kensal loam, sandy substratum	0	3,500	0	3,500	.7
Kloten loam, 9 to 30 percent slopes	0	0	1,800	1,800	.3
Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes	0	710	0	710	.1
Kratka fine sandy loam	0	484	0	484	.1
LaDelle silty clay loam	0	1,107	93	1,200	.2
Lallie silty clay loam	0	390	885	1,275	.2
Lamoure silty clay loam	0	1,120	550	1,670	.3
Lamoure silty clay loam, saline	0	860	0	860	.2
La Prairie silt loam	0	1,015	955	1,970	.4
La Prairie-Lamoure complex	0	1,250	0	1,250	.2
Larson loam	0	830	0	830	.2
Lemert sandy loam	0	2,425	0	2,425	.5
Letcher sandy loam	40	2,365	95	2,500	.5
Letcher sandy loam, till substratum	0	1,300	0	1,300	.2
Lohnes loamy coarse sand	0	4,800	185	4,985	1.0

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

Soil	Benson County	Eddy County	Nelson County	Total	Survey area
	Acres	*Acres*	*Acres*	*Acres*	*Percent*
Lohnes coarse sandy loam	0	2,275	45	2,320	.4
Ludden silty clay	0	87	286	373	.1
Ludden-Lamoure complex	0	580	0	580	.1
Maddock loamy sand, 0 to 3 percent slopes	95	690	285	1,070	.2
Maddock loamy sand, 3 to 6 percent slopes	157	1,225	107	1,489	.3
Maddock loamy sand, 6 to 9 percent slopes	89	935	26	1,050	.2
Maddock sandy loam, 0 to 3 percent slopes	130	800	370	1,300	.2
Maddock sandy loam, 3 to 6 percent slopes	59	628	213	900	.2
Maddock sandy loam, 6 to 9 percent slopes	0	153	373	526	.1
Maddock-Dickey sandy loams, 0 to 6 percent slopes	0	733	27	760	.1
Maddock-Dickey sandy loams, 6 to 9 percent slopes	0	913	57	970	.2
Maddock-Serden loamy fine sands, 9 to 30 percent slopes	0	62	863	925	.2
Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes	0	1,435	0	1,435	.3
Made land	0	146	17	163	(1)
Marsh	1,600	4,900	860	7,360	1.4
Marysland loam	250	6,800	235	7,285	1.4
Marysland and Arveson loams	1,330	2,000	500	3,830	.7
Minnewaukan loamy fine sand, 6 to 9 percent slopes	285	1,720	75	2,080	.4
Miranda-Cavour clay loams	0	1,370	510	1,880	.4
Osakis sandy loam	0	3,275	980	4,255	.8
Osakis sandy loam, gravelly substratum	0	480	100	580	.1
Osakis sandy loam, till substratum	0	344	0	344	.1
Overly silty clay loam	144	0	0	144	(1)
Parnell silty clay loam	0	2,665	28	2,693	.5
Peat	0	144	0	144	(1)
Perella silty clay loam	25	380	70	475	.1
Rauville silty clay loam	7	193	610	810	.2
Renshaw loam, 0 to 3 percent slopes	953	15	1,220	2,188	.4
Renshaw loam, 3 to 6 percent slopes	153	750	377	1,280	.2
Renshaw loam, gravelly substratum	15	3,950	6	3,971	.8
Renshaw loam, sandy substratum	112	2,040	0	2,152	.4
Renshaw loam, till substratum	0	620	0	620	.1
Ryan silty clay loam	0	267	47	314	.1
Ryan and Lamoure silty clay loams	0	1,210	275	1,485	.3
Serden-Hamar sands	350	2,110	530	2,990	.6
Sioux gravelly loam, 0 to 6 percent slopes	0	376	0	376	.1
Sioux gravelly loam, 6 to 25 percent slopes	200	2,570	280	3,050	.6
Spottswood loam	0	470	1,025	1,495	.3
Spottswood loam, sandy substratum	0	569	76	645	.1
Stirum sandy loam	440	2,010	250	2,700	.5
Svea loam	449	211	5,425	6,085	1.1
Svea loam, cobbly variant	5	39	1,805	1,849	.3
Svea-Barnes loams, 0 to 3 percent slopes	207	390	2,150	2,747	.5
Svea-Barnes loams, 3 to 6 percent slopes	440	940	4,575	5,955	1.1
Svea-Buse-Barnes loams, 6 to 9 percent slopes	451	197	2,375	3,023	.6
Svea-Cresbard loams	30	279	2,450	2,759	.5
Swenoda-Embden fine sandy loams	0	640	0	640	.1
Tiffany sandy loam	69	401	125	595	.1
Tiffany fine sandy loam, till substratum	0	527	0	527	.1
Tolna loam	2	1,512	0	1,514	.3
Tonka silt loam	66	2,530	350	2,946	.6
Totten sandy loam	0	4,350	0	4,350	.8
Totten loam	0	5,800	0	5,800	1.1
Totten loam, very wet	0	920	0	920	.2
Totten loam, till substratum	0	1,375	0	1,375	.3
Towner fine sandy loam, 0 to 3 percent slopes	95	1,640	2,100	3,835	.7
Towner fine sandy loam, 3 to 6 percent slopes	0	525	300	825	.2
Towner-Dickey fine sandy loams	0	1,200	0	1,200	.2
Vallers loam	15	7,700	10	7,725	1.5
Vang loam	475	107	208	790	.2
Venlo sandy loam	5	310	24	339	.1
Wahpeton silty clay	0	92	292	384	.1
Walsh loam, 3 to 6 percent slopes	0	710	93	803	.2
Walsh loam, 6 to 9 percent slopes	0	473	0	473	.1
Walsh clay loam, 0 to 3 percent slopes	0	124	530	654	.1
Walsh clay loam, 3 to 6 percent slopes	0	0	280	280	.1
Walsh clay loam, 6 to 9 percent slopes	0	0	399	399	.1
Walum sandy loam	0	6,300	40	6,340	1.2
Walum sandy loam, gravelly substratum	0	542	0	542	.1
Warsing loam	0	1,600	123	1,723	.3
Warsing loam, sandy substratum	0	912	0	912	.2

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

Soil	Benson County	Eddy County	Nelson County	Total	Survey area
	Acres	*Acres*	*Acres*	*Acres*	*Percent*
Warsing loam, till substratum	0	1,800	0	1,800	.3
Wyard loam	0	530	0	530	.1
Wyndmere sandy loam	520	2,309	471	3,300	.6
Wyndmere sandy loam, till substratum	0	1,210	0	1,210	.2
Wyrene sandy loam	99	5,900	0	5,999	1.1
Wyrene sandy loam, till substratum	4	860	0	864	.2
Wyrene-Totten sandy loams	0	1,200	0	1,200	.2
Water	1,180	3,882	238	5,300	1.0
Total	45,636	406,400	73,114	525,150	100.0

[1] Less than 0.05 percent.

early in summer. A perched water table forms above the dense subsoil in periods of heavy rainfall. Tillage is often delayed in the spring because of wetness.

These soils are suited to grain crops and grasses, but they are poorly suited to legumes.

Representative profile of Aberdeen loam in a cultivated field, 500 feet north and 800 feet west of the southeast corner of sec. 1, T. 149 N., R. 59 W., Nelson County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, fine, subangular blocky structure parting to moderate, medium and fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A2—7 to 11 inches, gray (10YR 6/1) very fine sandy loam, very dark gray (10YR 3/1) moist; moderate, medium, prismatic structure parting to moderate, medium, platy; soft, very friable, slightly sticky and slightly plastic; common roots; mildly alkaline; clear, smooth boundary.

B21t—11 to 16 inches, grayish-brown (2.5Y 5/2) heavy clay loam, very dark grayish brown (2.5Y 3/2) moist; strong, medium and fine, prismatic structure parting to strong, fine, angular blocky; hard, very firm, sticky and very plastic; few roots; distinct continuous very dark gray (10YR 3/1), black (10YR 2/1) moist clay films on faces of peds; moderately alkaline; gradual, wavy boundary.

B22t—16 to 20 inches, grayish-brown (2.5Y 5/2) heavy clay loam, very dark grayish brown (2.5Y 3/2) moist; strong, fine, prismatic structure parting to strong, medium and fine, angular blocky; hard, firm, sticky and plastic; few roots; distinct continuous clay films on faces of peds; few nests of gypsum crystals; strongly alkaline; clear, wavy boundary.

B3ca—20 to 25 inches, grayish-brown (2.5Y 5/2) heavy clay loam, very dark grayish brown (2.5Y 3/2) moist; weak, coarse, prismatic structure parting to moderate, medium, angular blocky; slightly hard, friable, sticky and plastic; few roots; distinct discontinuous clay films and strongly effervescent coatings of disseminated lime on faces of peds; slightly effervescent; strongly alkaline; clear, smooth boundary.

C1ca—25 to 35 inches, variegated light brownish-gray (2.5Y 6/2) and white (2.5Y 8/2) clay loam, grayish brown (2.5Y 5/2) and light gray (2.5Y 7/2) moist; weak, very coarse, prismatic structure parting to moderate, medium, angular blocky; hard, friable, sticky and plastic; distinct, discontinuous, violently effervescent coatings of disseminated lime on faces of peds; strongly effervescent; strongly alkaline; clear, smooth boundary.

C2—35 to 44 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, grayish brown (2.5Y 5/2) moist, few, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; weak, coarse angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent; strongly alkaline; clear, smooth boundary.

C3—44 to 50 inches, light yellowish-brown (10YR 6/4) very fine sandy loam, dark yellowish brown (10YR 4/4) moist; common, fine, prominent, strong-brown (7.5YR 5/6, moist) mottles; massive; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline; clear, smooth boundary.

C4—50 to 60 inches, brown (10YR 5/3) very fine sandy loam, dark brown (10YR 4/3) moist; common, medium, distinct, light-gray (5Y 6/1) mottles; massive; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The Ap or A1 horizon ranges from 6 to 10 inches in thickness. It is dark-gray or very dark gray loam or silt loam. In some places, where deep tillage has mixed part of the B2 horizon with the A1 and A2 horizons, the Ap horizon is clay loam. The A2 horizon is very fine sandy loam or loam 2 to 6 inches thick. The moderate prismatic structure parts to moderate platy where this horizon is thick and to moderate or weak platy where the horizon is thin.

The B2 horizon contains more sand than is within the defined range for the series, but this higher content of sand does not change the usefulness or behavior of these soils. The B2 horizon is grayish-brown or dark-gray heavy clay loam or silty clay loam 8 to 16 inches thick. It has strong or moderate prismatic structure that parts to strong or moderate angular blocky structure in the upper part, and it has moderate or weak prismatic structure that parts to moderate angular blocky structure in the lower part. In some places the upper 2 to 4 inches of the B2 horizon has secondary moderate platy structure. The typical profile has a B3ca horizon, but not all profiles have this horizon.

The C horizon is typically clay loam to a depth of about 35 inches and is very fine sandy loam below this depth, but in some profiles it is silty clay loam to a depth of about 40 inches and is stratified sand below that depth. In the typical profile, gypsum and other segregations of salt have accumulated in the B2 horizon, but in some places they are in the B3 horizon or in the upper part of the C horizon.

Aberdeen soils are adjacent to Exline, Colvin, and Gardena soils in many areas. They have a profile similar to that of Exline soils. They have a claypan B2t horizon, which Colvin and Gardena soils do not have, and they have a combined A1 and A2 horizon that is thicker than that of Exline soils.

Aberdeen loam (Ab).—This soil is nearly level and is in slight depressions on outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Colvin and Exline soils in slightly lower positions and Gardena soils in slightly higher positions. Also included is a 50-acre area in sections 1 and 12, T. 149 N., R. 59 W. consisting of a complex of about 70 percent Gardena loam and 30 percent Aberdeen loam. The surface layer in this area is clay loam. It is hard and cloddy when dry and sticky when wet in those cultivated areas where the subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grains and grasses, but it is poorly suited to legumes. Growth of most crops is reduced because root growth is limited by the dense subsoil and salts that have accumulated in the root zone. Controlling wetness and maintaining good tilth in cultivated areas are the main concerns of management. Capability unit IIIs–6P; windbreak suitability group 4.

Aberdeen-Exline loams (Ae).—Soils of this mapping unit are nearly level and in depressions on outwash plains. Aberdeen loam makes up about 50 to 60 percent of the complex, and Exline loam, in slightly lower positions, makes up about 30 to 40 percent.

Included with these soils in mapping are small areas of Colvin soils in depressions and areas of Gardena soils in slightly higher positions. Also included are a few acres where the surface layer is silty clay loam because tillage has mixed the subsoil into the plow layer. The surface layer in these areas is hard and cloddy when dry and sticky when wet.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this mapping unit are used for pasture and hay, but small areas are cultivated along with the adjoining soils. Soils of this complex are suited to salt-tolerant grains and grasses, but are poorly suited to legumes. The dense subsoil and salts that have accumulated in the root zone restrict the growth of most crops. Controlling wetness and maintaining good tilth in cultivated areas are the main concerns of management. Capability unit IVs–6P; Aberdeen soil is in windbreak suitability group 4, Exline soil is in windbreak suitability group 9.

Arveson Series

The Arveson series consists of deep, nearly level, poorly drained calcareous soils that formed in moderately coarse textured and coarse textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is sandy loam about 12 inches thick. It is dark gray in the upper 6 inches; in the lower 6 inches it is gray and contains an accumulation of lime. The substratum is 50 inches thick. The upper 9 inches is variegated light-gray and white friable sandy loam that contains an accumulation of lime. The next 11 inches is mottled, light-gray sand. The 8 inches below that is mottled, light-gray sandy loam. The next 8 inches is mottled, light olive-gray sand. The lower 14 inches is gray stratified sandy loam and sand.

Permeability is moderately rapid, and the available water capacity is low. The organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year and at or near the surface in spring and early in summer. Drains are difficult to install because outlets are not generally available.

These soils are suited to grasses, grain crops, and legumes, but tillage is often delayed or difficult because of wetness.

Representative profile of Arveson sandy loam in a pasture, 175 feet south and 1,400 feet east of the northwest corner of sec. 14, T. 148 N., R. 64 W., Eddy County:

A1—0 to 6 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; moderate, coarse and medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; strongly effervescent; moderately alkaline; clear, smooth boundary.

A12ca—6 to 12 inches, gray (10YR 5/1) sandy loam, very dark gray (10YR 3/1) moist; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; violently effervescent; mildly alkaline; clear, wavy boundary.

C1cag—12 to 21 inches, variegated light-gray (5Y 7/2) and white (N 8/0) sandy loam, light olive gray (5Y 6/2) and white (N 8/0) moist; weak, medium, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; mildly alkaline; gradual, irregular boundary.

IIC2g—21 to 32 inches, light-gray (5Y 7/2) sand, olive (5Y 5/3) moist; common, medium, distinct, yellowish-brown (10YR 5/6, moist) and few, fine, prominent, black (10YR 2/1, moist) mottles; single grained; loose, nonsticky and nonplastic; few roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC3g—32 to 40 inches, light-gray (5Y 7/2) sandy loam, olive gray (5Y 5/2) moist; common, medium, distinct, dark yellowish-brown (10YR 4/4, moist) and many, medium, prominent, black (10YR 2/1, moist) mottles; massive; slightly hard, very friable, slightly sticky and slightly plastic; few roots; very slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC4g—40 to 48 inches, light olive-gray (5Y 6/2) sand, olive gray (5Y 5/2) moist; common, medium, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; single grained; loose, nonsticky and nonplastic; very slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC5g—48 to 62 inches, gray (N 6/0) stratified sandy loam and sand, dark greenish gray (5BG 4/1) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 6 to 14 inches in thickness. It is very dark gray, dark-gray, or gray sandy loam or light loam. Typically it is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in places. The Cca horizon is light-gray, light olive-gray, or white sandy loam or light loam 6 to 16 inches thick and is mottled in places. It has weak prismatic structure that parts to moderate or weak subangular blocky structure. The IIC horizon is mottled light gray, gray, or light olive gray. In places it is sand, but typically it is stratified sandy loam or loamy sand and sand.

Arveson soils are in landscape positions similar to those

of Fossum, Hamar, and Wyndmere soils and are often adjacent to them. They have a profile similar to that of Wyndmere soils. Arveson soils contain more segregated lime closer to the surface than Fossum and Hamar soils. They are not so well drained as Wyndmere soils.

Arveson sandy loam (Ar).—This soil is nearly level and is in depressions on sandy outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Fossum soils in positions similar to those of Arveson soils. Also included are areas of Hecla and Wyndmere soils on slightly higher, better drained positions.

Surface runoff is very slow. The hazard of soil blowing is very severe.

Most areas of this soil are used for pasture and hay, but some are cultivated along with the adjoining soils. This soil is suited to grasses, grain crops, and legumes. Wetness, soil blowing, and droughtiness because of the low available water capacity are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Arvilla Series

The Arvilla series consists of shallow, nearly level to rolling, somewhat excessively drained soils that formed in moderately coarse textured glaciofluvial deposits overlying coarse textured glaciofluvial deposits. These soils are on outwash plains, on terraces along rivers and drainageways, and in areas of glacial till.

In a representative profile the surface layer is dark-gray sandy loam about 5 inches thick. The subsoil is very friable sandy loam about 13 inches thick; it is dark gray in the upper 7 inches and grayish brown in the lower 6 inches. The substratum is 42 inches thick. The upper 4 inches is grayish-brown loamy coarse sand. The next 20 inches is mottled, yellowish-brown sand and gravel. Below that is brown sand and gravel, and the lower 8 inches is gray sand.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes. The more sloping areas are better suited to grasses than to most other uses.

Representative profile of Arvilla sandy loam in a cultivated field, 180 feet south and 125 feet west of the northeast corner of the SE¼ sec. 5, T. 150 N., R. 60 W., Eddy County:

Ap—0 to 5 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, fine and medium, subangular blocky structure parting to moderate, fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B1—5 to 12 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; moderate, coarse, prismatic structure parting to moderate and weak, medium and fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; clear, wavy boundary.

B2—12 to 18 inches, grayish-brown (2.5Y 5/2) sandy loam, very dark grayish brown (2.5Y 3/2) moist; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; discontinuous dark-gray (10YR 4/1) organic coatings on faces of prisms; few granitic pebbles as large as 10 millimeters; neutral; clear, wavy boundary.

IIC1—18 to 22 inches, grayish-brown (2.5Y 5/2) loamy coarse sand (mainly shale), dark grayish brown (2.5Y 4/2) moist; weak, medium, subangular blocky structure; soft, very friable, slightly sticky and nonplastic; few roots; few fragments of shale as large as 10 millimeters; neutral; clear, wavy boundary.

IIC2—22 to 42 inches, yellowish-brown (10YR 5/4) sand and gravel, dark yellowish brown (10YR 4/4) moist; common, medium, distinct, reddish-yellow (7.5YR 6/6) mottles; single grained; loose, nonsticky and nonplastic; few fragments of shale as large as 20 millimeters; underside of some pebbles coated with lime; very slightly effervescent; mildly alkaline; clear, smooth boundary.

IIC3—42 to 52 inches, brown (10YR 5/3) sand and gravel, dark brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; common fragments of shale as large as 10 millimeters; few fragments of shale as large as 20 millimeters in size; underside of some pebbles coated with lime; very slightly effervescent; mildly alkaline; clear, smooth boundary.

IIC4—52 to 60 inches, light brownish-gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; common, medium, distinct, brownish-yellow (10YR 6/6) mottles; single grained; loose, nonsticky and nonplastic; few granitic pebbles as large as 5 millimeters; very slightly effervescent; mildly alkaline.

Depth to sand and gravel ranges from 14 to 26 inches, but the typical range is 15 to 20 inches. The A horizon ranges from 5 to 12 inches in thickness. It is dark gray or very dark gray. The B horizon ranges from 5 to 14 inches in thickness. It is dark gray, grayish brown, dark grayish brown, or brown. The B2 horizon typically has moderate prismatic structure that parts to moderate subangular blocky structure, but in some places the structure is weak. Organic coatings are on the faces of prisms in most profiles but are lacking in some. Lime coatings are on the underside of pebbles in one or more of the IIC horizons of the typical profile; but in some places they are present as soft segregated masses in the upper part of the IIC horizon. The content of gravel in the IIC horizon ranges from 10 percent to more than 40 percent by volume. The gravel is dominantly granitic, but some profiles contain one or more thin layers of shaly sand or gravel.

Arvilla soils are adjacent to Claire, Lohnes, Osakis, and Sioux soils in many areas. They formed in parent material similar to that of Osakis and Sioux soils. They have a profile similar to that of Osakis soils. Arvilla soils have less medium and coarse sand in the solum and more gravel in the substratum than Claire and Lohnes soils. They are more excessively drained than Osakis soils and are deeper to the IIC horizon than Sioux soils.

Arvilla sandy loam (As).—This soil is nearly level and is on outwash plains and terraces along drainageways and rivers. It has the profile described as representative of the series. The content of gravel in the substratum ranges from 10 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Claire and Osakis soils that are in positions similar to those of Arvilla soils.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Arvilla sandy loam, gravelly substratum, 0 to 3 per-

cent slopes (AtA).—This soil is on outwash plains and terraces along drainageways and rivers. It has a profile similar to the one described as representative of the series, but the substratum contains more than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Osakis soils in positions similar to those of Arvilla soils. Also included are areas of Arvilla soils that have a substratum that contains less than 40 percent gravel by volume.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes (AtB).—This soil is on outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but the substratum contains more than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Sioux soils on the summits and shoulder slopes, areas of Spottswood sandy loam on foot slopes and toe slopes, and areas of Arvilla soils that have a substratum containing less than 40 percent gravel by volume. Also included are cultivated areas that have a lighter colored surface layer on the summits and shoulder slopes.

Surface runoff is medium. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes (AvA).—This soil is on outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but the substratum typically contains less than 20 percent gravel by volume.

Included with this soil in mapping are small areas of Claire soils and Osakis soils in positions similar to those of Arvilla soils. Also included are areas of Arvilla soils that have a substratum that contains more than 40 percent gravel by volume.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. The soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes (AvB).—This soil is on outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but the substratum typically contains less than 20 percent gravel by volume.

Included with this soil in mapping are small areas of Claire soils and Sioux soils on summits and shoulder slopes, areas of Spottswood sandy loam and Lohnes soils on toe slopes, and areas of Arvilla soils that have a substratum containing more than 40 percent gravel by volume. Also included, in cultivated areas on summits and shoulder slopes, are areas of a soil that has a lighter colored surface layer.

Surface runoff is medium. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Arvilla-Sioux sandy loams, 6 to 9 percent slopes (AxC).—Soils of this mapping unit are on outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. The Sioux soils in this mapping unit have a profile similar to the one described as representative of the Sioux series, but they have a sandy loam surface layer. The substratum of these soils ranges from 10 percent to more than 40 percent gravel by volume. The Arvilla soils, on the back slopes, make up about 60 percent of the mapping unit, and the Sioux soils, on the summits and shoulder slopes, make up about 25 percent.

Included with these soils in mapping are small areas of Claire soils on the shoulder slopes and areas of Spottswood and Lohnes soils on the foot slopes and toe slopes. Also included, and making up about 15 percent of this mapping unit, are areas of strongly sloping Renshaw loam. Soils on the summits and shoulder slopes have a lighter colored surface layer in cultivated areas.

Surface runoff is rapid. The hazard of soil blowing is very severe.

Most areas of this mapping unit are in pasture, but some are cultivated along with the adjoining soils. Soils of the mapping unit are well suited to grasses, and they are suited to close-growing grain crops and legumes if protective measures are used. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVes–3; Arvilla soils in windbreak suitability group 6, Sioux soils in windbreak suitability group 10.

Barnes Series

The Barnes series consists of deep, nearly level to gently rolling, well-drained soils that formed in medium textured and moderately fine textured glacial till. These soils are on glacial till plains (fig. 6).

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The subsoil is brown firm clay loam about 10 inches thick. The substratum, in the upper 7 inches, is light-gray clay loam that has an accumulation of lime. It is mottled, light brownish gray in the lower 37 inches.

Permeability is moderate in the surface layers and

Figure 6.—**Profile of Barnes loam, a deep, well-drained soil that formed in medium textured and moderately fine textured glacial till.**

subsoil and moderately slow in the substratum. The available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes except on steep slopes and where stones limit the use of machinery. On steep slopes and stony areas these soils are better suited to grass than to most other uses.

Representative profile of Barnes loam, in an area of Barnes-Svea loams, 0 to 3 percent slopes, in a cultivated field, 150 feet north and 150 feet west of the southeast corner of the NE¼ sec. 26, T. 149 N., R. 62 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B2—6 to 16 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) moist; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; hard, firm, very sticky and plastic; common roots; clay films on faces of peds; tongues of A1 horizon extend to a depth of 12 inches; neutral; gradual, wavy boundary.

C1ca—16 to 23 inches, light-gray (10YR 7/2) clay loam, brown (10YR 5/3) moist; moderate, coarse, prismatic structure; slightly hard, friable, very sticky and very plastic; few roots; many pebbles and stones; violently effervescent; mildly alkaline; gradual, wavy boundary.

C2—23 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/4) moist; massive; few, fine, faint, yellowish-brown (10YR 5/6, moist) mottles; hard, firm, very sticky and plastic; strongly effervescent with large lime nodules; moderately alkaline.

The A horizon ranges from 4 to 9 inches in thickness. It is dark-gray or very dark gray loam or silt loam. The B horizon ranges from 4 to 20 inches in thickness. It is brown, dark grayish-brown, or light brownish-gray loam or clay loam. Typically the B horizon has clay films or organic stains on ped faces, but some profiles do not have them. In most places the B horizon is free of lime, but in some places it has an accumulation of lime in the lower part. The Cca horizon is loam or clay loam; some profiles lack this horizon. The C2 horizon is mottled, light brownish-gray or pale-yellow loam or clay loam.

The Barnes soils are adjacent to the Buse and Svea soils in many areas. They have a B2 horizon, which the Buse soils do not have, and a thinner A horizon than Svea soils. They have a profile similar to that of Barnes and Heimdal soils, but they are more clayey.

Barnes loam, 0 to 3 percent slopes (BaA).—This soil is on glacial till plains. It has a profile similar to the one described as representative of the series, but the surface layer is slightly thicker in most places.

Included with this soil in mapping are small areas of Heimdal soils in positions similar to those of Barnes soils. Also included are small areas of Svea soils in concave positions, areas of Wyard soils in shallow swales and depressions, areas of Tonka soils in deep depressions that are identified on the soil map by diamond symbols, and areas of Hamerly soils around the edges of some depressions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Nearly all areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness in depressions is the main concern of management. Capability unit IIc–6; windbreak suitability group 3.

Barnes loam, 3 to 6 percent slopes (BaB).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Heimdal soils in positions similar to those of Barnes soils, areas of Buse soils on the summits and shoulder slopes, and areas of Svea soils on toe slopes.

Surface runoff is medium. The hazard of soil blowing is slight.

Nearly all areas are cultivated. This soil is suited to grain crops, grasses, and legumes. Surface runoff is the main concern of management. Capability unit IIe–6; windbreak suitability group 3.

Barnes loam, 6 to 9 percent slopes (BaC).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Heimdal soils in positions similar to those of Barnes soils. Also included are small areas of Buse soils on the summits and shoulder slopes, areas of Emrick and Svea soils on foot slopes and toe slopes, areas of Wyard soils in shallow swales and depressions, areas of Tonka and Parnell soils in deep depressions that are identified on the soil map by a diamond symbol, and areas of Hamerly soils around the edges of some depressions. Soils on the summits and shoulder slopes in cultivated areas have a lighter colored surface layer in many places.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but some are used for pasture. This soil is suited to grasses, close-growing grain crops, and legumes. Surface runoff and wetness in depressions are the main concerns of man-

agement. Capability unit IIIe–6; windbreak suitability group 3.

Barnes-Svea loams, 0 to 3 percent slopes (BbA).—Soils of this mapping unit are on glacial till plains. The Barnes soils have the profile described as representative of the Barnes series. The Barnes soils, on convex slopes, make up about 50 to 60 percent of the mapping unit, and Svea soils, on concave slopes, make up about 25 to 35 percent.

Included with these soils in mapping are small areas of Heimdal soils on convex slopes, areas of Emrick soils on concave slopes, areas of Wyard soils in shallow swales and depressions, and areas of Tonka soils in deep depressions that are identified on the soil map by a diamond symbol. Also included are areas of Hamerly soils around the edges of some depressions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Nearly all areas of this mapping unit are cultivated. The soils are suited to grain crops, grasses, and legumes. Wetness in depressions is the main concern of management. Capability Unit IIc–6; Barnes soil is in windbreak suitability group 3, Svea soil in windbreak suitability group 1.

Barnes-Svea loams, 3 to 6 percent slopes (BbB).—Soils of this mapping unit are on glacial till plains. The Barnes soils, on shoulder slopes and back slopes, make up about 50 to 60 percent of this mapping unit, and the Svea soils, on foot slopes and toe slopes, make up about 20 to 30 percent.

Included with these soils in mapping are small areas of Heimdal soils on shoulder slopes and back slopes, Emrick soils on foot slopes and toe slopes, Buse soils on the summits and shoulder slopes, Wyard soils in shallow swales and depressions, and Tonka and Parnell soils in deep depressions that are identified on the soil map by a diamond symbol. Also included are Hamerly and Vallers soils around the edges of some of the depressions. Soils on the crests of knolls in cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is slight.

Nearly all areas of this mapping unit are cultivated. The soils are suited to grain crops, grasses, and legumes. Surface runoff and wetness in depressions are the main concerns of management. Capability unit IIe–6; Barnes soil in windbreak suitability group 3, Svea soil in windbreak suitability group 1.

Barnes-Svea stony loams, 3 to 6 percent slopes (BcB).—Soils of this mapping unit are on glacial till plains. About 15 percent of the unit is on a nearly level pitted plain. The Barnes and Svea soils have a profile similar to the one described as representative of their series, but they have a large number of stones on or near the surface. The Barnes soils, on summits, shoulder slopes, and back slopes, make up about 50 to 60 percent of the mapping unit, and the Svea soils, on foot slopes and toe slopes, make up about 20 to 30 percent.

Included with these soils in mapping are small areas of Heimdal soils on summits, shoulder slopes, and back slopes, Emrick soils on foot slopes and toe slopes, Wyard soils in shallow swales and depressions, Tonka and Parnell soils in deep depressions that are identified by a diamond symbol on the soil map, and Hamerly soils around the edges of some depressions.

Surface runoff is medium, and water ponds in depressions.

Soils of this mapping unit are used for pasture or are left idle. They are suited to grasses. Stones on or near the surface limit the use of farm machinery. Capability unit VIIs–8; windbreak suitability group 10.

Barnes-Svea-Buse loams, 6 to 9 percent slopes (BdC).—Soils of this mapping unit are on glacial till plains. The Barnes soils, on back slopes, make up about 50 percent of the mapping unit; the Svea soils, on foot slopes and toe slopes, make up about 25 percent; and the Buse soils, on the summits and shoulder slopes, make up about 15 percent.

Included with these soils in mapping are small areas of Heimdal soils on back slopes, areas of Emrick soils on foot slopes and toe slopes, areas of Tonka and Parnell soils in depressions that are identified by a diamond symbol on the soil map, and areas of Hamerly and Vallers soils around the edges of some of the depressions. In many places, soils in cultivated areas on the summits and shoulder slopes have a lighter colored surface layer. Erosion has removed the surface layer on the summits and shoulder slopes in some cultivated areas. Shallow gullies are in drainageways in places. Also included are small areas where the slopes range from 9 to 16 percent.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas of this mapping unit are cultivated. The more sloping areas are generally used for pasture. The soils are well suited to grasses and are suited to close-growing grain crops and legumes on the sloping and gently rolling areas if protective measures are used. Surface runoff and wetness in depressions are the main concerns of management. Capability unit IIIe–6; Barnes and Svea soils are in windbreak suitability group 3, Buse soil is in windbreak suitability group 10.

Barnes-Svea-Buse stony loams, 6 to 9 percent slopes (BeC).—Soils of this mapping unit are on glacial till plains. The Barnes, Svea, and Buse soils have a profile similar to the one described as representative of their series, but they have a large number of stones on or near the surface. The Barnes soils, on back slopes, make up about 50 percent of the mapping unit; the Svea soils, on foot slopes and toe slopes, make up about 25 percent; and the Buse soils, on the summits and shoulder slopes, make up about 15 percent.

Included with these soils in mapping are small areas of Heimdal soils on back slopes, areas of Emrick soils on foot slopes and toe slopes, and areas of Tonka and Parnell soils in depressions that are identified by a diamond symbol on the soil map. Also included are areas of Hamerly and Vallers soils around the edges of some depressions.

Surface runoff is rapid, and water ponds in depressions.

Soils of this mapping unit are either used for pasture or are left idle. They are suited to grasses. The stones on or near the surface limit the use of farm machinery. Capability unit VIIs–8; windbreak suitability group 10.

Bearden Series

The Bearden series consists of deep, nearly level, somewhat poorly drained, calcareous, saline soils that formed in moderately fine textured glaciofluvial deposits. These soils are in slight depressions on glacial outwash plains.

In a representative profile the surface layer is gray silt loam about 15 inches thick that has an accumulation of lime in the lower part. The substratum is 45 inches thick. The upper 13 inches is mottled, light-gray, friable silty clay loam that has an accumulation of lime. The next 12 inches is mottled, light-gray silty clay loam. The next 8 inches is mottled, light brownish-gray sandy clay loam. The next 4 inches is mottled, light brownish-gray gravelly loam. The next 4 inches is light olive-gray gravel and sand. The lower 4 inches is very dark gray sand.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in the spring and early in summer.

These soils are suited to salt-tolerant grain crops, grasses, and legumes, but tillage is often delayed because of wetness.

Representative profile of Bearden silt loam, saline, in a cultivated field, 330 feet north and 380 feet east of the center of sec. 20, T. 149 N., R. 58 W., Nelson County:

Ap—0 to 8 inches, gray (2.5Y 5/1) silt loam, very dark gray (2.5Y 3/1) moist; weak, medium and fine, subangular blocky structure parting to moderate medium granular; slightly hard, friable, slightly sticky and plastic; many roots; common segregations of salt; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

A12ca—8 to 15 inches, gray (N 6/0) silt loam, very dark gray (2.5Y 3/1) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and plastic; common roots; common segregations of salt; violently effervescent; mildly alkaline; clear, wavy boundary.

C1ca—15 to 28 inches, light-gray (2.5Y 7/1) silty clay loam, grayish brown (2.5Y 5/2) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, sticky and plastic; few roots; common distinct white (N 8/0) concentrations of lime; violently effervescent; mildly alkaline; clear, smooth boundary.

C2—28 to 40 inches, light-gray (2.5Y 7/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, brown (10YR 5/3, moist) mottles; weak, medium, subangular blocky structure; hard, friable, sticky and plastic; few roots; few pebbles as large as 5 millimeters; strongly effervescent; mildly alkaline; clear, smooth boundary.

C3—40 to 48 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, dark-brown (10YR 4/3, moist) mottles; massive; hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; slightly effervescent; mildly alkaline; clear, smooth boundary.

IIC4—48 to 52 inches, light brownish-gray (2.5Y 6/2) gravelly loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, dark-brown (10YR 4/3, moist) mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; few fragments of shale as large as 30 millimeters; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

IIC5—52 to 56 inches, light olive-gray (5Y 6/2) gravel and sand, olive gray (5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; many fragments of shale as large as 10 millimeters and common fragments of shale as large as 30 millimeters; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

IIC6—56 to 60 inches, very dark gray (10YR 3/1) sand, very dark brown (10YR 2/2) moist; single grained; loose, nonsticky and nonplastic; common granitic pebbles and fragments of shale as large as 10 millimeters and few granitic pebbles and fragments of shale as large as 20 millimeters; very slightly effervescent; mildly alkaline.

The A horizon ranges from 6 to 15 inches in thickness. It is gray or very dark gray silt loam or silty clay loam. Typically the A horizon has segregations of gypsum and other salts throughout and an accumulation of lime in the lower part, but it is noncalcareous in places. The C1ca horizon ranges from 10 to 20 inches in thickness. The C horizon is light gray, light brownish gray, light olive gray, or very dark gray. It typically is silty clay loam, but in many places the texture ranges from silty clay loam to sand and gravel below a depth of about 40 inches. The content of sand throughout the profile of these soils is greater than the defined range for the series; but this does not alter their usefulness or behavior.

Bearden soils are adjacent to Aberdeen, Colvin, and Exline soils in many places. They have a profile similar to that of Colvin soils, but they are better drained. They have an accumulation of lime in or just below the A horizon that is lacking in Aberdeen soils and Exline soils.

Bearden silt loam, saline (Bg).—This nearly level soil is in slight depressions on outwash plains. About 20 percent of the areas are nonsaline.

Included with this soil in mapping are small areas of Glyndon soils in positions similar to those of Bearden soils. Also included are areas of Gardena soils and Aberdeen soils in slightly higher positions and Colvin soils in lower positions. Cultivated areas of this soil generally have a lighter colored surface layer. In some areas as much as 20 percent of this mapping unit is nonsaline Bearden soils.

Surface runoff is slow, and water ponds in low places. The hazard of soil blowing is severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is better suited to salt-tolerant grain crops, grasses, and legumes than to most other uses. Wetness, salinity, and soil blowing are the main concerns of management. Capability unit IIIws-4L; windbreak suitability group 10.

Binford Series

The Binford series consists of shallow, nearly level to hilly, somewhat excessively drained soils that formed in moderately coarse textured overlying coarse textured shaly glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray sandy loam about 6 inches thick. The subsoil is dark grayish-brown, friable sandy loam about 7 inches thick. The substratum is light olive-gray stratified shaly gravel and sand in the upper 27 inches and light olive-gray stratified shaly and granitic sands in the lower 20 inches.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and

legumes, but on the moderately steep and steeper slopes they are better suited to grasses than to most other uses.

Representative profile of Binford sandy loam, in an area of Binford sandy loam, gravelly substratum, in a cultivated field, 275 feet south and 375 feet east of the northwest corner of the NE¼ sec. 27, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B2—6 to 13 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few shale pebbles as large as 5 millimeters; slightly acid; clear, wavy boundary.

IIC1—13 to 40 inches, light olive-gray (5Y 6/2) stratified shaly gravel and sand, olive gray (5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; few roots in top 6 inches; to percent gravel by volume; coatings of lime on the underside of pebbles; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC2—40 to 60 inches, light olive-gray (5Y 6/2) stratified shaly and granitic sands, olive gray (5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; common granitic pebbles as large as 5 millimeters and few pebbles and fragments of shale as large as 20 millimeters; slightly effervescent; mildly alkaline.

Depth to the sand and gravel substratum ranges from about 13 to 25 inches, but in most places it ranges from 13 to 20 inches. The A horizon ranges from 5 to 12 inches in thickness. It is very dark gray or dark gray. The B2 horizon ranges from about 6 to 14 inches in thickness. It is dark grayish brown or grayish brown. It has moderate or weak prismatic structure that parts to moderate or weak subangular blocky structure. In some places the B2 horizon has organic coatings on the faces of prisms. The IIC horizons are typically stratified shaly sand and gravel, but they contain a layer of granitic sand and gravel in places. In most places lime coats the undersides of the pebbles in one or more of the IIC horizons; but in some places lime is present as segregated soft masses in the upper part of the IIC horizon.

Binford soils are adjacent to Coe, Tolna, and Walum soils in many areas. They are not so excessively drained as Coe soils, but they are better drained than Tolna and Walum soils.

Binford sandy loam (Bh).—This nearly level soil is on outwash plains. It has a profile similar to the one described as representative of the series, but the content of gravel in the substratum ranges from 10 percent to 40 percent by volume.

Included with this soil in mapping are small areas of Walum soils in positions similar to those of Binford soils. Also included are areas of Vang soils on slightly lower concave positions and areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Binford sandy loam, gravelly substratum, 0 to 3 percent slopes (BkA).—This soil is on outwash plains. It has the profile described as representative of the series. The content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Binford soils that have a substratum that contains less than 40 percent gravel by volume. Also included are areas of Walum soils in positions similar to those of Binford soils and areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some areas are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Binford sandy loam, gravelly substratum, 3 to 6 percent slopes (BkB).—This soil is on outwash plains. The content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Binford soils that have a substratum that contains less than 40 percent gravel by volume. Also included are areas of Coe soils on the summits and shoulder slopes, areas of Vang soils on foot slopes, areas of Gardena soils on toe slopes, and areas of Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on the summits and shoulder slopes in cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some areas are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Binford sandy loam, sandy substratum, 0 to 3 percent slopes (BlA).—This soil is on outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Walum soils in positions similar to those of Binford soils. Also included are areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol, and small areas of Binford soils that have a substratum that contains more than 40 percent gravel by volume.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Binford sandy loam, sandy substratum, 3 to 6 percent slopes (BlB).—This soil is on outwash plains. It has a profile similar to the one described as representative

of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Coe soils on the summits and shoulder slopes, areas of Vang soils on foot slopes, and areas of Gardena soils on toe slopes. Also included are areas of Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol, and small areas of Binford soils that have a substratum that contains more than 40 percent gravel by volume. Soils on the summits and shoulder slopes in cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some areas are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Binford-Coe sandy loams, 6 to 9 percent slopes (BmC).—Soils of this mapping unit are on outwash plains. The Binford and Coe soils in this mapping unit have a profile similar to the one described as representative of their series, but content of gravel in the substratum ranges from 10 percent to more than 40 percent by volume. The Binford soils, on the back slopes, make up about 60 percent of this mapping unit, and the Coe soils, on the summits and shoulder slopes, make up about 25 percent.

Included with these soils in mapping are small areas of Vang soils on foot slopes and areas of Gardena soils on toe slopes. Also included are areas of Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on the summits and shoulder slopes in cultivated areas have a lighter colored surface layer.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is very severe.

Some areas of this mapping unit are cultivated, and others are used for pasture and hay. The soils are well suited to grasses, and they are suited to close-growing grain crops and legumes if protective measures are used. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVes–3; Binford soil is in windbreak suitability group 6, Coe soil is in windbreak suitability group 10.

Binford-Coe sandy loams, 9 to 12 percent slopes (BmD).—Soils of this mapping unit are on outwash plains. The Binford and Coe soils in this mapping unit have a profile similar to the one described as representative of their series, but the content of gravel in the substratum ranges from 10 percent to more than 40 percent by volume. The Binford soils, on the back slopes, make up about 50 percent of this mapping unit, and the Coe soils, on the summits and shoulder slopes, make up about 30 percent.

Included with these soils in mapping are small areas of Vang soils on the foot slopes, Gardena soils on the toe slopes, and Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on the summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is very rapid, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are used for pasture, but some are cultivated along with adjoining areas. The soils are better suited to grasses than to most other uses. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit VIs–3; windbreak suitability group 10.

Borup Series

The Borup series consists of deep, nearly level and gently sloping, poorly drained, calcareous soils that formed in medium-textured glaciofluvial deposits. These soils are on glacial outwash plains and in channels and seepage areas on the slopes of draws, coulees, and rivers.

In a representative profile the surface layer is silt loam about 11 inches thick that is dark gray in the upper part. In the lower part it is gray and contains an accumulation of lime. The substratum is 49 inches thick. The upper 23 inches is white, friable silt loam that contains an accumulation of lime. The next 20 inches is silt loam that is variegated light gray and white in the upper part and variegated light yellowish brown and light gray in the lower part. The lowermost 6 inches is light yellowish-brown sand and gravel.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year; it is at or near the surface in spring and early in summer in poorly drained areas, but it is closer to the surface for longer periods in very wet areas. Drains are difficult to install in these soils because outlets are not generally available.

These soils are better suited to grasses than to most other uses. If drained, they are suited to small grains and legumes.

Representative profile of Borup silt loam in a hayfield, 50 feet south and 1,300 feet west of the northeast corner of sec. 22, T. 149 N., R. 67 W., Eddy County:

A11—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and plastic; many roots; strongly effervescent; mildly alkaline; clear, smooth boundary.

A12ca—5 to 11 inches, gray (10YR 6/1) silt loam, very dark gray (10YR 3/1) moist; weak, medium, prismatic structure parting to moderate, fine, granular; slightly hard, friable, sticky and plastic; many gradual, irregular boundary.

C1ca—11 to 22 inches, white (N 8/0) silt loam, gray (5Y 5/1) moist; weak, medium, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, friable, sticky and plastic; common roots; few pebbles as large as 10 millimeters; violently effervescent; mildly alkaline; gradual, wavy boundary.

C2ca—22 to 34 inches, white (N 8/0) silt loam, gray (5Y 5/1) moist; weak, medium, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, friable, sticky and plastic; common roots; violently effervescent; mildly alkaline; gradual, wavy boundary.

C3ca—34 to 42 inches, variegated white (N 8/0) and light-gray (5Y 7/1) silt loam, gray (5Y 6/1 and 5/1) moist; massive; slightly hard, friable, sticky and plastic; few roots; few pebbles as large as 10 millimeters; violently effervescent; mildly alkaline; clear, wavy boundary.

C4—42 to 54 inches, variegated light-gray (5Y 7/1) and yellowish-brown (10YR 5/6) silt loam, gray (5Y 6/1) moist, yellowish red (5YR 4/6) moist, and dark brown (7.5YR 4/4) moist; few, fine, prominent, black (10YR 2/1, moist) mottles; massive; hard, firm, sticky and plastic; strongly effervescent; mildly alkaline; clear, wavy boundary.

IIC5—54 to 60 inches, light yellowish-brown (2.5Y 6/4) sand and gravel, olive brown (2.5Y 4/4) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 5 to 14 inches in thickness. It is very dark gray, dark-gray, or gray silt loam or loam. Typically it is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon is light-gray or white loam or silt loam. It has weak prismatic structure that parts to moderate or weak, subangular blocky structure. The C horizon is mottled, light-gray, light olive-gray, or yellowish-brown loam or silt loam. In most places the IIC horizon is sand and gravel but in a few places it is loam or silt loam throughout. Segregations of gypsum crystals and other salts are just below the Cca horizon in some places and are in the A horizon in a few places. The Borup soils mapped in this survey contain a higher percentage of sand than is within the defined range of the series, but this difference does not alter their usefulness and behavior.

Borup soils are adjacent to Glyndon, Marysland, Totten, and Vallers soils in many places. They have a profile similar to those of Glyndon, Marysland, and Vallers soils. Borup soils are more poorly drained than Glyndon soils. They contain less sand and gravel below the A horizon than Marysland soils. They contain more lime closer to the surface than Totten soils. They contain more silt throughout the profile than Vallers soils.

Borup silt loam (Bn).—This nearly level soil is in depressions on glacial outwash plains and in channels. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Divide, Glyndon, and Totten soils in slightly higher positions and areas of Marysland soils in positions similar to those of Borup soils. Also included are areas of very wet Borup soils and areas of Marysland soils in lower positions. A few areas have hummocky microrelief, and a few areas are saline.

Surface runoff is slow. The hazard of soil blowing is severe. Tillage is often delayed because of wetness.

Most areas of this soil are used for pasture and hay, but some areas are cultivated along with the adjoining better drained soils. This soil is better suited to grasses than to most other uses. If drained, it is suited to small grains and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Borup and Marysland silt loams, very wet (Bo).—Soils of this nearly level, undifferentiated mapping unit are in depressions on glacial outwash plains and in channels. The Marysland soil in this mapping unit has a profile similar to the one described as representative of the series, but the surface layer is silt loam. Composition of this mapping unit varies from area to area.

Included with these soils in mapping are small areas of Borup soils and Marysland soils in slightly higher positions that are not so wet and areas of Divide, Glyndon, and Totten soils in higher positions. The microrelief is hummocky in many areas, and a few areas are saline. Also included are areas that have an organic surface layer about 2 inches thick. In most years the water table is at or near the surface throughout nearly all of the growing season.

Surface runoff is very slow. These soils are not subject to soil blowing in their natural state because they are very wet and heavily vegetated. The hazard of soil blowing is severe if these soils are drained, and if the vegetation is destroyed by cultivation.

Soils of this mapping unit are used for hay and pasture. They are better suited to grasses than to most other uses. Wetness is the main concern of management. Capability unit Vw–8; windbreak suitability group 10.

Borup and Vallers loams, 3 to 6 percent slopes (BpB).—Soils of this undifferentiated mapping unit are in seepage positions along rivers, coulees, and draws. The seepage occurs at the contact of glaciofluvial deposits overlying firm glacial till or bedded shale, or at the contact between glacial till and bedded shale. A few areas are in glacial moraines. The Borup soils and Vallers soils in this mapping unit have profiles similar to the ones described as representative of their series; the Borup soils, however, have a loam surface layer, and both soils have sand and gravel lenses in the profile that carry seepage water from higher lying areas. Composition of this mapping unit varies from area to area.

Included with these soils in mapping are small areas of Colvin soils in positions similar to those of Borup and Vallers soils. The microrelief is hummocky in many areas, and a few areas are saline. Flowing springs are in some areas. Some areas have an organic surface layer 3 to 10 inches thick. The surface layer is silt loam or silty clay loam in some areas. Also included are a few areas where the slopes range from 6 to 10 percent.

Surface runoff is medium. These soils are not subject to soil blowing in their natural state because they are very wet and heavily vegetated. The hazard of soil blowing is severe if these soils are drained and the vegetation is destroyed by cultivation.

Soils of this mapping unit are used for pasture or are left idle. They are suited to grasses. Wetness, soil blowing, and overgrazing in pastures are the main concerns of management. Capability unit Vw–8; windbreak suitability group 2.

Brantford Series

The Brantford series consists of shallow, nearly level to gently rolling, well-drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured shaly glaciofluvial deposits. These soils are on glacial outwash plains that contain a high percentage of shale.

In a representative profile the surface layer is loam about 9 inches thick that is very dark gray in the upper 6 inches and very dark grayish brown in the lower 3 inches. The subsoil is dark grayish-brown, friable loam about 6 inches thick. The substratum is grayish-brown gravel and sand in the upper 25 inches and grayish-brown shaly sand and gravel in the lower 20 inches.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes. The more sloping ones are better suited to grasses than to other uses.

Representative profile of Brantford loam, in an area of Brantford loam, gravelly substratum, 0 to 3 percent slopes, in a cultivated field, 100 feet north and 150 feet east of the southwest corner of the NW¼ sec. 17, T. 151 N., R. 64 W., Benson County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, medium, subangular blocky structure parting to moderate, coarse and medium, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—6 to 9 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; moderate, medium, prismatic structure parting to weak, thick, platy and to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, wavy boundary.

B2—9 to 15 inches, dark grayish-brown (2.5Y 4/2) loam, very dark grayish brown (2.5Y 3/3) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; common roots; neutral; clear, wavy boundary.

IIC1—15 to 40 inches, grayish-brown (2.5Y 5/2) shaly gravel and sand, very dark grayish brown (2.5Y 3/2) moist; single grained; loose, nonsticky and nonplastic; very few roots in upper 11 inches; 45 percent gravel, by volume; thin coatings of lime on underside of pebbles; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIC2—40 to 60 inches, grayish-brown (2.5Y 5/2) shaly sand and gravel, dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; 20 to 30 percent gravel, by volume; thin coatings of lime on underside of pebbles; slightly effervescent; moderately alkaline.

Depth to sand and gravel ranges from 10 to 20 inches below the surface, but the typical range is 15 to 20 inches. The A horizon ranges from 5 to 12 inches in thickness. It is very dark gray, dark gray, or very dark grayish brown. The B2 horizon ranges from 6 to 12 inches in thickness. It is dark grayish brown, grayish brown, or dark gray. Typically the B2 horizon has moderate prismatic structure parting to moderate subangular blocky structure, but in some profiles the structure is weak. Organic coatings are on the faces of prisms in places. The IIC horizons are typically stratified shaly sand and gravel but contain a layer of granitic sand and gravel in places. In most places, coatings of lime are on the underside of pebbles in one or more of the IIC horizons. The upper part of the IIC horizon has an accumulation of soft masses of lime in a few places.

Brantford soils are adjacent to Coe, Kensal, and Vang soils in many areas. They are not so excessively drained and are deeper over the IIC horizon than Coe soils. They are better drained then Kensal soils, and they lack mottling in the B horizon, which is characteristic of Kensal soils. They are shallower over the IIC horizon than Vang soils.

Brantford loam, 3 to 6 percent slopes (BrB).—This soil is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the gravel content of the substratum ranges from 10 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Coe soils on summits and shoulder slopes, areas of Vang soils on foot slopes, areas of Gardena soils on toe slopes, and areas of Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on the summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–5; windbreak suitability group 6.

Brantford loam, gravelly substratum, 0 to 3 percent slopes (BsA).—This soil is on glacial outwash plains. It has the profile described as representative of the series. Gravel content in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Brantford soils that have a substratum containing less than 40 percent gravel by volume. Also included are areas of Kensal soils in positions similar to those of Brantford soils and areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–5; windbreak suitability group 6.

Brantford loam, gravelly substratum, 3 to 6 percent slopes (BsB).—This soil is on outwash plains. Gravel content in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Brantford soils that have a substratum containing less than 40 percent gravel by volume. Also included are Coe soils on summits and shoulder slopes, Vang soils on foot slopes, Gardena soils on toe slopes, and Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–5; windbreak suitability group 6.

Brantford loam, sandy substratum, 0 to 3 percent slopes (BtA).—This soil is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Brantford soils that have a substratum containing more than 40 percent gravel by volume. Also included are Kensal soils in positions similar to those of Brantford soils and Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–5; windbreak suitability group 6.

Brantford loam, sandy substratum, 3 to 6 percent slopes (BtB).—This soil is on outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Brantford soils that have a substratum containing more than 40 percent gravel by volume. Also included are Coe soils on summits and shoulder slopes, Vang soils on foot slopes, Gardena soils on toe slopes, and Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–5; windbreak suitability group 6.

Brantford-Coe loams, 6 to 9 percent slopes (BuC).—Soils of this mapping unit are on glacial outwash plains. The Brantford and Coe soils have a profile similar to the one described as representative of their series, but the gravel content of the substratum of each ranges from 10 percent to more than 40 percent by volume. Brantford soils, on back slopes, make up about 60 percent of the mapping unit, and Coe soils, on summits and shoulder slopes, make up about 25 percent.

Included with these soils in mapping are small areas of Vang soils on foot slopes and areas of Gardena soils on toe slopes. Also included are Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils on summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is moderate.

Some areas of this mapping unit are cultivated, and others are used for pasture and hay. The soils are well suited to grasses, and they are suited to close-growing grain crops and legumes if protective measures are used. Surface runoff, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–5; Brantford soil is in windbreak suitability group 6, Coe soil is in windbreak suitability group 10.

Brantford-Kensal loams (Bv).—Soils of this nearly level mapping unit are on glacial outwash plains. The Brantford and Kensal soils have a profile similar to the one described as representative of their series, but the content of gravel in the substratum of each soil is 10 percent to more than 40 percent by volume. The composition of this mapping unit is variable; some areas have mainly Brantford soils, others have mainly Kensal soils, and others have both soils.

Included with these soils in mapping are small areas of Vang soils in concave positions and areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–5; Brantford soil is in windbreak suitability group 6, Kensal soil is in windbreak suitability group 1.

Buse Series

The Buse series consists of deep, sloping to very steep, well-drained soils that formed in medium textured and moderately fine textured glacial till. These soils are on glacial till plains (fig. 7).

In a representative profile the surface layer is loam about 7 inches thick that is dark gray in the upper 3 inches and variegated dark gray and light brownish gray in the lower 4 inches. The substratum is 53 inches thick. The upper 7 inches is mottled, light brownish-

Figure 7.—**Profile of Buse loam, a deep, well-drained soil that formed in glacial till.**

gray, friable loam that has an accumulation of lime. The next 8 inches is variegated, light brownish-gray and light-gray loam that has an accumulation of lime. The next 12 inches is mottled, light brownish-gray loam. The lower 26 inches is mottled, light yellowish-brown loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is low.

These soils are better suited to grasses than to most other uses, but they are suited to close-growing grain crops and legumes on the sloping and moderately steep areas.

Representative profile of Buse loam, in an area of Buse-Barnes loams, 9 to 30 percent slopes, in a native pasture, 45 feet north and 580 feet east of the southwest corner of sec. 27, T. 150 N., R. 67 W., Eddy County:

A1—0 to 3 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, fine, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly effervescent; neutral; abrupt, smooth boundary.

ACca—3 to 7 inches, variegated dark-gray and light brownish-gray (10YR 4/1 and 6/2) loam, black and very dark grayish brown (10YR 2/1 and 3/2) moist; weak, coarse, prismatic structure parting to weak, medium, crumb; slightly hard, friable, slightly sticky and slightly plastic; many roots; smooth boundary.

C1ca—7 to 14 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; very few, fine, distinct, dark reddish-brown (5YR 3/3, moist) mottles; weak, coarse and medium, prismatic structure parting to weak, medium, crumb; hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; moderately alkaline; clear, irregular boundary.

C2ca—14 to 22 inches, variegated light brownish-gray and light-gray (2.5Y 6/2 and 7/2) loam, olive brown and light olive brown (2.5Y 4/4 and 5/4) moist; weak, coarse and medium, prismatic structure parting to weak, medium, platy; hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C3—22 to 34 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; few, fine, distinct, dark reddish-brown (5YR 3/3, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, platy; hard, friable, slightly sticky and slightly plastic; few roots; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C4—34 to 60 inches, light yellowish-brown (2.5Y 6/4) loam, olive brown (2.5Y 4/4) moist; few, fine, distinct, dark reddish-brown (5YR 3/3, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, platy; hard, friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline.

The A horizon ranges from 3 to 7 inches in thickness. It is dark gray or very dark gray. A transitional horizon, the AC horizon, if present, is dark gray, light brownish gray, or grayish brown and is 3 to 8 inches thick. The Cca horizon is mottled, light brownish-gray or light-gray loam or clay loam. The C horizons below the Cca horizon are mottled, light brownish-gray, light-gray, light yellowish-brown, or pale-yellow loam or clay loam. Various sized pebbles and stones are present throughout the profile in places.

Buse soils are adjacent to Barnes, Edgeley, Kloten, and Sioux soils in many places. They have a profile similar to that of Zell soils. They lack the B horizon that is characteristic of Barnes and Edgeley soils. They formed in glacial till unlike Edgeley soils which formed in very shaly glacial till overlying bedded shale. They lack the coarse textures that are typical of the IIC horizons of Sioux soils. They contain more clay throughout the profile than Zell soils.

Buse-Barnes loams, 9 to 30 percent slopes (BwE).—Soils of this mapping unit are on the side slopes of the Sheyenne River Valley and on glacial moraines. The Buse soils have the profile described as representative of the series. The Buse soils, on summits, shoulder slopes, and upper back slopes, make up about 55 percent of the mapping unit, and the Barnes soils, on back slopes and upper foot slopes, make up about 30 percent.

Included with these soils in mapping are small areas of Svea soils on lower foot slopes and toe slopes, and areas of Tonka and Parnell soils in depressions that are identified on the soil map by a diamond symbol. Also included are areas of Hamerly soils and Vallers soils around the edges of some of the depressions. Stones and boulders are common on the surface in some areas.

Surface runoff is very rapid, and water ponds in depressions. The hazard of soil blowing is slight, but the hazard of soil blowing is severe if the grass vegetation is destroyed by cultivation or overgrazing.

Most areas of this mapping unit are used for pasture. The soils are better suited to grasses than to most other uses. Surface runoff and soil blowing are the main concerns of management. Capability unit VIe–6; windbreak suitability group 8.

Buse-Edgeley loams, 9 to 30 percent slopes (BxD).—Soils of this mapping unit are on the side slopes of the Sheyenne River Valley. The Edgeley soils in this mapping unit formed in colluvium that weathered from glacial till and weathered shale and are underlain by weathered and bedded shale at a depth of less than 50 inches. Buse soils are upslope from Edgeley soils, and each makes up from 25 to 65 percent of the mapping unit.

Included with these soils in mapping are small areas of Barnes soils on back slopes associated with Buse soils. Also included are Kloten soils on back slopes associated with Edgeley soils and Walsh soils on toe slopes. Stones and boulders are common on the surface in some areas.

Surface runoff is very rapid, and the drainageways are gullied in places. The hazard of soil blowing is slight; it is severe if the grass vegetation is destroyed by overgrazing or cultivation.

Soils of this mapping unit are used for pasture, and they are better suited to grasses than to most other uses. Surface runoff and soil blowing are the main concerns of management. Capability unit VIe–6; windbreak suitability group 8.

Buse and Kloten loams, 6 to 25 percent slopes (ByE).—Soils of this undifferentiated mapping unit are on the side slopes of the Sheyenne River Valley. Composition of this mapping unit varies from area to area. Buse soils are upslope from Kloten soils.

Included with these soils in mapping are small areas of Barnes soils on back slopes associated with Buse soil and areas of Edgeley soils on back slopes and upper foot slopes associated with Kloten soils. Also included are Walsh soils and the shaly variant of Cavour clay loam on lower foot slopes and toe slopes. Stones and boulders are common on the surface in some areas.

Surface runoff is very rapid, and the drainageways are gullied in places. The hazard of soil blowing is slight; it is severe if the grass vegetation is destroyed by cultivation or overgrazing.

Soils of this mapping unit are used for pasture. They are better suited to grasses than to most other uses. Surface runoff and soil blowing are the main concerns of management. Capability unit VIe–6; Buse soil is in windbreak suitability group 8, Kloten soil is in windbreak suitability group 10.

Buse, Sioux, and Zell soils, 3 to 30 percent slopes (BzD).—Soils of this undifferentiated mapping unit are on morainic areas on glacial till plains and on glacial disintegration ridges on the outwash plain north and east of New Rockford. Composition of this mapping unit varies from area to area; glacial till, gravel, sand, and silt are deposited in a random pattern. Buse, Sioux, and Zell soils are on summits, shoulder slopes, and upper back slopes.

Included with these soils in mapping are small areas of Barnes, Eckman, Heimdal, and Renshaw soils on back slopes and areas of Emrick, Gardena, Hecla, and Svea soils on foot slopes and toe slopes. Also included are areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Stones and boulders are common on the surface in some areas.

Surface runoff is very rapid, and the drainageways are gullied in places. The hazard of soil blowing is slight; it is severe if the grass vegetation is destroyed by cultivation or overgrazing.

Most areas of this mapping unit are used for pasture, but in some areas the lower parts of the slopes are cultivated. The soils are better suited to grasses than to most other uses, but close-growing grain crops and legumes can be grown on small, less steep areas if protective measures are used. Surface runoff and soil blowing are the main concerns of management. Capability unit VIe–6; Buse soil is in windbreak suitability group 8, Sioux soil is in windbreak suitability group 10, Zell soil is in windbreak suitability group 8.

Cathay Series

The Cathay series consists of deep, nearly level to gently undulating, moderately well drained and somewhat poorly drained, claypan soils that formed in medium-textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is dark-gray loam about 8 inches thick. The subsurface layer is gray loam about 1 inch thick. The subsoil is firm clay loam and is dark grayish brown in the upper 8 inches and light olive brown in the lower 5 inches. Gypsum crystals are in the lower part of the subsoil. The substratum is mottled, light olive-brown clay loam. It contains many salt crystals and an accumulation of lime in the upper 10 inches and is variegated light brownish-gray and dark grayish-brown loam in the lower 18 inches.

Permeability is slow or moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The dense subsoil and the salts in the lower part of the subsoil limit root growth and water penetration. The water table is within 5 feet of the surface most of the year and at or near the surface in spring and early in summer. A water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops and grasses and poorly suited to legumes.

Representative profile of Cathay loam, in an area of Cathay-Heimdal loams, 0 to 3 percent slopes, in a cultivated field, 120 feet north and 375 feet east of the southwest corner of sec. 15, T. 150 N., R. 67 W., Eddy County:

Ap—0 to 8 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; few gray patches of bleached sand; slightly acid; abrupt, smooth boundary.

A2—8 to 9 inches, gray (10YR 5/1) loam, very dark gray and very dark grayish brown (10YR 3/1 and 3/2) moist; weak, medium, prismatic structure parting to weak, medium, platy; slightly hard, friable, nonsticky and nonplastic; many roots, slightly acid; clear, wavy boundary.

B21t—9 to 17 inches, dark grayish-brown (2.5Y 4/2) clay loam, very dark grayish brown (2.5Y 3/2) moist; moderate, medium, prismatic structure parting to strong, medium, angular blocky; hard, firm, sticky and plastic; light-gray (10YR 7/1) bleached silt and sand grains on the top and sides of prisms; very dark grayish-brown (10YR 3/2) organic stains on faces of prisms; neutral; gradual, wavy boundary.

B22t—17 to 22 inches, light olive-brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) moist; moderate, coarse and medium, prismatic structure; hard, firm, sticky and plastic; patches of dark grayish-brown (2.5Y 4/2) organic stains on faces of prisms; few nests of gypsum crystals; slightly effervescent; moderately alkaline; gradual, wavy boundary.

C1cacs—22 to 32 inches, light olive-brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) moist; common, coarse, distinct, light brownish-gray (2.5Y 6/2, moist) mottles; weak, coarse and medium, prismatic structure; hard, friable, sticky and plastic; few nests of gypsum crystals and many silt crystals; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2—32 to 60 inches, variegated light brownish-gray and dark grayish-brown (2.5Y 6/2 and 4/2) loam, olive brown (2.5Y 4/4), very dark grayish brown (2.5Y 3/2), and yellowish brown (10YR 5/6) moist; hard, friable, slightly sticky and slightly plastic; violently effervescent; moderately alkaline.

The A1 horizon ranges from 6 to 12 inches in thickness. It is dark-gray or very dark gray loam or silt loam. It is loam typically, but is clay loam or silty clay loam in places because tillage has mixed the B2 horizon with the A1 and A2 horizons. The A2 horizon is very fine sandy loam, loam, or silt loam ½ to 4 inches thick. The B2 horizon is dark grayish-brown or light olive-brown clay loam or loam 8 to 20 inches thick. It has strong or moderate prismatic structure that parts to strong angular blocky structure. The B2 horizon has an accumulation of lime, gypsum crystals, and other salts in the lower part of the profile in most places. The Cca horizon is clay loam or loam.

Cathay soils are adjacent to Cresbard, Heimdal, and Larson soils in many places. They have a profile similar to that of Cresbard and Larson soils. They formed in glacial till that contains less clay than Cresbard soils. They have a platy A2 horizon and a claypan B2t horizon, which Heimdal soils do not have. They have a thicker A1 horizon and A2 horizon than Larson soils.

Cathay loam (Ca).—This soil is nearly level and is in slight depressions on glacial till plains.

Included with this soil in mapping are small areas

of Heimdal soils and Emrick soils in slightly higher positions and areas of Larson soils and Miranda soils in slightly lower positions. Fram soils and Vallers soils are around the edges of some of the depressions that are identified on the soil map by a diamond symbol. These depressions contain Tonka soils. In some cultivated areas the surface layer is clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops and grasses, but it is poorly suited to legumes. Growth of most crops is reduced because of the dense subsoil and slow permeability. Wetness, maintenance of good soil tilth, and soil blowing are the main concerns of management. Capability unit IIIs–5P; windbreak suitability group 4.

Cathay-Heimdal loams, 0 to 3 percent slopes (ChA).—Soils of this mapping unit are on glacial till plains. Cathay soils have the profile described as representative of the Cathay series. Cathay soils, in concave positions, and Heimdal soils, on convex positions, each make up about 30 to 40 percent of the mapping unit.

Included with these soils in mapping are small areas of Larson soils and Miranda soils in concave positions, areas of Emrick soils on plane slopes, and areas of Fram soils and Vallers soils around the edges of some of the depressions that are identified on the soil map by a diamond symbol. These depressions contain Tonka soils or Parnell soils. In some cultivated areas the Cathay soils have a surface layer of clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this mapping unit are cultivated but some are used for pasture and hay. The soils are suited to grain crops and grasses, but they are poorly suited to legumes. Growth of most crops is reduced on the Cathay soil because of the dense subsoil and slow permeability. Wetness, maintenance of good soil tilth, and soil blowing are the main concerns of management. Capability unit IIIs–5P; Cathay soil is in windbreak suitability group 4, Heimdal soil is in windbreak suitability group 3.

Cathay-Heimdal loams, 3 to 6 percent slopes (ChB).—Soils of this mapping unit are on glacial till plains. Cathay soils, in concave positions, and Heimdal soils, on convex positions, each make up about 30 to 40 percent of the mapping unit.

Included with these soils in mapping are small areas of Larson soils and Miranda soils in concave positions, areas of Emrick soils on plane slopes, and areas of Fram soils and Vallers soils around the edges of some of the depressions that are identified on the soil map by a diamond symbol. Either Tonka soils or Parnell soils are in the depressions. In some cultivated areas the surface layer of the Cathay soils is clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers. In cultivated areas a lighter colored surface layer than is typical is on the summit of many knolls.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops and grasses, but they are poorly suited to legumes. Growth of most crops is reduced on the Cathay soils because of the dense subsoil and slow permeability. Wetness, maintaining good tilth, and soil blowing are the main concerns of management. Capability unit IIIs–5P; Cathay soil is in windbreak suitability group 4, Heimdal soil is in windbreak suitability group 3.

Cathay-Larson loams (Cm).—Soils of this nearly level mapping unit are in slight depressions on glacial till plains. Cathay soils make up about 40 to 50 percent of the mapping unit, and Larson soils, in slightly lower positions, make up about 30 to 40 percent.

Included with these soils in mapping are small areas of Heimdal soils and Emrick soils in slightly higher positions and areas of Fram, Vallers, and Miranda soils around the edges of some of the depressions that are identified on the soil map by a diamond symbol. Either Tonka soils or Parnell soils are in these depressions. In some cultivated areas the surface layer is clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight when the soils have good grass cover, but it is moderate if the grass cover is destroyed by cultivation or overgrazing.

Most areas of this mapping unit are used for pasture and hay, but small areas are cultivated along with the adjoining soils. Soils of this mapping unit are better suited to salt-tolerant grasses than to most other uses. Growth of most crops is reduced because of the dense subsoil, slow permeability, and high content of salt. Wetness, maintaining good tilth in tilled areas, and soil blowing are the main concerns of management. Capability unit IVs–6P; Cathay soil is in windbreak suitability group 4, Larson soil is in windbreak suitability group 9.

Cavour Series

The Cavour series consists of deep, nearly level, moderately well drained claypan soils that formed in medium-textured and moderately fine textured glacial till. These soils are on glacial till plains, flood plains, and terraces.

In a representative profile the surface layer is dark-gray loam about 4 inches thick. The subsoil, about 15 inches thick, is dark-gray, very firm, clay loam in the upper 4 inches and very dark gray, firm clay loam in the lower 11 inches. The substratum is 41 inches thick. The upper 9 inches is mottled, gray clay loam that contains an accumulation of lime. The next 20 inches is light olive-gray loam. The lower 12 inches is mottled, pale-olive loam.

Permeability is very slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is low. The dense subsoil and the salts in the lower part of the subsoil limit root growth

and water penetration. The water table is within 5 feet of the surface most of the year and at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall.

These soils are suited to salt-tolerant grasses and grain crops, except where they are too stony for use of farm machinery or are subject to flooding.

Representative profile of Cavour loam, in an area of Cavour-Cresbard loams, in a cultivated field, 120 feet south and 525 feet west of the northeast corner of the NW¼ sec. 5, T. 149 N., R. 59 W., Nelson County:

Ap—0 to 4 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium and fine, subangular blocky structure parting to moderate, fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B21t—4 to 8 inches, dark-gray (10YR 4/1) clay loam, black (10YR 2/1) moist; strong, medium, columnar structure parting to strong, medium and fine, angular blocky; very hard, very firm, very sticky and very plastic; distinct continuous clay films on faces of columns; few roots; neutral; clear, smooth boundary.

B22tcs—8 to 19 inches, very dark gray (10YR 3/1) clay loam, black (10YR 2/1) moist; moderate, coarse, prismatic structure parting to strong, medium and fine, angular blocky; hard, firm, sticky and very plastic; distinct continuous clay films on faces of prisms; threadlike segregations of salt and few nests of gypsum crystals; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1ca—19 to 28 inches, gray (5Y 6/1) clay loam, olive gray (5Y 5/2) moist; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to moderate, medium, blocky; hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; violently effervescent; moderately alkaline; clear, smooth boundary.

C2—28 to 48 inches, light olive-gray (5Y 6/2) clay loam, olive (5Y 5/3) moist; moderate, medium, blocky structure; hard, firm, sticky and plastic; few, fine, prominent concretions of iron; few prominent lime nodules and few pebbles as large as 5 millimeters; strongly effervescent; moderately alkaline; clear, smooth boundary.

C3—48 to 51 inches, pale-olive (5Y 6/4) sandy loam, olive (5Y 5/6) moist; common, fine, distinct, light-gray (5Y 7/1) mottles; hard, friable, slightly sticky and slightly plastic; common pebbles as large as 20 millimeters; slightly effervescent; moderately alkaline; clear, smooth boundary.

C4—51 to 60 inches, pale-olive (5Y 6/4) loam, olive (5Y 5/3) moist; common, fine, distinct, light-gray (5Y 7/1) mottles; hard, friable, sticky and plastic; common granitic pebbles and fragments of shale as large as 20 millimeters; strongly effervescent; moderately alkaline.

The A1 horizon ranges from 4 to 6 inches in thickness. It is very dark gray, dark gray, or gray. Typically, the A1 horizon is loam, but it is clay loam where deep tillage has mixed the B2 horizon with the A1 and A2 horizons. The A2 horizon is absent in some places; it appears as a thin gray coating on top of the B2 horizon in other places; or it is as much as 2 inches of gray platy loam in other places. The B2 horizon is dark gray or very dark gray and is 10 to 20 inches thick. It has strong or moderate, columnar, or prismatic structure that parts to strong or moderate, blocky structure. In a typical profile the B2 horizon has an accumulation of gypsum and other salts in the lower part, but this accumulation is lacking in places. It has an accumulation of lime in the lower part of the profile in places, but this is absent in the typical profile. Typically, the C horizon is clay loam, but in some places, it is clay loam to a depth of about 40 inches and it is stratified sandy loam, loam, or clay loam below a depth of 40 inches. Typically, an accumulation of lime is in the upper part of the C horizon, but this accumulation is lacking in places. Gypsum crystals and other salt segregations are present throughout the C horizon in some places.

Cavour soils are adjacent to the Cavour variant and to Cresbard, Hamerly, and Vallers soils in many places. Cavour soils have a profile similar to that of the Cavour variant, but they formed in material weathered from glacial till instead of shale. They have a thinner combined A1 and A2 horizon than Cresbard soils. They have a claypan B2t horizon, which Hamerly soils and Vallers soils lack.

Cavour-Cresbard loams (Cn).—Soils of this nearly level mapping unit are in low broad swales on the glacial till plain. Cavour soils have the profile described as representative of the series. Cavour soils make up about 45 percent of this mapping unit, and the Cresbard soils, in slightly higher positions, make up about 35 percent.

Included with these soils in mapping are small areas of Hamerly soils and Svea soils in slightly higher positions, and areas of Vallers soils around the edges of depressions that are identified on the soil map by a diamond symbol. Tonka soils and Parnell soils are in the depressions. In some cultivated areas the surface layer is clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas of this mapping unit are cultivated, but some areas are used for pasture and hay. The soils are suited to salt-tolerant grasses and grain crops, but they are poorly suited to legumes. The dense subsoil, slow permeability, and high content of salt restrict the growth of most crops. Wetness and maintenance of good tilth in cultivated areas are the main concerns of management. Capability unit IVs–6P; Cavour soil is in windbreak suitability group 9, Cresbard soil is in windbreak suitability group 4.

Cavour and Vallers stony clay loams (Co).—Soils of this nearly level undifferentiated mapping unit are on flood plains and low terraces along the James River and in broad shallow channels draining into the James River. Cavour soils and Vallers soils have a profile similar to the one described as representative of their series, but these soils have a clay loam surface layer and contain a large number of stones on or near the surface. The composition of this mapping unit varies from one area to another. Cavour soils are in slightly higher positions on the landscape than the Vallers soils.

Included with these soils in mapping are small areas of Cresbard, Hamerly, and Lamoure soils in slightly higher positions than Cavour soils and areas of Ludden soils and Miranda soils in positions similar to those of Vallers soils. Stones on or near the surface prevent the use of farm machinery.

Surface runoff is slow. Many areas are flooded every spring.

This mapping unit is used for pasture. The soils are better suited to grasses than to most other uses. Wetness is the main concern of management. Capability unit VIIsw–8; windbreak suitability group 10.

Cavour Variant

The Cavour variant is a moderately deep, gently

sloping, somewhat poorly drained claypan soil that formed in material that weathered from shale. This soil is on the lower side slopes of shale outcrops along the Sheyenne River.

In a representative profile the surface layer is dark-gray clay loam about 5 inches thick. The subsoil is dark-gray, firm silty clay about 9 inches thick. The substratum is 46 inches thick. The upper 12 inches is gray silty clay that contains an accumulation of lime. The next 6 inches is mottled, olive-gray silty clay that contains gypsum crystals. The lower 28 inches is mottled, light olive-gray bedded shale.

Permeability is very slow, and the available water capacity is low. The organic-matter content is high, and fertility is low. The dense subsoil layer and the salts in the upper part of the substratum limit root and water penetration. Water trapped in the shale often results in wet spots and springs.

This soil is suited to salt-tolerant grasses.

Representative profile of Cavour clay loam, shaly variant, in a pasture, 2,000 feet north and 1,200 feet east of the southwest corner of sec. 4, T. 150 N., R. 66 W., Eddy County:

A1—0 to 5 inches, dark-gray (10YR 4/1) clay loam, black (10YR 2/1) moist; weak, medium, prismatic structure parting to weak, fine, crumb; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B2t—5 to 14 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/1) moist; strong, medium, columnar structure parting to strong, fine, angular blocky; very hard, firm, sticky and plastic; few roots; very dark gray (5Y 3/1, moist) clay films on faces of peds, gray (5Y 5/1, moist) coatings on top of columns; few tongues extend to a depth of 18 inches; neutral; clear, wavy boundary.

C1ca—14 to 26 inches, gray (5Y 5/1) silty clay, dark gray (5Y 4/1) moist; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; very hard, firm, sticky and plastic; continuous clay films on faces of peds; strongly effervescent; moderately alkaline; clear, wavy boundary.

C2cs—26 to 32 inches, olive-gray (5Y 5/2) silty clay, olive gray (5Y 4/2) moist; many, coarse, prominent light-gray (5Y 7/1, moist) mottles; massive; hard, firm, sticky and plastic; common nests of gypsum crystals; slightly effervescent; moderately alkaline; gradual, wavy boundary.

R3—32 to 44 inches, light olive-gray (5Y 6/2) bedded shale, olive gray (5Y 4/2) moist; common, medium, distinct, light olive-brown (2.5Y 5/4, moist) mottles; strong, thin, platy structure; gradual boundary.

R4—44 to 60 inches, gray and light olive-gray (N 5/0 and 5Y 6/2) bedded shale; dark gray and olive gray (N 4/0 and 5Y 5/2) moist; few, coarse, prominent red (2.5YR 5/6, moist) and yellowish-brown (10YR 5/4, moist) mottles; strong, thin, platy structure.

Depth to the bedded shale ranges from 25 to 45 inches. The A1 horizon ranges from 4 to 9 inches in thickness. It is dark-gray or very dark gray loam or clay loam. The A2 horizon is absent in places; it appears as thin gray coatings on the top of columns in places, or is as much as 4 inches of gray platy loam in other places. The B2 horizon is silty clay or clay 6 to 16 inches thick. It has strong or moderate columnar or prismatic structure that parts to strong or moderate blocky structure. The C horizon is gray or olive-gray silty clay loam, silty clay, or clay. Typically an accumulation of lime and salts is in the upper part of the C horizon, but this accumulation does not occur in places. The R horizon is gray or light olive gray.

The Cavour variant is adjacent to Cavour, Edgeley, Kloten, and Walsh soils in many places. It has a profile similar to Cavour soils, but it formed in material that weathered from shale instead of glacial till. Unlike Edgeley, Kloten, and Walsh soils, it has a B2t horizon.

Cavour clay loam, shaly variant, 3 to 6 percent slopes (CpB).—This soil is on the lower slopes of shale outcrops along the Sheyenne River Valley.

Included with this soil in mapping are small areas of Edgeley, Kloten, and Walsh soils, small areas where the soils have slopes of as much as 12 percent, and areas where the soils have a surface layer that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is medium. The hazard of soil blowing is slight.

Most areas of this soil are used for pasture, but some are cultivated along with the adjoining soils. This soil is better suited to salt-tolerant grasses than to most other uses. Growth of crops is reduced because of the dense subsoil that limits root growth, permeability, and the high content of salt. Capability unit VIs–6p; windbreak suitability group 9.

Claire Series

The Claire series consists of deep, nearly level to gently undulating, excessively drained soils that formed in coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is dark-gray loamy coarse sand about 8 inches thick. The transitional layer between the surface layer and the substratum is dark grayish-brown coarse sand about 6 inches thick. The substratum is 46 inches thick. The upper 5 inches is dark grayish-brown loose coarse sand. The next 29 inches is grayish-brown coarse sand. The lower 12 inches is mottled, light-gray fine sand.

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

These soils are suited to grain crops, grasses, and legumes where they are nearly level and their surface layer is coarse sandy loam or finer. Where they are not nearly level or where their surface layer is coarser than coarse sandy loam, these soils are best suited to grasses.

Representative profile of Claire loamy coarse sand, 0 to 3 percent slopes, in a cultivated field, 670 feet north and 100 feet west of the southeast corner of the SW¼ sec. 2, T. 150 N., R. 63 W., Eddy County:

Ap—0 to 8 inches, dark-gray (10YR 4/1) loamy coarse sand, black (10YR 2/1) moist; very weak, fine, subangular blocky structure parting to single grained; loose, very friable, slightly sticky and nonplastic; common roots; neutral; abrupt, smooth boundary.

AC—8 to 14 inches, dark grayish-brown (10YR 4/2) coarse sand, very dark grayish brown (10YR 3/2) moist; weak, very coarse, prismatic structure parting to single grained; loose, very friable, slightly sticky and nonplastic; few roots; neutral; clear, wavy boundary.

C1—14 to 19 inches, dark grayish-brown (10YR 4/2) coarse sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; few roots; neutral; clear, wavy boundary.

C2—19 to 48 inches, grayish-brown (10YR 5/2) coarse sand, dark grayish brown (10YR 4/2) moist;

single grained; loose, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

C3—48 to 60 inches, light-gray (10YR 7/1) fine sand, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, dark reddish-gray (5YR 4/2, moist) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 4 to 10 inches in thickness. It is dark-gray or very dark gray loamy coarse sand, loamy sand, coarse sandy loam, or sandy loam. The AC horizon ranges from 6 to 10 inches in thickness. It is loamy coarse sand, loamy sand, or coarse sand. The C horizon is grayish brown, dark grayish brown, or light gray. Typically, it is coarse sand, but stratified coarse, medium, or fine sand with some strata of gravel are present in places. Most profiles are noncalcareous above a depth of 3 feet and slightly calcareous below that, but some profiles are noncalcareous throughout.

Claire soils are adjacent to Hamar, Lohnes, and Maddock soils in many places. Unlike Hamar soils, they lack mottling below the A horizon. They have a thinner A horizon than Lohnes soils. They formed in coarser sands than Maddock soils.

Claire loamy coarse sand, 0 to 3 percent slopes (CrA).—This soil is on outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Maddock soils in positions similar to those of Claire soils. Also included are areas of Serden soils on the summit of undulations, areas of Lohnes soils in concave positions, and areas of Hamar soils in shallow swales. This soil has been reworked to some extent by soil blowing in some areas.

Surface runoff is very slow because of the rapid permeability of this soil. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some areas are used for pasture and hay. This soil is better suited to grasses than to most other uses. Soil blowing and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIes–2; windbreak suitability group 10.

Claire loamy coarse sand, 3 to 6 percent slopes (CrB).—This soil is on outwash plains.

Included with this soil in mapping are small areas of Maddock soils in positions similar to those of Claire soils. Also included are areas of Serden soils on summits and shoulder slopes, areas of Lohnes soils on foot slopes and toe slopes, and areas of Hamar soils in shallow swales. This soil has been reworked to some extent by soil blowing in some areas.

Surface runoff is very slow because of the rapid permeability of this soil. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is better suited to grasses than to most other uses. Soil blowing and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIes–2; windbreak suitability group 10.

Claire coarse sandy loam (Cs).—This soil is nearly level and is on outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is coarse sandy loam.

Included with this soil in mapping are small areas of Maddock soils in positions similar to those of Claire soils. Also included are areas of Serden soils on summits and shoulder slopes, areas of Lohnes soils on foot slopes, toe slopes, and in concave positions, and areas of Hamar soils in shallow swales. This soil has been reworked to some extent by soil blowing in some areas. Areas where the slopes are 3 to 6 percent are included and make up about 20 percent of the acreage.

Surface runoff is very slow because of the rapid permeability of this soil. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is better suited to grasses and legumes than to most other uses, and are less suited to grain crops. Soil blowing and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit IVe–3; windbreak suitability group 10.

Claire-Lohnes-Hamar loamy coarse sands (Ct).—Soils of this gently undulating, wind-hummocked mapping unit are on outwash plains. Hamar soils have a profile similar to the one described as representative of the series, but they formed in coarser sands. Claire soils, on the convex slopes, make up about 40 percent of the mapping unit; Lohnes soils, on lower concave slopes, make up about 25 percent; and Hamar soils, in concave depressions, make up about 20 percent.

Included with these soils in mapping are small areas of Serden soils on the summits of undulations, areas of Maddock soils on the convex slopes, and areas of Hecla soils on the concave slopes. Also included are areas of Arveson, Fossum, Venlo, and Wyrene soils in swales. The soils of this mapping unit have been reworked by soil blowing.

Surface runoff is very slow because of the rapid permeability of these soils. The hazard of soil blowing is very severe.

Most areas of this mapping unit are in pasture and hay, but some are cultivated along with the adjoining soils. The soils are better suited to grasses than to most other uses. Soil blowing and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIes–2; Claire soil is in windbreak suitability group 10, Lohnes soil is in windbreak suitability group 7, Hamar soil is in windbreak suitability group 2.

Clontarf Series

The Clontarf series consists of moderately deep, nearly level, moderately well drained soils that formed in moderately coarse textured glaciofluvial deposits overlying coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is sandy loam about 13 inches thick that is very dark gray in the upper 7 inches and very dark grayish brown in the lower 6 inches. The subsoil is dark grayish-brown, friable sandy loam about 7 inches thick. The substratum is 40 inches thick. The upper 6 inches is grayish-brown sandy loam that contains an accumulation of lime. The next 10 inches is grayish-brown medium sand. The next 16 inches is brown medium sand. The lower 8 inches is gray sand and gravel.

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

These soils are suited to small grains, grasses, and legumes.

Representative profile of Clontarf sandy loam, in a cultivated field, 200 feet south and 150 feet west of the northeast corner of sec. 27, T. 149 N., R. 65 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A1—7 to 13 inches, very dark grayish-brown (10YR 3/2) sand loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure parting to weak, medium, granular; slightly hard, friable, slightly sticky and slightly plastic; common roots; few pebbles as large as 4 millimeters; slightly acid; gradual, smooth boundary.

B2—13 to 20 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; few pebbles as large as 4 millimeters; neutral; gradual, wavy boundary.

Cca—20 to 26 inches, grayish-brown (2.5Y 5/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few pebbles as large as 4 millimeters; strongly effervescent; mildly alkaline; clear, wavy boundary.

IIC1—26 to 36 inches, grayish-brown (10YR 5/2) medium sand, dark grayish brown (10YR 4/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC2—36 to 52 inches, brown (10YR 5/3) medium sand, dark grayish brown (10YR 4/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervesecent; mildly alkaline; gradual, wavy boundary.

IIC3—52 to 60 inches, gray (10YR 6/1) sand and gravel, grayish brown (10YR 5/2) moist; single grained; loose, nonsticky and nonplastic; strongly effervescent; mildly alkaline.

Depth to the IIC horizon ranges from 20 to 40 inches. The A horizon ranges from 12 to 18 inches in thickness. It is very dark gray, dark-gray, or very dark grayish-brown sandy loam or fine sandy loam. The B horizon ranges from 6 to 12 inches in thickness. It is sandy loam or fine sandy loam. The Cca horizon ranges from 0 to 12 inches in thickness. It is sandy loam or fine sandy loam. The IIC horizon is medium-textured sand or sand; most profiles have a layer of sand and gravel below a depth of 50 inches.

Clontarf soils are adjacent to Embden, Lohnes, and Osakis soils in many places. They have a profile similar to those of Embden and Osakis soils. Unlike Embden soils, they have medium-textured sand or sand within 40 inches of the surface. They have a B horizon, which Lohnes soils lack. They have a thicker A horizon than Osakis soils and lack mottles in the B horizon that are typical of Osakis soils.

Clontarf sandy loam (Cu).—This soil is nearly level and is on outwash plains.

Included with this soil in mapping are small areas of Embden, Lohnes, and Osakis soils in positions similar to those of Clontarf soils. Also included are small, gently sloping areas.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIe–3; windbreak suitability group 1.

Coe Series

The Coe series consists of very shallow, nearly level to steep, excessively drained soils that formed in medium-textured or moderately coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is dark-gray sandy loam about 6 inches thick (fig. 8). The substratum is light brownish-gray and gray, loose, shaly loamy coarse sand and gravel in the upper 10 inches and light brownish-gray and gray shaly coarse sand and gravel in the lower 44 inches.

Permeability is very rapid, and the available water capacity is very low. The organic-matter content is moderately low, and fertility is low.

These soils are suited to grasses.

Representative profile of Coe sandy loam, 6 to 25 percent slopes, in a pasture, 1,120 feet south and 200 feet east of the northwest corner of sec. 20, T. 150 N., R. 60 W., Nelson County:

A1—0 to 6 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, fine, subangular blocky structure parting to moderate, fine, granu-

Figure 8.—**Profile of Coe sandy loam, a very shallow, excessively drained soil. The substratum is 40 percent shaly gravel.**

lar; soft, friable, slightly sticky and slightly plastic; many roots; 15 to 25 percent fine shale gravel; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC1—6 to 16 inches, light brownish-gray and gray (2.5Y 6/2 and 6/1) shaly loamy coarse sand and gravel, dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; common roots in upper part and few roots in lower part; most of the gravel is platy and rounded fragments of shale; thin lime coatings on bottom of pebbles; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIC2—16 to 60 inches, light brownish-gray and gray (2.5Y 6/2 and 5Y 6/1) shaly coarse sand and gravel, dark gray and dark grayish brown (N 4/0 and 2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; sand and gravel largely composed of fragments of shale; strongly effervescent to a depth of 30 inches and slightly effervescent to a depth of 48 inches; moderately alkaline.

The A horizon ranges from 5 to 10 inches in thickness. It is dark-gray or very dark gray sandy loam, loam, or gravelly loam. The IIC horizons are typically stratified shaly sand and gravel, but they contain a layer of granitic sand and gravel in places. In most places lime coats the underside of pebbles in one or more of the IIC horizons, but some horizons lack lime.

Coe soils are adjacent to Binford, Brantford, and Sioux soils in many places. They lack a B horizon, which is a characteristic of Binford and Brantford soils. They are underlain by shaly deposits, unlike Sioux soils, which are underlain by granitic deposits.

Coe sandy loam, 0 to 6 percent slopes (CvB).—This soil is on low ridges and slopes adjacent to depressions and drainageways on outwash plains. The content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Sioux soils in positions similar to those of Coe soils. Also included are areas of Binford and Brantford soils on foot slopes and toe slopes, small areas of Coe soils that have a substratum of sand containing less than 40 percent gravel by volume, and small areas of soils that have a surface layer of gravelly loam or loam. Soils that have a lighter colored surface layer are common in cultivated areas.

Surface runoff is very slow because of the very rapid permeability of this soil. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is better suited to grasses than to most other uses, but it is suited to close-growing grain crops and legumes if protective measures are used. Surface runoff, soil blowing, and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIs–3; windbreak suitability group 10.

Coe sandy loam, 6 to 25 percent slopes (CvD).—This soil is on slopes adjacent to depressions and drainageways on outwash plains. It has the profile described as representative of the series. The content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Sioux soils in positions similar to those of Coe soils. Also included are Binford soils and Brantford soils on the lower part of back slopes, Vang soils on foot slopes, Gardena soils on toe slopes, and Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Some small areas of Coe soils have a substratum of sand that contains less than 40 percent gravel by volume. Soils that have a lighter colored surface layer are common on the slopes in cultivated areas.

Surface runoff is rapid to very rapid, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are used for pasture, but some are cultivated along with the adjoining soils. This soil is suited to grasses. Surface runoff, soil blowing, and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIIs–3; windbreak suitability group 10.

Colvin Series

The Colvin series consists of deep, nearly level, poorly drained and very poorly drained, calcareous soils that formed in moderately fine textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is silty clay loam about 16 inches thick. It is dark gray in the upper 8 inches, and it is gray and contains an accumulation of lime in the lower 8 inches. The substratum contains an accumulation of lime in the upper 23 inches and is 44 inches thick. The upper 11 inches is light-gray, friable silty clay loam. The next 8 inches is white silty clay loam. The next 5 inches is light-gray silty clay loam. The next 12 inches is mottled, light-gray sandy clay loam. The next 4 inches is mottled, light yellowish-brown, stratified coarse sand, silt loam, and silty clay loam. The lower 12 inches is mottled, light brownish-gray sandy clay loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and the fertility level is medium. The water table is within 3 feet of the surface most of the year and at or near the surface in spring and early in summer in poorly drained areas; it is closer to the surface for longer periods in very wet areas. Drains are difficult to install because outlets generally are not available.

These soils are suited to grasses and, when drained, to grain crops and legumes.

Representative profile of Colvin silty clay loam, very wet, in a cultivated field, 1,300 feet north and 900 feet east of the southwest corner of the NW¼ sec. 17, T. 149 N., R. 58 W., Nelson County:

Ap—0 to 8 inches, dark-gray (2.5Y 4/1) silty clay loam, very dark gray (2.5Y 3/1) moist; weak, medium, blocky structure parting to moderate, medium, granular; soft, friable, sticky and plastic; many roots; violently effervescent; neutral; abrupt, smooth boundary.

A12ca—8 to 16 inches, gray (N 6/0) silty clay loam, dark gray (2.5Y 4/1) moist; weak, medium and fine, subangular blocky structure; slightly hard, friable, sticky and plastic; common roots; violently effervescent; mildly alkaline; clear, wavy boundary.

C1cag—16 to 27 inches, light-gray (5Y 7/1) silty clay loam, gray (5Y 5/1) moist; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, friable, sticky and plastic; few roots; few pebbles as large as 5 millimeters; violently effervescent; mildly alkaline; clear, smooth boundary.

C2cag—27 to 35 inches, white (5Y 8/1) silty clay loam, olive gray (5Y 5/2) moist; weak, coarse, pris-

matic structure parting to moderate, coarse and medium, subangular blocky structure; slightly hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; violently effervescent; mildly alkaline; clear, wavy boundary.

C3cag—35 to 40 inches, light-gray (5Y 7/2) silty clay loam, olive gray (5Y 5/2) moist; weak, coarse and medium, subangular blocky structure; hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; violently effervescent; mildly alkaline; clear, smooth boundary.

C4g—40 to 48 inches, light-gray (5Y 7/1) sandy clay loam, olive (5Y 5/3) moist; common, distinct, yellowish-brown (10YR 5/6, moist) and dark yellowish-brown (10YR 4/4, moist) mottles; massive; hard, friable, sticky and plastic; common pebbles as large as 5 millimeters; strongly effervescent; neutral; clear, smooth boundary.

C5g—48 to 52 inches, light-gray (5Y 7/1) sandy clay loam, olive gray (5Y 5/2) moist; common, medium, distinct, yellowish-brown (10YR 5/6, moist) and dark yellowish-brown (10YR 4/4, moist) mottles; massive; hard, friable, sticky and plastic; common pebbles as large as 5 millimeters; slightly effervescent and strongly effervescent; mildly alkaline; clear, smooth boundary.

C6g—52 to 56 inches, light yellowish-brown (10YR 6/4) stratified coarse sand, silt loam, and silty clay loam, dark yellowish brown (10YR 4/4) moist; common, distinct, olive-gray (5Y 4/2, moist) mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; common pebbles as large as 10 millimeters; slightly effervescent; neutral; clear, smooth boundary.

C7g—56 to 60 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, dark grayish brown (2.5Y 4/2) moist; common, distinct, brownish-yellow (10YR 6/6, moist) and dark yellowish-brown (10YR 4/4, moist) mottles; massive; hard, friable, sticky and plastic; common pebbles as large as 10 millimeters; slightly effervescent; neutral.

The A horizon ranges from 6 to 16 inches in thickness, but typically is 7 to 14 inches thick. It is very dark gray, dark-gray, or gray silt loam or silty clay loam. The A horizon typically is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in places. The Cca horizon ranges from 6 to 30 inches in thickness, but typically is 6 to 20 inches thick. It is light-gray or white silty clay loam or clay loam that has moderate or weak prismatic structure parting to moderate or weak blocky structure. The C horizon is mottled, light gray, light olive gray, light brownish gray, and light yellowish brown. The upper part of the C horizon is silty clay loam or clay loam, but some profiles have sandy clay loam and stratified sand and gravel below a depth of about 40 inches as in the representative profile. Segregations of salt and gypsum crystals are in the A horizon and Cca horizons in some places. A few places have an organic surface layer as much as 5 inches thick.

Colvin soils have a profile similar to that of Bearden, Borup, and Marysland soils. They are more poorly drained than Bearden soils. They contain more clay between depths of 10 and 40 inches than Borup and Marysland soils.

Colvin silty clay loam (Cw).—This soil is nearly level and is in depressions on glacial outwash plains.

Included with this soil in mapping are small areas of Marysland soils in landscape positions similar to those of Colvin soils, some very wet Colvin soils and Marysland soils in lower landscape positions, and Bearden soils in slightly higher landscape positions. Microrelief is hummocky in some places, and a few small areas are saline. Some soils have a surface layer of silt loam.

Surface runoff is very slow, and water ponds in low places. The hazard of soil blowing is severe.

Most areas of this soil are used for pasture and hay, but some are cultivated along with adjoining better drained soils. Tillage is often delayed because of wetness. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Colvin silty clay loam, saline (Cx).—This soil is nearly level and is in depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but it contains soluble salts that adversely affect plant growth.

Included with this soil in mapping are small areas of nonsaline Colvin soils and Marysland soils in landscape positions similar to those of saline Colvin soils. Also included are very wet Colvin soils and Marysland soils in lower landscape positions and Bearden soils in slightly higher landscape positions. The microrelief is hummocky in some places. Some soils have a surface layer of silt loam.

Surface runoff is very slow, and water ponds in low places. The hazard of soil blowing is severe.

Most areas of this soil are used for pasture and hay, but some are cultivated along with the adjoining better drained soils. Tillage is often delayed because of wetness. This soil is suited to salt-tolerant grasses and, where drained, to salt-tolerant grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

Colvin silty clay loam, very wet (Cy).—This soil is nearly level and is in depressions on glacial outwash plains and in outwash channels. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of saline Colvin soils and Marysland soils in positions similar to those of Colvin soils, very wet. Also included are Bearden soils in slightly higher positions. Slough grasses, sedges, and rushes make up most of the vegetation. The water table is at or near the surface during nearly all the growing season in most years. Hummocky microrelief is common in most areas. Some soils have a surface layer of silt loam.

Runoff ponds in most areas. This soil is not subject to soil blowing in its native condition, but if it is drained and the grass is destroyed by cultivation the hazard of soil blowing is severe.

This soil is used for hay and pasture. It is suited to grasses. Wetness is the main concern of management. Capability unit Vw–8; windbreak suitability group 10.

Cresbard Series

The Cresbard series consists of deep, nearly level, moderately well drained claypan soils that formed in medium-textured and moderately fine textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is gray loam about 5 inches thick. The subsurface layer is gray silt loam about 2 inches thick. The subsoil is firm clay loam about 17 inches thick. The upper 6 inches is very dark gray, the next 5 inches is dark gray, and the lower 6 inches is very dark gray and contains an accumulation of lime and gypsum crystals. The substratum is 36 inches thick. The upper 12 inches is gray clay

loam that contains an accumulation of lime. The next 6 inches is mottled, gray loam. The lower 18 inches is mottled, light yellowish-brown loam.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The dense subsoil layer and the salts in the lower part of the subsoil limit root growth and water penetration. The water table is within 5 feet of the surface most of the year and at or near the surface in spring and early in summer. A perched water table forms just above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops and grasses, but they are poorly suited to legumes.

Representative profile of Cresbard loam, in an area of Cresbard-Cavour loams, in a cultivated field, 1,150 feet north and 200 feet west of the southeast corner of sec. 32, T. 150 N., R. 59 W., Nelson County:

Ap—0 to 5 inches, gray (10YR 5/1) loam, black (10YR 2/1) moist; weak, medium and fine, subangular blocky structure parting to moderate, medium, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A2—5 to 7 inches, gray (2.5Y 6/1) silt loam, very dark gray (2.5Y 3/1) moist; moderate, medium, platy structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots; neutral; abrupt, smooth boundary.

B21t—7 to 13 inches, very dark gray (10YR 3/1) clay loam, black (10YR 2/1) moist; moderate, coarse and medium, columnar structure parting to strong, medium and fine, angular blocky; hard, firm, sticky and very plastic; few roots; distinct continuous clay films on faces of columns; neutral; clear, smooth boundary.

B22t—13 to 18 inches, dark-gray (2.5Y 4/1) clay loam, black (2.5Y 2/1) moist; moderate, coarse and medium, prismatic structure parting to moderate, medium, angular blocky; hard, firm, sticky and plastic; few roots; distinct continuous clay films on faces of prisms; mildly alkaline; clear, wavy boundary.

B23ca—18 to 24 inches, very dark gray (2.5Y 3/1) clay loam, black (2.5Y 2/1) moist; moderate, coarse, prismatic structure parting to moderate, medium, angular blocky; hard, firm, sticky and plastic; distinct patches of clay films on faces of prisms; few pebbles as large as 10 millimeters; common segregations of lime and nests of gypsum crystals; strongly effervescent and violently effervescent; mildly alkaline; clear, wavy boundary.

C1ca—24 to 36 inches, light-gray (2.5Y 7/1) clay loam, light brownish gray (2.5Y 6/2) moist; weak, coarse, prismatic structure parting to strong, fine, angular blocky; hard, friable, sticky and plastic; few pebbles as large as 10 millimeters; violently effervescent; moderately alkaline; clear, smooth boundary.

C2—36 to 42 inches, gray (2.5Y 6/1) loam, gray (2.5Y 5/1) moist; common, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; moderate, medium and fine, angular blocky structure; hard, friable, slightly sticky and plastic; few pebbles as large as 10 millimeters; violently effervescent; moderately alkaline; clear, smooth boundary.

C3—42 to 56 inches, light yellowish-brown (2.5Y 6/4) loam, light olive brown (2.5Y 5/4) moist; common, fine, distinct, gray (2.5Y 5/1, moist) and yellowish-red (5YR 5/6, moist) mottles; massive; hard; friable, slightly sticky and slightly plastic; few pebbles as large as 10 millimeters; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C4—56 to 60 inches, light yellowish-brown (2.5Y 6/4) loam, light olive brown (2.5Y 5/4) moist; common, fine, distinct, gray (2.5Y 5/1, moist) and brownish-yellow (10YR 6/6, moist) mottles; massive; hard, friable, slightly sticky and slightly plastic; few pebbles as large as 10 millimeters; slightly effervescent; mildly alkaline.

The A1 horizon ranges from 4 to 8 inches in thickness. It is gray, dark-gray, or very dark gray loam or silt loam. In some profiles the Ap horizon is clay loam or silty clay loam where deep tillage has mixed part of the B2 horizon with the A1 and A2 horizons. The A2 horizon ranges from 1 to 5 inches in thickness. It is light-gray or gray loam or silt loam. The B2 horizon ranges from 8 to 18 inches in thickness. It is very dark gray or dark-gray clay loam or silty clay loam. It has strong or moderate, columnar, or prismatic structure that parts to strong or moderate, blocky structure. The lower part of the B horizon in most places has an accumulation of lime, gypsum, and other salts. The Cca horizon is clay loam or loam; some profiles lack this horizon. The C horizons below the Cca horizon are mottled, light-gray, gray, or light yellowish-brown loam or clay loam. Accumulations of gypsum and other segregations of salt are in the upper part of the C horizon in places.

Cresbard soils are adjacent to Cavour, Hamerly, and Svea soils in many places. They have a profile similar to that of Cavour soils. They have thicker combined A1 and A2 horizons than Cavour soils. They have a claypan B2t horizon which Hamerly and Svea soils lack.

Cresbard-Cavour loams (Cz).—Soils of this mapping unit are nearly level and are on glacial till plains. Cresbard soils have the profile described as representative of the series. Cresbard soils make up about 45 percent of the mapping unit, and Cavour soils, in slightly lower positions, make up about 35 percent.

Included with these soils in mapping are small areas of Hamerly soils and Svea soils in slightly higher positions and areas of Vallers soils around the edges of depressions that are identified on the soil map by a diamond symbol. Tonka soils and Parnell soils are in the depressions. In some cultivated areas the surface layer is clay loam or silty clay loam that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to salt-tolerant grain crops and grasses; they are poorly suited to legumes. Growth of most crops is reduced because of the dense subsoil, slow permeability, and the high content of salt. Wetness and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IIIs–6P; Cresbard soil is in windbreak suitability group 4, Cavour soil is in windbreak suitability group 9.

Dickey Series

The Dickey series consists of deep, nearly level to gently rolling, well-drained soils that formed in coarse deposits underlain by glacial till. These soils are on sand-mantled glacial till plains. These soils are mapped only with Hecla, Maddock, and Towner soils in this survey area (fig. 9).

In a representative profile the surface layer is dark-gray fine sandy loam about 6 inches thick. The next layer is dark grayish-brown, very friable loamy fine sand about 18 inches thick. The substratum is 36

Figure 9.—**Profile of Dickey fine sandy loam, a deep, well-drained soil that formed in coarse-textured deposits underlain by glacial till.**

inches thick. The upper 6 inches is yellowish-brown loam. The next 18 inches is light-gray loam that contains an accumulation of lime. The lower 12 inches is mottled, pale-yellow loam.

Permeability is rapid in the surface layers and subsoil and moderately slow in the substratum. The available water capacity is moderate. The organic-matter content is moderate, and fertility is medium. A perched water table is above the glacial till substratum during periods of heavy rainfall.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Dickey fine sandy loam, in an area of Hecla-Dickey fine sandy loams, 3 to 6 percent slopes, in a cultivated field, 100 feet north and 1,250 feet east of the southwest corner of the NW¼ sec. 18, T. 148 N., R. 63 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) fine sandy loam, black (10YR 2/1) moist; moderate, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; slightly acid; clear, smooth boundary.

Ac—6 to 24 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure parting to weak, fine, subangular blocky and to single grained; soft, very friable, slightly sticky and slightly plastic; common roots; neutral; clear, wavy boundary.

IIC1—24 to 30 inches, yellowish-brown (10YR 5/4) loam, dark yellowish brown (10YR 4/4) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, sticky and plastic; common roots; thin patchy dark-brown (10YR 3/3, moist) stains on faces of prisms; mildly alkaline; gradual, wavy boundary.

IIC2ca—30 to 48 inches, light-gray (2.5Y 7/2) loam, light olive brown (2.5Y 5/4) moist; massive; hard, friable, sticky and plastic; few roots; common, medium, distinct, segregations of lime; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIC3—48 to 60 inches, pale-yellow (2.5Y 7/4) loam, olive brown (2.5Y 4/4) moist; common, fine, prominent, dark-red (2.5Y 3/5, moist) mottles; massive; hard, friable, sticky and plastic; strongly effervescent; moderately alkaline.

Depth to glacial till ranges from 20 to 40 inches. The A horizon ranges from 6 to 15 inches in thickness. It is dark-gray and very dark gray fine sandy loam or sandy loam. The Ac horizon ranges from 8 to 18 inches in thickness. It is grayish-brown or dark grayish-brown loamy fine sand or loamy sand. Some profiles have a C horizon of yellowish-brown or pale-brown loamy fine sandy, loamy sand, fine sand, or sand that is as much as 10 inches thick. The IIC horizon is yellowish-brown, pale-yellow, or light-gray glacial till of loam or clay loam texture. An accumulation of lime is in some part of the IIC horizon in most places.

Dickey soils are adjacent to Barnes, Hecla, Heimdal, Maddock, and Towner soils in many places. They contain less clay between depths of 10 to 40 inches than Barnes and Heimdal soils. Unlike Hecla and Maddock soils, they have glacial till within 40 inches of the surface. They are better drained than Towner soils.

Divide Series

The Divide series consists of moderately deep, nearly level to gently sloping, somewhat poorly drained, calcareous soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and in outwash channels.

In a representative profile the surface layer is loam about 11 inches thick that is very dark gray in the upper 7 inches and dark gray and light gray and contains an accumulation of lime in the lower 4 inches. The substratum is 49 inches thick. The upper 5 inches is light-gray, friable loam that contains an accumulation of lime. The 6 inches below that is mottled, light brownish-gray loam. The next 6 inches is mottled, grayish-brown medium, coarse, and very coarse sand. The 22 inches below that is grayish-brown medium, coarse, and very coarse sand. The lowermost 10 inches is light brownish-gray coarse and very coarse sand.

Permeability is moderate in the surface layer and upper part of the substratum and very rapid in the lower part of the substratum. The available water capacity is low. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in spring and early in summer. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops, grasses, and legumes except in wet areas where drainage is needed. Undrained, wet areas are suited to grass.

Representative profile of Divide loam, sandy substratum, in a cultivated field, 240 feet south and 500

feet east of the northwest corner of the NE¼ sec. 25, T. 149 N., R. 67 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, fine, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

ACca—7 to 11 inches, variegated dark-gray and light-gray (10YR 4/1 and 7/1) loam, very dark gray and light brownish gray (10YR 3/1 and 6/2) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; violently effervescent; moderately alkaline; clear, wavy boundary.

C1ca—11 to 16 inches, light-gray (2.5Y 7/2) loam, light brownish gray (2.5Y 6/2) moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; tongues of C1ca horizon extend to a depth of 28 inches; violently effervescent; moderately alkaline; clear, irregular boundary.

C2—16 to 22 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; common, medium, distinct, light brownish-gray (2.5Y 6/2, moist) lime pockets and few, fine, faint, light yellowish-brown (2.5Y 6/4, moist) mottles; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and plastic; few roots; more lime concentrated in lower part; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC1—22 to 28 inches, grayish-brown (2.5Y 5/2) medium, coarse, and very coarse sand, dark brown (10YR 4/3) moist; common, coarse, distinct, yellowish-brown (10YR 5/4, moist) mottles; single grained; loose, nonsticky and nonplastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIC2—28 to 50 inches, grayish-brown (2.5Y 5/2) medium, coarse, and very coarse sand, dark grayish brown (10YR 4/2) moist; single grained; loose, nonsticky and nonplastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIIC1—50 to 60 inches, light brownish-gray (2.5Y 6/2) coarse and very coarse sand, grayish brown (2.5Y 5/2) moist; discontinuous dark bands less than ½ inch thick in upper part of horizon; single grained; loose, nonsticky and nonplastic; lime pockets throughout sands; slightly effervescent; moderately alkaline.

Depth to the sand and gravel substratum ranges from 20 to 36 inches. The A horizon ranges from 7 to 16 inches in thickness. It is very dark gray, dark gray, or light gray. Typically, it is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in places. The Cca horizon ranges from 5 to 20 inches in thickness. It is light gray or gray. The C horizon ranges from 0 to 10 inches in thickness. It is light brownish gray or light gray. The IIC horizon is grayish brown, light olive brown, or light brownish gray. Typically it is stratified granitic sand, but it contains a layer of shaly sand and gravel in some places. In most places lime coats the underside of pebbles in one or more of the IIC horizons. Segregations of salts and gypsum are in the A horizon and the Cca horizon in some places. Glacial till is below a depth of about 40 inches in places.

Divide soils have a profile similar to those of Fram, Marysland, Totten, and Warsing soils. They formed in glaciofluvial deposits rather than in glacial till as did Fram soils. They are better drained than Marysland soils. Unlike Totten and Warsing soils, they have an accumulation of lime in or just below the A horizon. They lack the alkaline B2t horizon that is characteristic of Totten soils.

Divide loam, 0 to 3 percent slopes (DvA).—This soil is in slight depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the content of gravel in the substratum ranges from less than 40 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Marysland soils in lower positions and areas of Renshaw soils and Warsing soils in slightly higher positions. Also included are soils in cultivated areas that have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; some areas that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Divide loam, 3 to 6 percent slopes (DvB).—This soil has a profile similar to the one described as representative of the series. About 55 percent of the areas are on glacial outwash plains, which contain a high percentage of shale in the substratum. The content of gravel in the substratum ranges from less than 40 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Brantford soils and Renshaw soils in slightly higher positions. Also included in some cultivated areas are soils that have a lighter colored surface layer.

Surface runoff is medium. The hazard of soil blowing is severe.

Some areas of this soil are cultivated, and other areas are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, surface runoff, droughtiness caused by the low available water capacity, and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Divide loam, saline (Dw).—This soil is nearly level and is in slight depressions on outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer and upper part of the substratum contain soluble salts that adversely affect plant growth. Content of gravel in the substratum is less than 40 percent by volume.

Included with this soil in mapping are small areas of nonsaline Divide soils and Totten soils in positions similar to those of saline Divide soils. Also included are areas of Marysland soils in lower positions, areas of Warsing soils in slightly higher positions, and areas of Divide soils where the substratum contains more than 40 percent gravel by volume. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; some areas that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to salt-tolerant grasses, and if drained, it is suited to salt-tolerant grain crops and legumes. Wetness, salinity, droughtiness caused by the low available water capacity, and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

Divide loam, gravelly substratum (Dx).—This soil is nearly level and is in slight depressions on glacial out-

wash plains. It has a profile similar to the one described as representative of the series, but the substratum contains more than 40 percent gravel by volume in most places.

Included with this soil in mapping are small areas of Marysland soils in lower positions, areas of Warsing soils in slightly higher positions, and areas of Totten soils and saline Divide soils in positions similar to those of Divide soils. Also included are small areas of Divide soils that have glacial till below a depth of 40 inches and areas of Divide soils that have a substratum that has less than 40 percent gravel by volume. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; some areas that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, droughtiness caused by the low available water capacity, and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Divide loam, sandy substratum (Dy).—This soil is nearly level and is in slight depressions on glacial outwash plains and in outwash channels. It has the profile described as representative of the series. Content of gravel in the substratum is less than 40 percent by volume.

Included with this soil in mapping are small areas of Marysland soils in lower positions, areas of Kensal soils and Warsing soils in slightly higher positions, and areas of Fram, Glyndon, Totten, and saline Divide soils in positions similar to those of Divide soils. Also included are small areas of Divide soils that have glacial till below a depth of 40 inches and areas of Divide soils that have a substratum that has more than 40 percent gravel by volume. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; some areas that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, droughtiness caused by the low available water capacity, and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Divide loam, till substratum (Dz).—This soil is nearly level and is in slight depressions on glacial outwash plains. It is generally adjacent to areas of glacial till. It has a profile similar to the one described as representative of the series, but glacial till is below a depth of 40 inches, and the content of gravel in the substratum above the glacial till ranges from less than 40 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Divide, Fram, and Totten soils in positions similar to those of Divide soils, areas of Marysland soils in lower positions, and areas of Warsing, Emrick, and Heimdal soils in slightly higher positions. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; some areas that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, droughtiness caused by the low available water capacity, and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Eckman Series

The Eckman series consists of deep, nearly level to sloping, well-drained soils that formed in medium-textured glaciofluvial deposits. These soils are on glacial outwash and lake plains.

In a representative profile the surface layer is about 9 inches thick. It is dark-gray loam in the upper 6 inches and silt loam in the lower 3 inches. The subsoil is grayish-brown, friable silt loam about 18 inches thick. The substratum is light brownish-gray silt loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Eckman loam, 3 to 8 percent slopes, in a cultivated field, 740 feet north and 200 feet east of the southwest corner of sec. 10, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—6 to 9 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; moderate, fine, subangular blocky structure parting to moderate, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; gradual, smooth boundary.

B21—9 to 17 inches, grayish-brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse and medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; mildly alkaline; gradual, wavy boundary.

B22—17 to 27 inches, grayish-brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; slightly effervescent; mildly alkaline; gradual, wavy boundary.

C1—27 to 42 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C2—42 to 60 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common segregations of lime; strongly effervescent; moderately alkaline.

The A horizon ranges from 7 to 10 inches in thickness. It is dark-gray or very dark gray loam or silt loam. The B horizon ranges from 8 to 18 inches in thickness. It is grayish-brown or dark grayish-brown loam or silt loam. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The C horizon is light brownish-gray or pale-brown silt loam or loam, but sand is below a depth of about 30

inches in some places. An accumulation of lime is in the upper part of the C horizon in some places.

Eckman soils are adjacent to Gardena, Glyndon, and Zell soils in many places. They have a profile similar to that of Gardena soils, but they have a thinner A horizon. They lack an accumulation of lime in and directly beneath the A horizon, which is typical of Glyndon soils. They have a B horizon, which Zell soils lack.

Eckman loam, 0 to 3 percent slopes (EaA).—This soil is on glacial outwash and lake plains. Included in mapping are small areas of Gardena soils.

Surface runoff is slow. The hazard of soil blowing is moderate.

Practically all areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIe–5; windbreak suitability group 3.

Eckman loam, 3 to 8 percent slopes (EaB).—This soil is on glacial outwash and lake plains. It has the profile described as representative of the series. In about 25 percent of the areas, slopes range from 6 to 8 percent.

Included with this soil in mapping are small areas of Zell soils on summits and on shoulder slopes and areas of Gardena soils on lower foot slopes and toe slopes.

Surface runoff is medium on the gentle slopes and rapid on the steeper slopes. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some areas, particularly the steeper ones, are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIe–5; windbreak suitability group 3.

Edgeley Series

The Edgeley series consists of moderately deep, nearly level to gently undulating, well-drained soils that formed in medium-textured glacial till and glaciofluvial deposits overlying bedded shale. These soils are on side slopes adjacent to the Sheyenne River Valley and drainageways leading to the Sheyenne River, on side slopes of the Sheyenne River Valley, and on high terraces along the Sheyenne River.

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The subsoil, which is about 26 inches thick, is very dark grayish-brown, very friable silt loam in the upper 9 inches and brown, friable silty clay loam in the lower 17 inches. Below this is gray, weathered and bedded shale.

Permeability is moderate above the bedded shale, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Edgeley loam, in a cultivated field, 1,150 feet north and 1,150 feet west of the southeast corner of the SW¼ sec. 19, T. 149 N., R. 58 W., Nelson County:

A1p—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to moderate, medium, granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B1—6 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many roots; few fragments of shale; neutral; clear, smooth boundary.

B2—15 to 32 inches, brown (10YR 5/3) silty clay loam, dark grayish brown (2.54Y 4/2) moist; few, fine, faint, light olive-brown (2.5Y 5/4, moist) mottles; weak, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; hard, friable, sticky and plastic; few roots; mildly alkaline; abrupt, smooth boundary.

R—32 to 60 inches, gray (5Y 5/1) bedded shale, very dark gray (5Y 3/1) moist; platy structure; hard; segregations of lime in weathering faults; slightly effervescent.

Depth to bedded shale ranges from 24 to 36 inches. The A horizon ranges from 5 to 9 inches in thickness. It is very dark gray or dark-gray loam or silt loam. The B horizon ranges from 6 to 26 inches in thickness. It is very dark grayish-brown, dark grayish-brown, grayish-brown, or brown loam, silt loam, clay loam, or silty clay loam that is mottled in the lower part in most places, and it has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The C horizon, where present, is loam, silt loam, or silty clay loam as much as 26 inches thick. Pebbles and stones are common throughout the profile above the shale.

Edgeley soils have a profile similar to that of the Barnes and Svea soils and the Edgeley variant. They are near the Barnes soils, the Cavour variant, and the Kloten and Svea soils. Edgeley soils have bedded shale within a depth of 36 inches; Barnes and Svea soils do not. Edgeley soils lack the sand and gravel IIC horizon that is typical of the Edgeley variant. They lack the alkaline B2t horizon of the Cavour variant. They have a B horizon, which Kloten soils lack.

Edgeley loam (Eb).—This soil is nearly level and is on side slopes adjacent to the Sheyenne River Valley and drainageways leading to the Sheyenne River. It has the profile described as representative of the series.

Included with this soil in mapping are areas of Svea soils in a landscape position similar to that of Edgeley loam and small areas of the Edgeley variant. Also included are areas of Kloten soils near the edge of drainageways and on side slopes of the Sheyenne River Valley. Cobblestones and stones are on the surface in some areas.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but some are used for pasture where they are associated with adjacent steeper soils. This soil is suited to grains, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIc–6; windbreak suitability group 3.

Edgeley and Cavour loams, 3 to 6 percent slopes (EcB).—Soils of this mapping unit are on side slopes and high terraces of the Sheyenne River Valley.

Included with these soils in mapping are small areas of the Cavour variant interspersed with Edgeley soils, areas of the Edgeley variant, and small areas of Renshaw soils that have till and shale in the lower part of their substratum. A few seepage areas and stones are common in some places. In a few places the Cavour soils have a clay loam surface layer that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Surface runoff is medium. The hazard of soil blowing is slight.

Most areas are used for pasture and hay, but some are cultivated along with adjoining soils. The soils are suited to small grains, legumes, and grasses. Growth of most crops is reduced on the Cavour soils because of the dense subsoil, slow permeability, and high salt content. The hazard of soil blowing and maintenance of good tilth in cultivated areas are the main concerns of management. Capability unit IIIs–6P; Edgeley soil is in windbreak suitability group 3, Cavour soil is in windbreak suitability group 9.

Edgeley Variant

The Edgeley variant is a moderately deep, nearly level, well-drained soil that formed in medium-textured glacial till or in glaciofluvial deposits. This soil has a coarse substratum of granitic gravel and fragments of shale underlain by bedded shale. It is on side slopes adjacent to the Sheyenne River Valley and to drainageways leading to the Sheyenne River.

In a representative profile the surface layer is very dark gray loam about 10 inches thick. The subsoil is grayish-brown, friable loam about 6 inches thick. The substratum is multicolored gravel and sand in the upper 14 inches and light-gray and gray weathered shale in the lower 30 inches.

Permeability is moderate in the surface layer and subsoil and rapid below the subsoil. The available water capacity is low. The organic-matter content is high, and fertility is medium.

This soil is suited to grain crops, grasses, and legumes.

Representative profile of Edgeley loam, gravelly variant, in a cultivated field, 100 feet south and 200 feet east of the northwest corner of the NE¼ sec. 6, T. 149 N., R. 59 W., Nelson County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, coarse, subangular blocky structure parting to moderate, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; few pebbles and fragments of shale; slightly acid; abrupt, smooth boundary.

A1—6 to 10 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, thick, platy structure parting to moderate, fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few pebbles and fragments of shale; slightly acid; clear, smooth boundary.

B2—10 to 16 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; moderate, coarse, prismatic structure parting to moderate, coarse, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; common pebbles and fragments of shale; neutral; abrupt, smooth boundary.

IIC—16 to 30 inches, multicolored gravel and sand; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

R1—30 to 40 inches, light-gray (5Y 7/1) weathered shale, very dark gray (5Y 3/1) moist; many, coarse, prominent, dark-brown (10YR 3/3, moist) mottles; strong, thin, platy structure; strongly effervescent; gradual, smooth boundary.

R2—40 to 60 inches, gray (5Y 6/1) weathered shale, very dark gray (5Y 3/1) moist; many, coarse, prominent, dark-brown (10YR 3/3, moist) mottles; strong, thin, platy structure; slightly effervescent.

Depth to bedded shale ranges from 24 to 36 inches. The A horizon ranges from 5 to 16 inches in thickness and is very dark and dark-gray loam or silt loam. The B horizon ranges from 6 to 16 inches in thickness and is grayish-brown or dark grayish-brown loam or silt loam. It has moderate or weak prismatic structure that parts to moderate or weak, angular or subangular blocky structure. The C horizon, where present, is mottled, light brownish-gray or light yellowish-brown loam or silt loam as much as 15 inches thick. The IIC horizon ranges from 3 to 15 inches in thickness. The R horizon is light-gray, gray, or dark-gray weathered or bedded shale. Pebbles and stones are common on the surface and throughout the profile in some places.

The Edgeley variant has a profile similar to that of Barnes, Renshaw, Edgeley, and Svea soils. In many places it is adjacent to Barnes and Renshaw soils and to the Svea variant. It has bedded shale within 36 inches of the surface; Barnes, Renshaw, and Svea soils lack bedded shale. They have a IIC horizon of sand and gravel above the bedded shale, which the Edgeley variant lacks.

Edgeley loam, gravelly variant (Ed).—This soil is nearly level and is on slopes adjacent to the Sheyenne River Valley and drainageways leading to the Sheyenne River.

Included with this soil in mapping are small areas of Edgeley, Barnes, and Renshaw soils. Also included are small areas of the Svea variant and of soils that have a profile similar to that of Edgeley loam, gravelly variant, but the depth to bedded shale is 36 to 60 inches. Cobblestones and stones are common on the surface in some areas.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but small areas adjacent to steeper soils are used for pasture. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIs–6; windbreak suitability group 3.

Egeland Series

The Egeland series consists of deep, nearly level to hilly, well-drained soils that formed in moderately coarse textured glaciofluvial deposits over coarse textured glaciofluvial deposits. These soils are on glacial outwash plains and sand-mantled glacial till plains.

In a representative profile the surface layer is dark-gray sandy loam about 8 inches thick. The subsoil is very friable sandy loam about 12 inches thick that is dark grayish brown in the upper 4 inches and grayish brown in the lower 8 inches. The substratum is light brownish-gray loamy fine sand in the upper 10 inches and light-gray sand in the lower 30 inches.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Egeland sandy loam, 6 to 12 percent slopes, in a cultivated field, 50 feet south and 25 feet west of the northeast corner of sec. 23, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 8 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, fine, granular structure; slightly hard, very friable, slightly

sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B21—8 to 12 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak, medium, prismatic structure parting to weak, fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; slightly acid; gradual, wavy boundary.

B22—12 to 20 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak, coarse and medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; neutral; gradual, wavy boundary.

C1—20 to 30 inches, light brownish-gray (2.5Y 6/2) loamy fine sand, grayish brown (2.5Y 5/2) moist; weak, coarse, prismatic structure parting to weak, medium and fine, subangular blocky and to single grained; soft, very friable, slightly sticky and nonplastic; few roots; neutral; gradual, wavy boundary.

C2—30 to 46 inches, light-gray (2.5Y 7/2) fine sand, light brownish gray (2.5Y 6/2) moist; single grained; loose, nonsticky and nonplastic; mildly alkaline; gradual, wavy boundary.

C3—46 to 60 inches, light-gray (2.5Y 7/2) fine sand, light brownish gray (2.5Y 6/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 5 to 10 inches in thickness and is dark-gray or very dark gray sandy loam or fine sandy loam. The B horizon ranges from 8 to 20 inches in thickness and is dark grayish-brown, grayish-brown, or brown sandy loam or fine sandy loam. The C horizon is light gray, light brownish gray, pale brown, or light yellowish brown. Typically, the texture of the profile grades from fine sandy loam or sandy loam to fine sand or sand with increasing depth, but in some areas there is an abrupt change to coarse sand and medium sand below a depth of about 30 inches. In areas of sand-mantled glacial till, loam glacial till is at a depth below 40 inches. The C horizon is generally noncalcareous or slightly calcareous, but in some places, the upper part has an accumulation of lime.

Egeland soils are adjacent to Clontarf, Embden, and Swenoda soils in many places. They have a profile similar to that of Embden and Swenoda soils. They have a thinner A horizon and are deeper to coarse sand than Clontarf soils. They are better drained than Embden soils and are deeper to glacial till than Swenoda soils.

Egeland sandy loam, 0 to 3 percent slopes (EeA).—This soil is on outwash plains.

Included with this soil in mapping are small areas of Embden and Hecla soils in concave positions. Also included are areas of Maddock soils in positions similar to those of Egeland soils, and areas of Egeland soils that have a surface layer and subsoil of fine sandy loam.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIe–3; windbreak suitability group 5.

Egeland sandy loam, 6 to 12 percent slopes (EeC).—This soil is on glacial outwash plains. It has the profile described as representative of the series. About 30 percent of the areas are hilly and have slopes of 9 to 12 percent.

Included with this soil in mapping are small areas of Maddock soils in positions similar to those of Egeland soils. Also included are areas of Embden and Hecla soils on foot slopes and toe slopes, and areas of Egeland soils that have a surface layer and subsoil of fine sandy loam. Soils on the summits and shoulder slopes in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is rapid to very rapid. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but hilly areas are used mainly for pasture and hay. This soil is suited to close-growing grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IVe–3; windbreak suitability group 5.

Egeland sandy loam, sandy substratum (Eg).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum below a depth of about 30 inches is medium and coarse sand.

Included with this soil in mapping are small areas of Arvilla soils and Maddock soils in positions similar to those of Egeland soils. Also included are areas of Clontarf soils and Embden soils in concave areas.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIe–3; windbreak suitability group 5.

Egeland fine sandy loam, till substratum, 0 to 3 percent slopes (EhA).—This soil is on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but the surface layer and subsoil are fine sandy loam and below a depth of about 40 inches, the substratum is glacial till.

Included with this soil in mapping are small areas of Heimdal and Egeland soils in convex positions. Also included are areas of Embden, Emrick, and Swenoda soils in concave positions.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIe–3M; windbreak suitability group 5.

Egeland fine sandy loam, till substratum, 3 to 6 percent slopes (EhB).—This soil is gently undulating and is on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but the surface layer and subsoil are fine sandy loam, and below a depth of about 40 inches, the substratum is glacial till.

Included with this soil in mapping are small areas of Heimdal soils on summits and shoulder slopes, areas of Egeland soils on back slopes, and areas of Emden, Emrick, and Swenoda soils on toe slopes and foot slopes. In some cultivated areas, soils on summit and shoulder slopes have a lighter colored surface layer.

Surface runoff is medium. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some areas are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 5.

Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes (EmC).—Soils of this mapping unit are gently rolling and are on sand-mantled glacial till. The Egeland and Embden soils have a profile similar to the one described as representative of their series, but the substratum below a depth of about 40 inches is glacial till. The Egeland soil, in convex positions, makes up about 50 percent of the mapping unit, and the Embden soil, in concave positions, makes up about 30 percent.

Included with these soils in mapping are small areas of Esmond soils on summits and shoulder slopes, areas of Heimdal and Egeland soils on back slopes, areas of Embden, Emrick, and Swenoda soils on foot slopes and toe slopes, and areas of Hamar and Tiffany soils in swales and depressions. Also included are a few areas of soils that have a surface layer and subsoil of fine sandy loam. In some cultivated areas, soils on summits and shoulder slopes have a lighter colored surface layer.

Surface runoff is generally rapid; water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are better suited to close-growing grain crops, grasses, and legumes than to most other uses. Surface runoff and soil blowing are the main concerns of management. Capability unit IVe–3M; windbreak suitability group 5.

Embden Series

The Embden series consists of deep, nearly level, gently undulating and gently rolling, moderately well drained soils that formed in moderately coarse textured glaciofluvial deposits over coarse textured glaciofluvial deposits. These soils are on glacial outwash plains and on glacial till plains that are mantled with sand.

In a representative profile the surface layer is dark gray and about 13 inches thick; it is sandy loam in the upper 5 inches and fine sandy loam in the lower 8 inches. The subsoil is dark grayish-brown, very friable fine sandy loam about 23 inches thick. The substratum is 24 inches thick. The upper 12 inches of the substratum is dark-brown fine sandy loam; the 6 inches below that is yellowish-brown fine sand; and the lower 6 inches is light yellowish-brown fine sand.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Embden sandy loam, in an area of Embden-Egeland sandy loams, 3 to 6 percent slopes, in a cultivated field, 450 feet south and 500 feet west of the northeast corner of sec. 19, T. 150 N., R. 59 W., Nelson County:

Ap—0 to 5 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; moderate, medium and fine, subangular blocky structure parting to moderate, fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A1—5 to 13 inches, dark-gray (10YR 4/1) fine sandy loam, black (10YR 2/1) moist; moderate, coarse, and medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; slightly acid; clear, wavy boundary.

B21—13 to 17 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; moderate, medium, prismatic structure parting to moderate, coarse and medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; slightly acid; clear, wavy boundary.

B22—17 to 36 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; moderate, very coarse and coarse, prismatic structure parting to weak, medium and fine, blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; slightly acid; clear, smooth boundary.

C1—36 to 48 inches, dark-brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few roots; slightly acid; clear, smooth boundary.

C2—48 to 54 inches, yellowish-brown (10YR 5/4) fine sand, dark brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; slightly acid; clear, smooth boundary.

C3—54 to 60 inches, light yellowish-brown (2.5Y 6/4) fine sand, olive brown (2.5Y 4/4) moist; single grained; loose, nonsticky and nonplastic; slightly acid.

The A horizon ranges from 12 to 20 inches in thickness. It is dark-gray or very dark gray fine sandy loam or sandy loam. The B horizon ranges from 8 to 24 inches in thickness. It is dark grayish-brown or grayish-brown fine sandy loam or sandy loam. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The C horizon is dark brown, yellowish brown, light yellowish brown, or light brownish gray. Typically, it grades from fine sandy loam to sand with increasing depth, but in some areas there is an abrupt change to coarse and medium sand below a depth of 30 inches. In areas of sand-mantled glacial till, loam glacial till is at a depth below 40 inches. The C horizon is generally noncalcareous or slightly calcareous, but in some places the upper part has an accumulation of lime.

Embden soils are adjacent to Clontarf, Egeland, Hecla, and Swenoda soils in many places. They have a profile similar to those of Clontarf, Egeland, and Swenoda soils. They have a finer textured C horizon than Clontarf soils. They have a thicker A horizon than Egeland soils. They have a finer textured solum than Hecla soils and a B horizon that Hecla soils lack. They are deeper to glacial till than Swenoda soils.

Embden sandy loam, 0 to 3 percent slopes (EnA).—This soil is on glacial outwash plains.

Included with this soil in mapping are small areas of Egeland soils and Clontarf soils in slightly higher positions. Also included are areas of Hecla soils in positions similar to those of Embden soils.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIe–3; windbreak suitability group 1.

Embden-Egeland sandy loams, 3 to 6 percent slopes (EoB).—Soils of this mapping unit are on outwash plains. Embden soils have the profile described as representative of the series. They are on lower back slopes, foot slopes, and toe slopes and make up about 45 percent of the mapping unit. Egeland soils are on summits, shoulder slopes, and upper back slopes and make up about 35 percent.

Included with these soils in mapping are small areas of Clontarf and Maddock soils on summits, shoulder slopes, and upper back slopes and areas of Hecla soils

on lower back slopes, foot slopes, and toe slopes. In some cultivated areas, soils on summits and shoulder slopes have a lighter colored surface layer.

Surface runoff is medium. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIIe–3; Embden soil is in windbreak suitability group 1, Egeland soil is in windbreak suitability group 5.

Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes (EsA).—Soils of this undifferentiated mapping unit are on sand-mantled glacial till. Depth of sand overlying the glacial till ranges from less than 6 inches to more than 5 feet. The Embden and Heimdal soils have profiles similar to those described as representative of their respective series, but they have a fine sandy loam surface layer. Heimdal soils are on summits, shoulder slopes, and upper back slopes, and Embden and Swenoda soils are on lower back slopes, foot slopes, and toe slopes.

Included with these soils in mapping are small areas of Esmond soils on summits, Egeland soils on shoulder slopes and upper back slopes, Emrick soils on foot slopes and toe slopes, Tiffany, Tonka, and Wyard soils in swales and depressions that are identified on the soil map by a diamond symbol, and Fram and Wyndmere soils around the edges of some of the depressions. A few areas have a sandy loam surface layer. Soils on the summits and shoulder slopes in some cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated; some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIIe–3M; Embden soil is in windbreak suitability group 1, Swenoda soil is in windbreak suitability group 1, Heimdal soil is in windbreak suitability group 3.

Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes (EsB).—Soils of this undifferentiated mapping unit are on sand-mantled glacial till. Depth of the sand overlaying the glacial till ranges from less than 6 inches to more than 5 feet. The Embden and Heimdal soils have a profile similar to the one described as representative of their series, but they have a fine sandy loam surface layer. Heimdal soils are on summits, shoulder slopes, and upper back slopes, and Embden soils and Swenoda soils are on lower back slopes, foot slopes, and toe slopes.

Included with these soils in mapping are small areas of Esmond soils on summits, Egeland soils on shoulder slopes and upper back slopes, Emrick soils on foot slopes and toe slopes, Tiffany, Tonka, and Wyard soils in swales and depressions, which are identified on the soil map by a diamond symbol, and Fram and Wyndmere soils around the edges of some of the depressions. Also included are a few areas of soils that have a sandy loam surface layer. Soils on the summits and shoulder slopes in some cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIIe–3M; Embden soil is in windbreak suitability group 1, Swenoda soil is in windbreak suitability group 1, Heimdal soil is in windbreak suitability group 3.

Emrick Series

The Emrick series consists of deep, nearly level to gently undulating, moderately well drained soils that formed in medium-textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is very dark gray loam about 9 inches thick. The subsoil is dark grayish-brown, friable loam about 8 inches thick. The substream is 43 inches of loam that contains an accumulation of lime in the upper 13 inches. It is light brownish gray in the upper 7 inches, and it is mottled, light brownish gray in the lower 36 inches.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Emrick loam, in an area of Heimdal-Emrick loams, 0 to 3 percent slopes, in a cultivated field, 150 feet south and 800 feet east of the northwest corner of sec. 30, T. 148 N., R. 66 W., Eddy County:

Ap—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, medium, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—5 to 9 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, smooth boundary.

B2—9 to 17 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; mildly alkaline; clear, wavy boundary.

C1ca—17 to 24 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slighty plastic; few roots; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C2ca—24 to 30 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; common, medium, distinct, white (2.5Y 8/1, moist) segregations of lime and few, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; slightly hard, friable, slightly sticky and slightly plastic; violently effervescent; moderately alkaline; gradual, wavy boundary.

C3—30 to 60 inches, light brownish-gray (2.5Y 6/2) loam, olive brown (2.5Y 4/4) moist; few, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline.

The A horizon ranges from 8 to 20 inches in thickness.

It is very dark gray or dark-gray loam, silt loam, or sandy loam. The B horizon ranges from 6 to 16 inches in thickness. It is dark grayish-brown or grayish-brown loam or silt loam. In some places the upper part of the B horizon is sandy loam. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. An accumulation of lime is in the lower part of the B horizon in some places. The Cca horizon is light brownish gray or light gray and is mottled in the lower part in places. Some profiles do not have a Cca horizon. The C horizon is mottled, light brownish gray, light gray, or light yellowish brown. Pebbles are common in many places, but some profiles are smooth and pebble-free because of water sorting. In some places the C horizon has thin strata of sand.

Emrick soils are adjacent to Fram soils and Heimdal soils in many places; they formed in similar parent material. They have a B horizon, which Fram soils lack, and are not so well drained as Heimdal soils. They have a profile similar to Svea soils, but they contain less clay.

Emrick sandy loam (Et).—This soil is nearly level and is on sand-mantled glacial till plains. It has a profile similar to the one described as representative of the series, but the surface layer, and in some places the upper part of the subsoil, is sandy loam.

Included with this soil in mapping are small areas of Heimdal soils in slightly higher positions, and areas of Swenoda soils and Embden soils in positions similar to those of Emrick soils. Also included are areas of Tiffany, Tonka, and Wyard soils in swales and shallow depressions that are indicated on the soil map by a diamond symbol, and areas of Fram soils and Wyndmere soils around the edges of some of these depressions.

Surface runoff is slow, and water ponds in the depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Emrick loam (Eu).—This soil is nearly level and is on glacial till plains.

Included with this soil in mapping are small areas of Heimdal soils in slightly higher positions. Also included are areas of Tonka soils and Wyard soils in swales and shallow depressions that are indicated on the soil map by a diamond symbol, and areas of Fram soils around the edges of some of the depressions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness in depressions and soil blowing are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

Esmond Series

The Esmond series consists of deep, sloping to steep, well-drained soils that formed in medium-textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is very dark gray loam about 5 inches thick. The next layer is dark-gray, friable loam about 4 inches thick. The substratum is variegated light brownish-gray and light-gray loam that has an accumulation of lime in the upper 11 inches, and is mottled, light yellowish-brown loam in the lower 40 inches.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, and fertility is low.

These soils are better suited to grasses than to most other uses.

Representative profile of Esmond loam, in an area of Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes, in a pasture, 800 feet south and 120 feet west of the northeast corner of sec. 23, T. 150 N., R. 66 W., Eddy County:

A—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, medium and fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; few pebbles; neutral; clear, wavy boundary.

AC—5 to 9 inches, dark-gray (10YR 4/1) loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few pebbles; common, fine, distinct, gray and light-gray (2.5Y 5/1 and 7/1, moist) segregations of lime; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1ca—9 to 20 inches, variegated light brownish-gray and light-gray (2.5Y 6/2 and 7/2) loam, olive brown and light olive brown (2.5Y 4/4 and 5/4) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; few pebbles; common, fine distinct, white (N 8/0, moist) segregations of lime; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2—20 to 60 inches, light yellowish-brown (2.5Y 6/4) loam, olive brown (2.5Y 4/4) moist; few, fine, distinct, dark reddish-brown (2.5Y 3/4, moist) and yellowish-brown (10YR 5/6, moist) mottles; massive, parting to weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few pebbles; strongly effervescent; moderately alkaline.

The A horizon ranges from 4 to 9 inches in thickness. It is very dark gray or dark-gray loam or sandy loam. The AC horizon, where present, is dark-gray or gray loam or sandy loam as much as 5 inches thick. It has an accumulation of lime in some places. The Cca horizon is light brownish gray, light gray, or light olive brown and is mottled in some places. The C2 horizon is mottled, light brownish gray, light gray, light yellowish brown, or grayish brown. Pebbles throughout the profile are common in many places, but some profiles are smooth and pebble-free because of water sorting.

Esmond soils are adjacent to Buse, Coe, Embden, and Heimdal soils in many places. They are underlain by glacial till, unlike Coe soils, which are underlain by shaly sand and gravel. They lack the B horizon that is characteristic of Embden soils and Heimdal soils. They contain less clay throughout the profile than Buse soils.

Esmond, Coe, and Embden soils, 6 to 25 percent slopes (EvD).—Soils of this undifferentiated mapping unit are on moraines where collapsed outwash is mixed with glacial till. The Esmond and Embden soils have a profile similar to the one described as representative of their series, but they contain more fragments of shale than is typical (fig. 10). Esmond soils are on the summits and shoulder slopes in areas of glacial till, Coe soils are on the summits and shoulder slopes in areas of stratified shaly sand and gravel, and Embden soils are on foot slopes and toe slopes.

Included with these soils in mapping are small areas of Heimdal soils on back slopes, Emrick soils on foot

Figure 10.—Shaly gravel pockets that are associated with glacial till. This parent material is typical of that in which Esmond, Coe, and Embden soils, 6 to 25 percent slopes, formed.

slopes and toe slopes in areas of glacial till, Binford soils and Brantford soils on back slopes, Vang soils on foot slopes in areas of shaly outwash, and Tolna soils and Tonka soils in depressions that are identified on the soil map by a diamond symbol. Most areas have a sandy loam surface layer.

Surface runoff is rapid to very rapid, and water ponds in depressions. The hazard of soil blowing is slight, but if grass vegetation is destroyed by cultivation or overgrazing, the hazard of soil blowing is very severe.

Most areas of this mapping unit are in pasture. The soils are better suited to grass than to most other uses. Surface runoff is the main concern of management. Capability unit VIe–6; Esmond soil is in windbreak suitability group 8, Coe soil is in windbreak suitability group 10, Embden soil is in windbreak suitability group 5.

Exline Series

The Exline series consists of deep, nearly level, somewhat poorly drained, claypan soils that formed in moderately fine textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is dark-gray loam about 4 inches thick. The subsoil is firm heavy clay loam about 20 inches thick. It is very dark gray in the upper 8 inches and dark gray in the lower 12 inches. Segregations of salt are common in the subsoils. The substratum is 36 inches of mottled, sandy clay loam. The upper 8 inches is light gray and has an accumulation of lime and segregations of salt. The 15 inches below that is light brownish gray. The lower 13 inches is light gray.

Permeability is very slow, and the available water capacity is low. The organic-matter content is high, and fertility is low. The dense subsoil and the salts in the lower part of the subsoil limit root growth and water penetration. The water table is within 5 feet of the surface most of the year, and it is at or near the surface in spring and early in summer. A perched water table forms just above the dense subsoil during periods of heavy rainfall.

These soils are suited to salt-tolerant grasses.

Representative profile of Exline loam, is a hayfield, 300 feet north and 160 feet east of the southwest corner of the NW¼ sec. 7, T. 149 N., R. 58 W., Nelson County:

A1—0 to 4 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B21t—4 to 12 inches, very dark gray (10YR 3/1) heavy clay loam, black (10YR 2/1) moist; strong, medium, prismatic structure parting to strong, medium, angular blocky; hard, firm, sticky and plastic; few roots; common segregations of salt; slightly effervescent; moderately alkaline; gradual, wavy boundary.

B22t—12 to 16 inches, dark-gray (10YR 4/1) heavy clay loam, black (10YR 2/1) moist; strong, medium, prismatic structure parting to strong, medium, angular blocky; hard, firm, sticky and plastic; few roots; few pebbles as large as 5 millimeters; common segregations of salt; slightly effervescent; strongly alkaline; gradual, wavy boundary.

B3sa—16 to 24 inches, dark-gray (10YR 4/1) heavy clay loam, very dark gray (10YR 3/1) moist; strong, medium, angular blocky structure; hard, firm, sticky and plastic; few pebbles as large as 5 millimeters; common segregations of salt; violently effervescent; strongly alkaline; clear, wavy boundary.

C1casa—24 to 32 inches, light-gray (2.5Y 7/1) sandy clay loam, gray (2.5Y 6/1) moist; common, fine, distinct, olive-yellow (2.5Y 6/8, moist) mottles; massive; hard, firm, sticky and plastic; common pebbles as large as 5 millimeters; common segregations of salt; violently effervescent; strongly alkaline; gradual, wavy boundary.

C2—32 to 47 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, grayish brown (2.5Y 5/2) moist; common, medium, distinct, light yellowish-brown (2.5Y 6/4, moist) mottles; massive; hard, firm, sticky and plastic; common pebbles as large as 5 millimeters; strongly effervescent; strongly alkaline; gradual, wavy boundary.

C3—47 to 60 inches, light-gray (2.5Y 7/2) sandy clay loam, grayish brown (2.5Y 5/2) moist; common, medium, distinct, yellow (2.5Y 7/6, moist) and light olive-brown (2.5Y 5/6, moist) mottles; massive; hard, firm, sticky and plastic; common pebbles as large as 5 millimeters and a few as large as 10 millimeters; few segregations of salt; strongly effervescent; strongly alkaline.

The A1 horizon ranges from 0 to 6 inches in thickness. It is dark-gray or very dark gray loam, clay loam, or silty clay loam. Most profiles do not have an A2 horizon, which

is either a thin gray coating on top of the B2t horizon or as much as 2 inches of gray platy loam or silt loam. The B2t horizon ranges from 8 to 16 inches in thickness. It is very dark gray or dark-gray heavy clay loam or silty clay. It has strong or moderate columnar or prismatic structure that parts to strong or moderate angular or subangular blocky structure. The B3sa horizon ranges from 6 to 10 inches in thickness. It is heavy clay loam or silty clay loam. The C horizon is mottled, light gray, light brownish gray, or light yellowish brown. Typically, it is clay loam or silty clay loam, but stratified sands are below a depth of about 40 inches in some places. Segregations of lime and salt typically occur throughout the C horizon, but they accumulate in the upper part in many places.

Exline soils are adjacent to Aberdeen and Colvin soils in many places. They have a thinner combined A and B2t horizon than Aberdeen soils. They have a B2t horizon, which Colvin soils lack, and they are not so wet as Colvin soils.

Exline loam (Ew).—This soil is nearly level and is in depressions on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Aberdeen soils in slightly higher positions and areas of Colvin soils in lower, more poorly drained, positions. Also included are a few areas that have a surface layer of clay loam or silty clay loam. In many cultivated areas the plow layer is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface layer.

Surface runoff is very slow, and water ponds in low areas. The hazard of soil blowing is severe.

Most areas of this soil are in hay or pasture, but some small areas are cultivated along with the adjoining soils. This soil is suited to salt-tolerant grasses. Growth of most crops is reduced because of the shallow root zone, slow permeability, and the high content of salt. Wetness and overgrazing of pastures are the main concerns of management. Capability unit VIw–4; windbreak suitability group 9.

Fargo Series

The Fargo series consists of deep, nearly level, poorly drained soils that formed in moderately fine textured and fine textured glaciolacustrine deposits. These soils are in ancient ice-blocked lakes in morainic areas.

In a representative profile the surface layer is very dark gray silty clay loam about 8 inches thick. The subsoil is olive-gray, firm silty clay about 12 inches thick. The substratum is 40 inches thick. The upper 15 inches is variegated light-gray and light olive-gray silty clay that has an accumulation of lime. The next 15 inches is variegated pale-olive and olive silty clay. The lower 10 inches is variegated pale-olive and olive silty clay that contains nests of gypsum crystals.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Fargo silty clay loam, in an area of Fargo and Nutley silty clay loams, in a cultivated field, 170 feet south and 30 feet east of the northeast corner of the SE¼SW¼ sec. 33, T. 150 N., R. 66 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate, fine granular structure; slightly hard, friable, sticky and plastic; many roots; slightly acid; abrupt, smooth boundary.

A12—6 to 8 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate, coarse, prismatic structure parting to moderate, very fine, angular blocky; hard, firm, sticky and plastic; many roots; patches of thin clay skins on faces of prisms; neutral; gradual, wavy boundary.

B2g—8 to 20 inches, olive-gray (5Y 5/2) silty clay, olive gray (5Y 4/2) moist; moderate, coarse and medium, prismatic structure parting to moderate, fine and very fine, angular blocky; very hard, firm, sticky and plastic; common roots; clay films and organic stains on all faces; very slightly effervescent; mildly alkaline; gradual, wavy boundary.

C1gca—20 to 35 inches, variegated light-gray and light olive-gray (5Y 7/2 and 6/2) silty clay, olive gray, olive, and light olive brown (5Y 4/2, 5/3, and 2.5Y 5/4) moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm, sticky and plastic; few roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2g—35 to 50 inches, variegated pale-olive and olive (5Y 6/3 and 5/3) silty clay, olive (5Y 4/3) and hard, firm, sticky and plastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C3gcs—50 to 60 inches, variegated pale-olive and olive (5Y 6/3 and 5/3) silty clay, olive (5Y 4/3) moist; massive; hard, firm, sticky and plastic; nests of gypsum crystals; strongly effervescent; moderately alkaline.

The A1 horizon ranges from 6 to 20 inches in thickness. It is silty clay loam, silty clay, or clay. The B horizon ranges from 6 to 16 inches in thickness. It is olive-gray, olive, or olive-brown silty clay loam, silty clay, or clay. The C horizon is mottled, or variegated, light-gray, light olive-gray, pale-olive, or olive silty clay loam, silty clay, or clay. Typically, lime accumulates in the upper part, but some C horizons do not have lime. Segregations of salt and nests of gypsum crystals are in some part of the C horizon in most places.

Fargo soils are adjacent to Nutley soils and to Parnell soils in many places. They are more poorly drained than Nutley soils and not so poorly drained as Parnell soils.

Fargo and Nutley silty clay loams (Fa).—Soils of this nearly level, undifferentiated mapping unit are in ancient ice-blocked lakes in glacial moraines. These soils have the profile described as representative of their series. The Fargo soils are in concave positions, and Nutley soils are in convex positions.

Included with these soils in mapping are small areas of Parnell soils and Perella soils in shallow depressions, and soils in saline areas around the edges of some of the depressions. Also included are areas of Fargo and Nutley soils that have glacial till in the substratum.

Surface runoff is very slow, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this mapping unit are cultivated, but some are in pasture and hay. The soils are suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIs–4; Fargo soil is in windbreak suitability group 1, Nutley soil is in windbreak suitability group 4.

Fordville Series

The Fordville series consists of moderately deep, nearly level, well-drained soils that formed in medium-

textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and river terraces.

In a representative profile the surface layer is dark-gray loam about 7 inches thick. The subsoil is friable loam about 10 inches thick that is dark grayish brown in the upper 4 inches and brown in the lower 6 inches. The upper 5 inches of the substratum is pale-brown loam, and the 38 inches below that is variegated granitic sand and gravel.

Permeability is moderate in the surface layer, subsoil, and upper part of the substratum, and it is very rapid in the lower part of the substratum. The available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Fordville loam in a cultivated field, 620 feet south and 50 feet west of the northeast corner of the SE¼ sec. 23, T. 149 N., R. 67 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; few rounded pebbles as large as 10 millimeters; neutral; abrupt, smooth boundary.

B21—7 to 11 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few rounded pebbles as large as 15 millimeters; mildly alkaline; gradual, wavy boundary.

B22—11 to 17 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few rounded pebbles as large as 15 millimeters; mildly alkaline; gradual, wavy boundary.

C1—17 to 22 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) moist; very weak, coarse and medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; many rounded pebbles as large as 15 millimeters; strongly effervescent; mildly alkaline; clear, smooth boundary.

IIC2—22 to 60 inches, variegated granitic sand and gravel; single grained; loose, nonsticky and nonplastic; strongly effervescent; mildly alkaline.

Depth to the sand and gravel IIC horizon ranges from 20 to 36 inches. The A horizon ranges from 5 to 12 inches in thickness. It is dark gray or very dark gray. The B2 horizon ranges from 5 to 12 inches in thickness. It is dark grayish brown, grayish brown, or brown. It has weak or moderate prismatic structure that parts to weak or moderate angular or subangular blocky structure, and in some places clay films and organic stains are on the faces of prisms. The C horizon ranges from 5 to 12 inches in thickness. It is pale-brown or light brownish-gray loam or sandy loam. It has weak or moderate prismatic structure that parts to weak or moderate angular or subangular blocky structure, and in places it has an accumulation of lime in the upper part of the profile. The IIC horizons are typically stratified granitic sand and gravel, and they contain a layer of shaly sand and gravel in places. They have an accumulation of lime in the upper part in some profiles, and lime coatings on the undersides of pebbles are common.

Fordville soils have a profile similar to that of Renshaw, Spottswood, and Warsing soils. They are deeper to sand and gravel than Renshaw soils. They are better drained than Spottswood soils and Warsing soils.

Fordville loam (Fd).—This soil is nearly level and is on glacial outwash plains and river terraces.

Included with this soil in mapping are small areas of Renshaw, Spottswood, and Warsing soils in positions similar to those of Fordville soils. Also included are a few areas of soils that have slopes of 3 to 5 percent.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Low available water capacity, because of the coarse-textured substratum, and soil blowing are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 3.

Fossum Series

The Fossum series consists of deep, nearly level, poorly drained, calcareous soils that formed in moderately coarse textured and coarse textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is sandy loam about 16 inches thick that is very dark gray in the upper 6 inches and dark gray in the lower 10 inches. The substratum is 44 inches thick. The upper 6 inches is gray and grayish-brown loose loamy sand. The 12 inches below that is mottled, light brownish-gray loamy sand. The lowermost 26 inches is mottled, grayish-brown sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate, and fertility is medium. The water table is within 3 feet of the surface most of the year; it is at or near the surface in spring and early in summer. Drains are difficult to install because outlets are not generally available.

These soils are suited to grasses and when drained to grain crops and legumes.

Representative profile of Fossum sandy loam, in an area of Fossum and Hamar sandy loams, in a cultivated field, 450 feet south and 1,150 feet west of the northeast corner of sec. 11, T. 150 N., R. 63 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam; black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to weak, fine, crumb; soft, very friable, slightly sticky and slightly plastic; many roots; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

A12—6 to 10 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; common, medium, distinct, dark grayish-brown, (2.5Y 4/2, moist) mottles; weak, medium, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common roots; strongly effervescent; mildly alkaline; gradual, smooth boundary.

A13—10 to 16 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; common, medium, distinct, dark grayish-brown (2.5Y 4/2, moist) mottles; weak, medium, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common roots; strongly effervescent and violently effervescent; mildly alkaline; clear, wavy boundary.

C1—16 to 22 inches, gray (10YR 5/1) and grayish-brown (2.5Y 5/2) loamy sand, dark gray (10YR 4/1) moist and dark grayish brown (2.5Y 4/2) moist;

very weak, medium, subangular blocky structure; loose, slightly sticky and nonplastic; few roots; strongly effervescent; mildly alkaline; clear, smooth boundary.

C2—22 to 34 inches, light brownish-gray (2.5Y 6/2) loamy sand, dark grayish brown (2.5Y 4/2) moist; common, fine, faint, dark yellowish-brown (10YR 4/4, moist) mottles; single grained; loose, slightly sticky and nonplastic; strongly effervescent; mildly alkaline; gradual boundary.

C3—34 to 60 inches, grayish-brown (2.5Y 5/2) sand, dark grayish brown (2.5Y 4/2) moist; common, fine, faint, light yellowish-brown (10YR 6/4, moist), dark yellowish-brown (10YR 4/4, moist), and strong-brown (7YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 8 to 18 inches in thickness. It is very dark gray or dark-gray sandy loam, fine sandy loam, or loam. Typically it is mottled in the lower part, but not in all profiles. The C horizon is grayish brown, gray, or light brownish gray, and mottles occur throughout the horizon in most places. Segregations of salt are in the A horizon and upper part of the C horizon in some places.

Fossum soils have a profile similar to that of Arveson, Hamar, and Venlo soils. They lack a concentration of segregated lime near the surface, which is a characteristic of Arveson soils. They are calcareous in the A horizon and upper part of the C horizon, unlike Hamar soils and Venlo soils which are noncalcareous.

Fossum sandy loam (Fm).—This soil is nearly level and is in depressions on glacial outwash plains.

Included with this soil in mapping are small areas of Arveson soils and Venlo soils in positions similar to those of Fossum soils, areas of Hamar soils and Wyndmere soils in slightly higher positions, and areas of Maddock soils and Hecla soils in higher, better drained positions.

Surface runoff is very slow. The hazard of soil blowing is very severe. Tillage is often delayed because of wetness.

Most areas of this soil are used for pasture and hay, but some are cultivated along with adjoining soils. This soil is suited to grasses and, where drained, to grain crops and legumes. Soil blowing, wetness, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Fossum loam (Fo).—This soil is nearly level and is in depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is loam.

Included with this soil in mapping are small areas of Arveson soils and Venlo soils in positions similar to those of Fossum soils and areas of Hamar soils and Wyndmere soils in slightly higher positions.

Surface runoff is very slow. The hazard of soil blowing is moderate. Tillage is often delayed because of wetness.

Most areas of this soil are used for pasture and hay, but some are cultivated along with adjoining soils. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness, droughtiness caused by the low available water capacity, and soil blowing in cultivated areas are the main concerns of management. Capability unit IIIw–5; windbreak suitability group 2.

Fossum and Hamar sandy loams (Fp).—Soils of this nearly level, undifferentiated mapping unit are in depressions on glacial outwash plains. The Fossum soil has the profile described as representative of the series. The Hamar soil has a profile similar to the one described as representative of the series, but the surface layer is sandy loam. The Fossum soils are in lower positions than Hamar soils.

Included with these soils in mapping are small areas of Arveson soils and Venlo soils in lower positions and areas of Wyndmere soils in slightly higher positions.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe. Tillage is often delayed because of wetness.

Most areas of this mapping unit are used for pasture and hay, but areas are cultivated along with adjoining soils. Soils of the mapping unit are suited to grasses and, where drained, to grain crops and legumes. Wetness, droughtiness caused by the low available water capacity, and soil blowing in cultivated areas are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Fram Series

The Fram series consists of deep, nearly level, gently sloping and gently undulating, somewhat poorly drained, calcareous soils that formed in medium-textured glacial till. These soils are on glacial till plains (fig. 11).

Figure 11.—**Profile of Fram loam, a deep, somewhat poorly drained, calcareous soil that formed in friable glacial till.**

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The substratum is light-gray, friable loam in the upper 16 inches and mottled, light yellowish-brown loam in the lower 38 inches.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in spring and early in summer. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Fram loam, 0 to 3 percent slopes, in a cultivated field, 150 feet south and 160 feet east of the northwest corner of the SW¼ sec. 32, T. 148 N., R. 67 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

C1ca—6 to 10 inches, light-gray (10YR 7/1) loam, grayish brown (10YR 5/2) moist; weak, very coarse, prismatic structure parting to weak, coarse, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; few dark grayish-brown (10YR 4/2, moist) tongues of A horizon material; violently effervescent; mildly alkaline; gradual, wavy boundary.

C12ca—10 to 22 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak, very coarse, prismatic structure parting to weak, coarse, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common to few roots with increasing depth; violently effervescent; moderately alkaline; diffuse, wavy boundary.

C3—22 to 60 inches, light yellowish-brown (2.5Y 6/4) loam, light olive brown (2.5Y 5/4) moist; few, fine, distinct, yellowish-brown (10YR 5/8, moist) mottles; weak, coarse and medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; strongly alkaline.

The A horizon ranges from 6 to 14 inches in thickness. It is dark-gray or very dark gray loam, fine sandy loam, or silt loam. Typically it is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon ranges from 6 to 20 inches in thickness. It is light-gray, gray, or light brownish-gray sandy loam, fine sandy loam, loam, or silt loam. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The lower part of the C horizon is mottled, light olive brown or light yellowish brown and contains thin strata of sand in some places. Pebbles occur throughout many profiles, but some are pebble free. In some places gypsum and soluble salts in the A horizon and Cca horizon adversely affect plant growth.

Fram soils are adjacent to Emrick, Tonka, Wyard, and Wyndmere soils in many places. Unlike the Emrick, Tonka, and Wyard soils, they lack a B horizon. They have a profile similar to Wyndmere soils, but they formed in glacial till containing less sand than the glaciofluvial deposits in which Wyndmere soils formed.

Fram loam, 0 to 3 percent slopes (FrA).—This soil is on glacial till plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Emrick soils and Heimdal soils in slightly higher positions, areas of Tonka soils and Wyard soils in depressions that are identified on the soil map by a diamond symbol, and areas of Vallers soils in slightly lower positions. Also included are small areas of saline and claypan soils. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Fram loam, 3 to 6 percent slopes (FrB).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Emrick soils and Heimdal soils on summits and shoulder slopes, areas of Tonka soils and Wyard soils in depressions that are identified on the soil map by a diamond symbol, and areas of Vallers soils in poorly drained concave positions. Also included are small areas of saline and claypan soils. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Fram loam, saline (Fs).—This soil is nearly level and is on glacial till plains. It has a profile similar to the one described as representative of the series, but the surface layer and the upper part of the substratum contain soluble salts that adversely affect plant growth.

Included with this soil in mapping are small areas of nonsaline Fram soils, areas of Emrick soils and Heimdal soils in slightly higher positions, areas of Tonka soils and Wyard soils in depressions that are identified on the soil map by a diamond symbol, and areas of Vallers soils in slightly lower positions. Also included are small areas of claypan soils. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to salt-tolerant grain crops, grasses, and legumes. Wetness, salinity, and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

Fram and Wyndmere fine sandy loams (Fw).—Soils of this nearly level, undifferentiated mapping unit are on sand-mantled glacial till. Depth of the sand overlying the glacial till ranges from less than 6 inches to more than 5 feet. These soils have a profile similar to the one described as representative of their series, but the Fram soil has a fine sandy loam surface layer, and in some places the Wyndmere soil has glacial till in the substratum.

Included with these soils in mapping are small areas of Emrick soils and Heimdal soils in slightly higher positions, areas of Tiffany soils and Vallers soils in slightly lower positions, and areas of Tonka soils and

Wyard soils in depressions that are identified on the soil map by a diamond symbol. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. These soils are suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIs–3; windbreak suitability group 1.

Gardena Series

The Gardena series consists of deep, nearly level and gently sloping, moderately well drained soils that formed in medium-textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is loam about 18 inches thick that is dark gray in the upper 7 inches and very dark gray below that. The subsoil is dark grayish-brown, friable silt loam about 10 inches thick. The substratum is 32 inches thick. The upper 8 inches is light brownish-gray silt loam that has an accumulation of lime. The 17 inches below that is light yellowish-brown light silt loam. The lowermost 7 inches is light-gray fine sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Gardena loam, 0 to 3 percent slopes, in a cultivated field, 650 feet north and 200 feet east of the southwest corner of sec. 10, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; mildly alkaline; abrupt, smooth boundary.

A12—7 to 18 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; mildly alkaline; gradual, wavy boundary.

B2—18 to 28 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; mildly alkaline; gradual, wavy boundary.

C1ca—28 to 36 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; weak, medium, prismatic structure parting to weak, medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C2—36 to 53 inches, light yellowish-brown (2.5Y 6/4) light silt loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; slightly effervescent; moderately alkaline; gradual, wavy boundary.

C3—53 to 60 inches, light-gray (2.5Y 7/2) fine sandy loam, light brownish-gray (2.5Y 6/2) moist; massive; soft, very friable, slightly sticky and slightly plastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 10 to 20 inches in thickness. It is dark-gray or very dark gray loam or silt loam. It has weak or moderate granular structure in the plow layer and weak or moderate prismatic structure that parts to weak or moderate subangular blocky structure in the rest of the horizon. The B horizon ranges from 8 to 18 inches in thickness. It is dark grayish-brown or brown loam or silt loam. It has weak or moderate prismatic structure that parts to weak or moderate angular and subangular block structure. It has an accumulation of lime in the lower part in places. The C horizon is light brownish gray, light yellowish brown, light gray, or pale yellow. It is silt loam or loam, but in some places sand is below a depth of about 40 inches. Lime has accumulated in the upper part of the C horizon in some places.

Gardena soils are adjacent to Aberdeen, Eckman, and Glyndon soils in many places. They lack an alkaline B2t horizon, which is typical of Aberdeen soils. They have a thicker A horizon than Eckman soils. They have a B horizon, which Glyndon soils lack.

Gardena loam, 0 to 3 percent slopes (GaA).—This soil is on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Eckman soils in slightly higher positions and areas of Glyndon soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is moderate.

Practically all areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIe–5; windbreak suitability group 1.

Gardena loam, 3 to 6 percent slopes (GaB).—This soil is on glacial outwash plains. Included in mapping are small areas of Eckman soils on summits and shoulder slopes.

Surface runoff is medium. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

Glyndon Series

The Glyndon series consists of deep, nearly level, somewhat poorly drained, calcareous soils that formed in medium-textured glaciofluvial deposits. These soils are on a glacial outwash plains and lake plains.

In a representative profile the surface layer is dark gray and is about 10 inches thick. It is loam in the upper part and silt loam in the lower part. The substratum is 50 inches thick. The upper 20 inches is light-gray, friable silt loam that contains an accumulation of lime. The next 12 inches is mottled, grayish-brown very fine sandy loam. The lower 18 inches is light brownish-gray loamy fine sand.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year; it is just below the surface in spring and early in summer. Tillage is often delayed in spring and early in summer because of wetness.

These soils are suited to grain crops, grasses, and legumes. Where they are saline, they are suited to salt-tolerant grasses.

Representative profile of Glyndon loam, in a cultivated field, 2,200 feet south and 820 feet east of the

northwest corner of sec. 15, T. 149 N., R. 62 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist, moderate, fine, granular structure and moderate, medium and fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many roots, slightly effervescent; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; very coarse, weak, prismatic structure parting to weak, medium and fine, angular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C1ca—10 to 30 inches, light-gray (10YR 6/1) silt loam, dark gray (10YR 4/1) moist, weak, coarse, prismatic structure parting to weak, medium and fine, angular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; mildly alkaline; clear, smooth boundary.

IIIC2—30 to 42 inches, grayish-brown (10YR 5/2) very fine sandy loam, very dark grayish brown (10YR 3/2) moist; common, medium, distinct, gray (2.5Y 6/1, moist) mottles; single grained; soft, very friable, nonsticky and nonplastic; strongly effervescent; mildly alkaline; gradual, wavy boundary.

IIC3—42 to 60 inches, light brownish-gray (10YR 6/2) loamy fine sandy, brown (10YR 5/3) moist; single grained; loose, nonsticky and nonplastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 6 to 12 inches in thickness. It is dark gray or very dark gray. Typically, it is calcareous, but it is noncalcareous in some places. The Cca horizon ranges from 10 to 24 inches in thickness. It is gray, light-gray, or grayish-brown loam or silt loam. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The IIC horizon is grayish brown, light brownish gray, or yellowish brown. It is silt loam or very fine sandy loam in the upper part and loamy fine sand, fine sand, or sand in the lower part. In some places thin strata of coarser material are below a depth of about 40 inches. In some places gypsum and soluble salts adversely affect plant growth.

Glyndon soils have profile characteristics similar to those of Borup and Marysland soils, and they formed in parent material similar to that of Gardena soils. They are better drained than Borup and Marysland soils. They lack a B2 horizon, which is a characteristic of Gardena soils.

Glyndon loam (Gd).—This soil is nearly level and is on glacial outwash plains and lake plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Gardena soils in slightly higher positions, areas of Borup soils in slightly lower positions, small areas of saline and claypan soils, and areas of Lallie soils on the lake plain of Stump Lake. Soils in many cultivated areas have a lighter colored surface layer, and in a few places the soils have a slit loam surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Glyndon loam, saline (Ge).—This soil is nearly level and is on glacial outwash plains and lake plains. It has a profile similar to the one described as representative of the series, but the surface layer and upper part of the substratum contain soluble salts that adversely affect plant growth.

Included with this soil in mapping are small areas of Gardena soils in slightly higher positions, areas of Borup soils in slightly lower positions, areas of nonsaline Glyndon soils, small areas of claypan soils, and areas of Lallie soils on the lake plain of Stump Lake. Soils in many cultivated areas have a lighter colored surface layer, and in a few places the soils have a silt loam surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is severe.

Some areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to salt-tolerant grasses and, where drained, to salt-tolerant grain crops. Wetness, salinity, and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

Gravel Pit

Gravel pit (Gp) consists of open excavations from which sand and gravel have been or are being removed. The areas are of little value in farming but are used by wildlife. Pits less than 3 acres in size are shown on the soil map by the standard symbol for a pit. Capability unit not assigned; windbreak suitability group 10.

Hamar Series

The Hamar series consists of deep, nearly level, somewhat poorly drained soils that formed in coarse-textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains and sand-mantled glacial till.

In a representative profile the surface layer is about 13 inches thick. It is very dark gray loamy sand in the upper 7 inches and mottled, dark gray loamy sand below that. The substratum is 47 inches thick. The upper 7 inches is mottled, light brownish-gray loose sand. The 20 inches below that is mottled, grayish-brown loamy sand. The lower 20 inches is mottled, light brownish-gray loamy sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate, and fertility is medium. The water table is within 5 feet of the surface most of the year; it is just below the surface in spring and early in summer. Tillage is often delayed in spring because of wetness.

These soils are suited to grasses and, if drained, to grain crops and legumes.

Representative profile of Hamar loamy sand, in a cultivated field, 520 feet north and 100 feet west of the southeast corner of sec. 2, T. 150 N., R. 63 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loamy sand, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to weak, fine, crumb; soft, very friable, very slightly sticky and nonplastic; many roots; slightly acid; abrupt, smooth boundary.

A12—7 to 13 inches, dark-gray (10YR 4/1) loamy sand, black (10YR 2/1) moist; common, medium, distinct, brown (10YR 5/3, moist) and dark-brown (10YR 3/3, moist) mottles; weak, medium, sub-

angular blocky structure; soft, very friable, very slightly sticky and nonplastic; common roots; slightly acid; clear, wavy boundary.

C1g—13 to 20 inches, light brownish-gray (2.5Y 6/2) sand, dark grayish brown (2.5Y 4/2) moist; many, fine, faint, dark-brown (10YR 3/3, moist) mottles; single grained; loose, nonsticky and nonplastic; common roots; slightly acid; gradual, smooth boundary

C2g—20 to 40 inches, grayish-brown (2.5Y 5/2) loamy sand, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, dark yellowish-brown (10YR 3/4, moist) mottles; single grained; soft, very friable, very slightly sticky and nonplastic; few roots; slightly acid; gradual, smooth boundary.

C3g—40 to 60 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; common, medium, distinct, brown (10YR 5/3, moist) and dark-brown (10YR 3/3, moist) mottles and a few iron concretions; soft, very friable, very slightly sticky and nonplastic; slightly acid.

The A horizon ranges from 10 to 20 inches in thickness. It is dark-gray or very dark gray loamy sand or sandy loam. Depth to mottling ranges from 5 to 15 inches but typically is about 10 inches. The B horizon, is mottled, loamy sand or sand that is as much as 15 inches thick. Some profiles do not have a B horizon. The C horizon is mottled, light brownish-gray, grayish-brown, light olive-brown, or light yellowish-brown loamy sand or sand. Typically, the C horizon is noncalcareous, but a zone of accumulated lime is in the lower part in some places. Glacial till is below a depth of about 40 inches where these soils are on sand-mantled glacial till.

In the mapping units Hamar loamy coarse sand (Ha), Hamar coarse sandy loam (Hc), and Claire-Lohnes-Hamar loamy coarse sands (Ct), the Hamar soils have more coarse sand throughout than is in the range defined for the Hamar series, but this difference does not alter their usefulness or behavior.

Hamar soils are adjacent to Hecla, Kratka, and Venlo soils in many places. They have mottles closer to the surface than Hecla soils. They lack glacial till within 40 inches of the surface, which is typical of Kratka soils. They are better drained than Venlo soils.

Hamar loamy coarse sand (Ha).—This soil is nearly level and is in depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but it contains more coarse sand throughout than is in the range defined for the Hamar series.

Included with this soil in mapping are small areas of Lohnes soils and Wyrene soils in slightly higher positions and areas of Arveson, Fossum, and Venlo soils in slightly lower positions.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVw–2; windbreak suitability group 2.

Hamar loamy sand (Hb).—This soil is nearly level and is in depressions on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Hecla soils and Wyndmere soils in slightly higher positions and areas of Arveson, Fossum, and Venlo soils in slightly lower positions.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVw–2; windbreak suitability group 2.

Hamar coarse sandy loam (Hc).—This soil is nearly level and is in depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but it contains more coarse sand throughout than is in the range defined for the Hamar series.

Included with this soil in mapping are small areas of Lohnes soils and Wyrene soils in slightly higher positions and areas of Arveson, Fossum, and Venlo soils in slightly lower positions.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Hamar sandy loam (Hd).—This soil is nearly level and is in depressions on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is sandy loam.

Included with this soil in mapping are small areas of Hecla soils and Wyndmere soils in slightly higher positions and areas of Arveson, Fossum, and Venlo soils in slightly lower positions.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Hamerly Series

This series consists of deep, nearly level and gently undulating, somewhat poorly drained, calcareous soils that formed in medium textured and moderately fine textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is dark-gray loam about 7 inches thick. The substratum is 53 inches thick. The upper 13 inches is light-gray, friable loam that contains an accumulation of lime. The lower 40 inches is light brownish-gray loam that contains mottles below a depth of 36 inches.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year; it is just below the surface in spring and early in summer. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops, grasses, and

legumes, except in saline areas where they are suited to salt-tolerant grasses.

Representative profile of Hamerly loam, 0 to 3 percent slopes, in a cultivated area, 130 feet north and 550 feet west of the southeast corner of the NE¼ sec. 33, T. 150 N., R. 67 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, fine, granular and crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

C1ca—7 to 20 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak, coarse, prismatic structure parting to weak, fine and medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—20 to 36 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; common, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; massive; hard, firm, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline.

The A horizon ranges from 6 to 14 inches in thickness. It is dark gray or very dark gray. Typically, it is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon is gray or light-gray loam or silt loam 10 to 20 inches thick; it is mottled in some places. It has weak or moderate prismatic structure that parts to weak or moderate angular or subangular blocky structure. The C horizon is light olive-brown or light brownish-gray loam or clay loam. Mottles are in some part of the C horizon in most places. In some places the A horizon or the Cca horizon contains gypsum and soluble salts, which adversely affect plant growth.

Hamerly soils are adjacent to Svea, Tonka, and Vallers soils in many places. They lack a B horizon, which is typical of Svea soils and Tonka soils. They are better drained than Vallers soils.

Hamerly loam, 0 to 3 percent slopes (HeA).—This soil is on glacial till plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Barnes soils and Svea soils in slightly higher positions, areas of Vallers soils in slightly lower positions, and areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Also included are small areas of saline and claypan soils. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Hamerly loam, 3 to 6 percent slopes (HeB).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Barnes soils and Svea soils in slightly higher positions, areas of Vallers soils in poorly drained concave positions, and areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Also included are small areas of saline and claypan soils. Soils in many cultivated areas have a lighter colored surface layer. In a few areas, the soils have slopes of 6 to 9 percent.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Hamerly loam, saline (Hf).—This soil is nearly level and is on glacial till plains. It has a profile similar to the one described as representative of the series, but the surface layer and the upper part of the substratum contain soluble salts that adversely affect plant growth.

Included with this soil in mapping are small areas of nonsaline Hamerly soils and Cresbard soils in positions similar to those of Hamerly loam, saline, soils. Also included are areas of Barnes soils and Svea soils in slightly higher positions, areas of Vallers soils and Cavour soils in poorly drained concave positions, and areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to salt-tolerant grasses and, where drained, to grain crops and legumes. Wetness, salinity, and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

Hamerly-Svea loams, 0 to 3 percent slopes (HgA).—Soils of this mapping unit are on glacial till plains. Hamerly soils, in convex positions, make up about 55 percent of the mapping unit, and Svea soils, in concave and level positions, make up about 30 percent.

Included with these soils in mapping are small areas of Barnes soils in convex positions, areas of Vallers soils in poorly drained concave positions, and areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Also included are small areas of saline and claypan soils. Some Hamerly soils in cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is severe on the Hamerly soils and slight on the Svea soils.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Hamerly-Svea loams, 3 to 6 percent slopes (HgB).—Soils of this mapping unit are on glacial till plains. Hamerly soils, in convex positions, make up about 45 percent of the mapping unit, and Svea soils, in concave and level positions, make up about 35 percent.

Included with these soils in mapping are small areas of Barnes soils on summits and shoulder slopes, areas of Vallers soils in poorly drained concave positions, and

areas of Tonka soils in depressions that are identified on the soil map by a diamond symbol. Also included are small areas of saline and claypan soils. Some Hamerly soils in cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is severe on the Hamerly soils and slight on the Svea soils.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIes–4L; windbreak suitability group 1.

Hecla Series

The Hecla series consists of deep, nearly level, gently sloping and gently undulating, moderately well drained soils that formed in coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and sand-mantled glacial till plains.

In a representative profile the surface layer is very dark gray loamy sand about 16 inches thick. The layer below that is dark grayish-brown, very friable loamy sand about 16 inches thick. The substratum is grayish-brown and mottled; it is fine sand in the upper 18 inches and loamy sand in the lower 10 inches.

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

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Hecla loamy sand, in an area of Hecla-Hamar loamy sands, in a cultivated field, 600 feet north and 800 feet west of the southeast corner of the SW¼ sec. 15, T. 150 N., R. 62 W., Eddy County:

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand, black (10YR 2/1) moist; weak, very fine, crumb structure; soft, very friable, very slightly sticky and nonplastic; many roots; slightly acid; abrupt, smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1) loamy sand, black (10YR 2/1) moist; weak, coarse, subangular blocky structure; soft, very friable, very slightly sticky and nonplastic; common roots; slightly acid; clear, smooth boundary.

AC—16 to 32 inches, dark grayish-brown (10YR 4/2) loamy sand, very dark brown (10YR 2/2) moist; weak, coarse and medium, subangular blocky structure; soft, very friable, very slightly sticky and nonplastic; common roots; slightly acid; gradual, wavy boundary.

C1—32 to 50 inches, grayish-brown (10YR 5/2) fine sand, very dark grayish brown (10YR 3/2) moist; few, fine, faint, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; few roots; slightly acid; gradual, wavy boundary.

C2—50 to 60 inches, grayish-brown (2.5Y 5/2) loamy sand, very dark grayish brown (2.5Y 3/2) moist; few, fine, faint, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, very slightly sticky and nonplastic; neutral.

The A horizon ranges from 15 to 30 inches in thickness. It is dark-gray or very dark gray loamy sand, loamy fine sand, sandy loam, or fine sandy loam. The AC horizon ranges from 6 to 10 inches in thickness. It is dark grayish-brown, brown, or dark-gray loamy sand or loamy fine sand. Mottles are in the lower part of the A horizon and the AC horizon in places. The C horizon is grayish-brown, dark grayish-brown, light olive-brown, light yellowish-brown, or brown loamy fine sand, loamy sand, fine sand, or sand. The C horizon is mottled throughout in most places. Lime has accumulated in the C horizon in some places, but in most places this horizon is noncalcareous. Thin strata of fine to coarse sand are in the C horizon in places. Glacial till is below a depth of 40 inches in some places.

Hecla soils are adjacent to Dickey, Hamar, and Maddock soils in many places. Unlike Dickey soils, they lack glacial till between depths of 20 and 40 inches. They are better drained than Hamar soils. They have a thicker A horizon and are not so well drained as Maddock soils.

Hecla loamy sand, 0 to 3 percent slopes (HhA).—This soil is on glacial outwash plains.

Included with this soil in mapping are small areas of Maddock soils and Claire soils in slightly higher convex positions, areas of Hamar soils and Wyndmere soils in lower concave positions, and areas of Lohnes soils in positions similar to those of Hecla soils. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, wetness in low positions, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; windbreak suitability group 1.

Hecla loamy sand, 3 to 6 percent slopes (HhB).—This soil is on glacial outwash plains.

Included with this soil in mapping are small areas of Maddock soils and Claire soils on summits and shoulder slopes, areas of Hamar soils and Wyndmere soils in concave positions, and areas of Lohnes soils in positions similar to those of Hecla soils. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is medium, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, wetness in low positions, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; windbreak suitability group 1.

Hecla sandy loam, 0 to 3 percent slopes (HkA).—This soil is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but it has a surface layer of sandy loam.

Included with this soil in mapping are small areas of Maddock soils and Claire soils in slightly higher convex positions, areas of Hamar soils and Wyndmere soils in lower concave positions, and areas of Lohnes soils in positions similar to those of Hecla soils. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe..

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, wetness in low positions, and droughtiness caused by the low

available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Hecla sandy loam, 3 to 6 percent slopes (HkB).—This soil is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but it has a surface layer of sandy loam.

Included with this soil in mapping are small areas of Maddock soils and Claire soils on summits and shoulder slopes, areas of Hamar soils and Wyndmere soils in concave positions, and areas of Lohnes soils in positions similar to those of Hecla soils. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is medium, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, wetness in low positions, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Hecla-Dickey fine sandy loams, 3 to 6 percent slopes (HlB).—Soils of this mapping unit are on sand-mantled glacial till. The Hecla soil has a profile similar to the one described as representative of the series, but it has a surface layer of fine sandy loam. The Dickey soil has the profile described as representative of the series. Hecla soils, on foot slopes and toe slopes, make up about 45 percent of the mapping unit, and Dickey soils, on back slopes, make up about 40 percent.

Included with these soils in mapping are small areas of Heimdal soils and Maddock soils on summits and shoulder slopes, areas of Emrick soils on foot slopes and toe slopes, and areas of Hamar soils and Kratka soils in shallow swales. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is medium, and water ponds in low places. The hazard of soil blowing is very severe.

Some areas of this mapping unit are cultivated, but others are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, wetness in low positions, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3M; Hecla soil is in windbreak suitability group 1, Dickey soil is in windbreak suitability group 5.

Hecla-Hamar loamy sands (Hm).—Soils of this nearly level mapping unit are on glacial outwash plains. The Hecla soil has the profile described as representative of the series. Hecla soils, in convex positions, make up about 40 percent of the mapping unit, and Hamar soils, in concave positions, make up about 35 percent.

Included with these soils in mapping are small areas of Maddock soils in convex positions, areas of Fossum soils and Wyndmere soils in concave positions, and areas of Arveson soils and Venlo soils in poorly drained depressions. Also included are areas of soils that have been reworked by soil blowing.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Some areas of this mapping unit are cultivated, and others are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing, wetness in concave positions, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; Hecla soil is in windbreak suitability group 1, Hamar soil is in windbreak suitability group 2.

Hecla-Maddock loamy sands, 0 to 3 percent slopes (HnA).—Soils of this mapping unit are on glacial outwash plains. The Maddock soil has a profile similar to the one described as representative of the series, but it has a surface layer of loamy sand. Hecla soils, in level and concave positions, make up about 65 percent of the mapping unit, and Maddock soils, in convex positions, make up about 25 percent.

Included with these soils in mapping are small areas of Lohnes soils in level and concave positions, areas of Claire soils in convex positions, and areas of Hamar soils in shallow swales. Also included are areas of soils that have been reworked by soil blowing.

Surface runoff is slow, and water ponds in shallow swales. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing, wetness in shallow swales, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; Hecla soil is in windbreak suitability group 1, Maddock soil is in windbreak suitability group 5.

Hecla-Maddock loamy sands, 3 to 6 percent slopes (HnB).—Soils of this mapping unit are on glacial outwash plains. The Maddock soil has a profile similar to the one described as representative of the series, but it has a surface layer of loamy sand. Hecla soils, on foot slopes and toe slopes, make up about 50 percent of the mapping unit, and Maddock soils, on shoulder slopes and back slopes, make up about 40 percent.

Included with these soils in mapping are small areas of Lohnes soils on foot slopes and toe slopes, areas of Claire soils on shoulder slopes and back slopes, and areas of Hamar soils in swales. Also included are areas of soils that have been reworked by soil blowing.

Surface runoff is medium, and water ponds in swales. The hazard of soil blowing is very severe.

Some areas of this mapping unit are cultivated, and others are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing, wetness in swales, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; Hecla soil is in windbreak suitability group 1, Maddock soil is in windbreak suitability group 5.

Heimdal Series

The Heimdal series consists of deep, nearly level to steep, well-drained soils that formed in medium-textured glacial till. These soils are on glacial till plains and sand-mantled glacial till plains.

In a representative profile the surface layer is dark-gray loam about 7 inches thick. The subsoil is friable loam about 9 inches thick; it is dark grayish brown in the upper part and pale brown in the lower part. The substratum is 44 inches thick. The upper 9 inches is

light-gray loam that has an accumulation of lime. The 25 inches below that is mottled, light olive-brown loam. The lowermost 10 inches is mottled, light brownish-gray loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes, except on steep slopes where they are better suited to grasses than to most other uses.

Representative profile of Heimdal loam, in an area of Heimdal-Emrick loams, 0 to 3 percent slopes, in a cultivated field, 225 feet south and 0.1 mile west of the northeast corner of sec. 25, T. 148 N., R. 67 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, medium, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B21—7 to 12 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; patchy organic stains on faces of prisms; neutral; clear, wavy boundary.

B22—12 to 16 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; neutral; clear, wavy boundary.

C1ca—16 to 25 inches, light-gray (2.5Y 7/2) loam, light olive brown (2.5Y 5/4) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; violently effervescent; mildly alkaline; gradual, wavy boundary.

C2—25 to 50 inches, light olive-brown (2.5Y 5/4) loam, olive brown (2.5Y 4/4) moist; few, medium, faint, yellowish-brown (10YR 5/6, moist) mottled; massive; hard, friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C3—50 to 60 inches, light brownish-gray (2.5Y 6/2) loam, olive brown (2.5Y 4/4) moist; few, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; massive; hard, friable, slightly sticky and slightly plastic; common segregations of lime and pockets of gypsum crystals; strongly effervescent; mildly alkaline.

The A horizon ranges from 5 to 10 inches in thickness. It is dark-gray or very dark gray loam, silt loam, fine sandy loam, or sandy loam. The B horizon ranges from 6 to 16 inches in thickness. It is dark grayish-brown, brown, or pale-brown loam or silt loam. The upper part of the B horizon is fine sandy loam or sandy loam in places. It has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. The Cca horizon is loam or silt loam. The C horizon is light gray, light brownish gray, light brown, light olive brown, light yellowish brown, or pale yellow. In most places, lime has accumulated in the upper part and mottles are below the lime. Pebbles occur throughout the profile in many places, but some profiles are free of pebbles. Thin strata of sand are in the C horizon in places.

Heimdal soils are adjacent to Barnes, Emrick, and Esmond soils in many places. They have a profile similar to that of Barnes and Emrick soils. They are better drained than Emrick soils. They have a B horizon and the Esmond soils do not. They contain less clay in the A horizon and B horizon than Barnes soils.

Heimdal sandy loam, 0 to 3 percent slopes (HoA).—This soil is on sand-mantled glacial till It has a profile similar to the one described as representative of the series, but the surface layer, and in some places the upper part of the subsoil, is sandy loam.

Included with this soil in mapping are small areas of Egeland soils and Heimdal loam in convex positions, areas of Embden, Emrick, and Swenoda soils in concave positions, areas of Kratka, Tiffany, Tonka, and Wyard soils in swales and depressions that are identified on the soil map by a diamond symbol, and areas of Fram soils and Wyndmere soils around the edges of some of the depressions. Also included are areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Soil blowing and wetness in swales and depressions are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 3.

Heimdal sandy loam, 3 to 6 percent slopes (HoB).—This soil is on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but the surface layer, and in some places the upper part of the subsoil, is sandy loam.

Included with this soil in mapping are small areas of Heimdal loam and Egeland soil on summits, shoulder slopes, and back slopes, areas of Embden, Emrick, and Swenoda soils on foot slopes and toe slopes, areas of Kratka, Tiffany, Tonka, and Wyard soils in swales and depressions that are identified on the soil map by a diamond symbol and areas of Fram soils and Wyndmere soils around the edges of some of the depressions. Also included are areas of soils that have been reworked to some extent by soil blowing. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in swales and depressions. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, and wetness in swales and depressions are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 3.

Heimdal sandy loam, 6 to 9 percent slopes (HoC).—This soil is on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but the surface layer, and in some places the upper part of the subsoil, is sandy loam.

Included with this soil in mapping are small areas of Heimdal loam and Esmond soils on summits and shoulder slopes, areas of Egeland soils on back slopes, and areas of Embden, Emrick, and Swenoda soils on foot slopes and toe slopes. Also included are areas of soils that have been reworked to some extent by soil blowing. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer.

Surface runoff is rapid. The hazard of soil blowing is very severe.

Some areas of this soil are cultivated, but others are used for pasture and hay. This soil is suited to close-growing grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of

management. Capability unit IVe–3M; windbreak suitability group 3.

Heimdal loam, 0 to 3 percent slopes (HpA).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Emrick soils in concave positions. Also included are areas of Tonka soils and Wyard soils in depressions, which are identified on the soil map by a diamond symbol, and areas of Fram soils around the edges of some of the depressions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness in depressions and soil blowing are the main concerns of management. Capability unit IIe–5; windbreak suitability group 3.

Heimdal loam, 3 to 6 percent slopes (HpB).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Esmond soils on summits and shoulder slopes, areas of Emrick soils on foot slopes and toe slopes, areas of Parnell, Tonka, and Wyard soils in depressions that are identified on the soil map by a diamond symbol, and areas of Fram soils around the edges of some of the depressions. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated. This soil is suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIe–5; windbreak suitability group 3.

Heimdal loam, 6 to 9 percent slopes (HpC).—This soil is on glacial till plains.

Included with this soil in mapping are small areas of Esmond soils on summits and shoulder slopes and areas of Emrick soils on foot slopes and toe slopes. Also included are soils, on summits and shoulder slopes in many cultivated areas, that have a lighter colored surface layer. Some drainageways are gullied. About 15 percent of this mapping unit is moderately eroded.

Surface runoff is rapid. The hazard of soil blowing is moderate.

Some areas of this soil are cultivated, but others are used for pasture and hay. This soil is suited to close-growing grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIIe–5; windbreak suitability group 3.

Heimdal-Embden fine sandy loams, 9 to 15 percent slopes (HrD).—Soils of this mapping unit are on sand-mantled glacial till. These soils have a profile similar to the one described as representative of their series, but the surface layer, and in some places the upper part of the subsoil, of the Heimdal soils in fine sandy loam, and the surface layer of the Embden soils is fine sandy loam. Heimdal soils, on shoulder slopes and back slopes, make up about 45 percent of the mapping unit, and Embden soils, on foot slopes and toe slopes, make up about 35 percent.

Included with these soils in mapping are small areas of Esmond soils on summits and shoulder slopes, Egeland soils on back slopes, Emrick soils and Swenoda soils on foot slopes and toe slopes, Kratka, Tiffany, Tonka, and Wyard soils in swales and depressions that are identified on the soil map by a diamond symbol, and areas of Fram soils and Wyndmere soils around the edges of some of the depressions. Cobblestones, stones, and boulders are on the summits and shoulder slopes in many areas. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer. In some areas the soils have been reworked to some extent by soil blowing.

Surface runoff is very rapid, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas of this mapping unit are used for pasture, but a few areas are cultivated. The soils are better suited to grasses than to most other uses, but grain crops and legumes can be grown. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IVe–3M; Heimdal soil is in windbreak suitability group 3, Embden soil is in windbreak suitability group 5.

Heimdal-Embden fine sandy loams, 15 to 25 percent slopes (HrE).—Soils of this mapping unit are on sand-mantled glacial till. These soils have a profile similar to the one described as representative of their series, but the surface layer, and in some places the upper part of the subsoil, of the Heimdal soils is fine sandy loam, and the surface layer of the Embden soils is fine sandy loam. Heimdal soils, on the shoulder slopes and back slopes, make up about 50 percent of the mapping unit, and Embden soils, on foot slopes and toe slopes, make up about 30 percent.

Included with these soils in mapping are small areas of Esmond soils on summits and shoulder slopes. Egeland soils on back slopes, and Emrick soils and Swenoda soils on foot slopes and toe slopes. Also included are Kratka, Tiffany, Tonka, and Wyard soils in swales and depressions, which are identified on the soil map by a diamond symbol, and areas of Fram soils and Wyndmere soils around the edges of some of the drainageways. Cobblestones, stones, and boulders are on the summits and shoulder slopes in many areas. In some areas the soils have been reworked to some extent by soil blowing.

Surface runoff is very rapid, and water ponds in depressions. The hazard of soil blowing is very severe.

The soils of this mapping unit are used for pasture. They are better suited to grasses than to most other uses. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit VIe–3; Heimdal soil is in windbreak suitability group 8, Embden soil is in windbreak suitability group 5.

Heimdal-Emrick loams, 0 to 3 percent slopes (HsA).—Soils of this mapping unit are on glacial till plains. The Heimdal and Emrick soils have the profile described as representative of their series. Heimdal soils, in convex positions, make up about 50 percent of the mapping unit, and Emrick soils, in concave positions, make up about 30 percent.

Included with these soils in mapping are small areas of Tonka soils and Wyard soils in swales and depressions, which are identified on the soil map by a diamond symbol, and areas of Fram soils and Vallers soils around the edges of some of the depressions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Practically all areas of this mapping unit are cultivated. The soils are suited to grain crops, grasses, and legumes. Wetness in depressions and soil blowing are the main concerns of management. Capability unit IIe–5; Heimdal soil is in windbreak suitability group 3, Emrick soil is in windbreak suitability group 1.

Heimdal-Emrick loams, 3 to 6 percent slopes (HsB).—Soils of this mapping unit are on glacial till plains. Heimdal soils, on shoulder slopes and back slopes, make up about 45 percent of the mapping unit, and Emrick soils, on foot slopes and toe slopes, make up about 35 percent.

Included with these soils in mapping are Esmond soils on summits and shoulder slopes, Tonka soils and Wyard soils in swales and depressions that are identified on the soil map by a diamond symbol, and Fram soils and Vallers soils around the edges of some of the depressions. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is moderate.

Practically all areas of this mapping unit are cultivated. The soils are suited to grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIe–5; Heimdal soil is in windbreak suitability group 3, Emrick soil is in windbreak suitability group 1.

Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes (HtC).—Soils of this mapping unit are on glacial till plains. Heimdal soils on shoulder slopes and back slopes, make up about 50 percent of this mapping unit, Emrick soils, on foot slopes and toe slopes, make up about 25 percent, and Esmond soils, on summits and shoulder slopes, make up about 15 percent.

Included with these soils in mapping are small areas of Parnell, Tonka, and Wyard soils in depressions that are identified on the soil map by a diamond symbol. Also included are areas of Fram soils and Vallers soils around the edges of the depressions. Soils on summits and shoulder slopes in many cultivated areas have a lighter colored surface layer. Shallow gullies have formed in some drainageways.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this mapping unit are cultivated, but some are used for pasture and hay. The soils are suited to close-growing grain crops, grasses, and legumes. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIIe–5; Heimdal soil is in windbreak suitability group 3, Emrick soil is in windbreak suitability group 3, Esmond soil is in windbreak suitability group 8.

Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes (HtD).—Soils of this mapping unit are on glacial till plains. Heimdal soils, on shoulder slopes and back slopes, make up about 45 percent of the mapping unit, Emrick soils, on foot slopes and toe slopes, make up about 25 percent, and Esmond soils, on summits and shoulder slopes, make up about 20 percent.

Included with these soils in mapping are small areas of Parnell, Tonka, and Wyard soils in depressions that are identified on the soil map by a diamond symbol. Also included are areas of Fram soils and Vallers soils around the edges of the depressions. Cobblestones and stones are on the summits and shoulder slopes in some areas. Shallow gullies have formed in some drainageways. Soils on the summits and shoulder slopes in many cultivated areas have a lighter colored surface layer.

Surface runoff is very rapid, and water ponds in depressions. The hazard of soil blowing is moderate.

Some areas of this mapping unit are cultivated, but others are used for pasture. The soils are better suited to grasses than to most other uses, but close-growing grain crops and legumes can be grown if protective measures are used. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IVe–5; Heimdal soil is in windbreak suitability group 3, Emrick soil is in windbreak suitability group 3, Esmond soil is in windbreak suitability group 8.

Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes (HtE).—Soils of this mapping unit are on glacial till plains. Heimdal soils, on shoulder slopes and back slopes, make up about 40 percent of this mapping unit, Emrick soils, on foot slopes and toe slopes, make up about 25 percent, and Esmond soils, on summits and shoulder slopes, make up about 25 percent.

Included with these soils in mapping are small areas of Parnell, Tonka, and Wyard soils in depressions, which are identified on the soil map by a diamond symbol. Also included are Fram soils and Vallers soils around the edges of the depressions. Cobblestones and stones are on the summits and shoulder slopes in many areas. Shallow gullies have formed in some drainageways.

Surface runoff is very rapid, and water ponds in the depressions. The hazard of soil blowing is moderate.

Practically all areas of this mapping unit are in native pasture or are idle. The soils are better suited to grasses than to most other uses. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit VIe–5; Heimdal soil is in windbreak suitability group 8, Emrick soil is in windbreak suitability group 3, Esmond soil is in windbreak suitability group 8.

Kensal Series

The Kensal series consists of moderately deep, nearly level, moderately well drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured shaly glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray loam about 8 inches thick. The subsoil is about 16 inches thick. The upper 6 inches is dark grayish-brown, friable loam. The 4 inches below that is mottled, grayish-brown, friable loam. The lowermost 6 inches is mottled, grayish-brown, very friable heavy sandy loam. The substratum is light brownish gray; it is shaly loamy sand in the upper 6 inches and shaly sand and gravel in the lower 30 inches.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Kensal loam in a cultivated field, 280 feet west and 50 feet north of the southeast corner of sec. 28, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 8 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, medium, subangular blocky and granular structure; slightly hard, friable, slightly sticky and nonplastic; many roots; few pebbles 2 to 15 millimeters in size; neutral; abrupt, smooth boundary.

B21—8 to 14 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; hard, friable, slightly sticky and slightly plastic; common roots; thin patches of organic stains on vertical prism faces; few rounded pebbles 2 to 15 millimeters in size; neutral; clear, wavy boundary.

B22—14 to 18 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; moderate, medium and fine, prismatic structure parting to moderate, medium and fine, angular blocky; hard, friable, slightly sticky and slightly plastic; common roots; thin patches of very dark grayish-brown (2.5Y 3/2, moist) clay films on faces of prisms; common pebbles 2 to 10 millimeters in size; neutral; clear, wavy boundary.

B3—18 to 24 inches, grayish-brown (2.5Y 5/2) heavy sandy loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; light olive-gray and pale-olive (5Y 6/2 and 6/3) shale grains; very weak, coarse, prismatic structure parting to very weak, medium and fine, subangular blocky structure parting to single grained; slightly hard, very friable, slightly sticky and slightly plastic; few roots; common shale pebbles 2 to 25 millimeters in size; neutral; clear, wavy boundary.

IIC1—24 to 30 inches, light brownish-gray (2.5Y 6/2) shaly loamy sand, dark grayish brown (2.5Y 4/2) moist; single grained; loose, slightly sticky and nonplastic; few shale pebbles 2 to 10 millimeters in size; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC2—30 to 60 inches, light brownish-gray (2.5Y 6/2) shaly sand and gravel, dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

Depth to the sand and gravel ranges from 20 to 30 inches. The A horizon ranges from 5 to 12 inches in thickness. It is very dark gray or dark gray. The B horizon ranges from 5 to 16 inches in thickness. It is dark grayish brown or grayish brown. Mottles occur in the lower part of the B horizon and throughout the B horizon in some places. The B horizon has moderate or weak prismatic structure that parts to moderate or weak angular or subangular blocky structure. It has clay films on faces of prisms in many but not all places. The IIC horizons are typically stratified shaly sand and gravel, but they contain a layer of granitic sand and gravel in places. In most places lime coats the underside of pebbles in one or more of the IIC horizons, and in some places soft masses of lime have accumulated in the upper part of the IIC horizon.

Kensal soils are adjacent to Brantford, Tolna, and Vang soils in many places. They are not so well drained as Brantford soils and have mottling in the B horizon, which Brantford soils do not have. They are better drained than Tolna soils. They are not so well drained as Vang soils.

Kensal loam (Ke).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series. The content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Kensal soils that have a substratum containing less than 40 percent gravel by volume, areas of Brantford soils in positions similar to those of Kensal soils, and areas of Tolna soils in depressions, which are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–5; windbreak suitability group 1.

Kensal loam, sandy substratum (Kf).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Kensal soils that have a substratum containing more than 40 percent gravel by volume, areas of Brantford soils in positions similar to those of Kensal soils, and areas of Tolna soils in depressions, which are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is moderate.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–5; windbreak suitability group 1.

Kloten Series

The Kloten series consists of shallow, moderately steep to steep, well-drained soils that formed in medium-textured glacial till or glaciofluvial deposits overlying bedded shale. These soils are on slopes of the Sheyenne River Valley, in drainageways leading to the Sheyenne River, and on high terraces along the Sheyenne River.

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The top 10 inches of the substratum is gray, friable loam, and the lower 44 inches is gray bedded shale.

Permeability is moderate above the bedded shale and very slow in the shale. The available water capacity is very low. The organic-matter content is high, and fertility is low.

These soils are better suited to grasses than to most other uses.

Representative profile of Kloten loam, 9 to 30 percent slopes, in grass, 1,310 feet south and 1,300 feet east of the northwest corner of the SW¼ sec. 19, T. 149 N., R. 58 W., Nelson County:

A—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium and moderate, very fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; few small shale chips; neutral; clear, wavy boundary.

C1—6 to 16 inches, gray (5Y 5/1) loam, very dark gray (5Y 3/1) moist; weak, medium and moderate,

very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; few shale chips in upper part increasing to many in the lower part; neutral; clear, wavy boundary.

R—16 to 60 inches, gray (5Y 5/1) and dark-gray (5Y 4/1) bedded shale; strong-brown (7.5YR 5/6, dry) stains on plate surfaces; platy; hard; very few roots in cracks to a depth of 24 inches.

Depth to bedded shale ranges from 10 to 20 inches but typically is 10 to 14 inches. The A horizon ranges from 4 to 10 inches in thickness. It is very dark gray, dark gray, or gray. The C horizon occurs only in some profiles; it is light olive gray or gray and is as much as 14 inches thick. Pebbles and stones are common above the shale in some places.

Kloten soils have profile characteristics that are similar to those of Buse, Edgeley, and Sioux soils. They have a shale substratum, however, which Buse soils do not have, and they are not so deep to bedded shale as Edgeley soils. They lack a sand and gravel substratum, which is a characteristic of Sioux soils.

Kloten loam, 9 to 30 percent slopes (KoE).—This soil is on side slopes of the Sheyenne River Valley, on drainageways leading to the Sheyenne River, and on high terraces along the Sheyenne River. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Buse soils and Edgeley soils in positions similar to those of Kloten soils and small areas of soils that are less than 10 inches deep to bedded shale. Stones and boulders are common on the surface in some places. Some drainageways are gullied.

Surface runoff is very rapid. The hazard of soil blowing is moderate.

Most areas of this soil are used for pasture. The soil is better suited to grasses than to most other uses. Surface runoff, soil blowing, and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIes–5; windbreak suitability group 10.

Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes (KsE).—Soils of this mapping unit are on side slopes of the Sheyenne River Valley, on drainageways leading to the Sheyenne River, and on high terraces along the Sheyenne River. Sioux soils, on summits and shoulder slopes, make up about 25 percent of this mapping unit, Kloten soils, downslope from the Sioux soils on back slopes, make up about 40 percent, and Edgeley soils, on foot slopes and toe slopes, make up about 30 percent.

Included with these soils in mapping are small areas of Coe soils on summits and shoulder slopes and small areas of soils that are less than 10 inches deep to bedded shale. Springs and small wet areas occur in some places at the contact point between the glaciofluvial deposits and the bedded shale. Stones and boulders are common on the surface, and some drainageways are gullied.

Surface runoff is very rapid. The hazard of soil blowing is moderate.

Areas of this mapping unit are used for pasture. The soils are better suited to grasses than to most other uses. Surface runoff, soil blowing, and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIes–5; Kloten soil is in windbreak suitability group 10, Sioux soil is in windbreak suitability group 10, Edgeley soil is in windbreak suitability group 8.

Kratka Series

The Kratka series consists of deep, nearly level, poorly drained soils that formed in moderately coarse textured glaciofluvial and eolian deposits overlying glacial till. These soils are on broad flats and drainageways surrounded by sand-mantled glacial till.

In a representative profile the surface layer is very dark gray fine sandy loam about 13 inches thick. The subsoil is mottled, dark-gray, very friable loamy fine sand about 10 inches thick. The substratum is 37 inches thick. The upper 8 inches is mottled, gray loam. The next 6 inches is yellowish-brown coarse sand. The lower 15 inches is gray clay loam.

Permeability is rapid in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is moderate. The organic-matter content is moderate, and fertility is medium. The water table is within 5 feet of the surface most of the year; it is just below the surface in spring and early in summer. A perched water table forms above the glacial till substratum during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to grasses and, if drained, to grain crops and legumes.

Representative profile of Kratka fine sandy loam in a cultivated field, 1,040 feet south and 1,560 feet east of the northwest corner of sec. 31, T. 149 N., R. 66 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) moist; weak, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A1—7 to 13 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) moist; very weak, coarse, prismatic structure parting to weak, fine, granular; soft, very friable, slightly sticky and slightly plastic; many roots; slightly acid; clear, smooth boundary.

Bg—13 to 23 inches, dark-gray (10YR 4/1) loamy fine sand, very dark grayish brown (10YR 3/2) moist; common, medium, distinct, dark-brown (10YR 3/3, moist) and dark reddish-brown (5YR 3/3, moist) mottles; weak, coarse and medium, prismatic structure parting to weak, medium, subangular blocky; soft, very friable, slightly sticky and nonplastic; common roots; slightly acid; abrupt, smooth boundary.

IIC1g—23 to 31 inches, gray (10YR 5/1) loam, dark gray (10YR 4/1) moist; many, medium, prominent, dark-brown (10YR 3/3, moist) and dark-brown (10YR 3/3, moist) mottles; massive; slightly hard, friable, sticky and plastic; few roots; common pebbles as large as 15 millimeters; slightly acid; abrupt, wavy boundary.

IIIC2g—31 to 37 inches, yellowish-brown (10YR 5/4) coarse sand, dark brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; common pebbles as large as 30 millimeters; slightly acid; gradual, wavy boundary.

IIIC3g—37 to 45 inches, pale-brown (10YR 6/3) coarse sand, dark yellowish brown (10YR 4/4) moist; single grained; loose, nonsticky and nonplastic; common pebbles as large as 30 millimeters; neutral; abrupt, wavy boundary.

IVC4g—45 to 60 inches, gray (N 5/0) clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, very sticky and very plastic; slightly effervescent; neutral.

Depth to the glacial till ranges from 20 to 40 inches but typically is 24 to 36 inches. Depth to mottling ranges from 5 to 15 inches but typically is about 10 inches. The

A horizon ranges from 8 to 18 inches in thickness. It is very dark gray or dark-gray fine sandy loam, sandy loam, or loamy sand. The lower part of the A horizon is mottled in many places. The B horizon ranges from 6 to 12 inches in thickness. It is motted, dark grayish-brown or dark-gray loamy fine sandy or loamy sand. The IIC horizon is gray, yellowish brown, or pale brown. Typically, it is glacial till of loam or clay loam texture, but strata of sand are in the glacial till in most places.

Kratka soils are adjacent to Dickey, Towner, Hamar, and Wyndmere soils in many places. They are more poorly drained than Dickey soils and Towner soils. Unlike Hamar soils and Wyndmere soils, they have glacial till within 40 inches of the surface.

Kratka fine sandy loam (Kf).—This soil is nearly level and is on broad flats and in concave drainageways that are surrounded by sand-mantled glacial till.

Included with this soil in mapping are small areas of Kratka soils that have a surface layer of loamy fine sand. Also included are areas of Hecla, Embden, and Swenoda soils in slightly higher positions, areas of Tiffany soils and Ulen soils in positions similar to those of Kratka soils, and areas of Venlo soils in lower and more poorly drained positions.

Surface runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; those that are adjacent to more poorly drained soils are used for pasture and hay. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

LaDelle Series

The LaDelle series consists of deep, nearly level, moderately well drained soils that formed in moderately fine textured alluvial sediments. These soils are on flood plains and levees of the Sheyenne and James Rivers.

In a representative profile the surface layer is dark-gray silty clay loam about 21 inches thick. The substratum is 39 inches thick. The upper 9 inches is gray, friable silty clay loam. The 5 inches below that is dark-gray silty clay loam. The lowermost 25 inches is grayish-brown silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Some flooding occurs in spring and during periods of heavy rainfall in summer.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of LaDelle silty clay loam in a cultivated field, 1,480 feet west and 500 feet north of the southeast corner of sec. 2, T. 150 N., R. 65 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak, fine, crumb structure; slightly hard, friable, sticky and plastic; many roots; common earthworm casts; neutral; abrupt smooth boundary.

A1—7 to 21 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak, medium, prismatic structure parting to moderate, medium, crumb; slightly hard, friable, sticky and plastic; many roots; neutral; gradual, wavy boundary.

C1—21 to 30 inches, gray (10YR 5/1) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; few roots; few, fine, white (2.5Y 8/2, moist) mases of lime; neutral; abrupt, smooth boundary.

A1b—30 to 35 inches, dark-gray (10YR 4/1) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; weak, medium, prismatic structure parting to weak, medium and fine, subangular blocky; slightly hard, friable, sticky and plastic; few, fine, white (2.5Y 8/2, moist) masses of lime; few roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

C2—35 to 60 inches, grayish-brown (2.5Y 5/2) sity clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, sticky and plastic; many, coarse, white (2.5Y 8/2, moist) masses of lime; strongly effervescent; mildly alkaline.

The A horizon ranges from 12 to 22 inches in thickness. It is dark-gray or very dark gray silty clay loam or silt loam. A weakly developed B horizon occurs in some profiles. The C horizon is gray, grayish brown, or light brownish gray. A dark-gray or very dark gray buried A horizon is common below a depth of about 20 inches.

LaDelle, Lamoure, and La Prairie soils formed in similar alluvial sediments and are in similar positions on the landscape. LaDelle soils are better drained than Lamoure soils. They contain less fine and coarse sand in the upper 40 inches than La Prairie soils.

LaDelle silty clay loam (La).—This soil is nearly level and is on flood plains and levees that are dissected in many places by old stream channels.

Included with this soil in mapping are small areas of Lamoure soils in old stream channels and areas of La Prairie soils in positions similar to those of LaDelle soils.

Surface runoff is slow, and water ponds in old stream channels. This soil is subject to flooding in spring and during periods of heavy rainfall in summer.

Some areas of this soil are cultivated, if they are large enough for cultivation to be economically feasible. Many areas are dissected by channels, are covered with trees and shrubs, are used for pasture, or are left idle. This soil is suited to grain crops, grasses, and legumes. Wetness because of flooding is the main concern of management. Capability unit IIc–6; windbreak suitability group 1.

Lallie Series

The Lallie series consists of deep, nearly level, poorly drained and very poorly drained soils that formed in fine textured and moderately fine textured glaciofluvial deposits. These soils are in dry lake basins.

In a representative profile the surface layer is dark-gray silty clay loam about 2 inches thick. The substratum is 58 inches thick. The upper 22 inches is mottled, light-gray and gray, friable silty clay loam. The 8 inches below that is very dark gray silty clay that contains segregations of salt and snail shells. The lowermost 28 inches is mottled, light-gray and gray silty clay. Salt crystals are common throughout the profile.

Permeability is slow, and the available water capacity is moderate. The organic-matter content is moderate, and fertility is low. The water table is within 5 feet of the surface most of the year. Water ponds on the surface in spring and during periods of heavy rainfall.

These soils are suited to salt-tolerant grain crops and grasses.

Representative profile of Lallie silty clay loam, in native vegetation, 1,300 feet south and 10 feet west of the northeast corner of the NW¼ sec. 21, T. 151 N., R. 61 W., Nelson County:

A—0 to 2 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; moderate, medium and fine, granular structure; slightly hard, friable, sticky and plastic; many roots; common fine white (2.5Y 8/2, moist) salt crystals; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1g—2 to 24 inches, light-gray (5Y 7/1) and gray (5Y 6/1) silty clay loam, dark gray (5Y 4/1) moist; common, medium, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, friable, sticky and plastic; common roots; few fine white (2.5Y 8/2, moist) salt crystals; violently effervescent; mildly alkaline; abrupt, wavy boundary.

IIA1bg—24 to 32 inches, very dark gray (5Y 3/1) silty clay, black (N 2/0) moist; weak, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; hard, firm, very sticky and very plastic; few roots; common fine white (2.5Y 8/2, moist) salt crystals; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIC2g—32 to 60 inches, light-gray (5Y 7/1) and gray (5Y 6/1) silty clay, olive gray (5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; massive; very hard, very firm, very sticky and very plastic; few, medium and (5Y 6/1) silty clay, olive gray (5Y 4/2) moist; fine, white (2.5Y 8/2, moist) salt crystals; strongly effervescent; mildly alkaline.

The A horizon ranges from 1 to 3 inches in thickness. It is dark-gray or very dark gray silty clay loam, silt loam, or silty clay. The Cg horizon is gray or light-gray silty clay or silty clay loam. A buried A horizon of very dark gray or dark-gray silty clay occurs in most places. Salts are within 12 inches of the surface in most places.

Lallie soils have profile characteristics similar to those of Bearden and Colvin soils, but they have a thinner A horizon and contain less lime in the A horizon and C horizon than Bearden and Colvin soils.

Lallie silty clay loam (Lb).—This soil is nearly level and is in dry lake basins.

Included with this soil in mapping are small areas of dispersed and saline soils in positions similar to those of Lallie soils. Also included are small areas of Bearden soils and Colvin soils in slightly higher positions.

Surface runoff is very slow, and water ponds in spring and during periods of heavy rainfall. The hazard of soil blowing is severe.

Some areas of this soil are used for pasture and hay; others are idle. The higher areas are cultivated. This soil is better suited to salt-tolerant grasses and grain crops than to most other uses. Wetness and soil blowing are the main concerns of management. Capability unit IVs–4L; windbreak suitability group 10.

Lamoure Series

The Lamoure series consists of deep, nearly level, poorly drained, calcareous soils that formed in moderately fine textured or fine textured alluvial sediments. These soils are on flood plains of the Sheyenne and James Rivers and their tributaries.

In a representative profile the surface layer is about 19 inches thick. It is very dark gray silty clay loam in the upper 7 inches and dark gray silty clay loam in the lower 12 inches. The subsoil is gray, firm silty clay loam about 27 inches thick. The substratum is dark-gray silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year. Flooding occurs in places in spring and during periods of heavy rainfall in summer.

These soils are better suited to grasses than to most other uses, but where drained they are suited to grain crops and legumes. Salinity reduces crop yields in some areas.

Representative profile of Lamoure silty clay loam in a cultivated field, 800 feet east and 600 feet north of the southwest corner of the NE¼ sec. 3, T. 149 N., R. 64 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate, fine, crumb structure; slightly hard, firm, sticky and plastic; many roots; slightly effervescent; neutral; abrupt, smooth boundary.

A1—7 to 19 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, firm, sticky and plastic; common roots; few gypsum crystals; common, fine, distinct, white (2.5Y 8/2, moist) lime segregations; strongly effervescent; moderately alkaline; gradual, wavy boundary.

B2g—19 to 46 inches, gray (5Y 5/1) silty clay loam, very dark gray (5Y 3/1) moist; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; slightly hard, firm, sticky and plastic; few roots; few gypsum crystals; common, fine, distinct, white (2.5Y 8/2, moist) lime segregations; violently effervescent; mildly alkaline; clear, wavy boundary.

A1b—46 to 60 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; massive; hard, firm, sticky and plastic; few, fine, distinct, white (2.5Y 8/2, moist) lime segregations; strongly effervescent; mildly alkaline.

The A horizon ranges from 12 to 20 inches in thickness. It is dark-gray or very dark gray silty clay loam or silt loam. In some places the A horizon is moderately saline and contains common to many segregations of salt and gypsum crystals. The B horizon is gray or dark-gray silty clay or silty clay loam. A buried A horizon of dark gray or very dark gray is common below a depth of about 36 inches. Strata of sand or gravel occur in some profiles below a depth of 40 inches. The C horizon, where it occurs, contains few to many segregations of salt and gypsum crystals.

Lamoure soils are adjacent to LaDelle and La Prairie soils in many places. They contain more lime and are more poorly drained than LaDelle soils and La Prairie soils.

Lamoure silty clay loam (Le).—This soil is nearly level and is on flood plains and in shallow channels and oxbows. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately saline Lamoure soils, Ludden soils in swales, and LaDelle soils in slightly higher positions.

Surface runoff is very slow, and water ponds in the swales. This soil is subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is severe.

Some areas of this soil are cultivated, if they are large enough for cultivation to be economically feasible.

Other areas are used for pasture and hay or, if they are covered by trees and shrubs, are used for pasture or are left idle. This soil is suited to grasses and, if drained, to small grains and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Lamoure silty clay loam, saline (Lm).—This soil is nearly level and is on flood plains of drainageways leading to the Sheyenne and James Rivers. It has a profile similar to the one described as representative of the series, but the surface layer contains soluble salts and gypsum that adversely affect plant growth.

Included with this soil in mapping are small areas of nonsaline Lamoure soils and Ryan soils, small areas of LaDelle soils in slightly higher positions, and strongly saline soils in a few areas that are nearly bare of vegetation.

Surface runoff is very slow, and water ponds in swales. This soil is subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is severe.

Some areas of this soil are cultivated, if they are large enough for cultivation to be economically feasible. Other areas are used for hay and pasture. This soil is suited to salt-tolerant grasses and, where drained, to salt-tolerant grain corps. Wetness and soil blowing are the main concerns of management. Capability unit IIIws–4L; windbreak suitability group 10.

La Prairie Series

The La Prairie series consists of deep, nearly level, moderately well drained soils that formed in medium-textured and moderately fine textured alluvial sediments. These soils are on flood plains, fans, and levees along the Sheyenne and James Rivers.

In a representative profile the surface layer is dark-gray silt loam about 21 inches thick. The subsoil is dark-gray, firm silty clay loam about 11 inches thick. The substratum is light brownish-gray silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. These soils are subject to flooding during periods of high runoff.

These soils are suited to grains, grasses, and legumes.

Representative profile of La Prairie silt loam, in a pasture, 2,350 feet north and 60 feet west of the southeast corner of the NE¼ sec. 23, T. 150 N., R. 63 W., Eddy County:

A11—0 to 10 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; moderate, fine, angular blocky structure; slightly hard; friable, slightly sticky and sightly plastic; many roots; neutral; clear, wavy boundary.

A12—10 to 21 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; weak, coarse, prismatic structure parting to moderate, fine, angular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; gradual, wavy boundary.

B2—21 to 32 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; weak, coarse, prismatic structure parting to moderate, medium and fine, angular blocky; slightly hard, firm, very sticky and very plastic; common roots; common, fine, white (2.5Y 8/2, moist) segregations of lime; strongly effervescent; mildly alkaline; clear, wavy boundary.

C—32 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; massive; slightly hard, firm, very sticky and very plastic; few roots; common, medium and fine, white (2.5Y 8/2, moist) segregations of lime; strongly effervescent; moderately alkaline.

The A horizon ranges from 15 to 35 inches in thickness. It is dark-gray or very dark gray silt loam or light silty clay loam. The B horizon is gray, dark-gray, very dark gray, or grayish-brown silty clay loam or silt loam. The C horizon is light brownish-gray or grayish-brown silty clay loam or silt loam. In some places stratified sand, silt, and clay are below a depth of about 40 inches. A buried A horizon of dark-gray or very dark gray silty clay loam or silt loam is below a depth of about 20 inches in some places.

La Prairie soils are adjacent to LaDelle and Lamoure soils in many areas. They formed in coarser textured sediment than LaDelle soils, and they are better drained, contain less lime, and are shallower to lime than Lamoure soils.

La Prairie silt loam (Ln).—This soil is nearly level and is on fans and levees. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Lamoure soils in old stream channels, areas of LaDelle soils in positions similar to those of La Prairie soils, and small areas of Walsh soils on valley side slopes.

Surface runoff is slow, and ponding occurs in stream channels. This soil is subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is slight.

Some areas of this soil are cultivated, if they are large enough for cultivation to be economically feasible. Many areas, however, are covered by trees and shrubs, are dissected by channels, or are not accessible and are used for pasture or are left idle. This soil is suited to grains, grasses, and legumes. Wetness is the main concern of management. Capability unit IIc–6; windbreak suitability group 1.

La Prairie-Lamoure complex (Lp).—This mapping unit consists of nearly level La Prairie soils on dissected flood plains and Lamoure soils in channels where the relief ranges from 3 to 6 feet. Each kind of soil makes up 20 to 70 percent of the acreage of this mapping unit.

Included with these soils in mapping are small areas of LaDelle soils in positions similar to those of La Prairie soils, small areas of Ludden soils and of moderately saline Lamoure soils in positions similar to those of nonsaline Lamoure soils, and small areas of Rauville soils, which are more poorly drained than La Prairie and Lamoure soils.

Surface runoff is slow on La Prairie soils, and ponding occurs on Lamoure soils. These soils are subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is only slight on La Prairie soils but is severe on Lamoure soils.

Most areas of these soils are either used for pasture or are left idle, although a few areas are used for hay. The soils are suited to grasses. Wetness and soil blowing, where the soils are cultivated, are the main concerns of management. Capability unit VIew–6; La Prairie soils are in windbreak suitability group 1, Lamoure soils are in windbreak suitability group 2.

Larson Series

This series consists of deep, nearly level and gently sloping, somewhat poorly drained and moderately well drained claypan soils that formed in medium textured or moderately fine textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is gray silt loam about 1 inch thick. The subsoil is dark-gray very firm clay loam about 9 inches thick. The substratum is clay loam that is 44 inches thick. The upper 6 inches is olive gray and contains gypsum crystals and segregations of salt. The 14 inches below that is light olive gray. The lowermost 24 inches is mottled, pale olive.

Pearmeability is slow, and the available water capacity is moderate. The organic-matter content is high, and the fertility is low. The dense subsoil and the salts in the lower part of the subsoil restrict root growth and water table forms above the dense subsoil during periods of the surface most of the year, and it is at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops and grasses, but they are poorly suited to legumes.

Representative profile of Larson loam, in a cultivated field, 500 feet north and 100 feet east of the southwest corner of the NW¼ sec. 1, T. 149 N., R. 64 W., Eddy County:

AP—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure and weak, fine, crumb; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A2—6 to 7 inches, gray (10YR 5/1) silt loam, black (10YR 2/1) moist; moderate, medium, subangular blocky structure parting to moderate, fine, platy; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, wavy boundary.

B21t—7 to 13 inches, dark-gray (5Y 4/1) clay loam, black (5Y 2/1) moist; strong, medium, columnar structure parting to moderate, medium and fine, angular blocky; hard, very firm, sticky and plastic; few roots; thin gray (5Y 5/1) coatings on top of columns; mildly alkaline; gradual, wavy boundary.

B22t—13 to 16 inches, dark-gray (5Y 4/1) clay loam, very dark gray (5Y 3/1) moist; strong, medium, prismatic structure parting to moderate, medium, angular blocky; hard, very firm, sticky and plastic; very slightly effervescent; mildly alkaline; gradual, wavy boundary.

C1cs—16 to 22 inches, olive-gray (5Y 5/2) clay loam, dark olive gray (5Y 3/2) moist; moderate, medium, prismatic structure parting to moderate, fine, angular blocky; slightly hard, firm, sticky and plastic; common gypsum crystals and common fine segregations of salt; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C2ca—22 to 36 inches, light olive-gray (5Y 6/2) clay loam, olive (5Y 4/3) moist; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; slightly hard, firm, sticky and plastic; violently effervescent; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; massive; hard, firm, sticky and plastic; strongly effervescent; moderately alkaline.

The A1 horizon ranges from 5 to 8 inches in thickness. It is very dark gray or dark-gray loam or silt loam. The A2 horizon ranges from 0 to 4 inches in thickness. It is gray or light gray. It appears as coatings on the top of the columnar B2 horizon in some places. The B horizon ranges from 8 to 18 inches in thickness. It is dark-gray or very dark gray clay loam or silty clay loam. It has strong or moderate columnar or prismatic structure that parts to strong or moderate angular blocky structure. Lime, gypsum, and other salts have accumulated in the lower part of the B horizon in many places. The C horizon is olive-gray, light olive-gray, or pale-olive clay loam or loam. Lime, gypsum, and other salts have accumulated in the upper part in most places.

Larson soils are adjacent to Cathay, Emrick, and Fram soils in many places; these soils formed in similar parent material. Larson soils have a thinner combined A1 and A2 horizon than Cathay soils. They have an A2 horizon and B2t horizon, which Emrick soils and Fram soils lack.

Larson loam (Lr).—This soil is nearly level and gently sloping and is on glacial till plains.

Included with this soil in mapping are small areas of Heimdal soils and Emrick soils in slightly higher positions, Cathay soils in positions similar to those of Larson soils, Miranda soils in slightly lower positions, and Fram soils and Vallers soils around the edges of some depressions, which are identified on the soil map by a diamond symbol. Tonka soils are in the depressions. Stones are common on the surface in some areas. In some cultivated areas the surface layer is clay loam or silty clay loam that is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface and subsurface layers.

Runoff is slow on the nearly level areas and medium on the gently sloping areas. Water ponds in the depressions. Seepage areas occur in some gently sloping areas. The hazard of soil blowing is slight.

Most areas of this soil are cultivated, but some are used for pasture and hay. This soil is suited to grain crops and grasses; it is poorly suited to legumes. Growth of most crops is reduced because of the dense subsoil and slow permeability. Correcting wetness and maintaining good tilth in cultivated areas are the main concerns of management. Capability unit IVs–6P; windbreak suitability group 9.

Lemert Series

This series consists of deep, nearly level, somewhat poorly drained and poorly drained soils that formed in moderately coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray sandy loam about 3 inches thick. The subsoil is dark-gray, firm sandy loam about 9 inches thick. The substratum is 48 inches thick. The upper 5 inches is mottled, white loam that has an accumulation of lime. The 5 inches below that is light-gray loam that also has an accumulation of lime. The next 27 inches is light olive-brown medium and coarse sand. The lowermost 11 inches is light brownish-gray clay loam.

Permeability is slow in the subsoil and rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is low. The dense subsoil and salt in the lower part of the subsoil restrict root growth and water penetration.

The water table is within 4 feet of the surface most of the year. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to salt-tolerant grasses.

Representative profile of Lemert sandy loam in a hay meadow, 100 feet south and 900 feet west of the northeast corner of the SE¼ sec. 36, T. 149 N., R. 65 W., Eddy County:

A1—0 to 3 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; weak, medium, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B21t—3 to 7 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; strong, medium, columnar structure parting to strong, medium, subangular blocky; extremely hard, firm, sticky and plastic; common roots; thick continuous clay films on faces of peds; few pebbles as large as 5 millimeters; strongly effervescent; strongly alkaline; gradual, wavy boundary.

B22t—7 to 12 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; strong, medium, prismatic structure parting to strong, medium, subangular blocky; extremely hard, firm, sticky and plastic; few roots; thick continuous clay films on faces of peds; few pebbles as large as 5 millimeters; white (10YR 8/1) segregations of lime in ped interiors; violently effervescent in ped interiors; very strongly alkaline; gradual, wavy boundary.

C1ca—12 to 17 inches, white (2.5Y 8/1) loam, light gray (2.5Y 7/1) moist; few, fine, distinct, light olive-brown (2.5Y 5/6 moist) mottles; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; thin clay (2.5Y 5/1) coatings on faces of prisms; violently effervescent; very strongly alkaline; gradual, wavy boundary.

C2ca—17 to 22 inches, light-gray (2.5Y 7/2) loam, light brownish gray (2.5Y 6/2) moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, sticky and plastic; few pebbles as large as 5 millimeters; violently effervescent; very strongly alkaline; clear, wavy boundary.

IIC3—22 to 49 inches, light olive-brown (2.5Y 5/4) medium and coarse sand, olive brown (2.5Y 4/4) moist; single grained; loose, nonsticky and nonplastic; common pebbles as large as 10 millimeters; slightly effervescent; strongly alkaline, clear, wavy boundary.

IIIC4—49 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, sticky and plastic; slightly effervescent; moderately alkaline.

The A1 horizon ranges from 1 to 5 inches in thickness. It is very dark gray or dark-gray sandy loam or loam. The A2 horizon is absent in most places, but it appears as a thin gray coating on top of the B2t horizon in some places, and in other places it is gray platy sandy loam and as thick as 2 inches. The B2 horizon ranges from 6 to 14 inches in thickness. It is dark gray or gray. It has strong or moderate prismatic or columnar structure that parts to strong or moderate subangular blocky structure. The C horizon is light-gray or white sandy loam or loam. The IIC horizon is light olive-brown or olive-brown medium and coarse sand. Glacial till of clay loam texture is below a depth of 40 inches in most places.

Lemert soils are adjacent to Letcher, Lohnes, Osakis, and Totten soils in many places. They have an alkaline B2t horizon, which Lohnes soils and Osakis soils do not have. They have a thinner A horizon than Letcher soils. They formed in glaciofluvial deposits that contain less clay than Totten soils.

Lemert sandy loam (Ls).—This soil is nearly level and is in slight depressions on outwash plains.

Included with this soil in mapping are areas of Letcher soils and Totten soils in slightly higher positions and areas of Arveson soils and Borup soils in lower positions. In some cultivated areas the soils have a surface layer that is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface layer.

Surface runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are used for hay and pasture, but some areas are cultivated. This soil is suited to salt-tolerant grasses. Growth of most crops is reduced because of the dense subsoil and slow permeability of the soil. Wetness, soil blowing, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit VIw–4; windbreak suitability group 9.

Letcher Series

The Letcher series consists of deep, nearly level, somewhat poorly drained, claypan soils that formed in moderately coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray sandy loam about 7 inches thick. The subsurface layer is dark-gray sandy loam about 2 inches thick. The subsoil is very firm sandy loam that is dark grayish brown in the upper 3 inches and very dark grayish brown in the lower 6 inches. The substratum is 42 inches thick. The upper 6 inches is variegated light olive-gray and light-gray sandy loam that has an accumulation of lime. The 4 inches below that is variegated olive-gray and light-gray sandy loam that also has an accumulation of lime. The next 7 inches is mottled, grayish-brown coarse sand, and the 9 inches below that is mottled, light brownish-gray medium sand. The lowermost 16 inches is mottled, light-gray coarse and very coarse sand (fig. 12).

Permeability is slow in the subsoil and rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is low. The dense subsoil and the salts in the lower part of the subsoil limit root and water penetration. The water table is within 5 feet of the surface most of the year; it is at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to grain crops and grasses; they are poorly suited to legumes.

Representative profile of Letcher sandy loam, in a cultivated field, 165 feet north and 150 feet east of the southwest corner of the SE¼ sec. 27, T. 149 N., R. 65 W., Eddy County:

A1p—0 to 7 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; weak, fine, crumb structure; soft, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A2—7 to 9 inches, dark-gray (10YR 4/1) sandy loam, black (19YR 2/1) moist; moderate, medium, prismatic structure parting to weak, fine, platy and

Figure 12.—**Profile of Letcher sandy loam. The growth of roots and the downward movement of water are restricted because the subsoil is very firm and the soil contains salts.**

crumb; slightly hard, very friable, slightly sticky and slightly plastic; many roots; few tongues of A1 horizon; neutral; abrupt, irregular boundary.

B21t—9 to 12 inches, dark grayish-brown (2.5Y 4/2) sand loam, very dark grayish brown (2.5Y 3/2) moist; strong, coarse, columnar structure parting to strong, medium, angular blocky; very hard, very firm, sticky and plastic; few roots; black organic stains, clay films, and clear sand grains on faces of columns; neutral; gradual, wavy boundary.

B22t—12 to 18 inches, very dark grayish-brown (2.5Y 3/2) broken sandy loam, black (10YR 2/1) moist; strong, coarse, columnar structure parting to strong, medium, angular blocky; very hard, very firm, sticky and plastic; gray and light-gray (5Y 6/1 and 7/1) streaks of lime and gypsum inside columns and black and very dark gray (10YR 2/1 and 3/1) organic stains and clay films on faces of columns; strongly effervescent lime streaks inside columns, but the main body of the column is noneffervescent; mildly alkaline; abrupt, irregular boundary.

C1ca—18 to 24 inches, variegated light olive-gray and light-gray (5Y 6/2 and 7/1) sandy loam, olive gray (5Y 5/2) moist; weak, medium, subangular blocky structure and weak, fine, granular; hard, friable, slightly sticky and plastic; violently effervescent; moderately alkaline; clear, wavy boundary.

C2ca—24 to 28 inches, variegated olive-gray and light-gray (5Y 5/2 and 7/2) sandy loam, olive gray and light olive gray (5Y 4/2 and 6/2) and strong brown (7.5YR 5/6) moist; weak, medium, subangular blocky structure and weak, fine, granular; hard, friable, slightly sticky and plastic; very dark grayish-brown (2.5Y 3/2) coatings as much as ¼ inch thick on faces of peds; violently effervescent; moderately alkaline; abrupt, wavy boundary.

IIC1—28 to 35 inches, grayish-brown (2.5Y 5/2) coarse sand, very dark grayish brown (2.5Y 3/2) moist; common, medium, faint, light olive-brown (2.5Y 5/4, moist) mottles; single grained; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline; clear, wavy boundary.

IIC2—35 to 44 inches, light brownish-gray (2.5Y 6/2) medium sand, olive brown (2.5Y 4/4) moist; common, coarse, prominent, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; strongly effervescent; moderately alkaline; clear, wavy boundary.

IIC3—44 to 60 inches, light-gray (2.5Y 7/2) coarse and very coarse sand, light olive brown (2.5Y 5/4) moist; many, coarse, distinct, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; few pebbles as large as 5 millimeters; strongly effervescent; moderately alkaline; few pockets of lime.

The A1 horizon ranges from 5 to 10 inches in thickness. It is very dark gray or dark-gray sandy loam or loam. The A2 horizon is a thin gray or dark-gray coating on top of the B2 horizon in some places, but in most places it is gray or dark-gray platy sandy loam that is as thick as 5 inches. Some profiles do not have an A2 horizon. The B2 horizon is dark grayish-brown, very dark grayish-brown, or dark-gray sandy loam or sandy clay loam. Most B2 horizons have an accumulation of lime and soluble salts in the lower part. Clay films, organic stains, and clear sand grains are common on the column faces of the B2 horizon in most places. The C horizon is light olive-gray, olive-gray, or light-gray sandy loam or loam. The IIC horizon is mottled, grayish-brown, light grayish-brown, light brownish-gray, or light-gray stratified medium coarse and very coarse sand. Loam or clay loam glacial till is at a depth below 40 inches in some places.

Letcher soils are adjacent to Arveson, Lemert, Totten, and Wyndmere soils in many places. They have an alkaline B2 horizon, which Arveson soils and Wyndmere soils lack. They have a thicker combined A1 and A2 horizon than Lemert soils, and they are not so poorly drained as Totten soils.

Letcher sandy loam (Lt).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Totten soils and Letcher, till substratum, soils. Also included are small areas of Lemert soils and Borup soils in lower positions and areas of Walum soils and Kensal soils in slightly higher positions. In some cultivated areas the soils have a surface layer that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers.

Runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe.

Some areas of this soil are cultivated; others are in hay and pasture. This soil is better suited to salt-tolerant grain crops and grasses than to most other uses; it is poorly suited to legumes. Growth of most crops is reduced because of the dense subsoil and slow permeability of the soil. Wetness, soil blowing, droughtiness caused by the low available water capacity, and maintaining good tilth are the main concerns of management. Capability unit IIIe–3P; windbreak suitability group 9.

Letcher sandy loam, till substratum (Lu).—This soil is nearly level and is on glacial plains and sand-mantled

glacial till. It has a profile similar to the one described as representative of the series, but the glacial till is at a depth between 40 to 60 inches.

Included with this soil in mapping are small areas of Totten soils and Fram soils in positions similar to those of Letcher soils, small areas of Lemert, Borup, and Vallers soils in lower positions, and areas of Embden soils and Walum soils in slightly higher positions. In some cultivated areas the soils have a surface layer that is hard and cloddy when dry and sticky when wet because some of the dense subsoil has been mixed with the surface and subsurface layers. In a few areas the depth to glacial till is more than 60 inches.

Runoff is slow, and water ponds in low places. The hazard of soil blowing is very severe.

Some areas of this soil are cultivated; others are in hay and pasture. This soil is better suited to salt-tolerant grain crops and grasses than to most other uses; it is poorly suited to legumes. Growth of most crops is reduced because of the dense subsoil and slow permeability of the soil. Wetness, soil blowing, droughtiness caused by the low available water capacity, and maintaining good tilth are the main concerns of management. Capability unit IIIe–3P; windbreak suitability group 9.

Lohnes Series

The Lohnes series consists of deep, nearly level, moderately well drained soils that formed in coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray loamy coarse sand about 16 inches thick. The next layer is dark grayish-brown, very friable loamy coarse sand about 14 inches thick. The substratum is mottled, brown coarse sand in the upper 17 inches and mottled, grayish-brown coarse sand in the lower 13 inches.

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

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Lohnes loamy coarse sand, in a hay meadow, 300 feet south and 75 feet west of the southeast corner of the NE¼ sec. 22, T. 150 N., R. 62 W., Eddy County:

A1—0 to 16 inches, very dark gray (10YR 3/1) loamy coarse sand, black (10YR 2/1) moist; weak, fine, subangular blocky structure and single grained; soft, very friable, slightly sticky and nonplastic; many roots; neutral; gradual, wavy boundary.

AC—16 to 30 inches, dark grayish-brown (10YR 4/2) loamy coarse sand, very dark brown (10YR 2/2) moist; very weak, medium and fine, subangular blocky structure parting to single grained; loose, very friable, slightly sticky and nonplastic; common roots; neutral; gradual, wavy boundary.

C1—30 to 47 inches, brown (10YR 5/3) coarse sand, dark brown (10YR 4/3) moist; few, fine, faint, dark yellowish-brown (10YR 4/4, moist) mottles; single grained; loose, nonsticky and nonplastic; few roots; mildly alkaline; gradual, wavy boundary.

C2—47 to 60 inches, grayish-brown (2.5Y 5/2) coarse sand, dark grayish brown (2.5Y 4/2) moist; common, fine, faint, brownish-yellow (10YR 6/6, moist) mottles in the upper part and common, fine, distinct, brownish-yellow (10YR 6/6, moist) mottles in the lower part; single grained; loose, nonsticky and nonplastic; moderately alkaline.

The A horizon ranges from 10 to 30 inches in thickness. It is very dark gray or dark-gray loamy coarse sand, loamy sand, coarse sandy loam, or sandy loam. The AC horizon ranges from 5 to 16 inches in thickness. It is dark grayish-brown, very dark grayish-brown, or dark-gray loamy coarse sand, loamy sand, or coarse sand. The C horizon is brown, grayish-brown, light brownish-gray, or dark grayish-brown stratified coarse, medium, and fine sand that has some strata of gravel, but it is typically coarse sand. Faint mottles are in the lower part of the AC horizon in many places, and they become more distinct and numerous with increasing depth. Most profiles are noncalcareous above a depth of 3 feet, and they are slightly calcareous below that depth.

Lohnes, Claire, Hamar, and Hecla soils formed in similar parent material. Lohnes soils are not so well drained as Claire soils. They are better drained than Hamar soils. They contain more coarse sand throughout the profile than Hecla soils.

Lohnes loamy coarse sand (Lv).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Claire, Hecla, and Osakis soils in positions similar to those of Lohnes soils, small areas of Hamar soils and Wyrene soils in shallow swales, and small areas of soils that have been reworked to some extent by soil blowing.

Surface runoff is slow, and water ponds in the swales. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; windbreak suitability group 7.

Lohnes coarse sandy loam (Lw).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is coarse sandy loam.

Included with this soil in mapping are small areas of Claire, Hecla, and Osakis soils in positions similar to those of Lohnes soils, small areas of Hamar soils and Wyrene soils in shallow swales, and small areas of soils that have been reworked to some extent by soil blowing. This mapping unit includes small areas of soils that have a slightly higher percentage of silt and clay in the surface layer than is in the range defined for the Lohnes series.

Surface runoff is slow, and water ponds in the swales. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 7.

Ludden Series

The Ludden series consists of deep, nearly level, poorly drained soils that formed in fine-textured alluvial sediment. These soils are on flood plains and in shallow channels and oxbows along the Sheyenne and James Rivers.

In a representative profile the surface layer is about 30 inches thick. The upper 7 inches is dark-gray silty clay. The 9 inches below that is very dark gray clay. The lowermost 14 inches is dark-gray clay that contains an accumulation of lime. The substratum in the upper 11 inches is light olive-gray, firm clay that contains an accumulation of lime; it is gray clay in the lower 19 inches.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year. Some flooding occurs in spring and during periods of heavy rainfall in summer.

These soils are better suited to grasses than to most other uses. If drained, they are suited to grain crops and legumes.

Representative profile of Ludden silty clay in a cultivated field, 160 feet north and 1,000 feet east of the southwest corner of sec. 32, T. 149 N., R. 58 W., Nelson County:

A11p—0 to 7 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/1) moist; moderate, medium, angular blocky structure parting to moderate, medium, granular; very hard, firm, sticky and very plastic; many roots; few segregations of lime and salt; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

A12—7 to 16 inches, very dark gray (5Y 3/1) clay, black (N 1/0) moist; weak, coarse and medium, prismatic structure parting to moderate, fine and very fine, angular blocky; hard, firm, very sticky and very plastic; common roots; few segregations of lime and salt; strongly effervescent; mildly alkaline; clear, irregular boundary.

A13ca—16 to 30 inches, dark-gray (N 4/0) clay, black (5Y 2/1) moist; weak, coarse, prismatic structure parting to moderate, fine and very fine, subangular blocky; hard, firm, very sticky and very plastic; few roots; common segregations of lime; violently effervescent; mildly alkaline; clear, smooth boundary.

C1cag—30 to 41 inches, light olive-gray (5Y 6/2) clay, dark olive gray (5Y 3/2) moist; weak, coarse, prismatic structure parting to moderate, fine and very fine, subangular blocky; hard, firm, very sticky and very plastic; black organic stains on faces of prisms; common segregations of lime; violently effervescent; mildly alkaline; clear, smooth boundary.

C2g—41 to 60 inches, gray (5Y 5/1) clay, very dark gray (5Y 3/1) moist; massive; hard, firm, very sticky and very plastic; common segregations of lime; violently effervescent; mildly alkaline.

The A horizon ranges from 20 to 40 inches in thickness. It is dark-gray or very dark gray silty clay, silty clay loam, or clay. In some areas the upper part of the A horizon is silty clay loam. In most places the A horizon has an accumulation of lime in the lower part. Segregations of salt are in or just below the A horizon in some places. The C horizon is dark-gray, gray, or light olive-gray silty clay or clay that has an accumulation of lime in the upper part in most places. A buried A horizon is in the lower part of some profiles.

Ludden soils are adjacent to Lamoure, Ryan, and Wahpeton soils in many places. They formed in finer textured alluvium than Lamoure soils. They lack the alkaline B2t horizon that is a characteristic of Ryan soils. They are more poorly drained and have lime closer to the surface than Wahpeton soils.

Ludden silty clay (Lx).—This soil is nearly level and is on flood plains and in shallow channels and oxbows. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately saline Ludden soils, Ryan soils, and Lamoure soils in positions similar to those of Ludden soils. Also included are areas of Wahpeton soils in slightly higher positions.

Runoff is slow, and water ponds in low places. This soil is subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is severe.

Some areas of this soil are cultivated if they are large enough for cultivation to be economically feasible. Other areas are used for pasture and hay, and some are left idle. This soil is better suited to grasses than to most other uses. If drained, it is suited to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIw–4; windbreak suitability group 1.

Ludden-Lamoure complex (Lz).—Soils of this nearly level mapping unit are in shallow channels and oxbows. The Ludden soil has a profile similar to the one described as representative of the series, but it has a surface layer of silty clay loam. The Ludden soils are in deeper, more poorly drained positions, and the Lamoure soils are in slightly higher positions. Composition of this mapping unit is variable from area to area; each soil makes up 20 to 70 percent of the acreage.

Included with these soils in mapping are small areas of Ryan soils and saline Ludden soils in positions similar to those of nonsaline Ludden soils. Also included are areas of saline Lamoure soils in positions similar to those of nonsaline Lamoure soils and areas of Rauville soils in lower, more poorly drained areas.

Runoff is slow, and water ponds on the Ludden soils. The soils of this mapping unit are subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is severe in drained and cultivated areas.

Most areas of this mapping unit are left idle; a few areas are used for pasture. The soils are better suited to grasses than to most other uses. Wetness and soil blowing are the main concerns of management. Capability unit Vw–8; Ludden soil is in windbreak suitability group 1, Lamoure soil is in windbreak suitability group 2.

Maddock Series

The Maddock series consists of deep, nearly level to very steep, well-drained soils that formed in coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and sand-mantled glacial till plains.

In a representative profile the surface layer is dark-gray sandy loam about 7 inches thick. The subsoil is dark grayish-brown, very friable loamy sand about 13 inches thick. The substratum is 40 inches thick. The upper 15 inches is brown loamy sand. The 5 inches below that is pale-brown loamy sand. The next 8 inches is pale-brown sand. The lowermost 12 inches is grayish-brown sand.

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

Where slopes are 9 percent or less and where these

soils have a moderately coarse textured surface layer the soils are suited to grain crops, grasses, and legumes. Where slopes are 6 percent or less and where the surface layer is coarse textured these soils are suited to grain crops, grasses, and legumes.

Representative profile of Maddock sandy loam, 0 to 3 percent slopes, in a cultivated field, 1,200 feet south and 160 feet west of the northeast corner of sec. 8, T. 150 N., R. 63 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, medium and fine, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

B2—7 to 20 inches; dark grayish-brown (10YR 4/2) loamy sand, very dark grayish brown (10YR 3/2) moist; weak, coarse, angular blocky structure parting to weak, medium and fine, subangular bocky; soft, very friable; slightly sticky and nonplastic; common roots; neutral; clear, smooth boundary.

C1—20 to 35 inches, brown (10YR 5/3) loamy sand, dark grayish brown (10YR 4/2) moist; weak, medium and fine, subangular blocky structure parting to single grained; soft, very friable, very slightly sticky and nonplastic; few roots; few pebbles as large as 5 millimeters; neutral; clear, smooth boundary.

C2—35 to 40 inches, pale-brown (10YR 6/3) loamy sand, grayish brown (10YR 5/2) moist; single grained; loose, very slightly sticky and nonplastic; few roots; few pebbles as large as 5 millimeters; slightly effervescent; mildly alkaline; gradual, smooth boundary.

C3—40 to 48 inches, pale-brown (10YR 6/3) sand, dark brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; few pebbles as large as 10 millimeters; slightly effervescent; mildly alkaline; clear, smooth boundary.

C4—48 to 60 inches, grayish-brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) moist; single grained; loose, nonsticky and nonplastic; few pebbles as large as 5 millimeters; slightly effervescent; mildly alkaline.

The A horizon ranges from 7 to 15 inches in thickness. It is dark-gray or very dark gray loamy sand, loamy fine sand, sandy loam, or fine sandy loam. The B horizon ranges from 6 to 16 inches in thickness. It is dark grayish-brown or grayish-brown loamy sand or loamy fine sand. The C horizon is brown, pale brown, grayish brown, or light brownish gray. It is loamy sand, loamy fine sand, sand, or fine sand; the sand is stratified in places. Typically, the C horizon is noncalcareous above a depth of 40 inches. It becomes increasingly calcareous with depth. Some profiles are noncalcareous throughout. Glacial till is below a depth of 40 inches in places.

Maddock soils are adjacent to Dickey, Hecla, and Serden soils in many places. Unlike Dickey soils, they lack glacial till between depths of 20 and 40 inches. They have a thinner A horizon than Hecla soils and a thicker A horizon than Serden soils.

Maddock loamy sand, 0 to 3 percent slopes (MaA).—This soil is on glacial outwash plains and sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but it has a surface layer of loamy sand.

Included with this soil in mapping are small areas of Claire soils and Serden soils in convex positions and areas of Hecla soils and Lohnes soils in concave positions on glacial outwash plains. Also included are small areas of Dickey soils in convex positions and areas of Towner soils in concave positions on sand-mantled glacial till. About 10 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches. Some areas of this soil have been reworked to some extent by soil blowing.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; windbreak suitability group 5.

Maddock loamy sand, 3 to 6 percent slopes (MaB).—This soil is on glacial outwash plains and sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but it has a surface layer of loamy sand.

Included with this soil in mapping are small areas of Claire soils and Serden soils on summits and shoulder slopes and areas of Hecla soils and Lohnes soils on foot slopes and toe slopes on glacial outwash plains. Also included are small areas of Dickey soils on summits, shoulder slopes, and back slopes, and areas of Towner soils on foot slopes and toe slopes on sand-mantled glacial till. About 25 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches. Some areas of this soil have been reworked to some extent by soil blowing.

Surface runoff is medium, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–2; windbreak suitability group 5.

Maddock loamy sand, 6 to 9 percent slopes (MaC).—This soil is on glacial outwash plains and sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but it has a surface layer of loamy sand.

Included with this soil in mapping are small areas of Claire soils and Serden soils on summits, shoulder slopes, and back slopes, areas of Hecla soils and Lohnes soils on foot slopes and toe slopes, and areas of Hamar soils in swales on glacial outwash plains. Also included are small areas of Dickey soils and Heimdal soils on summits, shoulder slopes, and back slopes, areas of Towner soils on foot slopes and toe slopes, and areas of Hamar soils and Kratka soils in swales on sand-mantled glacial till. About 30 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches. Many areas of this soil have been reworked to some extent by soil blowing.

Surface runoff is rapid, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas of this soil are used for pasture; some are cultivated. This soil is better suited to grasses than to most other uses. It is suited to grain crops and legumes if protective measures are used. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit VIe–2; windbreak suitability group 5.

Maddock sandy loam, 0 to 3 percent slopes (MbA).—This soil is on glacial outwash plains and sand-mantled glacial till. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Claire soils and Serden soils in convex positions and areas of Hecla soils and Lohnes soils in concave positions on glacial outwash plains. Also included are small areas of Dickey soils in convex positions and areas of Towner soils in concave positions on sand-mantled glacial till. Some areas of this soil have been reworked to some extent by soil blowing. About 5 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 5.

Maddock sandy loam, 3 to 6 percent slopes (MbB).—This soil is on glacial outwash plains and sand-mantled glacial till.

Included with this soil in mapping are small areas of Claire soils and Serden soils on summits and shoulder slopes and areas of Hecla soils and Lohnes soils on foot slopes and toe slopes on glacial outwash plains. Also included are small areas of Dickey soils on summits, shoulder slopes, and back slopes and areas of Towner soils on foot slopes and toe slopes on sand-mantled glacial till. About 5 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches. Some areas of this soil have been reworked to some extent by soil blowing.

Surface runoff is medium, and water ponds in low places. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 5.

Maddock sandy loam, 6 to 9 percent slopes (MbC).—This soil is on glacial outwash plains and sand-mantled glacial till.

Included with this soil in mapping are small areas of Claire soils and Serden soils on summits, shoulder slopes, and back slopes, areas of Hecla soils and Lohnes soils on foot slopes and toe slopes, and areas of Hamar soils in swales on glacial outwash plains. Also included are small areas of Dickey soils and Heimdal soils on summits, shoulder slopes, and back slopes, areas of Towner soils on foot slopes and toe slopes, and areas of Hamar soils and Kratka soils in swales on sand-mantled glacial till. About 20 percent of the acreage of this soil has glacial till at a depth of 40 to 60 inches. Many areas of this soil have been reworked to some extent by soil blowing.

Surface runoff is rapid, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas of this soil are used for pasture; some are cultivated. This soil is better suited to grasses than to most other uses. It is suited to grain crops and legumes if protective measures are used. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–3; windbreak suitability group 5.

Maddock-Dickey sandy loams, 0 to 6 percent slopes (MdB).—Soils of this mapping unit are on sand-mantled glacial till. About 20 percent of the acreage is nearly level. The Maddock soil has a profile similar to the one described as representative of the series, but it has glacial till at a depth of 40 to 60 inches in most places. The Dickey soil has a profile similar to the one described as representative of the series, but it has a surface layer of sandy loam. The Maddock soils, on back slopes, make up about 40 percent of the mapping unit, and Dickey soils, on summits, shoulder slopes, and back slopes, make up about 35 percent.

Included with these soils in mapping are small areas of Heimdal soils on summits and shoulder slopes, areas of Hecla soils and Towner soils on foot slopes and toe slopes, and areas of Hamar soils and Kratka soils in shallow swales. Also included are a few areas of soils that have a surface layer of fine sandy loam. Some areas of this mapping unit have been reworked to some extent by soil blowing.

Surface runoff is slow on the nearly level areas and medium on the gently undulating areas. Water ponds in swales. The hazard of soil blowing is very severe.

Most areas of this mapping unit are cultivated; some are used for pasture and hay. The soils are suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 5.

Maddock-Dickey sandy loams, 6 to 9 percent slopes (MdC).—Soils of this mapping unit are on sand-mantled glacial till. The Maddock soil has a profile similar to the one described as representative of the series, but it has glacial till at a depth of 40 to 60 inches in most places. The Dickey soil has a profile similar to the one described as representative of the series, but the surface layer is sandy loam. The Maddock soils, on back slopes, make up about 30 percent.

Included with these soils in mapping are small areas of Heimdal soils on summits and shoulder slopes, areas of Hecla soils and Towner soils on foot slopes and toe slopes, and areas of Hamar soils and Kratka soils in shallow swales. Also included are a few areas of soils that have a surface layer of fine sandy loam. Some areas of this mapping unit have been reworked by soil blowing.

Surface runoff is rapid, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas of this mapping unit are used for pasture; some are cultivated. The soils are better suited to grasses than to most other uses. They are suited to grain crops and legumes if protective measures are used. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVe–3M; windbreak suitability group 5.

Maddock-Serden loamy fine sands, 9 to 30 percent slopes (MeD).—Soils of this mapping unit are on glacial outwash plains. About 20 percent of the acreage has been wind modified. Blowout areas are common, and relief is 5 to 20 feet.

The Maddock soil has a profile similar to the one described as representative of the series, but it has a surface layer of loamy fine sand. The Serden soil has

the profile described as representative of the series. In wind-modified areas, the surface layer of the Maddock soils and Serden soils is fine sand in most places.

In moderately steep and hilly areas, the Maddock soils, on back slopes, make up about 50 percent of the mapping unit, and the Serden soils, on summits, shoulder slopes, and upper back slopes, make up about 40 percent. Included in mapping are small areas of Hecla soils on foot slopes and toe slopes.

In the wind-modified areas, the Maddock soils and the Serden soils each make up about 40 percent of the mapping unit. Included in mapping are small areas of Hecla soils on foot slopes and toe slopes and areas of Hamar soils and Venlo soils in swales.

Surface runoff is very rapid, and water ponds in swales. The hazard of soil blowing is very severe.

Areas of this mapping unit are used for pasture or are left idle. Soils of the mapping unit are suited to grasses; they are not suited to grain crops and legumes. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit VIe–2; Maddock soil is in windbreak suitability group 5, Serden soil is in windbreak suitability group 7.

Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes (MfD).—Soils of this mapping unit are on sand-mantled glacial moraines. The Maddock soil has a profile similar to the one described as representative of the series, but it has a surface layer of loamy fine sandy. The Hecla soil has a profile similar to the one described as representative of the series, but it has a surface layer of loamy fine sand. Maddock soils on back slopes, Serden soils on summits and shoulder slopes, and Hecla soils on foot slopes and toe slopes each make up about 30 percent of the mapping unit.

Included with these soils in mapping are small areas of Hamar soils and Venlo soils in swales and areas of Esmond soils and Heimdal soils on summits and shoulder slopes where the glacial till is within 40 inches of the surface. Some areas of this mapping unit have been reworked by soil blowing.

Surface runoff is very rapid, and water ponds in swales. The hazard of soil blowing is very severe.

Areas of this mapping unit are either used for pasture or are left idle. The soils are suited to grasses; they are not suited to grain crops and legumes. Soil blowing, surface runoff, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit VIe–2; Maddock soil is in windbreak suitability group 5, Serden soil is in windbreak suitability group 7, Hecla soil is in windbreak suitability group 5.

Made Land

Made land (Mg) consists of areas from which a part or all of the surface layer and subsoil have been removed. It includes city dumps, sewage lagoons, abandoned highways, and other areas where the surface covering has been removed. Capability unit and windbreak suitability group not assigned.

Marsh

Marsh (Mh) consists of shallow lakes, marshy areas, and depressions that are wet during most or all of the growing season. These areas are too wet for soil examination. The vegetation consists of rushes, cattails, reeds, sedges, and other aquatic plants that have little or no value as livestock feed. Water occupies the center of some of the areas. This land type is used as wildlife habitat. Capability unit Vw–8; windbreak suitability group 10.

Marysland Series

The Marysland series consists of moderately deep, nearly level, poorly drained, calcareous soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and channels.

In a representative profile the surface layer, about 12 inches thick, is very dark gray loam in the upper part and gray silty loam that has an accumulation of lime in the lower part. The layer below that, which is about 12 inches thick, is friable silt loam that contains an accumulation of lime. It is gray in the upper part and light gray in the lower part. Below that is about 5 inches of dark-gray sandy clay loam. The underlying material is medium-textured and coarse-textured sand that is light olive gray in the upper 11 inches and gray in the lower 12 inches (fig. 13).

Permeability is moderately rapid, and the available

Figure 13.—**Profile of Marysland loam, a moderately deep, nearly level, poorly drained, calcareous soil.**

water capacity is moderate. Organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year and at or near the surface in spring and early in summer in poorly drained areas; it is closer to the surface for longer periods in very wet areas. Drains are difficult to install because outlets are not generally available.

These soils are suited to grasses and, where drained, to crops and legumes.

Representative profile of Marysland loam, in a drainage channel, 190 feet north and 700 feet east of the southwest corner of sec. 24, T. 149 N., R. 64 W., Eddy County:

All—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, fine, crumb structure; slightly hard, friable, slightly sticky and plastic; many roots; violently effervescent; moderately alkaline; clear, wavy boundary.

A12ca—7 to 12 inches, gray (N 5/0) silt loam, very dark gray (N 3/0) moist; weak, very coarse, prismatic structure parting to weak, fine, crumb; slightly hard, friable, slightly sticky and plastic; common roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C1ca—12 to 17 inches, gray (N 5/0) silt loam, very dark gray (N 3/0) moist; weak, very coarse, prismatic structure parting to moderate, fine, crumb; soft, friable, slightly sticky and plastic; common roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2ca—17 to 24 inches, light-gray (N 6/0) silt loam, dark gray (5Y 4/1) moist; weak, very coarse, prismatic structure parting to moderate, fine, crumb; slightly hard, friable, slightly sticky and plastic; few roots; violently effervescent; moderately alkaline; abrupt, wavy boundary.

IIAb—24 to 29 inches, dark-gray (N 4/0) sandy clay loam, black (10YR 2/1) moist; few, fine, faint, dark-brown (10YR 3/3, moist) mottles; massive; slightly hard, friable, sticky and plastic; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

IIC1—29 to 40 inches, light olive-gray (5Y 6/2) medium and coarse sand, olive (5Y 5/3) moist; few, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; few white (N 8/0, moist) segregations of lime that are violently effervescent; moderately alkaline; gradual, wavy boundary.

IIC2—40 to 60 inches, gray (5Y 6/1) medium and coarse sand, olive gray (5Y 5/2) moist; few, fine, prominent, black (10YR 2/1, moist) and many, coarse, prominent, dark reddish-brown (5YR 3/3, moist) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

Depth to sand ranges from 24 to 40 inches, but typically is 24 to 30 inches. The A horizon ranges from 9 to 16 inches in thickness. It is very dark gray, dark-gray, or gray loam or silt loam. Typically, the A horizon is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon ranges from 10 to 20 inches in thickness. It is dark-gray, gray, or light-gray loam or silt loam. It has weak or moderate prismatic structure that parts to weak or moderate blocky and crumb structure. The IIC horizon consists of stratified sands that contain gravel in places. A buried A horizon above the IIC horizon occurs in most places. Soils in a few places have an organic surface layer as much as 6 inches thick.

Marysland soils are adjacent to Borup, Divide, and Totten soils in many places. They have coarser sand and gravel at a shallower depth than Borup soils. They are more poorly drained than Divide soils. They lack the alkaline B2t horizon that is typical of Totten soils.

Marysland loam (Mm).—This soil is nearly level and is in depressions on glacial outwash plains and channels. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Borup soils in positions similar to those of Marysland soils and small areas of Divide soils and Totten soils in slightly higher positions. The microrelief is hummocky in some areas. A few small areas are saline.

Surface runoff is very slow. The hazard of soil blowing is severe.

Most areas of this soil are used for pasture and hay; some are cultivated along with adjoining better drained soils. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Marysland and Arveson loams (Mn).—Soils of this nearly level, undifferentiated mapping unit are in depressions on glacial outwash plains and channels. The Arveson soil has a profile similar to the one described as representative of the series, but the surface layer is loam. Composition of this mapping unit varies from area to area.

Included with these soils in mapping are small areas of Borup soils in positions similar to those of Marysland soils and Arveson soils and small areas of Divide, Letcher, Stirum, Totten, and Wyndmere soils in slightly higher positions. The microrelief is hummocky in some areas. A few small areas are saline.

Surface runoff is very slow. The hazard of soil blowing is severe.

Most areas of this mapping unit are used for pasture and hay; some are cultivated along with adjoining better drained soils. The soils are suited to grasses and, where drained, to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Minnewaukan Series

The Minnewaukan series consists of deep, gently rolling and sloping, poorly drained soils that formed in coarse-textured alluvial sediment. These soils are on beaches of lakes, some of which are dry.

In a representative profile the surface layer is dark-gray loamy fine sand about 3 inches thick. The layer below that is grayish-brown loamy coarse sand and gravel about 2 inches thick. The substratum is 55 inches thick. The upper 11 inches is mottled, light brownish-gray, very friable loamy sand. The 12 inches below that is variegated gray and light olive-gray loamy sand. The next 8 inches is light-gray fine sand, and the 14 inches below that is variegated dark-brown and brown fine sand. The lowermost 18 inches is pale-olive fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low, and fertility is low. The water table is within 5 feet of the surface most of the year.

These soils are suited to grasses, small grains, and legumes.

Representative profile of Minnewaukan loamy fine sand, 6 to 9 percent slopes, in a pasture on the beach of Free People's Lake, 1,050 feet south and 150 feet west of the northeast corner of sec. 17, T. 151 N., R. 63 W., Benson County:

A—0 to 3 inches, dark-gray (10YR 4/1) loamy fine sand, black (10YR 2/1) moist; weak, fine, granular and subangular blocky structure; soft, very friable, slightly sticky and nonplastic; many roots; few pebbles as large as 5 millimeters; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

AC—3 to 5 inches, grayish-brown (2.5Y 5/2) loamy coarse sand and gravel, dark grayish brown and very dark grayish brown (2.5Y 4/2 and 3/2) moist; single grained; loose; nonsticky and nonplastic; many roots; slightly effervescent; mildly alkaline; clear, smooth boundary.

C1—5 to 16 inches, light brownish-gray (2.5Y 6/2) loamy sand, dark grayish brown and olive brown (2.5Y 4/2 and 4/3) moist; many, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; soft, very friable, slightly sticky and nonplastic; few roots; common pebbles as large as 20 millimeters; slightly effervescent; mildly alkaline; clear, wavy boundary.

C2g—16 to 28 inches, variegated gray and light olive-gray (5Y 6/1 and 6/2) loamy sand, olive gray and olive (5Y 4/2 and 4/3) moist; very weak, coarse, prismatic structure parting to single grained; soft; loose, slightly sticky and nonplastic; few roots; common pebbles as large as 20 millimeters; sand and pebbles are about 30 percent fragments of shale; few, fine, accumulations of lime; slightly effervescent; mildly alkaline; clear, wavy boundary.

C3g—28 to 36 inches, light-gray (5Y 7/2) fine sand, variegated olive gray and gray (5Y 5/2 and 5/1) moist; single grained; loose, nonsticky and nonplastic; few pebbles as large as 10 millimeters; slightly effervescent; mildly alkaline; clear, wavy boundary.

C4g—36 to 50 inches, variegated dark-brown and brown (10YR 4/3 and 5/3) fine sand, dark brown (10YR 3/3) moist; single grained; loose, nonsticky and nonplastic; few small soft accumulations of iron-manganese; slightly effervescent; moderately alkaline; clear, wavy boundary.

C5g—50 to 60 inches, pale-olive (5Y 6/3) fine sand, olive (5Y 4/3) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 2 to 6 inches in thickness. It is very dark gray or dark-gray sand, fine sand, loamy sand, loamy fine sand, sandy loam, or fine sandy loam. Typically, the C horizon consists of stratified sand, loamy sand, and sandy loam. A buried A horizon is in the C horizon in some places. Glacial till and fine lacustrine sediment are below a depth of about 40 inches in places. Gypsum crystals and other salts are throughout the profile in some places.

Minnewaukan soils have profile characteristics similar to those of Arveson soils and Fossum soils and are adjacent to Lallie soils in many places. They lack the accumulation of lime in the upper part of the C horizon that is typical of Arveson soils. They have a thinner A horizon than Fossum soils. They contain more sand throughout the upper 40 inches than Lallie soils.

Minnewaukan loamy fine sand, 6 to 9 percent slopes (MwC).—This soil is on beaches of existing and dry lakes.

Included with this soil in mapping are small areas of Buse, Coe, and Sioux soils in sloping places and areas of Arveson soils and Lallie soils in nearly level places. Some areas are saline and others have many stones on the surface. Also included are small areas of soils in which the surface layer ranges from sand to sandy loam.

Runoff is rapid, and water ponds in some of the nearly level areas. The hazard of soil blowing is very severe.

Most areas of this soil are either used for pasture or are left idle; some are used for hay and others are cultivated. This soil is better suited to grasses than to most other uses, but small grains and legumes can be grown if erosion is adequately controlled. Soil blowing, wetness, surface runoff in sloping areas, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVs–2; windbreak suitability group 10.

Miranda Series

The Miranda series consists of deep, nearly level, moderately well drained claypan soils that formed in medium textured and moderately fine textured glacial till. These soils are in low broad swales on glacial till plains.

In a representative profile the surface layer is dark-gray clay loam about 2 inches thick. The subsoil is gray, firm clay loam about 6 inches thick. The substratum is mottled, light brownish-gray clay loam that has an accumulation of lime in the upper 22 inches and is mottled, grayish-brown clay loam in the lower 30 inches.

Permeability is very slow, and the available water capacity is low. The organic-matter content is moderate, and fertility is low. The dense subsoil and salts in the lower part of the subsoil limit root growth and water penetration. The water table is within 4 feet of the surface most of the year, and it is at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to salt-tolerant grasses.

Representative profile of Miranda clay loam, in an area of Miranda-Cavour clay loams, in a pasture, 80 feet south and 135 feet east of the northwest corner of sec. 26, T. 148 N., R. 67 W., Eddy County:

A1 and A2—0 to 2 inches, dark-gray (10YR 4/1) clay loam, very dark gray (10YR 3/1) moist; weak, very fine, platy and crumb structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; very slightly effervescent; mildly alkaline; clear, smooth boundary.

B2t—2 to 8 inches, gray (10YR 5/1) clay loam, very dark grayish brown (10YR 3/2) moist; strong, coarse, columnar structure parting to strong and moderate, fine, angular blocky; very hard, firm, very sticky and plastic; organic stains on faces of columns; common roots; strongly effervescent; moderately alkaline; clear, wavy boundary.

C1ca—8 to 30 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/4) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; very hard, firm, sticky and plastic; few roots in upper part; violently effervescent; strongly alkaline; gradual, wavy boundary.

C2—30 to 60 inches, grayish-brown (2.5Y 5/2) clay loam, light olive brown (2.5Y 5/4) moist; common, medium, distinct, dark reddish-brown (5YR 3/3, moist) and yellowish-brown (10YR 5/4, moist) mottles; massive; very hard, firm, sticky and plastic; common pockets of sand; strongly effervescent; strongly alkaline.

The A1 horizon ranges from 1 to 4 inches in thickness. It is dark-gray or very dark gray loam or clay loam. The A2 horizon is either a thin gray coating on top of the B2 horizon or gray platy loam that is as thick as 2 inches. In some

places the A1 and A2 horizons are eroded and the B2 horizon is exposed. The B2 horizon ranges from 6 to 10 inches in thickness. It is gray, dark-gray, or very dark gray clay loam or silty clay loam. It has strong or moderate columnar-prismatic structure that parts to strong or moderate angular blocky structure. Lime, gypsum, and other soluble salts have accumulated in the lower part of the B horizon in some places. The C horizon is mottled, light brownish-gray, grayish-brown, or olive-gray clay loam or loam. Pockets and strata of sand occur throughout the C horizon in most places.

Miranda soils have profile characteristics similar to those of Cavour soils and Larson soils and are adjacent to Vallers soils and Cavour soils in many places. They have a thinner combined A1 and A2 horizon than Cavour soils and Larson soils. They have an alkaline B2t horizon, which Vallers soils do not have.

Miranda-Cavour clay loams (Mx).—Soils of this mapping unit are in low, broad, nearly level swales on the glacial till plain. The Miranda soils have the profile described as representative of the series. The Cavour soils have a profile similar to the one described as representative of the series, but the surface layer is clay loam. Miranda soils make up about 50 percent of the mapping unit, and Cavour soils, in slightly higher positions, make up about 40 percent.

Included with these soils in mapping are small areas of Hamerly soils in slightly higher positions, areas of Vallers soils in lower, more poorly drained swales, and areas of Tonka soils and Parnell soils in depressions, which are identified on the soil map by a diamond symbol. In some cultivated areas the surface layer is hard and cloddy when dry and sticky when wet because some of the subsoil has been mixed with the surface and subsurface layers. Also included are some grassed areas where the surface layer is loam.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas are used for pasture and hay; some are cultivated along with adjoining soils. The soils of this mapping unit are better suited to salt-tolerant grasses than to most other uses. Growth of most crops is reduced because of the dense subsoil, slow permeability, and high content of salt. Wetness, the high content of salt, and slow permeability are the main concerns of management. Capability unit VIs–6p; windbreak suitability group 9.

Nutley Series

The Nutley series consists of deep, nearly level, well-drained soils that formed in moderately fine textured and fine textured glaciolacustrine sediment. These soils are in ancient ice-blocked lakes in morainic areas. These soils are mapped only in a complex with Fargo soils. The mapping unit is Fargo and Nutley silty clay loams. It is described under the Fargo series.

In a representative profile the surface layer is dark-gray silty clay loam about 7 inches thick. The subsoil is light brownish-gray, friable silty clay loam about 21 inches thick. The substratum is 32 inches thick. The upper 12 inches is mottled, light brownish-gray clay loam. The 10 inches below that is variegated, light brownish-gray and gray clay loam. The next 6 inches is light brownish-gray medium sand. The lowermost 4 inches is light brownish-gray silty clay loam.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Nutley silty clay loam, in an area of Fargo and Nutley silty clay loams, in a cultivated field, 240 feet north and 75 feet west of approach, 1,800 feet west of the southeast corner of sec. 31, T. 150 N., R. 66 W., Eddy County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, sticky and plastic; many roots; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

B21—7 to 14 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, medium and fine, angular blocky structure; slightly hard, friable, sticky and plastic; common roots; tongues of A horizon extend into this horizon; strongly effervescent; mildly alkaline; gradual, wavy boundary.

B22—14 to 28 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, medium and fine, angular blocky structure; hard, friable, sticky and plastic; few roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C1—28 to 40 inches, light brownish-gray (2.5Y 6/2) silty clay loam, olive brown (2.5Y 4/4) moist; few, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, sticky and plastic; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C2—40 to 50 inches, variegated, light brownish-gray and gray (2.5Y 6/2 and 6/0) clay loam, olive brown and gray (2.5Y 4/4 and 5/0) moist; massive; hard, friable, sticky and plastic; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

IIC3—50 to 56 inches, light brownish-gray (2.5Y 6/2) medium sand, dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

IIIC4—56 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay loam, olive brown (2.5Y 4/4) moist; massive; hard, firm, sticky and plastic; strongly effervescent; moderately alkaline.

The A horizon ranges from 6 to 12 inches in thickness. It is dark-gray or very dark gray silty clay loam or silty clay. The B horizon ranges from 6 to 22 inches in thickness. It is light brownish-gray, grayish-brown, or dark grayish-brown silty clay loam or silty clay. It has moderate or strong angular blocky structure. Tongues of A horizon extend into the B horizon in most places. The C horizon is light brownish gray, gray, or light olive gray. Sand strata or glacial till are below a depth of about 40 inches in many places.

Nutley soils are adjacent to Fargo soils in many places. They are better drained than Fargo soils.

Osakis Series

The Osakis series consists of shallow, nearly level, moderately well drained soils that formed in moderately coarse textured glaciofluvial deposits overlying coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray sandy loam about 6 inches thick. The subsoil is friable sandy loam about 12 inches thick. It is dark grayish brown in the upper 6 inches and mottled,

grayish brown in the lower 6 inches. The substratum, in the upper 12 inches, is mottled, olive-gray loamy coarse sand that has an accumulation of lime; in the lower 30 inches it is variegated light yellowish-brown and light brownish-gray sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Osakis sandy loam in a cultivated field, 110 feet north and 450 feet west of the southeast corner of sec. 26, T. 150 N., R. 66 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure and moderate, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; common pebbles as large as 5 millimeters and few as large as 20 millimeters; neutral; abrupt, smooth boundary.

B21—6 to 12 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure parting to moderate, coarse and medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; common pebvles as large as 20 millimeters and few as large as 40 millimeters; thin very dark brown (10YR 2/2, moist) organic coats on faces of prisms; neutral; clear, wavy boundary.

B22—12 to 18 inches, grayish-brown (2.5Y 5/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; many pebbles as large as 10 millimeters and common pebbles as large as 20 millimeters; thin patchy organic coat on faces of prisms; mildly alkaline; clear, wavy boundary.

IIC1ca—18 to 30 inches, olive-gray (5Y 5/2) crushed loamy coarse sand, olive (5Y 4/3) moist; common, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky and single grained; soft, very friable, slightly sticky and nonplastic; few roots; common white (N 8/0, moist) nodules and segregations of lime; common pebbles as large as 10 millimeters and few pebbles as large as 25 millimeters; violently effervescent; mildly alkaline; gradual, wavy boundary.

IIC2—30 to 60 inches, variegated, light yellowish-brown and light brownish-gray (2.5Y 6/4 and 6/2) sand and gravel, olive brown and dark grayish brown (2.5Y 4/4 and 4/2) moist; common, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; single grained; loose, nonsticky and nonplastic; strongly effervescent; moderately alkaline.

Depth to the sand and gravel substratum ranges from 10 to 20 inches, but typically is 15 to 20 inches. The A horizon ranges from 5 to 12 inches in thickness. It is dark gray or very dark gray. The B horizon ranges from 5 to 16 inches in thickness. It is dark grayish brown, grayish brown, dark gray, or light olive brown. It has moderate to weak prismatic structure that parts to moderate or weak subangular blocky structure. Mottles are in the lower part of the B horizon and are throughout the B horizon in some places. Clay films, organic coats, and bleached sand grains are on the faces of prisms in places. An accumulation of lime is in the lower part of the B horizon in some places. The IIC horizon typically consists of stratified granitic sand and gravel but contains a layer of shaly sand and gravel in places. In most places, lime has accumulated in the upper part of the IIC horizon. Lime coats the underside of pebbles in one or more of the IIC horizon in most places. Glacial till is below a depth of about 40 inches in some places.

Osakis soils are adjacent to Arvilla, Clontarf, and Tolna soils in many places. They have mottles in the B horizon, unlike Arvilla soils and Clontarf soils. They are better drained than Tolna soils, and they lack a platy A2 horizon, which is a characteristic of Tolna soils.

Osakis sandy loam (Os).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series. The content of gravel in the substratum ranges from 10 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Arvilla, Clontarf, and Lohnes soils in positions similar to those of Osakis soils and small areas of Divide soils in slightly lower positions. Glacial till is at a depth below 40 inches in places.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 1.

Osakis sandy loam, gravelly substratum (Ot).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains more than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Arvilla, Clontarf, and Lohnes soils in positions similar to those of Osakis soils, small areas of Divide soils in slightly lower positions, and areas of Osakis soils that contain less than 40 percent gravel by volume in the substratum. Glacial till is at a depth below 40 inches in some places.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 1.

Osakis sandy loam, till substratum (Ou).—This soil is nearly level and is on glacial outwash plains generally adjacent to areas of glacial till. It has a profile similar to the one described as representative of the series, but glacial till is at a depth below 40 inches. The content of gravel in the substratum above the glacial till ranges from 10 percent to more than 40 percent by volume.

Included with this soil in mapping are small areas of Clontarf soils and Lohnes soils in positions similar to those of Osakis soils and small areas of Divide soils and Fram soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is very severe.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 1.

Overly Series

The Overly series consists of deep, nearly level, moderately well drained soils that formed in moderately fine textured glaciofluvial deposits. These soils are in a basin on a glacial outwash plain.

In a representative profile the surface layer is very dark gray silty clay loam about 11 inches thick. The subsoil is dark-gray firm silty clay loam about 14 inches thick. The substratum is 35 inches thick. The upper 9 inches is light-gray silty clay loam that contains an accumulation of lime. The next 14 inches is light yellowish-brown silty clay loam. The lower 12 inches is grayish-brown silty clay loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Overly silty clay loam, in a cultivated field, 1,200 feet north and 400 feet west of the southeast corner of sec. 6, T. 151 N., R. 64 W., Benson County:

A1p—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, sticky and plastic; many roots; neutral; abrupt, smooth boundary.

A12—7 to 11 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; weak, coarse and medium, subangular blocky structure; slightly hard, friable, sticky and plastic; common roots; neutral; gradual, smooth boundary.

B21—11 to 18 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; moderate, coarse and medium, prismatic structure parting to strong and moderate, medium and fine, subangular blocky structure; hard, firm, sticky and plastic; common roots; neutral; gradual, smooth boundary.

B22—18 to 25 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; weak, coarse and medium, prismatic structure parting to moderate, medium, subangular blocky; hard, firm, sticky and plastic; common roots; neutral; gradual, wavy boundary.

C1ca—25 to 34 inches, light-gray (2.5Y 7/2) silty clay loam, light brownish gray (2.5Y 6/2) moist; massive; hard, firm, sticky and plastic; violently effervescent; mildly alkaline; gradual, wavy boundary.

C2—34 to 48 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) moist; massive; hard, firm, sticky and plastic; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C3—48 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, sticky and plastic; many gypsum crystals; strongly effervescent; mildly alkaline.

The A horizon ranges from 8 to 16 inches in thickness. It is very dark gray or dark gray. The B horizon ranges from 10 to 20 inches in thickness. It is dark gray or dark grayish brown. It has weak to moderate prismatic structure that parts to moderate to strong subangular blocky structure. The C horizon is light-gray, light yellowish-brown, or grayish-brown silty clay loam or silt loam. Typically, an accumulation of lime is in the upper part of the C horizon, but some profiles lack this accumulation. Segregations of salt and gypsum crystals are in the lower part of the C horizon in some places.

Overly soils are adjacent to Bearden, Colvin, Gardena, Vang, and Walsh soils in many places. Unlike Bearden soils and Colvin soils, they have a B horizon. They formed in finer textured deposits than Gardena, Vang, and Walsh soils.

Overly silty clay loam (Ov).—This soil is nearly level and is in a basin surrounded by coarse-textured glacial outwash.

Included with this soil in mapping are small areas of Bearden soils in slightly lower positions and areas of Vang soils and Walsh soils in slightly higher areas along the edges of this mapping unit.

Runoff is slow, and water ponds in low places. This soil receives runoff from adjacent higher lying areas. The hazard of soil blowing is slight.

Most areas of this soil are cultivated. The soil is suited to small grains, grasses, and legumes. Timely tillage is the main concern of management. Capability unit IIc–6; windbreak suitability group 1.

Parnell Series

The Parnell series consists of deep, nearly level, very poorly drained soils that formed in medium textured or moderately fine textured local alluvium overlying glacial till. These soils are in closed depressions on glacial till plains.

In a representative profile the surface layer is dark-gray silty clay loam about 18 inches thick. The subsoil is mottled, dark-gray, very firm silty clay about 22 inches thick. The substratum is mottled, dark-gray silty clay loam.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. These soils receive runoff from the surrounding higher lying areas in spring and during periods of heavy rainfall. Drains are difficult to install because outlets are not generally available.

These soils are suited to grasses and, where drained, to grain crops and legumes.

Representative profile of Parnell silty clay loam, in a depression, 300 feet south and 120 feet west of the northeast corner of sec. 16, T. 149 N., R. 67 W., Eddy County:

A—0 to 18 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; weak, coarse, prismatic structure parting to moderate, fine, crumb; slightly hard, friable, sticky and plastic; many roots; neutral; gradual, wavy boundary.

B2tg—18 to 40 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/1) moist; few, fine, faint, olive (5Y 4/4, moist) mottles; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; very hard, very firm, sticky and plastic; few roots; few thin patchy clay films on faces of blocks; few concretions of iron; slightly effervescent; neutral; gradual, wavy boundary.

Cg—40 to 60 inches, dark-gray (5Y 4/1) silty clay loam, black (5Y 2/1) moist; many medium, distinct, olive (5Y 4/4, moist) mottles; massive; very hard, very firm, sticky and plastic; neutral.

Thickness of the local alluvium overlying the glacial till ranges from about 3 feet to more than 5 feet. The A horizon ranges from 10 to 20 inches in thickness. It is dark-gray or very dark gray silty clay loam, clay loam, or silt loam. The B horizon ranges from 12 to 36 inches in thickness. It is dark gray or very dark gray. It has weak or moderate prismatic structure that parts to moderate or strong subangular blocky structure and is mottled in most places. The C horizon is mottled, very dark gray or dark-gray silty clay loam or silt loam alluvium in some places, and in others it is mottled, olive or olive-gray clay loam glacial till. A partly

decomposed layer of organic matter as much as 3 inches thick is on the surface in some areas. Snail shells and concretions of iron are common throughout the profile in most places.

Parnell soils are adjacent to Tonka and Vallers soils in many places. They lack an A2 horizon, which is a characteristic of Tonka soils. They have a B2t horizon, unlike Vallers soils.

Parnell silty clay loam (Pa).—This soil is nearly level and is in closed depressions on glacial till plains.

Included with this soil in mapping are small areas of Tonka soils in positions similar to those of Parnell soils and areas of Fram, Hamerly, and Vallers soils along the edge of some of the depressions.

Runoff ponds on this soil, and wetness limits the use of the soil in all but the driest years. Vegetation generally consists of sedges, bullrushes, cattails, and prairie cordgrass.

Areas of this soil are used mainly for pasture and hay. Some are left idle and used for wildlife habitat. In dry years some areas are cultivated. This soil is better suited to grasses and wetland vegetation than to most other uses. If drainage is feasible, the soil is suited to grain crops, grasses, and legumes. Wetness is the main concern of management. Capability unit IIIw–7; windbreak suitability group 2.

Peat

Peat (Pe) consists of deposits of peat that are underlain by coarse-textured glaciofluvial deposits. Depth to mineral deposits, consisting of sand and gravel, ranges from 2 feet to more than 5 feet but typically the range is 2 to 4 feet. This land type is in very poorly drained, depressed flats and outwash channels that receive seepage from higher lying areas. The water table is at or near the surface most of the year. Hummocks, 1 to 2 feet high, are common in some areas. Vegetation is mainly slough grasses and sedges.

Areas of this land type are used for pasture or are left idle for use as wildlife habitat. In dry seasons some areas are cut for hay. Capability unit Vw–8; windbreak suitability group 10.

Perella Series

The Perella series consists of deep, nearly level, poorly drained soils that formed in moderately fine textured glaciofluvial deposits over moderately coarse textured and coarse textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is dark-gray silty clay loam about 18 inches thick. The subsoil is grayish-brown, firm silty clay loam about 10 inches thick. The substratum is 32 inches thick. The upper 8 inches is mottled, light olive-gray sandy loam. The 6 inches below that is mottled, light olive-gray sandy clay loam. The lowermost 18 inches is mottled, light-gray sand.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year; it is at or near the surface in spring and early in summer. Drains are difficult to install in most areas because outlets are not generally available.

These soils are suited to grasses and, where drained, to grain crops and legumes.

Representative profile of Perella silty clay loam, in a pasture, 1,200 feet north and 1,000 feet east of the southwest corner of sec. 21, T. 150 N., R. 59 W., Nelson County:

A11—0 to 5 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; weak, medium, subangular blocky structure parting to moderate, fine, granular; soft, very friable, slightly sticky and plastic; many roots; neutral; clear, smooth boundary.

A12—5 to 18 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; few, fine, faint, dark grayish-brown and very dark grayish-brown (10YR 4/2 and 3/2, moist) mottles; weak, coarse and medium, subangular blocky structure parting to moderate, fine, subangular blocky; slightly hard, friable, sticky and plastic; many roots; slightly effervescent; neutral; clear, wavy boundary.

B2g—18 to 28 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; few, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky; hard, firm, sticky and plastic; common roots; slightly effervescent; mildly alkaline; clear, smooth boundary.

IIC1—28 to 36 inches, light olive-gray (5Y 6/2) sandy loam, olive gray (5Y 4/2) moist; common, medium, distinct, dark yellowish-brown (10YR 4/4, moist), light brownish-gray (10YR 6/2, moist), and gray (N 5/0, moist) mottles; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few roots; neutral; clear, smooth boundary.

IIIC2—36 to 42 inches, light olive-gray (5Y 6/2) sandy clay loam, olive gray (5Y 5/2) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) and dark yellowish-brown (10YR 4/4, moist) mottles; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; neutral; clear, smooth boundary.

IVC3—42 to 60 inches, light-gray (5Y 6/1) sand, gray (5Y 5/1) moist; common, medium, distinct, light olive-brown (2.5Y 5/4, moist) and olive-brown (2.5Y 4/4, moist) mottles; single grained; loose, nonsticky and nonplastic; neutral.

The A horizon ranges from 10 to 20 inches in thickness. It is dark-gray or very dark gray silty clay loam or silt loam. Mottles occur in the lower part of the A horizon in most places. The B horizon ranges from 10 to 20 inches in thickness. It is mottled, dark grayish brown, grayish brown, or gray. The B horizon has moderate or strong prismatic structure that parts to moderate or strong subangular blocky structure. The C horizon is light olive gray, olive gray, or light gray and is mottled in most places. Most profiles are noncalcareous, but a few have gypsum, lime, and other soluble salts throughout the C horizon. The Perella soils mapped in this survey area contain a higher percentage of sand than that in the range defined for the series, but this difference does not alter their use and behavior.

Perella soils are adjacent to Bearden, Colvin, and Tiffany soils in many places. Unlike Bearden, Colvin, and Tiffany soils, they have a B2g horizon.

Perella silty clay loam (Pr).—This soil is nearly level and is in depressions on glacial outwash plains.

Included with this soil in mapping are small areas of Colvin soils in positions similar to those of Perella soils, small areas of Bearden soils in slightly higher positions, areas of Perella soils that have a silt loam surface layer, and areas of Perella soils that are silt loam or silty clay loam throughout the substratum.

Surface runoff is very slow, and water ponds in spring and during periods of heavy rainfall. In a few

areas, drainage ditches remove surface water to permit cultivation. The hazard of soil blowing is slight.

Most areas of this soil are used for pasture and hay; some are cultivated along with adjoining better drained soils or soils in areas that have been drained. This soil is suited to grasses and, where drained, to grain crops and legumes. Wetness is the main concern of management. Capability unit IIw–6; windbreak suitability group 2.

Rauville Series

The Rauville series consists of deep, nearly level, very poorly drained soils that formed in moderately fine textured alluvial sediments. These soils are on flood plains of the Sheyenne and James Rivers.

In a representative profile the surface layer is silty clay loam about 21 inches thick. It is very dark gray in the upper 2 inches, dark gray in the next 10 inches, and gray in the lower 9 inches. The substratum is 39 inches thick. The upper 15 inches is gray, friable sandy clay loam, loam, and sand that has been mixed by frost churning. The next 14 inches is mottled, gray sand. The lower 10 inches is mottled, light-gray sand.

Permeability is slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year. Some flooding occurs in spring and during periods of heavy rainfall.

These soils are better suited to grasses than to most other uses.

Representative profile of Rauville silty clay loam, in hayland, 500 feet north and 150 feet east of the southwest corner of the NW¼ sec. 13, T. 149 N., R. 59 W., Nelson County:

A11—0 to 2 inches, very dark gray (5Y 3/1) silty clay loam, black (5Y 2/1) moist; moderate, fine, granular structure; hard, friable, sticky and plastic; many roots; violently effervescent; moderately alkaline; clear, broken boundary.

A12g—2 to 12 inches, dark-gray (N 4/0) silty clay loam, black (N 2/0) moist; strong, fine; granular structure; very hard, friable, sticky and plastic; common roots; tongues of A11 horizon extend through this horizon; violently effervescent; moderately alkaline; clear, broken boundary.

A13g—12 to 21 inches, gray (N 5/0) silty clay loam, very dark gray (N 3/0) moist; strong, fine, granular structure; very hard, friable, sticky and plastic; common roots; tongues of A11 horizon extend into this horizon; violently effervescent; moderately alkaline; clear, wavy boundary.

C1g—21 to 36 inches, gray (5Y 6/1) sandy clay loam, loam, and sand mixed by frost churning, olive gray (5Y 5/2) moist; moderate, fine, granular structure and single grained; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; moderately alkaline; clear, smooth boundary.

IIC2—36 to 50 inches, gray (5Y 6/1) sand, dark gray (5Y 4/1) moist; common, fine, very dark brown (10YR 2/2, moist) mottles; single grained; loose, nonsticky and nonplastic; few concretions of iron and coarse, sand-sized shale; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIC3—50 to 60 inches, light-gray (5Y 7/1) sand, gray (5Y 5/1) moist; common, medium, distinct, dark-brown and very dark brown (10YR 3/3 and 2/2, moist) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 10 to 30 inches in thickness. It is gray, dark-gray, or very dark gray silty clay loam or silt loam. Mottles are in the lower part of the A horizon in many places. A surface layer of partly decomposed organic matter as much as 3 inches thick is present in some areas. The Cg and IICg horizons are light olive gray, light olive brown, light gray, or gray. Profiles are calcareous in most places, but they are noncalcareous in some areas.

Rauville soils mapped in this survey contain a higher percentage of sand than is in the range defined for the series, but this difference does not alter their usefulness and behavior.

Rauville soils are adjacent to Lamoure soils and Ludden soils in many places. They are more poorly drained than Lamoure soils and Ludden soils.

Rauville silty clay loam (Ra).—This soil is nearly level and is in depressions on flood plains and in oxbows and old channels of the Sheyenne and James Rivers.

Included with this soil in mapping are small areas of Lamoure soils and Ludden soils in slightly higher areas. Also included are a few areas that have a surface layer of silt loam.

Surface runoff is very slow, and water ponds in some areas. This soil is subject to flooding in spring and during periods of heavy rainfall.

Practically all areas of this soil are used for pasture and hay. This soil is suited to grasses. Wetness is the main concern of management. Capability unit Vw–8; windbreak suitability group 10.

Renshaw Series

The Renshaw series consists of shallow, nearly level and gently sloping, somewhat excessively drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains, on terraces along rivers and drainageways, and in areas of glacial till (fig. 14).

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The subsoil is variegated, dark grayish-brown and grayish-brown, friable loam about 9 inches thick. The substratum is brown sand and gravel in the upper 21 inches and pale-brown sand in the lower 24 inches.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Renshaw loam, 0 to 3 percent slopes, in a cultivated field, 100 feet north and 1,300 feet east of the southwest corner of sec. 18, T. 150 N., R. 58 W., Nelson County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

B2—6 to 15 inches, variegated, dark grayish-brown and grayish-brown (10YR 4/2 and 5/2) loam, very dark grayish brown and very dark brown (10YR 3/2 and 2/2) moist; strong and moderate, medium, prismatic structure parting to strong and moderate, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; thin clay skins on faces of prisms; common roots; neutral; abrupt, wavy boundary.

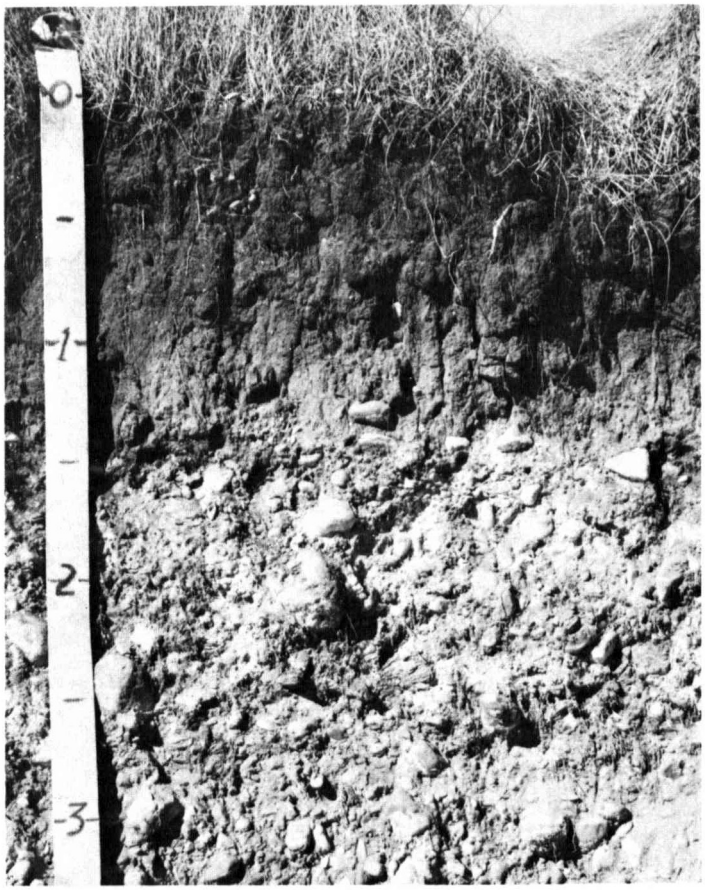

Figure 14.—**Profile of Renshaw loam, a shallow, somewhat excessively drained soil. The substratum is sand and gravel.**

IIC1—15 to 24 inches, brown (10YR 5/3) sand and gravel, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; underside of large pebbles coated with lime; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC2—24 to 36 inches, brown (10YR 5/3) sand and gravel, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; underside of large pebbles coated with lime; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC3—36 to 42 inches, pale-brown (10YR 6/3) sand, brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; underside of large pebbles coated with lime; common pebbles as large as 5 millimeters and few pebbles as large as 20 millimeters; strongly effervescent; mildly alkaline; gradual, wavy boundary.

IIC4—42 to 60 inches, pale-brown (10YR 6/3) sand, dark grayish brown (10YR 4/2) moist; single grained; loose, nonsticky and nonplastic; underside of large pebbles coated with lime; common pebbles as large as 5 millimeters and few pebbles as large as 20 millimeters; slightly effervescent; mildly alkaline.

Depth to the sand and gravel substratum ranges from 10 to 20 inches, but in most places it is 15 to 20 inches. The A horizon ranges from 5 to 8 inches in thickness. It is dark gray or very dark gray. The B horizon ranges from 5 to 12 inches in thickness. It is dark gray, grayish brown, dark grayish brown, or brown. The B horizon has moderate or strong prismatic structure that parts to moderate or strong subangular blocky structure. Thin clay skins and organic coats are on the faces of prisms in most places. The IIC horizons are typically stratified granitic sand and gravel and contain a layer of shaly sand and gravel in some places. Soft masses of lime have accumulated in the upper part of the IIC horizon in some places and lime coats the underside of pebbles in one or more of the IIC horizons in most places. Glacial till is below a depth of 40 inches in some places.

Renshaw soils are adjacent to Fordville, Sioux, and Warsing soils in many places, and all of these soils are underlain by sand and gravel. Renshaw soils are shallower to the sand and gravel IIC horizon than Fordville soils. They are deeper to the sand and gravel IIC horizon than Sioux soils. They are better drained than Warsing soils and lack mottling in the B horizon, which is typical of Warsing soils.

Renshaw loam, 0 to 3 percent slopes (ReA).—This soil is nearly level and is on glacial outwash plains and on terraces along drainageways and rivers. It has the profile described as representative of the series. Content of gravel in the substratum is about 40 percent by volume.

Included with this soil in mapping are small areas of Fordville soils and Warsing soils in positions similar to those of Renshaw soils.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Droughtiness caused by the low available water capacity is the main concern of management. Capability unit IIIs–6; windbreak suitability group 6.

Renshaw loam, 3 to 6 percent slopes (ReB).—This soil is on glacial outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. Content of gravel in the substratum is about 40 percent by volume.

Included with this soil in mapping are small areas of Sioux soils on summits and shoulder slopes and areas of Fordville soils on foot slopes and toe slopes. Soils in cultivated areas commonly have a lighter-colored surface layer on the summits and shoulder slopes.

Surface runoff is medium. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Surface runoff and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–6; windbreak suitability group 6.

Renshaw loam, gravelly substratum (Rn).—This soil is nearly level and is on glacial outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but the content of gravel in the substratum is more than 40 percent by volume.

Included with this soil in mapping are small areas of Renshaw soils that have a substratum that contains less than 40 percent gravel by volume. Also included are areas of Fordville soils and Warsing soils in positions similar to those of Renshaw soils.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Droughtiness caused by the low available

water capacity is the main concern of management. Capability unit IIIs–6; windbreak suitability group 6.

Renshaw loam, sandy substratum (Rs).—This soil is nearly level and is on glacial outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but the content of gravel in the substratum is less than 40 percent by volume.

Included with this soil in mapping are small areas of Renshaw soils that have a substratum that contains more than 40 percent gravel by volume. Also included are areas of Fordville soils and Warsing soils in positions similar to those of Renshaw soils.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Droughtiness caused by the low available water capacity is the main concern of management. Capability unit IIIs–6; windbreak suitability group 6.

Renshaw loam, till substratum (Rt).—This soil is nearly level and is on glacial outwash plains, on terraces along drainageways and rivers, and in areas of glacial till. It has a profile similar to the one described as representative of the series, but glacial till is below a depth of about 40 inches. The content of gravel in the substratum above the glacial till is about 40 percent by volume.

Included with this soil in mapping are small areas of Fordville, Heimdal, and Warsing soils in positions similar to those of Renshaw soils. Also included are areas of Divide soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Droughtiness caused by the low available water capacity is the main concern of management. Capability unit IIIs–6; windbreak suitability group 6.

Ryan Series

The Ryan series consists of deep, nearly level, poorly drained claypan soils that formed in moderately fine textured and fine textured alluvial sediment. These soils are on flood plains of the Sheyenne and James Rivers.

In a representative profile the surface layer is gray silty clay loam about 3 inches thick. The subsoil is firm silty clay loam about 20 inches thick. It is dark gray in the upper 4 inches and gray below that. It has segregations of salt in the lower 16 inches. The substratum is light-gray silty clay loam that contains gypsum crystals.

Permeability is very slow, and the available water capacity is low. The organic-matter content is high, and fertility is low. The dense subsoil and the salts in the lower part of the subsoil limit root and water penetration. The water table is within 5 feet of the surface most of the year and at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to salt-tolerant grain crops, except where they are complexly associated with saline Lamoure soils, and there they are suited to salt-tolerant grasses.

Representative profile of Ryan silty clay loam, in an area of Ryan and Lamoure silty clay loams, in a pasture, 1,600 feet north and 135 feet east of the southwest corner of sec. 8, T. 150 N., R. 67 W., Eddy County:

A1 and A2—0 to 3 inches, gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) moist; weak, fine, platy structure and weak, very fine, crumb; slightly hard, very friable, sticky and plastic; many roots; moderately alkaline; abrupt, wavy boundary.

B21t—3 to 7 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; strong, medium, columnar structure parting to strong, fine, angular blocky; very hard, firm, very sticky and very plastic; common roots; strongly alkaline; clear, wavy boundary.

B22tcs—7 to 23 inches, gray (N 5/0) silty clay loam, black (10YR 2/1) moist; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky; very hard, firm, very sticky and very plastic; common, medium, prominent, light-gray (10YR 7/1, moist) and light brownish-gray (10YR 6/2, moist) segregations of salt and lime; slightly effervescent; few roots; strongly alkaline; gradual, wavy boundary.

Ccs—23 to 60 inches, light-gray (10YR 6/1) silty clay loam, dark grayish brown (2.5Y 4/2) moist; massive; very hard, firm, very sticky and very plastic; common gypsum crystals; strongly effervescent; strongly alkaline.

The A1 horizon is very dark gray, dark-gray, or gray silty clay or silty clay loam as much as 4 inches thick. The A2 horizon is absent in some places; it appears as a thin gray coating on top of the B2 horizon in other places, or it is as much as 2 inches of gray platy silt loam in other places. In some places the A1 and A2 horizons have eroded and the B2 horizon is exposed. The B2 horizon is very dark gray, dark-gray, or gray silty clay loam, silty clay, or clay. It has strong or moderate columnar or prismatic structure that parts to strong or moderate angular or subangular blocky structure. The C horizon is light-gray, light olive-gray, or gray silty clay loam, silty clay, or clay. The upper part typically has an accumulation of lime, gypsum, and soluble salts. An accumulation of lime, gypsum, and ther soluble salts is in the lower part of most profiles. Buried A horizons of black or very dark gray are in the C horizon below a depth of 40 inches in some places.

Ryan soils are adjacent to Lamoure soils and Ludden soils in many places. They have an alkaline B2t horizon, which Lamoure and Ludden soils do not have.

Ryan silty clay loam (Ry).—This soil is nearly level and is on flood plains of the Sheyenne and James Rivers.

Included with this soil in mapping are small areas of Lamoure soils and Ludden soils in slightly higher positions and areas of Rauville soils in lower positions. In some cultivated areas the surface layer is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow. This soil is subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is slight.

Most areas are used for pasture and hay; some are cultivated. This soil is better suited to salt-tolerant

grasses than to most other uses. Salt-tolerant grain crops are not so well suited. Growth of most crops is reduced because of the dense subsoil, very slow permeability, and high content of salt. Wetness, poor plant growth, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IVs–6P; windbreak suitability group 9.

Ryan and Lamoure silty clay loams (Rz).—These soils are nearly level and are in flood plains of the Sheyenne and James Rivers. The Ryan soil has the profile described as representative of the series. The Lamoure soil has a profile similar to the one described as representative of the series, but in most places it is saline. The Lamoure soils are in slightly higher positions. This mapping unit varies in composition from area to area.

Included with these soils in mapping are small areas of Ludden soils and La Prairie soils in slightly higher positions and areas of Rauville soils in lower positions. Shallow channels that drain higher positions cross these soils in places. In some cultivated areas the surface layer of the Ryan soil is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface and subsurface layers.

Surface runoff is slow. These soils are subject to flooding in spring and during periods of heavy rainfall. The hazard of soil blowing is slight on the Ryan soil, and it is severe on the Lamoure soil if grass vegetation is destroyed by cultivation or overgrazing.

Most areas are used for pasture and hay; a few areas are cultivated. These soils are better suited to salt-tolerant grasses than to most other uses. Growth of most crops is reduced because of the dense subsoil and very slow permeability of the Ryan soils and the high content of salt. Wetness and poor plant growth are the main concerns of management. Capability unit VIw–4; Ryan soil is in windbreak suitability group 9, Lamoure soil is in windbreak suitability group 2.

Serden Series

The Serden series consists of deep, nearly level to gently rolling, excessively drained soils that formed in coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and sand-mantled glacial moraines.

In a representative profile the surface layer is dark-gray loamy fine sand about 2 inches thick. The substratum is grayish-brown, loose fine sand in the upper 22 inches; grayish-brown sand in the next 26 inches; and dark-gray loamy fine sand in the lower 10 inches.

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

These soils are better suited to grasses than to most other uses.

Representative profile of Serden loamy fine sand, in an area of Maddock-Serden loamy fine sands, 9 to 30 percent slopes, in a pasture, 900 feet south and 150 feet west of the northeast corner of the SE¼ sec. 11, T. 149 N., R. 59 W., Nelson County:

A1—0 to 2 inches, dark-gray (10YR 4/1) loamy fine sand, black (10YR 2/1) moist; single grained; loose, slightly sticky and nonplastic; many roots; neutral; clear, wavy boundary.

C1—2 to 24 inches, grayish-brown (10YR 5/2) fine sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; common roots; few fragments of shale as large as 4 millimeters; neutral; gradual; wavy boundary.

C2—24 to 50 inches, grayish-brown (10YR 5/2) sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; few roots; few fragments of shale and rounded pebbles as large as 5 millimeters; mildly alkaline; clear, wavy boundary.

IIAb—50 to 60 inches, dark-gray (10YR 4/1) loamy fine sand, black (10YR 2/1) moist; massive; soft, very friable, slightly sticky and nonplastic; neutral.

The A horizon ranges from 1 to 4 inches in thickness. It is dark-gray or very dark gray loamy fine sand, loamy sand, sand, or fine sand. An AC horizon as much as 6 inches thick is present in places. The C horizon is grayish-brown, light brownish-gray, or light-gray loamy fine sand, fine sand, or sand. In some places dark-gray loamy fine sand buried A horizons are in the C horizon. Most profiles are noncalcareous, but lime is present in the lower part of the C horizon in places.

Serden soils are similar to Claire, Hamar, and Maddock soils, because they have a high content of sand. Serden soils formed in finer sands than Claire soils. They lack mottles in the upper part of the C horizon, which is a characteristic of Hamar soils. They have a thinner A horizon than Maddock soils.

Serden-Hamar sands (Se).—These soils are nearly level and are on glacial outwash plains that have been reworked by soil blowing. Low hummocks and blown-out areas are numerous. Some of the blow-outs are actively eroding. Part or all of the original surface layer has been removed. The Serden and Hamar soils have profiles similar to those described as representative of their respective series, but the surface layer is loamy fine sand, loamy sand, fine sand, sand, or coarse sand. Serden soils are on summits, shoulder slopes, and upper back slopes, and they make up about 35 percent of this mapping unit. Hamar soils are on toe slopes, and they make up about 30 percent.

Included with these soils in mapping are small areas that are gently undulating to gently rolling. Also included are small areas of Claire soils on summits and shoulder slopes, areas of Maddock soils on back slopes, areas of Hecla soils and Lohnes soils on foot slopes, areas of Wyndmere soils in shallow swales, and areas of Arveson, Fossum, and Venlo soils in poorly drained swales and depressions.

Surface runoff is slow, and water ponds in swales and depressions. The hazard of soil blowing is very severe.

Practically all areas are used for pasture or are left idle, but a few areas are used for hay. These soils are better suited to grasses than to most other uses. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit VIes–2; Serden soil is in windbreak suitability group 7, Hamar soil is in windbreak suitability group 2.

Sioux Series

The Sioux series consists of very shallow, nearly level to steep, excessively drained soils that formed in medium-textured glaciofluvial deposits. These soils are on glacial outwash plains, on terraces along drainageways and rivers, and in areas of glacial till.

In a representative profile the surface layer is very

dark gray gravelly loam about 7 inches thick. The substratum is 53 inches thick. The upper 8 inches is variegated, brown and grayish-brown sand and gravel. The next 9 inches is variegated, pale-brown and light brownish-gray sand. The lower 30 inches is variegated, pale-brown and light brownish-gray sand and gravel.

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

These soils are suited to grasses.

Representative profile of Sioux gravelly loam, 6 to 25 percent slopes, in a pasture, 800 feet north and 400 feet east of the southwest corner of sec. 26, T. 150 N., R. 66 W., Eddy County:

A1—0 to 7 inches, very dark gray (10YR 3/1) gravelly loam, black (10YR 2/1) moist; weak, fine, granular structure and single grained; soft, very friable, slightly sticky and slightly plastic; many roots; neutral; clear, wavy boundary.

IIC1—7 to 15 inches, variegated brown and grayish-brown (10YR 5/3 and 5/2) sand and gravel, brown and dark grayish brown (10YR 4/3 and 4/2) moist; single grained; loose, nonsticky and nonplastic; very few roots; underside of pebbles coated with lime; strongly effervescent; mildly alkaline; clear, wavy boundary.

IIC2—15 to 24 inches, variegated pale-brown and light brownish-gray (10YR 6/3 and 6/2) sand, brown and dark grayish brown (10YR 4/3 and 4/2) moist; single grained; loose, nonsticky and nonplastic; few pebbles as large as 15 millimeters; underside of pebbles coated with lime; strongly effervescent; mildly alkaline; clear, wavy boundary.

IIC3—24 to 60 inches, variegated pale-brown and light brownish-gray (10YR 6/3 and 6/2) sand and gravel, brown and dark grayish brown (10YR 4/3 and 4/2) moist; single grained; loose, nonsticky and nonplastic; underside of pebbles coated with lime; strongly effervescent; mildly alkaline; clear, wavy boundary.

Depth to the sand and gravel substratum ranges from 7 to 10 inches. The A horizon ranges from 7 to 10 inches in thickness. It is very dark gray or dark-gray sandy loam, gravelly loam, or loam. The IIC horizons are typically stratified granitic sand and gravel and contain a layer of shaly sand and gravel in some places. In most places lime coats the underside of pebbles in one or more of the IIC horizons.

Sioux soils are adjacent to Arvilla soils and Renshaw soils in many places. All of these soils are underlain by sand and gravel. Sioux soils lack the B2 horizon, which is a characteristic of Arvilla soils and Renshaw soils.

Sioux gravelly loam, 0 to 6 percent slopes (SoB).—This soil is on low ridges and slopes adjacent to depressions and drainageways, on glacial outwash plains, and on terraces along the Sheyenne and James Rivers.

Included with this soil in mapping are small areas of Arvilla soils and Renshaw soils on back slopes. Also included are areas of Fordville soils and Clontarf soils on foot slopes and toe slopes. In a few areas the soils have a surface layer of sandy loam or loam. Soils in cultivated areas commonly have a lighter colored surface layer.

Surface runoff is slow and medium. The hazard of soil blowing is very severe.

Some areas of this soil are used for pasture and hay, and others are cultivated along with adjoining soils. This soil is better suited to grasses than to most other uses. Surface runoff, soil blowing, and droughtiness caused by the very low available water capacity are the main concerns of management. Capability unit VIIs–3; windbreak suitability group 10.

Sioux gravelly loam, 6 to 25 percent slopes (SoE).—This soil is on slopes adjacent to depressions and drainageways on glacial outwash plains, on terraces along the Sheyenne and James Rivers, and on moraines in areas of glacial till. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Arvilla soils and Renshaw soils on back slopes, areas of Fordville soils and Clontarf soils on foot slopes and toe slopes, and, where mapped in morainic areas, small areas of Buse soils on summits and shoulder slopes, areas of Barnes soils and Heimdal soils on back slopes, and areas of Emrick soils and Svea soils on foot slopes and toe slopes. Also included are small areas that have a surface layer of sandy loam or loam.

Surface runoff is rapid and very rapid. The hazard of soil blowing is moderate.

Most areas are used for pasture; some are used for hay or are cultivated along with the adjoining soils. This soil is better suited to grasses than to most other uses. Surface runoff, soil blowing, droughtiness caused by the very low available water capacity, and overgrazing of pasture are the main concerns of management. Capability unit VIIs–3; windbreak suitability group 10.

Spottswood Series

The Spottswood series consists of moderately deep, nearly level, moderately well drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and terraces along drainageways and rivers.

In a representative profile the surface layer is loam about 14 inches thick that is very dark gray in the upper 8 inches and dark gray in the lower 6 inches. The subsoil is dark grayish-brown, friable loam in the upper 6 inches and brown, friable sandy clay loam in the lower 5 inches. The substratum is brown sand in the upper 11 inches and brown sand and gravel in the lower 24 inches.

Permeability is moderate in the surface layer and subsoil and very rapid in the substratum. The available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Spottswood loam, in a cultivated field, 400 feet south and 600 feet east of the northwest corner of sec. 11, T. 150 N., R. 61 W., Nelson County:

Ap—0 to 8 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, coarse, subangular blocky structure parting to moderate, fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—8 to 14 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; neutral; gradual, wavy boundary.

B21—14 to 20 inches, dark grayish-brown (10YR 4/2) loam,

very dark brown (10YR 2/2) moist; weak to moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky, and slightly plastic; common roots; neutral; gradual, wavy boundary.

B22—20 to 25 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; common roots; neutral; clear, wavy boundary.

IIC1—25 to 36 inches, brown (10YR 5/3) sand, dark brown (10YR 3/3) moist; single grained; loose, nonsticky and nonplastic; few fragments of shale and pebbles as large as 10 millimeters; neutral; gradual, wavy boundary.

IIC2—36 to 60 inches, brown (10YR 5/3) sand and gravel, dark brown (10YR 5/3) moist; single grained; loose, nonsticky and nonplastic; common fragments of shale and pebbles as large as 5 millimeters and a few pebbles as large as 20 millimeters; slightly effervescent; mildly alkaline.

Depth to the sand and gravel substratum ranges from 20 to 36 inches. The A horizon ranges from 12 to 18 inches in thickness. It is dark gray or very dark gray. The B horizon ranges from 11 to 20 inches in thickness. It is dark-brown, dark grayish-brown, grayish-brown, or brown loam or sandy clay loam. It has weak to strong prismatic structure that parts to moderate or strong subangular blocky structure. Thin clay films and organic stains occur on faces of prisms in some places. The C horizon ranges from 0 to 12 inches in thickness. It is loam or sandy loam. The C horizon has an accumulation of lime in some places.

The IIC horizons are typically stratified granitic sand and gravel and contain a layer of shaly sand and gravel in some places. An accumulation of lime is in the upper part of the IIC horizon in some places. Lime coats the underside of pebbles in one or more of the IIC horizons in most places.

Spottswood soils are adjacent to Fordville, Gardena, and Renshaw soils in many places. They have a thicker A horizon than Fordville soils and Renshaw soils. They have thinner deposits overlying sand and gravel than Gardena soils.

Spottswood loam (Sp).—This soil is nearly level and is on glacial outwash plains and on terraces along drainageways and rivers. It has the profile described as representative of the series. Content of gravel in the substratum is about 40 percent.

Included with this soil in mapping are small areas of Fordville, Gardena, Renshaw, and Warsing soils in positions similar to those of Spottswood soils.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIs–6; windbreak suitability group 3.

Spottswood loam, sandy substratum (Sr).—This soil is nearly level and is on glacial outwash plains and terraces along drainageways and rivers. It has a profile similar to the one described as representative of the series, but the content of gravel in the substratum is less than 40 percent.

Included with this soil in mapping are small areas of Fordville, Gardena, Renshaw, and Warsing soils. Also included are areas of Spottswood soils where the content of gravel is more than 40 percent.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas of this soil are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIIs–6; windbreak suitability group 3.

Stirum Series

The Stirum series consists of deep, nearly level, poorly drained, claypan soils that formed in moderately coarse textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is dark-gray sandy loam about 8 inches thick. The subsoil, about 14 inches thick, is mottled, gray, friable sandy loam that has an accumulation of lime. The substratum is 38 inches thick. The upper 18 inches is mottled, light-gray sandy loam. The 6 inches below that is mottled, gray sandy clay loam. The next 5 inches is mottled, light-gray loamy sand and 9 inches of yellowish-brown sand.

Permeability is moderately slow in the surface layer and subsoil and moderately rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is low. The dense subsoil and the salts in the lower part of the subsoil limit root and water penetration. The water table is within 5 feet of the surface during most of the year, and it is at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. Tillage is often delayed in spring because of wetness.

These soils are suited to salt-tolerant grain crops and grasses, but they are poorly suited to legumes.

Representative profile of Stirum sandy loam, in a hayfield, 60 feet south and 1,100 feet east of the northwest corner of the NE¼ sec. 23, T. 150 N., R. 62 W., Eddy County:

A11—0 to 4 inches, dark gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, medium and fine, subangular blocky structure and moderate, fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots; strongly effervescent; moderately alkaline; clear, smooth boundary.

A12—4 to 8 inches, dark-gray (10YR 4/1) sandy loam, very dark gray (10YR 3/1) moist; weak, medium, platy structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots; few medium segregations of lime; strongly effervescent; moderately alkaline; clear, smooth boundary.

B21t—8 to 16 inches, gray (5Y 5/1) sandy loam, dark gray (5Y 4/1) moist; few, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, very coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; few roots; few fine segregations of lime; thin organic coats and clear sand grains on faces of prisms; strongly to violently effervescent; moderately alkaline; gradual, smooth boundary.

B22ca—16 to 22 inches, gray (5Y 5/1) sandy loam, dark gray (5Y 4/1) moist; common, medium, prominent, yellowish-brown (10YR 5/8) mottles, weak, coarse, prismatic structure parting to moderate, coarse, subangular blocky; hard, friable, slightly sticky and slightly plastic; common medium segregations of lime and few to common gypsum crystals; strongly to violently effervescent; moderately alkaline; gradual, smooth boundary.

C1g—22 to 40 inches, light-gray (5Y 6/1) sandy loam, gray (5Y 5/1) moist; common, medium, prominent,

yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to moderate, coarse, subangular blocky; hard, friable, slightly sticky and slightly plastic; common medium segregations of lime and few to common gypsum crystals; strongly to violently effervescent; moderately alkaline; gradual, smooth boundary.

C2g—40 to 46 inches, gray (5Y 6/1) sandy clay loam, dark gray (5Y 4/1) moist; common, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; hard, friable, sticky and plastic; few medium segregations of lime and few to common gypsum crystals; violently effervescent; mildly alkaline; gradual, smooth boundary.

C3g—46 to 51 inches, light gray (5Y 7/1) sandy loam, gray (5Y 5/1) moist; common, medium, distinct, brownish-yellow (10YR 6/6) mottles; massive; hard, friable, slightly sticky and slightly plastic; violently effervescent; mildly alkaline; gradual, smooth boundary.

C4g—51 to 57 inches, light-gray (5Y 7/1) loamy sand, gray (5Y 6/1) moist; many, medium distinct, brownish-yellow (10YR 6/6) mottles; massive; slightly hard, very friable, slightly sticky and nonplastic; slightly to strongly effervescent; mildly alkaline; gradual, smooth boundary.

C5g—57 to 60 inches, yellowish-brown (10YR 5/6) sand, dark yellowish brown (10YR 4/4) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A1 horizon is 5 to 10 inches thick. It is dark-gray or very dark gray sandy loam or fine sandy loam. The B2 horizon is mottled, gray, light-gray, or grayish-brown sandy loam, fine sandy loam, or loam. It has weak to moderate, very coarse and coarse prismatic structure that has some prisms as large as 18 inches in diameter. Typically, lime has accumulated in the B2 horizon. Crystals of gypsum and other soluble salts are in the lower part of the B2 horizon and in the upper part of the C horizon in most places. The C horizon is mottled, gray, light-gray, light olive-gray, yellowish-brown, or grayish-brown sandy loam, sandy clay loam, loamy sand, or sand.

Stirum soils are adjacent to Arveson, Lemert, Letcher, and Totten soils in many places. All of these soils are underlain by coarse-textured material. Stirum soils have an alkaline B2 horizon, which Arveson soils do not have. They lack the distinct strong columnar-prismatic structure in the B2 horizon, which is a characteristic of Lemert soils and Letcher soils. They formed in coarser textured deposits than Totten soils.

Stirum sandy loam (Ss).—This soil is nearly level and is on glacial outwash plains.

Included with this soil in mapping are small areas of Letcher soils and Wyndmere soils in positions similar to Stirum soils. Also included are areas of Hecla soils and Lohnes soils in slightly higher positions and areas of Arveson soils and Lemert soils in slightly lower positions. In some cultivated areas the surface layer is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Some areas of this soil are cultivated, but others are in hay and pasture. The soil is suited to salt-tolerant grain crops and grasses; it is poorly suited to legumes. Growth of most crops is reduced because of the shallow root zone and slow permeability. Wetness, soil blowing, maintenance of good soil tilth in cultivated areas, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IVws–3; windbreak suitability group 9.

Svea Series

The Svea series consists of deep, nearly level to gently rolling, moderately well drained soils that formed in medium-textured and moderately fine textured glacial till. These soils are on glacial till plains.

In a representative profile the surface layer is very dark gray loam in the upper 6 inches and dark-gray silt loam in the lower 5 inches. The subsoil is dark grayish-brown, friable silt loam in the upper 8 inches and grayish-brown, friable loam in the lower 4 inches. The substratum is 37 inches thick. The upper 7 inches is pale-yellow loam that has an accumulation of lime. The next 6 inches is pale-yellow loam. The lower 24 inches is variegated, light-gray and pale-yellow loam.

Permeability is moderate in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is high. The organic-matter content is high, and fertility is high.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Svea loam, in a cultivated field, 75 feet south and 800 feet east of the northwest corner of the NE¼ sec. 10, T. 149 N., R. 59 W., Nelson County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to moderate, medium, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A12—6 to 11 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; weak, coarse and medium, prismatic structure parting to moderate, coarse and medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, wavy boundary.

B2—11 to 19 inches, dark grayish-brown (10YR 4/2) silt loam, variegated, very dark grayish brown and very dark brown (10YR 3/2 and 2/2) moist; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, friable, sticky and plastic; common roots; neutral· clear, smooth boundary.

B3—19 to 23 inches, grayish-brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, friable, sticky and plastic; few roots; common pebbles as large as 5 millimeters; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1ca—23 to 30 inches, pale-yellow (2.5Y 7/3) loam, light olive brown (2.5Y 5/4) moist; weak, coarse, prismatic structure parting to weak, medium and fine, subangular blocky; slightly hard, friable, sticky and plastic; common pebbles as large as 5 millimeters and a few as large as 20 millimeters; violently effervescent; mildly alkaline; gradual, wavy, boundary.

C2—30 to 36 inches, pale-yellow (2.5Y 7/3) loam, light olive brown (2.5Y 5/4) moist; weak, medium, subangular blocky structure; slightly hard, friable, sticky and plastic; common pebbles as large as 5 millimeters and a few as large as 20 millimeters; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, variegated, light-gray and pale-yellow (2.5Y 7/2 and 7/3) loam, light olive brown (2.5Y 5/4) moist; few, fine, prominent, yellowish-red (5YR 4/6, moist) mottles; massive; slightly hard, friable, sticky and plastic; common, medium, distinct, white segregations of lime; common pebbles as large as 5 millimeters; strongly effervescent; moderately alkaline.

The A horizon is 8 to 20 inches thick. It is very dark gray or dark-gray loam or silt loam. The B horizon is 8 to 16 inches thick. It is dark grayish-brown, grayish-brown, or dark-gray loam, silt loam, or light clay loam. It has moderate or weak prismatic structure that parts to moderate subangular blocky structure. Thin clay films or organic coats are on the faces of prisms in some places. Lime has accumulated in the lower part of the B horizon and in the upper part of the C horizon in most places. The C horizon is mottled, pale-yellow, light-gray, light brownish-gray, light yellowish-brown, or light olive-brown loam or clay loam. Segregations of gypsum and other salts are common throughout the C horizon in some places.

Svea, Barnes, Cresbard, and Hamerly soils formed in similar parent material and are adjacent to each other in many places. Svea soils have a thicker A horizon than Barnes soils. They lack the alkaline B2t horizon, which is a characteristic of Cresbard soils. They have a B horizon, which Hamerly soils lack.

Svea loam (St).—This soil is nearly level and is on glacial till plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Barnes soils in slightly higher positions, Wyard soils in shallow swales and depressions, Tonka soils in deeper depressions that are indicated on the detailed map by a diamond symbol, and Hamerly soils around the edges of some of the depressions. Also included in some places west of McVille are small areas of the Svea variant and of the Edgeley variant in positions similar to those of Svea soils.

Surface runoff is slow, and water ponds in swales and depressions. The hazard of soil blowing is slight.

Most areas are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness in swales and soil blowing are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Svea-Barnes loams, 0 to 3 percent slopes (SvA).—These soils are on glacial till plains. Svea soils are in concave positions, and they make up about 50 to 60 percent of this mapping unit. Barnes soils are in convex positions, and they make up about 25 to 35 percent.

Included with these soils in mapping are small areas of Wyard soils in shallow swales and depressions, Tonka soils in deeper depressions that are identified on the detailed map by a diamond symbol, and Hamerly soils around the edges of some of the depressions. Also included are a few areas of Emrick soils in concave positions and areas of Heimdal soils in convex positions.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas are cultivated. These soils are suited to grain crops, grasses, and legumes. Wetness in swales and depressions and soil blowing are the main concerns of management. Capability unit IIc–6; Svea soil is in windbreak suitability group 1, Barnes soil is in windbreak suitability group 3.

Svea-Barnes loams, 3 to 6 percent slopes (SvB).—These soils are on glacial till plains. Svea soils are on the lower back slopes, foot slopes, and toe slopes, and they make up about 45 to 55 percent of the mapping unit. Barnes soils are on summits, shoulder slopes, and upper back slopes, and they make up about 25 to 35 percent.

Included with these soils in mapping are small areas of Buse soils on summits and shoulder slopes, Wyard soils in shallow swales and depressions, Parnell soils and Tonka soils in deeper depressions that are identified on the detailed soil map by a diamond symbol, and Hamerly soils and Vallers soils around the edges of some of the depressions. Also included are a few small areas of Emrick soils on foot slopes and toe slopes and areas of Heimdal soils on back slopes. Soils in many cultivated areas have a lighter colored surface layer on the summits and shoulder slopes.

Surface runoff is medium, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas are cultivated. These soils are suited to grain crops, grasses, and legumes. Surface runoff, wetness in swales and depressions, and soil blowing are the main concerns of management. Capability unit IIe–6; Svea soil is in windbreak suitability group 1, Barnes soil is in windbreak suitability group 3.

Svea-Buse-Barnes loams, 6 to 9 percent slopes (SwC).—These soils are on glacial till plains. Svea soils are on the lower back slopes, foot slopes, and toe slopes, and they make up about 45 percent of the mapping unit. Buse soils are on summits and shoulder slopes, and Barnes soils are on back slopes; each makes up about 20 percent of the mapping unit.

Included with these soils in mapping are small areas of Parnell soils and Tonka soils in depressions that are identified on the detailed soil map by a diamond symbol and areas of Hamerly soils and Vallers soils around the edges of some of the depressions. Also included are a few small areas of Emrick soils on foot slopes and toe slopes, Esmond soils on summits and shoulder slopes, and Heimdal soils on back slopes. Soils in some cultivated areas have a lighter colored surface layer on the summits and shoulder slopes. Shallow gullies have formed in some drainageways.

Surface runoff is rapid, and water ponds in depressions. The hazard of soil blowing is slight on the Svea soils and Barnes soils. It is severe on the Buse soils.

Some areas are cultivated. The more steeply sloping areas are generally used for pasture. These soils are suited to grasses, close-growing grain crops, and legumes if protective measures are used. Surface runoff, wetness in depressions, and soil blowing are the main concerns of management. Capability unit IIIe–6; Svea soil is in windbreak suitability group 3, Buse soil is in windbreak suitability group 8, Barnes soil is in windbreak suitability group 3.

Svea-Cresbard loams (Sx).—These soils are nearly level and are on glacial till plains. Svea soils make up about 50 percent of the mapping unit, and Cresbard soils, in slightly lower positions, make up about 30 percent.

Included with these soils in mapping are small areas of Barnes soils in slightly higher positions, Parnell soils and Tonka soils in depressions that are identified on the detailed soil map by a diamond symbol, Hamerly soils and Vallers soils around the edges of some of the depressions, and Cavour soils in lower positions. Also included are small areas of the Svea variant. In some cultivated areas the surface layer is clay loam that is hard and cloddy when dry and sticky when wet, because some of the dense subsoil of the Cresbard soil has been mixed with the surface and subsurface layers.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. These soils are suited to grain crops and

grasses. Growth of crops is reduced on Cresbard soils, because the subsoil is dense and permeability is slow. Wetness, maintenance of good tilth in cultivated areas, and soil blowing are the main concerns of management. Capability unit IIIs–6P; Svea soil is in windbreak suitability group 1, Cresbard soil is in windbreak suitability group 4.

Svea Variant

The Svea variant is a moderately deep and deep, nearly level, moderately well drained soil. It formed in medium-textured and moderately fine textured glacial till that has a cobbly, stony, or gravelly contact layer at a depth of 18 to 36 inches. The contact layer separates two different glacial tills. This soil is on the smooth glacial till plain adjacent to entrenched streams west of McVille.

In a representative profile the surface layer is dark-gray loam about 13 inches thick. The subsoil is variegated grayish-brown and dark grayish-brown, friable loam about 7 inches thick. The substratum is 40 inches thick. The upper 5 inches is variegated sand and gravel. The next 11 inches is mottled, light brownish-gray sandy clay loam. Below this is 8 inches of mottled, light brownish-gray stratified coarse sand and clay loam till. The lowermost 16 inches is mottled, light-gray clay loam.

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

The soil is suited to grain crops, grasses, and legumes.

Representative profile of Svea loam, cobbly variant, in a cultivated field, 125 feet north and 225 feet east of the southwest corner of sec. 31, T. 150 N., R. 59 W., Nelson County:

Ap—0 to 5 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to moderate, medium, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A12—5 to 13 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, smooth boundary.

B2—13 to 20 inches, variegated grayish-brown and dark grayish-brown (10YR 5/2 and 4/2) loam, dark grayish brown and very dark grayish brown (10YR 4/2 and 3/2) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots; neutral; abrupt, smooth boundary.

IIC1—20 to 25 inches, variegated sand and gravel; common, medium, distinct, iron stains; single grained; loose, nonsticky and nonplastic; few roots; lime coatings on underside of pebbles; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC2—25 to 36 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, grayish brown (2.5Y 5/2) moist; few, medium, prominent, dark-red (2.5Y 3/6, moist) mottles; strong, very coarse, prismatic structure parting to moderate, coarse, subangular blocky; hard, firm, sticky and plastic; prominent continuous clay films on faces of prisms; common, medium segregations of white lime; slightly effervescent; mildly alkaline; clear, smooth boundary.

IIC3—36 to 44 inches, light brownish-gray (2.5Y 6/2) stratified coarse sand and clay loam till; grayish brown (2.5Y 5/2) moist; few, medium, prominent, strong-brown (7.5YR 5/6, moist) mottles; massive; hard, firm, sticky and plastic; common medium segregations of white lime; slightly effervescent; mildly alkaline; clear, smooth boundary.

IIIC4—44 to 54 inches, light-gray (5Y 6/1) clay loam, gray (5Y 5/1) moist; common, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; massive; hard, firm, sticky and plastic; common medium segregations of white lime; strongly effervescent; mildly alkaline; gradual, wavy boundary.

IIIC5—54 to 60 inches, light-gray (5Y 6/1) clay loam, gray (5Y 5/1) moist; common, medium, prominent, strong-brown (7.5YR 5/6, moist) mottles; massive; hard, firm, sticky and plastic; common fine segregations of white lime; strongly effervescent; mildly alkaline.

The Svea variant has a cobbly, stony, or gravelly contact layer between two deposits of glacial till at a depth of 18 to 36 inches, which the Svea soils do not have.

The A horizon ranges from 8 to 16 inches in thickness. It is very dark gray or dark-gray loam or silt loam. The B horizon ranges from 6 to 16 inches in thickness. It is grayish-brown, dark grayish-brown, or dark-gray loam, silt loam, or clay loam. It has moderate or weak prismatic structure that parts to moderate subangular blocky structure. In some places thin clay films or organic coats are on the faces of prisms in the B horizon. In some places a light brownish-gray loam or clay loam C horizon is above the IIC horizon, and it generally has an accumulation of lime. The IIC1 horizon, which separates the two glacial tills, is either a layer of stones or cobblestones imbedded in a loam matrix or 12 inches of sand and gravel. The IIIC horizon is light brownish-gray or light-gray glacial till of loam or clay loam. Bedded shale is in the lower part of some profiles.

The Svea variant is adjacent to the Edgeley variant and to Svea soils in many places. It has a profile similar to that of Svea soils. It lacks the weathered and bedded shale directly below the gravelly contact layer, which is a characteristic of the Edgeley variant. It has a gravelly contact layer at a depth of 18 to 36 inches, which Svea soils do not have.

Svea loam, cobbly variant (Su).—This soil is nearly level and is on the smooth glacial till plain adjacent to entrenched streams west of McVille.

Included with this soil in mapping are areas of Spottswood soils and Svea soils in similar positions, small areas of Barnes soils and Renshaw soils in slightly higher positions, Wyard soils in shallow swales and depressions, Tonka soils in deeper depressions that are identified on the detailed soil map by a diamond symbol, and Hamerly soils around the edges of some of the depressions. Also included are a few areas of the Edgeley variant in positions similar to those of the Svea variant.

Surface runoff is slow, and water ponds in swales and depressions. The hazard of soil blowing is slight.

Most areas are cultivated. This soil is suited to grain crops, grasses, and legumes. Wetness in swales and depressions and soil blowing are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 1.

Swenoda Series

The Swenoda series consists of deep, nearly level and gently undulating, moderately well drained soils that formed in moderately coarse textured glaciofluvial deposits overlying medium textured or moderately fine textured glacial till. These soils are on sand-mantled glacial till plains.

In a representative profile the surface layer is very dark gray fine sandy loam in the upper 8 inches and very dark grayish-brown sandy loam in the lower 10 inches. The subsoil is mottled, dark grayish-brown, very friable sandy loam about 10 inches thick. The substratum is mottled, grayish-brown loamy sand in the upper 2 inches, light-gray clay loam in the next 8 inches, and light brownish-gray clay loam in the lowermost 12 inches.

Permeability is moderately rapid in the surface layer, subsoil, and upper part of the substratum and moderately slow in the lower part of the substratum. The available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Swenoda fine sandy loam, in an area of Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes, in a cultivated field, 350 feet north and 525 feet east of the southwest corner of sec. 31, T. 149 N., R. 66 W., Eddy County:

Ap—0 to 8 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) moist; weak, medium and fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—8 to 18 inches, very dark grayish-brown (10YR 3/2) sand loam, very dark brown (10YR 2/2) moist; very weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; gradual, wavy boundary.

B2—18 to 28 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; few, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; mildly alkaline; gradual, wavy boundary.

C1—28 to 30 inches, grayish-brown (10YR 5/2) loamy sand, dark grayish brown (10YR 4/2) moist; few, medium, distinct, yellowish-brown (10YR 5/6, moist) mottles; very weak, medium, prismatic structure parting to single grained; soft, very friable, slightly sticky and nonplastic; few roots; mildly alkaline; abrupt, wavy boundary.

IIC2—30 to 38 inches, light-gray (2.5Y 7/2) clay loam, light brownish gray (2.5Y 6/2) moist; massive; hard, firm, sticky and plastic; strongly effervescent; moderately alkaline; gradual, wavy boundary.

IIC3—38 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; massive; hard, firm, sticky and plastic; slightly to strongly effervescent; moderately alkaline.

Depth to the glacial till IIC horizon ranges from 20 to 40 inches. The A horizon ranges from 12 to 20 inches in thickness. It is very dark gray, dark-gray, or very dark grayish-brown sandy loam or fine sandy loam. The B horizon ranges from 10 to 20 inches in thickness. It is sandy loam or fine sandy loam. The C horizon ranges from 0 to 12 inches in thickness. It is mottled, grayish-brown, brown, or yellowish-brown sandy loam, fine sandy loam, loamy sand, or loamy fine sand. The IIC horizon is light-gray or light brownish-gray glacial till of loam or clay loam, and it is calcareous in most places.

Swenoda soils are adjacent to and have profile characteristics similar to those of Embden, Emrick, and Heimdal soils in many places. They have glacial till at a depth between 20 and 40 inches, which Embden soils do not have. They are deeper to glacial till than Emrick soils and Heimdal soils.

Swenoda-Embden fine sandy loams (Sz).—These soils are nearly level and are on sand-mantled glacial till plains. The sand overlying the glacial till is less than 1 foot to more than 5 feet deep. Swenoda and Embden soils each make up about 40 percent of the mapping unit.

Included with these soils in mapping are small areas of Egeland soils and Heimdal soils in convex positions, Emrick soils in positions similar to those of Swenoda soils and Embden soils, Kratka soils and Tiffany soils in swales and depressions that are identified on the detailed soil map by a diamond symbol, and Wyndmere soils around the edges of some of the depressions. Also included are a few areas of soils that have a surface layer of sandy loam.

Surface runoff is slow, and water ponds in swales and depressions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. These soils are suited to grain crops, grasses, and legumes. Soil blowing and wetness in swales and depressions are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Tiffany Series

The Tiffany series consists of deep, nearly level, poorly drained soils that formed in moderately coarse textured glaciofluvial deposits over coarse textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains and sand-mantled glacial till plains.

In a representative profile the surface layer is dark-gray sandy loam about 16 inches thick that has mottles in the lower 10 inches. The subsoil is mottled, grayish-brown, very friable sandy loam about 9 inches thick. The substratum is 35 inches thick. In the upper 15 inches it is mottled light olive-brown loamy sand. In the 8 inches below that it is light brownish-gray fine sand, and in the next 6 inches it is grayish-brown sand. In the lowermost 14 inches it is light brownish-gray sand.

Permeability is moderately rapid, and the available water capacity is low. The organic-matter content is high, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in spring and early in summer. Tillage is often delayed in spring because of wetness.

These soils are suited to grasses and, if drained, to small grains and legumes.

Representative profile of Tiffany sandy loam in a cultivated field, 75 feet south and 800 feet east of the northwest corner of the NE¼, sec. 31, T. 151 N., R. 62 W., Benson County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to moderate, fine, crumb; soft, very friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A12—6 to 16 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; common, fine, faint, very dark grayish-brown (10YR 3/2, moist) mottles; weak, medium, prismatic structure parting to weak, medium and fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; neutral; clear, smooth boundary.

B2g—16 to 25 inches, grayish-brown (2.5Y 5/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, very dark grayish-brown (10YR 3/2, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots; neutral; clear, smooth boundary.

C1g—25 to 28 inches, light olive-brown (2.5Y 5/4) loamy sand, olive brown (2.5Y 4/4) moist; common, medium, distinct, dark-brown (10YR 3/3, moist) mottles; very weak, coarse, prismatic structure parting to single grained; soft, very friable, slightly sticky and nonplastic; few roots; few concretions of iron; neutral; gradual, smooth boundary.

C2g—28 to 40 inches, light olive-brown (2.5Y 5/4) loamy sand, olive brown (2.5Y 4/4) moist; common, medium, distinct, dark yellowish-brown (10YR 3/4, moist) mottles; very weak, coarse, prismatic structure parting to single grained; soft, very friable, slightly sticky and nonplastic; few roots; few concretions of iron; neutral; clear, smooth boundary.

C3g—40 to 48 inches, light brownish-gray (2.5Y 6/2) fine sand, dark grayish brown (2.5Y 4/2) moist; many, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

C4g—48 to 54 inches, grayish-brown (2.5Y 5/2) sand, dark grayish brown (2.5Y 4/2) moist; common fine, distinct, light yellowish-brown (10YR 6/4, moist) mottles; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

C5g—54 to 60 inches, light brownish-gray (2.5Y 6/2) sand, grayish brown (2.5Y 5/2) moist; many, medium, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; single grained; loose, nonsticky and nonplastic; neutral.

The A horizon ranges from 8 to 18 inches in thickness. It is dark-gray or very dark gray fine sandy loam, sandy loam, or loam. Mottles are common below a depth of 10 inches, but they are within 5 inches of the surface in some places. The B horizon ranges from 5 to 12 inches in thickness. It is mottled, grayish-brown or dark-gray fine sandy loam or sandy loam. The C horizon is mottled, light olive brown, light brownish gray, grayish brown, or light olive gray. Typically, the soil material is noncalcareous, but the C horizon is calcareous in some places. Glacial till is below a depth of 36 inches where the soil is in sand-mantled glacial till plains.

Tiffany soils are adjacent to Embden, Venlo, and Wyndmere soils in many places. They are more poorly drained than Embden soils. They are better drained than Venlo soils. They lack the accumulation of lime in the upper part of the C horizon, which is a characteristic of Wyndmere soils.

Tiffany sandy loam (Tf).—This soil is nearly level and is in depressions on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Hamar soils and Wyndmere soils in slightly higher positions and Arveson, Fossum, and Venlo soils in slightly lower positions. Also included are small areas of soils that have a surface layer of fine sandy loam or loam.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay where they are associated with the more poorly drained soils. This soil is suited to grasses and, if drained, to small grains and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Tiffany fine sandy loam, till substratum (Tg).—This soil is nearly level and is in depressions and swales on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but the surface texture is fine sandy loam and glacial till is below a depth of 36 inches.

Included with this soil in mapping are small areas of Kratka soils in positions similar to those of Tiffany soils and small areas of Fram soils and Wyndmere soils in slightly higher positions.

Surface runoff is very slow. The hazard of soil blowing is very severe.

Most areas are cultivated. This soil is suited to grasses and, if drained, to small grains and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIw–3; windbreak suitability group 2.

Tolna Series

The Tolna series consists of moderately deep, nearly level, somewhat poorly drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are in shallow swales and depressions on glacial outwash plains.

In a representative profile the surface layer is dark-gray loam about 6 inches thick. The subsoil is about 24 inches thick. The upper 3 inches is dark grayish-brown friable loam. Below that is 8 inches of light brownish-gray friable loam. The lowermost 13 inches is mottled, pale-olive, very friable to loose, heavy fine sandy loam. The substratum is shaly coarse sand and gravel that is mottled and light brownish gray in the upper 10 inches and is variegated light olive gray and light brownish gray in the lower 20 inches.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is high, and fertility is medium. Drains are difficult to install because outlets generally are not available.

These soils are suited to grasses and, if drained, to small grains and legumes.

Representative profile of Tolna loam, in a cultivated field, 1,000 feet south and 200 feet west of the northeast corner of the NW¼ sec. 18, T. 149 N., R. 64 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, fine, granular and very fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many roots; few rounded pebbles of shale 10 millimeters or less in diameter; medium acid; abrupt, smooth boundary.

B21—6 to 9 inches, dark grayish-brown (2.5Y 4/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate, medium, prismatic structure parting to moderate, coarse and medium, platy; hard, friable, sticky and slightly plastic; common roots; very dark gray (10YR 3/1, moist), thin, continuous clay films on faces of prisms; few bleached sand grains on faces of peds; common shale pebbles as large as 20 millimeters; medium acid; clear, wavy boundary.

B22—9 to 17 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; few, fine, faint, yellowish-brown (10YR 5/4, moist) mottles; moderate, medium, prismatic structure parting to moderate, coarse and medium, platy; hard, friable,

sticky and slightly plastic; common roots; dark-gray (2.5Y 4/1, moist), thin, continuous clay films and few bleached sand grains on faces of peds; common shale pebbles as large as 10 millimeters; medium acid, clear, wavy boundary.

B3—17 to 30 inches, pale-olive (5Y 6/3) heavy fine sandy loam, olive (5Y 4/3) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; very weak, coarse, prismatic structure parting to weak, coarse, medium and fine, subangular blocky; soft, very friable to loose, slightly sticky and very slightly plastic; few roots; medium acid; clear, wavy boundary.

IIC1—30 to 40 inches, light brownish-gray (2.5Y 6/2) shaly coarse sand and gravel, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; single grained; loose, nonsticky and nonplastic; common fragments of shale as large as 30 millimeters and few as large as 40 millimeters; slightly acid; clear, wavy boundary.

IIC2—40 to 60 inches, variegated light olive-gray (5Y 6/2) and light brownish-gray (2.5Y 6/2) shaly coarse sand and gravel, olive gray (5Y 4/2) and dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; common shale gravel that ranges from 2 to 30 millimeters and a few that range from 30 to 50 millimeters; slightly effervescent; mildly alkaline.

Depth to the sand and gravel substratum ranges from 16 to 40 inches but typically is 24 to 30 inches. The A horizon ranges from 6 to 10 inches in thickness. It is dark gray or very dark gray. The B2 horizon ranges from 10 to 16 inches in thickness. It is dark grayish-brown, light brownish-gray, and grayish-brown loam or heavy sandy loam. In most places, clay films and bleached sand grains are on the faces of prisms. The B3 horizon ranges from 5 to 13 inches in thickness. It is grayish-brown or pale-olive sandy loam to sandy clay loam. The IIC horizons are typically stratified shaly sand and gravel, but they contain a layer of granitic sand and gravel in some places. Lime coats the undersides of pebbles in the lower part of the IIC horizon in some places.

Tolna soils are adjacent to Binford, Brantford, Kensal, and Walum soils in many places. All of these soils are underlain by shaly coarse-textured deposits. Tolna soils are more poorly drained than Binford, Brantford, Kensal, and Walum soils.

Tolna loam (Tn).—This soil is nearly level and is in shallow swales and depressions on glacial outwash plains that contain a high percentage of shale.

Included with this soil in mapping are small areas of Binford, Brantford, Kensal, and Walum soils in slightly higher, better drained positions.

Surface runoff is ponded. The hazard of soil blowing is slight. Tillage is often delayed because of wetness in spring and in summer after heavy rains.

Most areas are cultivated. This soil is suited to grasses and, if drained, to small grains and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIw–6; windbreak suitability group 2.

Tonka Series

The Tonka series consists of deep, nearly level, poorly drained soils that formed in medium-textured local alluvium-colluvium overlying medium-textured and moderately fine textured glacial till. These soils are in swales and depressions on glacial till plains.

In a representative profile the surface layer is mottled, dark-gray silt loam about 7 inches thick. The subsurface layer is mottled, light-gray, very fine sandy loam about 4 inches thick. The subsoil is mottled gray, firm clay loam about 17 inches thick. The substratum is mottled, gray loam 32 inches thick.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils receive runoff from the surrounding higher lying areas in spring and during periods of heavy rainfall. Drains are difficult to install because outlets generally are not available.

These soils are suited to grasses and, where drained, to grain crops and legumes.

Representative profile of Tonka silt loam, in a cultivated field, 200 feet north and 1,000 feet east of the southwest corner of sec. 28, T. 149 N., R. 67 W., Eddy County:

Ap—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; few, fine, faint, yellowish-brown (10YR 5/4, moist) mottles; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—5 to 7 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; common, fine, faint, yellowish-brown (10YR 5/4, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, platy; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, smooth boundary.

A2—7 to 11 inches, light-gray (2.5Y 7/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) mottles; weak, coarse, prismatic structure parting to moderate, fine, platy; slightly hard, very friable, slightly sticky and slightly plastic; many roots; neutral; clear, smooth boundary.

B21t—11 to 19 inches, gray (5Y 5/1) clay loam, dark gray (5Y 4/1) moist; many, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; moderate, medium, prismatic structure parting to weak, medium, platy, hard, firm, sticky and plastic; common roots; neutral; gradual, smooth boundary.

B22t—19 to 28 inches, gray (5Y 5/1) clay loam, dark gray (5Y 4/1) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; moderate, medium, prismatic structure parting to moderate, fine, angular blocky; hard, firm, sticky and plastic; few roots; neutral; clear, wavy boundary.

C—28 to 60 inches, gray (5Y 6/1) loam, dark gray (5Y 4/1) moist; many, coarse, prominent, yellowish-brown (10YR 5/4, moist) mottles; massive; hard, friable, slightly sticky and slightly plastic; neutral.

The A1 horizon ranges from 6 to 20 inches in thickness. It is dark-gray or very dark gray silt loam, loam, or light silty clay loam. The A2 horizon ranges from 4 to 18 inches in thickness. It is light-gray, gray, or grayish-brown very fine sandy loam, loam, or silt loam. The B2 horizon ranges from 10 to 20 inches in thickness. It is clay loam, silty clay loam, or silty clay. The substratum is gray or olive-gray loam or clay loam.

Tonka soils are adjacent to Parnell, Vallers, and Wyard soils in many places. They have a platy A2 horizon, which the Parnell soils do not have. They have a B horizon, which the Vallers soils do not have. They have a more strongly developed B2t horizon and are more poorly drained than Wyard soils.

Tonka silt loam (To).—This soil is nearly level and is in swales and depressions on glacial till plains.

Included with this soil in mapping are small areas of Parnell soils in positions similar to those of Tonka soils. Also included are small areas of Fram, Hamerly,

and Vallers soils around the edges of some of the depressions

Surface runoff is ponded. The hazard of soil blowing is slight.

Many areas are used for pasture, hay, or are left idle and used for wildlife habitats. Tillage is often delayed because of wetness, and crops drown in places after periods of heavy rainfall. This soil is better suited to grasses and wetland vegetation than to most other uses. If drained, it is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–6; windbreak suitability group 2.

Totten Series

The Totten series consists of moderately deep, nearly level, poorly drained and very poorly drained, claypan soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains and in meltwater channels.

In a representative profile the surface layer is very dark gray loam about 5 inches thick. The subsoil is about 21 inches thick. The upper 5 inches is dark-gray, friable sandy clay loam. The next 7 inches is light-gray, friable sandy clay loam. The lower 9 inches is mottled, light-gray, friable loam that contains an accumulation of lime. The substratum is 34 inches thick. The upper 8 inches is mottled, light yellowish-brown coarse sand. Below this is 6 inches of light yellowish-brown gravelly coarse sand. The lowermost 20 inches is variegated light olive-brown and light yellowish-brown stratified coarse sand, gravelly coarse sand, and sandy gravel.

Permeability is moderately slow in the surface layer and subsoil and rapid in the substratum. The available water capacity is low. The organic-matter content is medium, and fertility is low. The water table is within 5 feet of the surface most of the year and at or near the surface in spring and early in summer. A perched water table forms above the dense subsoil during periods of heavy rainfall. The dense subsoil and the salts in the subsoil limit root and water penetration. Tillage is often delayed in spring because of wetness.

These soils are suited to salt-tolerant grasses and, if drained, to salt-tolerant small grains.

Representative profile of Totten loam, in a cultivated field, 180 feet south and 90 feet west of the northeast corner of the NW¼ sec. 7, T. 149 N., R. 65 W., Eddy County:

Ap—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, fine, angular blocky structure parting to moderate, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; few pebbles as large as 5 millimeters; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

B21t—5 to 10 inches, dark-gray (10YR 4/1) sandy clay loam, very dark gray (10YR 3/1) moist; interior of prisms are light brownish gray (2.5Y 6/2) moist; moderate, very coarse, prismatic structure parting to strong, fine and very fine, angular blocky; hard, friable, sticky and plastic; common roots; bleached sand grains coat faces of prisms; violently effervescent in ped interiors and strongly effervescent on ped exteriors; moderately alkaline; clear, irregular boundary.

B22t—10 to 17 inches, light-gray (2.5Y 7/2) sandy clay loam, light olive brown (2.5Y 5/4) moist; many, fine and medium, distinct, yellowish-brown (10YR 5/6, moist) and gray (5Y 6/1, moist) mottles; very dark gray (10YR 3/1, moist) coatings on faces of prisms; moderate, very coarse, prismatic structure parting to moderate, fine and very fine, angular blocky; hard, friable, slightly sticky and slightly plastic; few roots; diffuse lime in interiors of peds; violently effervescent; moderately alkaline; gradual, wavy boundary.

B3ca—17 to 26 inches, light-gray (5Y 7/1) loam, olive gray (5Y 5/2) moist; many, fine and medium, prominent, yellowish-brown (10YR 5/6, moist), many, medium, distinct, gray (5Y 6/1, moist), and few, fine, prominent, black (10YR 2/1, moist) mottles; discontinuous coatings of dark grayish brown (2.5Y 4/2) on faces of prisms; moderate, very coarse, prismatic structure parting to moderate, coarse and medium, platy and moderate and strong, fine and very fine, angular blocky; hard, friable, slightly sticky and slightly plastic; few roots; slightly effervescent; strongly effervescent in interior of peds; moderately alkaline; clear, irregular boundary.

IIC1—26 to 34 inches, light yellowish-brown (2.5Y 6/4) coarse sand, light olive brown (2.5Y 5/4) moist; few, fine, prominent, black (10YR 2/1, moist) mottles; single grained; slightly hard, loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIC2—34 to 40 inches, light yellowish-brown (10YR 6/4) gravelly coarse sand, dark yellowish brown (10YR 4/4) moist; single grained; loose, nonsticky and nonplastic; 25 percent by volume fragments coarser than 2 millimeters; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC3—40 to 60 inches, variegated light olive-brown and light yellowish-brown (2.5Y 5/4 and 10YR 6/4) stratified coarse sand, gravelly coarse sand, and sandy gravel, olive brown and brown (2.5Y 4/4 and 10YR 5/3) moist; single grained; loose, nonsticky and nonplastic; 10 percent to more than 60 percent by volume fragments coarser than 2 millimeters in some strata; strongly effervescent; moderately alkaline.

Depth to the sand and gravel substratum ranges from 15 to 40 inches, but typically is 20 to 30 inches. The A horizon ranges from 5 to 12 inches in thickness. It is dark-gray or very dark gray silt loam, loam, or sandy loam. The B2 horizon ranges from 10 to 20 inches in thickness. It is light brownish-gray, dark-gray, gray, or light-gray sandy clay loam or clay loam. It has strong to weak prismatic structure that parts to strong or moderate angular blocky structure.

Organic coatings and bleached sand grains are on the faces of prisms in most places. The interior of the peds in the B2 horizon vary considerably in color, amount of visible salts, and content of lime within short distances. Some profiles are highly convoluted and the B2 horizon contains material from the B3 and IIC horizons.

The B3 horizon ranges from 0 to 12 inches in thickness. It is mottled, light-gray or gray sandy clay loam, loam, or sandy loam. It has weak or moderate prismatic structure that parts to weak or moderate platy and angular blocky structure. The IIC horizons are typically stratified granitic sand and gravel, but in some areas they contain mainly stratified shaly sand and gravel. Glacial till is below a depth of 40 inches in some places.

Totten soils are adjacent to Divide, Lemert, and Marysland soils in many places. They have an alkaline B2t horizon, which Divide and Marysland soils do not have. They contain more clay in the A and B horizons than Lemert soils.

Totten sandy loam (Ts).—This soil is nearly level and is on glacial outwash plains and in meltwater channels. It has a profile similar to the one described as representative of the series, but it has a surface layer of sandy loam.

Included with this soil in mapping are small areas

of Totten loam and Totten loam, very wet. Also included are Lemert, Wyrene, and Marysland soils and some cultivated areas where the soils have a surface layer that is lighter colored and is hard and cloddy when dry and sticky when wet because some of the subsoil has been mixed with the surface layer (fig. 15).

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Some areas are cultivated, and others are in hay and pasture. This soil is better suited to salt-tolerant grasses than to most other uses, and, if drained, it is suited to salt-tolerant small grains. Growth of most crops is reduced because the subsoil is dense and permeability is moderately slow. Wetness, soil blowing, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IVws–3; windbreak suitability group 9.

Totten loam (Tt).—This soil is nearly level and is on glacial outwash plains and in meltwater channels. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Totten sandy loam, Divide soils, Warsing soils in slightly higher positions, and areas of Marysland soils and Totten loams, very wet, in slightly lower positions. In some cultivated areas the soils have a surface layer that is lighter colored and is hard and cloddy when dry and sticky when wet because some of the subsoil has been mixed with the surface layer.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is slight.

Some areas are cultivated, but others are in hay and pasture. This soil is better suited to salt-tolerant grasses than to most other uses, and, if drained, it is suited to salt-tolerant small grains. Growth of most crops is reduced because the subsoil is dense and permeability is moderately slow. Wetness, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IVws–6; windbreak suitability group 9.

Totten loam, very wet (Tu).—This soil is nearly level and is in depressions on glacial outwash plains and in meltwater channels.

Figure 15.—**Totten soils have a cloddy surface layer after a seedbed has been prepared.**

Included with this soil in mapping are small areas of Borup soils and Marysland soils in similar positions. Also included are small areas of Totten loam and Divide soils in slightly higher positions. In some cultivated areas the soils have a surface layer that is lighter colored and is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface layer.

Surface runoff is ponded. The water table is within 3 feet of the surface most of the year and at the surface for longer periods early in summer. Drains are difficult to install because outlets are not generally available.

Most areas are used for hay and pasture, but some are cultivated along with the adjoining better drained soils. This soil is better suited to salt-tolerant grasses than to most other uses. Wetness, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit Vw–8; windbreak suitability group 10.

Totten loam, till substratum (Tv).—This soil is nearly level and is on glacial outwash plains and in meltwater channels. It has a profile similar to the one described as representative of the series, but glacial till is below a depth of about 40 inches.

Included with this soil in mapping are small areas of Totten sandy loam and Divide soils in similar positions. Also included are small areas of Marysland soils and Totten loams, very wet, in slightly lower positions. In some cultivated areas the soils have a surface layer that is lighter colored and is hard and cloddy when dry and sticky when wet because some of the subsoil has been mixed with the surface layer.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is slight.

Some areas are cultivated, and others are in hay and pasture. This soil is better suited to salt-tolerant grasses than to most other uses, and, if drained, it is suited to salt-tolerant small grains. Growth of most crops is reduced because the subsoil is dense and permeability is moderately slow. Wetness, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IVws–6; windbreak suitability group 9.

Towner Series

The Towner series consists of deep, nearly level and gently undulating, moderately well drained soils that formed in coarse-textured deposits underlain by glacial till. These soils are on sand-mantled glacial till plains.

In a representative profile the surface layer is very dark gray fine sandy loam about 18 inches thick. The substratum is 42 inches thick. The upper 9 inches is dark grayish-brown, very friable loamy fine sand. Below that is 19 inches of light olive-brown loam. The next 10 inches is light olive-brown sand. The lower most 4 inches is mottled, pale-yellow loam.

Permeability is rapid in the surface layer and subsoil and moderately slow in the substratum. The available water capacity is moderate. The organic-matter content is high, and fertility is medium. A perched

water table forms above the glacial till substratum during periods of heavy rainfall.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Towner fine sandy loam, 0 to 3 percent slopes, in a cultivated field, 50 feet south and 1,600 feet east of the northwest corner of sec. 19, T. 148 N., R. 63 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) moist; moderate, fine subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A12—6 to 18 inches, very dark gray (10YR 3/1) light fine sandy loam, black (10YR 2/1) moist; moderate and weak, fine subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many roots; neutral; gradual, wavy boundary.

C—18 to 27 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; very weak, coarse, prismatic structure parting to single grained; soft, very friable, slightly sticky and nonplastic; common roots; few pebbles as large as 5 millimeters; mildly alkaline; abrupt, wavy boundary.

IIC2—27 to 46 inches, light olive-brown (2.5Y 5/4) loam, olive brown (2.5Y 4/4) moist; massive; hard, friable, sticky and plastic; few roots; few pebbles as large as 30 millimeters; moderately alkaline; abrupt, wavy boundary.

IIIC3—46 to 56 inches, light olive-brown (2.5Y 5/4) sand, olive brown (2.5Y 4/4) moist; single grained; loose, nonsticky and nonplastic; few pebbles as large as 20 millimeters; moderately alkaline; abrupt, wavy boundary.

IVC4—56 to 60 inches, pale-yellow (2.5Y 7/3) loam, light olive brown (2.5Y 5/4) moist; few, fine, distinct, dark yellowish-brown (10YR 3/4, moist) mottles; massive; hard, friable, sticky and plastic; common fine segregations of lime; strongly effervescent; moderately alkaline.

Depth to glacial till ranges from 20 to 40 inches. The A horizon ranges from 16 to 23 inches in thickness. It is very dark gray or dark-gray fine sandy loam or sandy loam. The lower part of the A horizon is loamy fine sand or loamy sand in places. The C horizon ranges from 8 to 12 inches in thickness. It is dark grayish-brown or grayish-brown loamy fine sand or loamy sand. Mottles are in the C horizon in some places. Typically, the IIC horizon is loam or glacial till of clay loam that is broken by pockets or layers of coarser textured material, but in some places the IIC horizon is on glacial till.

Towner soils are adjacent to Dickey, Emrick, Hecla, Maddock, and Svea soils in many places. They have a thicker A horizon than Dickey soils. They have coarser textured A and C horizons than Emrick and Svea soils. They lack a B horizon, which is a characteristic of Emrick and Svea soils. They have glacial till at a depth of 20 to 40 inches, which Hecla soils and Maddock soils do not have.

Towner fine sandy loam, 0 to 3 percent slopes (TwA).—This soil is on sand-mantled glacial till. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Dickey, Heimdal, and Maddock soils in convex positions, Emrick soils and Hecla soils in positions similar to those of Towner soils, and Hamar soils and Kratka soils in shallow swales. Some areas of this soil have been reworked to some extent by soil blowing. Also included are some soils that are underlain by bedded shale instead of glacial till. They are adjacent to the Sheyenne River Valley and drainageways leading to the Sheyenne River and make up about 10 percent of the acreage.

Surface runoff is slow, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas are cultivated, and some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and wetness in swales are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Towner fine sandy loam, 3 to 6 percent slopes (TwB).—This soil is on sand-mantled glacial till.

Included with this soil in mapping are small areas of Dickey, Heimdal, and Maddock soils on summits, shoulder slopes, and upper back slopes. Also included are areas of Emrick soils and Hecla soils on lower back slopes, foot slopes, and toe slopes and Hamar soils and Kratka soils in shallow swales. This soil has been reworked to some extent by soil blowing in some areas.

Surface runoff is medium, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing, surface runoff, and wetness in swales are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Towner-Dickey fine sandy loams (Tx).—These soils are nearly level and are on sand-mantled glacial till. Towner soils are in plane and concave positions and make up about 50 percent of the mapping unit. Dickey soils are in convex positions and make up about 30 percent.

Included with these soils in mapping are small areas of Heimdal soils and Maddock soils in convex positions. Also included are areas of Emrick soils and Hecla soils in flat and concave positions and Hamar soils and Kratka soils in shallow swales. These soils have been reworked to some extent by soil blowing in some areas.

Surface runoff is slow, and water ponds in swales. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. These soils are suited to grain crops, grasses, and legumes. Soil blowing and wetness in swales are the main concerns of management. Capability unit IIIe–3M; Towner soil is in windbreak suitability group 1, Dickey soil is in windbreak suitability group 5.

Vallers Series

The Vallers series consists of deep, nearly level, poorly drained, calcareous soils that formed in medium-textured and moderately fine textured glacial till. These soils are in depressions and drainageways on glacial till plains.

In a representative profile the surface layer is dark-gray loam about 8 inches thick. The substratum is 42 inches thick and has an accumulation of lime in the upper 28 inches. The upper 11 inches is mottled, variegated gray and light-gray, friable clay loam. Below this is 6 inches of light-gray loam. The next 11 inches is mottled white loam and then 4 inches of mottled light-gray loam. The next 6 inches is mottled, gray loam. The lowermost 4 inches is mottled olive loam.

Permeability is moderately slow, and the available

water capacity is high. The organic-matter content is high, and fertility is medium. The water table is within 3 feet of the surface most of the year and at or near the surface in spring and early in summer. Drains are difficult to install because outlets generally are not available.

These soils are suited to grasses and, where drained, to grain crops and legumes.

Representative profile of Vallers loam, in a hay field, 150 feet south and 120 feet west of the northeast corner of sec. 16, T. 149 N., R. 67 W., Eddy County:

A1—0 to 8 inches, dark-gray (N 4/0) loam, black (10YR 2/1) moist; moderate, medium, subangular blocky structure; slightly hard, friable, slighty sticky and slightly plastic; many roots; strongly effervescent; mildly alkaline; clear, smooth boundary.

C1gca—8 to 19 inches, variegated gray and light-gray (N 5/0 and 7/0) and light yellowish-brown (10YR 6/4) clay loam, dark gray and light gray (N 4/0 and 6/0) and yellowish brown (10YR 5/4) moist; weak, medium, platy subangular blocky and crumb structure; hard, friable, sticky and plastic; common roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2gca—19 to 25 inches, light-gray (N 6/0) loam, gray (5Y 5/1) moist; weak, fine, granular structure; hard, friable, slightly sticky and slighty plastic; few roots; few pebbles; violently effervescent; moderately alkaline; gradual, wavy boundary.

C3gca—25 to 36 inches, white (N 8/0) loam, light gray (5Y 6/1) moist; few, fine, distinct, dark yellowish-brown (10YR 4/4, moist) mottles; massive; hard, friable, slightly sticky and slightly plastic; few roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C4g—36 to 40 inches, light-gray (5Y 6/1) loam, gray (5Y 5/1) moist; many, coarse, distinct, yellowish-brown (10YR 5/4, moist) mottles; massive; hard, firm, slightly sticky and slightly plastic; few roots; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C5g—40 to 46 inches, gray (5Y 5/1) loam, dark gray (5Y 4/1) moist; many, coarse, distinct, yellowish-brown (10YR 5/4, moist) mottles; massive; hard, firm, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; clear, wavy boundary.

C6g—46 to 60 inches, olive (5Y 5/3) loam, olive (5Y 4/3) moist; many, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; massive; hard, firm, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 8 to 14 inches in thickness. It is very dark gray or dark-gray loam, silt loam, or clay loam. Typically, the A horizon is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon ranges from 8 to 30 inches in thickness. It is gray, light-gray, or white loam or clay loam. The C horizon is mottled, light-gray, gray, or olive loam or clay loam. In most places pebbles are few to common throughout the profile, and in some places stones are on the surface. In some places gypsum and soluble salts are in the lower part of the A horizon and upper part of the C horizon; they adversely affect plant growth.

Vallers soils are adjacent to Fram, Hamerly, Parnell, and Tonka soils in many places. They are not so well drained as Fram soils and Hamerly soils. They have an accumulation of lime that is closer to the surface than Parnell and Tonka soils, and they lack a B horizon, which is a characteristic of Parnell soils and Tonka soils.

Vallers loam (Va).—This soil is nearly level and is in depressions and drainageways on glacial till plains. Included with this soil in mapping are small areas of Fram soils and Hamerly soils in slightly higher positions and Parnell soils and Tonka soils in slightly lower positions. Also included are small areas of saline and claypan soils. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is very slow, and water ponds in some areas. Tillage is often delayed because of wetness. The hazard of soil blowing is severe.

Some areas are cultivated; others are used for pasture and hay. These soils are suited to grasses and, where drained, to grain crops and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Vang Series

The Vang series consists of moderately deep, nearly level, well-drained soils that formed in medium-textured glaciofluvial deposits over coarse textured shaly glaciofluvial deposits. These soils are in slight depressions on glacial outwash plains.

In a representative profile the surface layer is very dark gray loam about 12 inches thick. The subsoil is dark grayish-brown, friable loam about 6 inches thick. The substratum is 42 inches thick. The upper 15 inches is light brownish-gray loam that has an accumulation of lime in the lower 9 inches. The lowermost 27 inches is grayish-brown stratified shaly gravel and sand.

Permeability is moderate in the surface layer, the subsoil, and in the upper part of the substratum. It is very rapid in the lower part of the substratum. The available water capacity is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Vang loam, in a cultivated field, 800 feet south and 550 feet west of the northeast corner of sec. 30, T. 151 N., R. 64 W., Benson County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; abrupt, smooth boundary.

A1—7 to 12 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; neutral; clear, wavy boundary.

B2—12 to 18 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure parting to hard, friable, slightly sticky and slightly plastic; few roots; few fragments of shale as large as 10 millimeters; neutral; clear, wavy boundary.

C1—18 to 24 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak, medium and fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots; common pebbles as large as 4 millimeters and as large as 15 millimeters; slightly effervescent; mildly alkaline; clear, wavy boundary.

C2ca—24 to 33 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common pebbles and fragments of shale as large as 4 millimeters and few as large as 15 millimeters; violently effervescent; mildly alkaline; abrupt, smooth boundary.

IIC1—33 to 46 inches, grayish-brown (2.5Y 5/2) shaly

gravel, dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC2—46 to 60 inches, grayish-brown (2.5Y 5/2) shaly sand and gravel; dark grayish brown (2.5Y 4/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

Depth to the shaly sand and gravel substratum ranges from 20 to 40 inches. The A horizon ranges from 6 to 12 inches in thickness. It is very dark gray and dark gray. The B horizon ranges from 6 to 16 inches in thickness. It is dark grayish brown or grayish brown. It has weak or moderate prismatic structure that parts to weak or moderate subangular blocky structure. The C horizon ranges from 0 to 16 inches in thickness. It is light brownish gray or grayish brown. It contains an accumulation of lime in some places.

The IIC horizons are typically stratified shaly sand and gravel, but they are granitic sand and gravel in some places. In some profiles, lime has accumulated in the upper part of the IIC horizon, and lime coats the underside of pebbles in one or more of the IIC horizons.

Vang soils are adjacent to Brantford, Kensal, and Tolna soils in many places. They are deeper to the sand and gravel substratum than Brantford and Kensal soils, and they are better drained than Tolna and Kensal soils.

Vang loam (Vn).—This soil is nearly level and is in slight depressions on shaly glacial outwash plains.

Included with this soil in mapping are small areas of Brantford, Gardena, and Kensal soils in positions similar to those of Vang soils. Also included are small areas of Vang soils that have a slope of 3 to 6 percent.

Surface runoff is slow, and water ponds in slight depressions. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness in depressions and soil blowing are the main concerns of management. Capability unit IIs–6; windbreak suitability group 3.

Venlo Series

The Venlo series consists of deep, nearly level, very poorly drained soils that formed in coarse-textured glaciofluvial deposits. These soils are in depressions on glacial outwash plains.

In a representative profile the surface layer is very dark gray sandy loam in the upper 7 inches and mottled, dark-gray loamy sand in the lower 8 inches. The substratum is 45 inches thick. The upper 6 inches is mottled, gray loose loamy sand. The next 3 inches is mottled, gray sand. The 8 inches below that is dark-gray sandy loam. The lowermost 28 inches is gray sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate, and fertility is medium. The water table is within 3 feet of the surface most of the year, and it is at or near the surface in spring and early in summer. Drains are difficult to install because outlets are not generally available.

These soils are suited to grasses.

Representative profile of Venlo sandy loam, in a hay field, 1,300 feet north and 500 feet west of the southeast corner of sec. 4, T. 150 N., R. 63 W., Eddy County:

A11—0 to 7 inches, very dark gray (N 3/0) sandy loam, black (N 2/0) moist; weak, medium and fine, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many roots; medium acid; gradual, smooth boundary.

A12—7 to 15 inches, dark-gray (5Y 4/1) moist; many, fine, faint, very dark-brown (10YR 2/2, moist) mottles; weak, fine, subangular blocky structure; soft, very friable, slightly sticky and nonplastic; common roots; slightly acid; clear, smooth boundary.

C1g—15 to 21 inches, gray (5Y 6/1) loamy sand, dark gray (5Y 4/1) moist; common, fine, faint, very dark-brown (10YR 2/2, moist) mottles; very weak, fine, subangular blocky structure and single grained; loose, slightly sticky and nonplastic; few roots; neutral; gradual, smooth boundary.

C2g—21 to 24 inches, gray (5Y 6/1) sand, dark gray (5Y 4/1) moist; common, fine, faint, grayish-brown (10YR 5/2, moist) mottles; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

IIAb—24 to 32 inches, dark-gray (5Y 4/1) sandy loam, very dark gray (5Y 3/1) moist; weak, medium, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

IICg—32 to 60 inches, gray (5Y 6/1) sand, dark gray (5Y 4/1) moist; single grained; loose, nonsticky and nonplastic; mildly alkaline.

The A horizon ranges from 10 to 20 inches in thickness. It is dark-gray or very dark gray sandy loam or loamy sand. The C horizon is mottled, gray, light-gray, light olive-gray, or light greenish-gray loamy sand or sand. Some profiles have a buried A horizon of dark-gray sandy loam. Typically, the soil material is noncalcareous, but it is slightly calcareous in the lower profile in a few areas.

Venlo soils are adjacent to Arveson, Fossum, and Hamar soils in many places, and all have similar profile characteristics. They lack the prominent accumulation of lime within 16 inches of the surface, which is a characteristic of Arveson soils. They lack lime, which is a characteristic of Fossum soils. They are more poorly drained than Hamar soils.

Venlo sandy loam (Vo).—This soil is nearly level and is in depressions on glacial outwash plains.

Included with this soil in mapping are small areas of Arveson soils and Fossum soils in positions similar to those of Venlo soils. Also included are small areas of Hamar, Wyndmere, and Wyrene soils in slightly higher positions. In some areas this soil has been reworked to some extent by soil blowing.

Surface runoff is ponded. The hazard of soil blowing is very severe in areas where the soil is drained and vegetation is destroyed.

Most areas are used for pasture and hay; some are cultivated along with the adjoining, better drained soils. This soil is better suited to grasses than to most other uses. Wetness is the main concern of management. Capability unit Vw–8; windbreak suitability group 2.

Wahpeton Series

The Wahpeton series consists of deep, nearly level, moderately well drained soils that formed in fine-textured alluvial sediment. These soils are on levees of the Sheyenne River.

In a representative profile the surface layer is about 26 inches thick. It is dark-gray silty clay in the upper 21 inches and gray clay in the lower 5 inches. The substratum is firm clay 34 inches thick. The upper 20 inches is gray, the next 9 inches is dark gray, and the lowermost 5 inches is gray.

Permeability is moderate, and the available water

capacity is high. The organic-matter content is high, and fertility is high. Some flooding occurs in spring and during periods of heavy rainfall in summer.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Wahpeton silty clay, in a cultivated field, 800 feet south and 1,500 feet west of the northeast corner of the SE¼ sec. 24, T. 149 N., R. 59 W., Nelson County:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) moist; moderate, medium, subangular blocky structure parting to strong, fine, granular; hard, firm, sticky and plastic; many roots; slightly acid; abrupt, smooth boundary.

A12—7 to 17 inches, dark-gray (N 4/0) silty clay, black (N 2/0) moist; moderate, medium, prismatic structure parting to strong, very fine, angular blocky; very hard, firm, sticky and plastic; common roots; neutral; clear, wavy boundary.

A13—17 to 21 inches, dark-gray (N 4/0) silty clay, very dark gray (N 3/0) moist; weak, coarse, prismatic structure parting to moderate, medium, angular blocky; very hard, firm, sticky and plastic; few roots; neutral; clear, irregular boundary.

A14—21 to 26 inches, gray (5Y 5/1) clay, very dark gray (5Y 3/1) moist, coarse, prismatic structure parting to moderate, medium, subangular blocky; very hard, firm, very sticky and very plastic; black organic coats on faces of prisms; slightly effervescent; mildly alkaline; clear, irregular boundary.

C1—26 to 35 inches, gray (5Y 6/1 and 5/1) clay, dark gray and very dark gray (5Y 4/1 and 3/1) moist; massive; very hard, firm, very sticky and very plastic; many, fine, distinct, segregations of white lime; strongly effervescent; mildly alkaline; clear, smooth boundary.

C2—35 to 46 inches, gray (5Y 5/1) clay, very dark gray (5Y 3/1) moist; massive; very hard, firm, very sticky and very plastic; common, medium, distinct, segregations of white lime; strongly effervescent; mildly alkaline; clear, smooth boundary.

IIAb—46 to 55 inches, dark-gray (5Y 4/1) clay, very dark gray (5Y 3/1) moist; massive; very hard, firm, very sticky and very plastic; common, medium, distinct, segregations of white lime; strongly effervescent; mildly alkaline; clear smooth boundary.

IIC—55 to 60 inches, gray (5Y 6/1) clay, very dark gray (5Y 3/1) moist; massive; very hard, firm, very sticky and very plastic; common, medium, distinct, segregations of white lime; strongly effervescent; mildly alkaline.

The A horizon ranges from 16 to 30 inches in thickness. It is dark gray or very dark gray. Below the plow layer the A horizon has strong to moderate blocky structure. The C horizon is light gray or gray. Most profiles have a buried A horizon. The C horizon is calcareous, and lime has accumulated in the upper part in some places. Segregations of salt and gypsum crystals are in the lower part of the C horizon in some places.

Wahpeton soils are adjacent to La Prairie, Ludden, and Ryan soils in many places. They formed in finer sediment than La Prairie soils. They lack the accumulation of lime within 16 inches of the surface, which is a characteristic of Ludden soils. They lack the alkaline B2 horizon, which is a characteristic of Ryan soils.

Wahpeton silty clay (Wa).—This soil is nearly level and is on levees of the Sheyenne River.

Included with this soil in mapping are small areas of La Prairie soils in positions similiar to those of Wahpeton soils. Also included are small areas of Ludden soils in slightly lower positions.

Surface runoff is slow. Tillage is often delayed because of wetness. The hazard of soil blowing is severe.

Most areas are cultivated; a few areas are in pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIs–4; windbreak suitability group 1.

Walsh Series

The Walsh series consists of deep, nearly level to sloping, moderately well drained and well drained soils. They formed in medium-textured and moderately fine textured glaciofluvial-colluvial deposits. These soils are on foot slopes and fans in the Sheyenne River Valley.

In a representative profile the surface layer is very dark gray loam about 19 inches thick. The subsoil is dark grayish-brown, friable heavy loam about 11 inches thick. The substratum is 30 inches thick. The upper 16 inches is variegated light brownish-gray and white loam that has an accumulation of lime. Below this is 8 inches of variegated gray and white loam. The lowermost 6 inches is light brownish-gray loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium.

These soils are suited to grasses, grain crops, and legumes.

Representative profile of Walsh loam, 3 to 6 percent slopes, in a pasture, 1,300 feet north and 210 feet west of the southeast corner of sec. 21, T. 150 N., R. 62 W., Eddy County:

A1—0 to 19 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many roots; slightly acid; clear, smooth boundary.

B2—19 to 30 inches, dark grayish-brown (2.5Y 4/2) heavy loam, very dark grayish brown (2.5Y 3/2) moist; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; common roots; neutral; clear, smooth boundary.

C1ca—30 to 46 inches, variegated light brownish-gray and white (2.5Y 6/2 and N 8/0) loam, dark grayish brown and light gray (2.5Y 4/2 and 7/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; few fragments of shale; violently effervescent; mildly alkaline; gradual, smooth boundary.

C2—46 to 54 inches, variegated gray and white (5Y 5/1 and N 8/0) loam, very dark grayish brown and light gray (2.5Y 3/2 and 7/2) moist; massive; hard, friable, slightly sticky and slightly plastic; few fragments of shale; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C3—54 to 60 inches, light brownish-gray (2.5Y 6/2) loam, olive brown (2.5Y 4/4) moist; massive; hard, friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 8 to 20 inches in thickness. It is very dark gray and dark-gray loam, silt loam, or clay loam. The B horizon ranges from 10 to 20 inches in thickness. It is dark grayish-brown, grayish-brown, or olive-gray loam, silt loam, or clay loam. The C horizon is light brownish-gray, grayish-brown, olive-gray, or light olive-gray loam, silt loam, or clay loam. It is commonly noncalcareous. Lime has accumulated in the upper part of the C horizon in some places. In a few places shaly sand and gravel or weathered shale are below a depth of 40 inches.

Walsh soils are adjacent to Edgeley, La Prairie, and Vang soils in many places. All these soils have similar profile characteristics. Walsh soils are deeper than Edgeley

and Vang soils. They have a B horizon, which La Prairie soils do not have.

Walsh loam, 3 to 6 percent slopes (WbB).—This soil is on foot slopes and fans in the Sheyenne River Valley. Most areas are below steep slopes of bedded shale or shaly sand and gravel, but a few areas are below steep slopes of glacial till. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Edgeley, Svea, and Vang soils on the upper part of the slopes and areas of La Prairie soils on the lower part.

Surface runoff is medium. This soil receives runoff from adjacent steeper slopes. Wet spots, springs, and drainage channels are present in some areas. The hazard of soil blowing is slight.

Most areas are cultivated or are in hay. Areas that are not large enough to be economical or that are dissected by channels are used for pasture or are left idle. This soil is suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIe–6; windbreak suitability group 1.

Walsh loam, 6 to 9 percent slopes (WbC).—This soil is on foot slopes and fans in the Sheyenne River Valley. Most areas are below steep slopes of bedded shale or shaly sand and gravel. A few are below steep slopes of glacial till.

Included with this soil in mapping are small areas of Barnes, Edgeley, and Vang soils on the upper part of side slopes. Also included are a few small areas of soils that have slopes of 9 to 12 percent.

Surface runoff is rapid. This soil receives runoff from adjacent steeper slopes. Wet spots, springs, and drainage channels are in some areas. The hazard of soil blowing is slight.

Most areas are cultivated or are in hay. Areas that are not large enough to be economical or that are dissected by channels are used for pasture or are left idle. This soil is suited to grain crops, grasses, and legumes if protective measures are used. Surface runoff and soil blowing are the main concerns of management. Capability unit IIIe–6; windbreak suitability group 1.

Walsh clay loam, 0 to 3 percent slopes (WcA).—This soil is on foot slopes and fans in the Sheyenne River Valley. Most areas are below steep slopes of bedded shale or shaly sand and gravel. A few are below steep slopes of glacial till. This soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam.

Included with this soil in mapping are small areas of Edgeley, Svea, and Vang soils near the base of steep slopes and La Prairie soils along the edge of the fans. Also included are small areas of Walsh soils that have a surface layer of loam.

Surface runoff is slow. This soil receives runoff from adjacent steeper slopes. The hazard of soil blowing is slight.

Most areas are cultivated or are in hay. Areas that are not large enough to be economical or that are dissected by channels are used for pasture or are left idle. This soil is suited to grain crops, grasses, and legumes. Soil blowing is the main concern of management. Capability unit IIc–6; windbreak suitability group 1.

Walsh clay loam, 3 to 6 percent slopes (WcB).—This soil is on foot slopes and fans in the Sheyenne River Valley. Most areas are below steep slopes of bedded shale or shaly sand and gravel. A few are below steep slopes of glacial till. The soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam.

Included with this soil in mapping are small areas of Edgeley, Svea, and Vang soils on the upper part of the slopes and areas of La Prairie soils on the lower part.

Surface runoff is medium. This soil receives runoff from adjacent steeper slopes. Wet spots, springs, and drainage channels are present in some areas. The hazard of soil blowing is slight.

Most areas are cultivated or are in hay. Areas that are not large enough to be economical or that are dissected by channels are used for pasture or are left idle. This soil is suited to grain crops, grasses, and legumes. Surface runoff and soil blowing are the main concerns of management. Capability unit IIe–6; windbreak suitability group 1.

Walsh clay loam, 6 to 9 percent slopes (WcC).—This soil is on foot slopes and fans in the Sheyenne River Valley. Most areas are below steep slopes of bedded shale or shaly sand and gravel. A few are below steep slopes of glacial till. This soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam.

Included with this soil in mapping are small areas of Barnes, Edgeley, and Vang soils on the upper part of the slopes. Also included are small areas of soils that have slopes of as much as 12 percent.

Surface runoff is rapid. This soil receives runoff from adjacent steeper slopes. Wet spots, springs, and drainage channels are present in some areas. The hazard of soil blowing is slight.

Most areas are cultivated or are in hay. Areas that are not large enough to be economical or that are dissected by channels are used for pasture or are left idle. This soil is suited to grain crops, grasses, and legumes if protective measures are used. Surface runoff and soil blowing are the main concerns of management. Capability unit IIIe–6; windbreak suitability group 1.

Walum Series

The Walum series consists of moderately deep, nearly level, moderately well drained soils that formed in moderately coarse textured glaciofluvial deposits overlying coarse textured shaly glaciofluvial deposits. These soils are on glacial outwash plains that contain a high percentage of shale.

In a representative profile the surface layer is very dark gray sandy loam about 6 inches thick. The subsoil is mottled, dark-gray, friable sandy loam about 10 inches thick. The substratum is 44 inches thick. The upper 8 inches is mottled, light brownish-gray loamy sand. Below this is 6 inches of light brownish-gray loamy sand that has an accumulation of lime. The next 10 inches is light-gray shaly sand. The lowermost 20 inches is variegated light-gray, light brownish-gray, and grayish brown stratified shaly sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Walum sandy loam, in a cultivated field, 150 feet south and 500 feet east of the center of sec. 11, T. 149 N., R. 65 W., Eddy County:

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) moist; moderate, medium, subangular blocky structure parting to moderate, fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many roots; few pebbles as large as 10 millimeters; neutral; abrupt, smooth boundary.

B2—6 to 16 inches, dark-gray (10YR 4/1) sandy loam, very dark grayish brown (10YR 3/2) moist; few, fine, distinct, yellowish-brown (10YR 5/4, moist) and dark yellowish-brown (10YR 4/4, moist) mottles; moderate, coarse and medium, prismatic structure parting to moderate, coarse and medium, angular blocky; hard, friable, slightly sticky and slightly plastic; common roots; few fragments of shale as large as 10 millimeters; thin organic stains on faces of prisms; tongues of A1 horizon extend as far as 6 inches into this horizon; neutral; gradual, wavy boundary.

IIIC1—16 to 24 inches, light brownish-gray (2.5Y 6/2) loamy sand, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) and dark yellowish-brown (10YR 4/4, moist) and few, fine, prominent, black (10YR 2/1, moist) mottles; very weak, coarse, prismatic and subangular blocky structure parting to single grained; soft, very friable, slightly sticky and nonplastic; few roots; few fragments of shale as mildly alkaline; clear, wavy boundary.

IIC2ca—24 to 30 inches, light brownish-gray (2.5Y 6/2) loamy sand, olive gray (5Y 5/2) moist; very weak, coarse, prismatic structure parting to single grained; soft, very friable, slightly sticky and slightly plastic; few roots; few fragments of shale as large as 20 millimeters; common segregations of white lime; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC3—30 to 40 inches, light-gray (2.5Y 7/2) shaly sand, grayish brown (2.5Y 5/2) moist; single grained; loose, nonsticky and nonplastic; few fragments of shale as large as 20 millimeters; few segregations of white lime; strongly effervescent; moderately alkaline; clear, wavy boundary.

IIC4—40 to 60 inches, variegated light-gray, light brownish-gray, and grayish-brown (2.5Y 7/2, 6/2, and 5/2) stratified shaly sand and gravel; grayish brown and dark grayish brown (2.5Y 5/2 and 4/2) moist; single grained; loose, nonsticky and nonplastic; few granitic pebbles as large as 50 millimeters; lime coats on underside of pebbles; slightly effervescent; moderately alkaline.

Depth to the sand and gravel ranges from 14 to 25 inches. The A horizon ranges from 5 to 10 inches in thickness. It is very dark gray or dark gray. The B horizon ranges from 5 to 14 inches in thickness. It is dark gray, grayish brown, or light brownish gray. The B horizon has moderate or weak prismatic structure. Organic coatings are on the faces of prisms in the B horizon in most places.

The IIC horizons are typically stratified shaly sand and gravel, but they are granitic sand and gravel in some places. A layer of loamy sand is in the upper part of the IIC horizon in most places. Lime has accumulated in the upper part of the IIC horizon in most places, and lime coats the underside of pebbles in one or more of the IIC horizons.

Walum soils are adjacent to Binford, Tolna, and Vang soils in many places. They have mottling in the B horizon, which Binford soils do not have. They are better drained than Tolna soils. They are not so deep to sand and gravel as Vang soils.

Walum sandy loam (Wd).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series. Content of gravel in the substratum is less than 40 percent by volume.

Included with this soil in mapping are small areas of Walum soils that have a substratum containing more than 40 percent gravel. Binford soils in positions similar to those of Walum soils are also included, as are Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas are cultivated. Some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 1.

Walum sandy loam, gravelly substratum (We).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains more than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Walum soils that contain less than 40 percent gravel, areas of Binford soils in positions similar to those of Walum soils, and small areas of Tolna soils in depressions that are identified on the soil map by a diamond symbol.

Surface runoff is slow, and water ponds in depressions. The hazard of soil blowing is very severe.

Most areas are cultivated. Some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 1.

Warsing Series

The Warsing series consists of shallow, nearly level, moderately well drained soils that formed in medium-textured glaciofluvial deposits overlying coarse-textured glaciofluvial deposits. These soils are on glacial outwash plains.

In a representative profile the surface layer is very dark gray loam about 7 inches thick. The subsoil is friable loam about 8 inches thick that is dark grayish brown in the upper 6 inches and mottled grayish brown below that. The substratum is 45 inches thick. The upper 3 inches is variegated light-gray and white loam that has an accumulation of lime. Below that is 6 inches of light brownish-gray sand and gravel that has an accumulation of lime. The lowermost 36 inches is variegated pale-brown and very pale brown sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Warsing loam, in a cultivated field, 1,000 feet south and 700 feet east of the northwest corner of the SW¼ sec. 25, T. 150 N., R. 66 W., Eddy County:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate, medium and very fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; neutral; few pebbles as large as 30 millimeters; neutral; abrupt, smooth boundary.

B21—7 to 13 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; moderate, coarse and medium, prismatic structure parting to moderate, medium and fine, angular blocky; hard, friable, slightly sticky and slightly plastic; common roots; thin, discontinuous, very dark gray (10YR 3/1, moist) organic stains on faces of prisms; few pebbles as large as 10 millimeters; neutral; gradual, wavy boundary.

B22—13 to 15 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5 4/2) moist; few, fine, faint, yellowish-brown (10YR 5/4, moist) and light olive-brown (2.5Y 5/4, moist) mottles; moderate, coarse and medium, prismatic structure parting to moderate, medium, angular blocky; hard, friable, slightly sticky and slightly plastic; common roots; few, thin, discontinuous organic stains on faces of prisms; few pebbles as large as 10 millimeters; common threads of lime; strongly effervescent; mildly alkaline; clear, broken boundary.

C1ca—15 to 18 inches, variegated light-gray and white (2.5Y 7/2 and N 8/0) loam, grayish brown and light brownish gray (2.5Y 5/2 and 6/2) moist; weak, coarse, prismatic structure parting to moderate, very fine, angular blocky; hard, friable, sticky and slightly plastic; few roots; common soft accumulations of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC2ca—18 to 24 inches, light brownish-gray (2.5Y 6/2) sand and gravel, olive brown (2.5Y 4/4) moist; single grained; loose, nonsticky and nonplastic; very few roots; lime coats on underside of pebbles; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC3—24 to 60 inches, variegated pale-brown and very pale brown (10YR 6/3 and 7/3) sand and gravel, olive brown (2.5Y 4/4) dark brown (10YR 4/3) moist; single grained; loose, nonsticky and nonplastic; lime coats on undersides of pebbles; strongly effervescent; moderately alkaline.

Depth to the sand and gravel ranges from 10 to 20 inches. The A horizon ranges from 5 to 10 inches in thickness. It is very dark gray or dark gray. The B horizon ranges from 6 to 16 inches in thickness. It is dark grayish brown, grayish-brown, or brown. The B horizon is mottled in the lower part and mottled throughout in some places. Organic stains are on the faces of prisms in most places. Lime has accumulated in the lower part of the B horizon in most places.

The C horizon ranges from 0 to 6 inches in thickness. It is variegated light gray, white, light brownish gray, or gray. The IIC horizons are typically stratified granitic sand and gravel but are shaly sand and gravel in some places. Lime has accumulated in the upper part of the IIC horizon in many places, and lime coats the underside of pebbles in most places. Glacial till is below a depth of 40 inches in some places.

Warsing soils are adjacent to Divide, Fordville, Osakis, and Renshaw soils in many places. All of these soils are underlain by coarse-textured deposits. Warsing soils have a B horizon which the Divide soils do not have. They have mottles in the B horizon, which the Fordville and Renshaw soils do not have. They contain less sand in the A and B horizons than Osakis soils.

Warsing loam (Wf).—This soil is nearly level and is on glacial outwash plains. It has the profile described as representative of the series. Content of gravel in the substratum is 40 percent or more by volume.

Included with this soil in mapping are small areas of Warsing soils that have a substratum that contains less than 40 percent gravel by volume, areas of Renshaw soils in positions similar to those of Warsing soils, and small areas of Divide soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 1.

Warsing loam, sandy substratum (Wg).—This soil is nearly level and is on glacial outwash plains. It has a profile similar to the one described as representative of the series, but the substratum contains less than 40 percent gravel by volume.

Included with this soil in mapping are small areas of Warsing soils that have a substratum that contains more than 40 percent gravel by volume, areas of Renshaw soils in positions similar to those of Warsing soils, and small areas of Divide soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 1.

Warsing loam, till substratum (Wm).—This soil is nearly level and is on glacial outwash plains. It generally is located adjacent to areas of glacial till. This soil has a profile similar to the one described as representative of the series, but glacial till is below a depth of 40 inches.

Included with this soil in mapping are small areas of Emrick, Renshaw, and Warsing soils in positions similar to those of this soil. Also included are small areas of Divide soils in slightly lower positions.

Surface runoff is slow. The hazard of soil blowing is slight.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Soil blowing and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 1.

Wyard Series

The Wyard series consists of deep, nearly level, somewhat poorly drained soils that formed in medium-textured and moderately fine textured glacial till. These soils are in shallow depressions and swales on glacial till plains.

In a representative profile the surface layer is loam about 20 inches thick. It is dark gray in the upper 10 inches and gray in the lower 10 inches. Below this is a layer of mottled, grayish-brown, friable loam about 6 inches thick. The subsoil is mottled, light olive-

brown, friable loam about 6 inches thick. The substratum is mottled, pale-yellow loam that has an accumulation of lime in the upper 10 inches. It is mottled, light yellowish-brown loam in the lower 18 inches.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils receive runoff from the surrounding higher areas in spring and during periods of heavy rainfall.

These soils are suited to grasses and, if drained, to small grains and legumes.

Representative profile of Wyard loam, in a cultivated field, 1,000 feet north and 200 feet east of the southwest corner of sec. 15, T. 148 N., R. 67 W., Eddy County:

Ap—0 to 6 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, medium, subangular blocky structure parting to weak, medium, crumb; hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

A11—6 to 10 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; moderate, coarse, prismatic structure parting to weak, medium, platy, and weak, coarse, subangular blocky; hard, friable, slightly sticky and slightly plastic; many roots; few bleached sand grains on faces of peds; neutral; gradual, wavy boundary.

A12—10 to 20 inches, gray (10YR 5/1) loam, black (10YR 2/1) moist; very dark brown (10YR 2/2) moist rubbed; few, medium, distinct, yellowish-brown (10YR 5/4, moist) mottles; few, discontinuous light-gray (10YR 6/1) coatings of bleached sand and silt grains on faces of peds; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky structure parting to moderate, medium, platy; hard, friable, slightly sticky and slightly plastic; many roots; neutral; clear, wavy boundary.

A and B—20 to 26 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; moderate, coarse, prismatic structure parting progressively to moderate, medium and fine, subangular blocky and weak, medium, platy; hard, friable, slightly sticky and slightly plastic; few roots; neutral; gradual, wavy boundary.

B2—26 to 32 inches, light olive-brown (2.5Y 5/4) loam, olive brown (2.5Y 4/4) moist; common, fine, distinct, yellowish-brown (10YR 5/6, moist) mottles; moderate, coarse, prismatic structure parting to moderate, medium and fine, angular blocky; hard, friable, slightly sticky and slightly plastic; few roots; few pebbles; neutral; clear, wavy boundary.

C1ca—32 to 42 inches, pale-yellow (2.5Y 7/3) loam, light olive brown (2.5Y 5/4) moist; few, medium, distinct, light olive-brown (2.5Y 5/6, moist) mottles; weak, coarse, prismatic structure parting to weak, medium, subangular blocky structure parting to weak, medium, platy; hard, friable, slightly sticky and slightly plastic; few roots; few pebbles; common masses of segregated lime; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2—42 to 60 inches, light yellowish-brown (2.5Y 6/4) loam, olive brown (2.5Y 4/4) moist; few, medium, distinct, light olive-brown (2.5Y 5/6, moist) mottles; weak, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few pebbles; few small masses of segregated lime; strongly effervescent; moderately alkaline.

The A horizon ranges from 16 to 24 inches in thickness. It is gray or dark-gray silt loam or loam. The horizon below that, the A and B, ranges from 2 to 10 inches in thickness. It is mottled, gray or grayish-brown loam or silt loam. The B2 horizon ranges from 6 to 10 inches in thickness. It is mottled, grayish-brown, brown, or light olive-brown loam or light clay loam. The C horizon is light brownish-gray, grayish-brown, pale-yellow, or light yellowish-brown loam or clay loam. It commonly is mottled and has an accumulation of lime in the upper part in most places.

Wyard soils have profile characteristics similar to those of Emrick, Fram, Hamerly, Svea, and Tonka soils and are often adjacent to these soils in many places. They are not so well drained as Emrick soils and Svea soils. They have a B horizon, which Fram and Hamerly soils do not have. They lack the B2t horizon, which is a characteristic of Tonka soils.

Wyard loam (Wn).—This soil is nearly level and is in shallow depressions and swales on glacial till plains.

Included with this soil in mapping are small areas of Tonka soils in slightly lower positions and areas of Emrick, Fram, Hamerly, and Svea soils in slightly higher positions.

Surface runoff is ponded. Wetness commonly limits tillage during the growing season. The hazard of soil blowing is slight.

This soil is suited to grasses and, if drained, to small grains and legumes. Wetness is the main concern of management. Capability unit IIw–6; windbreak suitability group 1.

Wyndmere Series

The Wyndmere series consists of deep, nearly level, somewhat poorly drained, calcareous soils that formed in moderately coarse textured glaciofluvial deposits overlying coarse textured glaciofluvial deposits. These soils are in slight depressions on glacial outwash plains.

In a representative profile the surface layer is sandy loam about 14 inches thick that is dark gray in the upper part and gray in the lower part. The next layer is gray, very friable sandy loam about 12 inches thick and has an accumulation of lime. The substratum is 34 inches thick. The upper 10 inches is mottled, grayish-brown fine sand. Below this is 14 inches of variegated light-gray and light yellowish-brown sand. The lower 10 inches is mottled, light-gray sand.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is moderate, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in spring and early in summer. Tillage is often delayed because of wetness.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Wyndmere sandy loam, in a native hay field, 600 feet south and 100 feet west of the northeast corner of the SE¼ sec. 25, T. 148 N., R. 64 W., Eddy County:

A11—0 to 6 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; moderate, fine, subangular blocky and granular structure; slightly hard, very friable, sticky and slightly plastic; many roots; strongly effervescent; moderately alkaline; clear, smooth boundary.

A12ca—6 to 14 inches, gray (N 6/0) sandy loam, very dark gray (10YR 3/1) moist; weak, coarse, prismatic structure parting to weak, fine, subangular blocky; soft, very friable, sticky and slightly plastic; common roots; violently effervescent; moderately alkaline; gradual, smooth boundary.

C1ca—14 to 26 inches, gray (N 6/0) sandy loam, very

dark gray (2.5Y 3/1) moist; weak, coarse, prismatic structure parting to weak, fine, subangular blocky; soft, very friable, sticky and slightly plastic; common roots; violently effervescent; moderately alkaline; clear, wavy boundary.

IIC2—26 to 36 inches, grayish-brown (2.5Y 5/2) fine sand, dark grayish brown (2.5Y 4/2) moist; common, fine, distinct, yellowish-brown (10YR 5/4, moist) and common, fine, prominent, black (10YR 2/1, moist) mottles; single grained; loose, nonsticky and nonplastic; few roots; moderately alkaline; clear, wavy boundary.

IIC3—36 to 50 inches, variegated light-gray (2.5Y 7/2) and light yellowish-brown (10YR 6/4) sand, dark grayish brown (2.5Y 4/2) and dark yellowish brown (10YR 4/4) moist; single grained; loose, nonsticky and nonplastic; few roots in upper part; moderately alkaline; clear, wavy boundary.

IIC4—50 to 60 inches, light-gray (2.5Y 7/2) sand, grayish brown (2.5Y 5/2) moist; common, medium, distinct, yellowish-brown (10YR 5/4, moist) and few, fine, prominent, black (10YR 2/1, moist) mottles; single grained; loose, nonsticky and nonplastic; moderately alkaline.

The A horizon ranges from 6 to 14 inches in thickness. It is dark-gray or very dark gray or gray sandy loam, fine sandy loam, or loam. The A horizon typically is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon is dark-gray, gray, or light-gray sandy loam, fine sandy loam or light loam. It is mottled in the lower part in some places. The IIC horizon is mottled, grayish brown, light olive brown, light gray, or light yellowish brown. Soluble salts, which adversely affect plant growth, have accumulated in the A horizon and Cca horizon in some places. Glacial till is below a depth of 40 inches in some places.

Wyndmere soils are adjacent to Arveson, Fossum, Hamar, and Wyrene soils in many places. All of these soils formed in similar parent material. Wyndmere soils are not so poorly drained as Arveson soils and Fossum soils. They have an accumulation of lime directly beneath the surface layer, which Hamar soils do not have. They are underlain by finer sands than Wyrene soils.

Wyndmere sandy loam (Wo).—This soil is nearly level and is in slight depressions on outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Stirum, Hamar, and Wyrene soils in positions similar to those of Wyndmere soils, small areas of Arveson and Fossum soils in slightly lower positions, and areas of Clontarf, Hecla, and Lohnes soils in slightly higher positions.

In some places the surface layer is fine sandy loam. Soils in many cultivated areas have a lighter colored surface layer. On about 5 percent of the acreage of this soil, soluble salts that adversely affect plant growth, have accumulated.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. The soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIs–3; windbreak suitability group 1.

Wyndmere sandy loam, till substratum (Wp).—This soil is nearly level and is in slight depressions on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but glacial till is below a depth of 40 inches.

Included with this soil in mapping are small areas of Fram and Kratka soils in positions similar to those of Wyndmere soils. Also included are small areas of Arveson and Fossum soils in slightly lower positions and Emrick, Hecla, and Swenoda soils in slightly higher positions. Soils in many cultivated areas have a lighter colored surface layer. On as much as 20 percent of the acreage, this soil in some areas has slopes of 3 to 6 percent.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness and soil blowing are the main concerns of management. Capability unit IIIs–3; windbreak suitability group 1.

Wyrene Series

The Wyrene series consists of moderately deep, nearly level, somewhat poorly drained soils that formed in moderately coarse textured glaciofluvial deposits over coarse-textured glaciofluvial deposits. These soils are in slight depressions on glacial outwash plains.

In a representative profile the surface layer is dark-gray sandy loam about 8 inches thick. The substratum is 52 inches thick. The upper 13 inches is gray, friable sandy loam that has an accumulation of lime. Below this is 8 inches of light yellowish-brown coarse sand. The next 13 inches is mottled, light yellowish-brown coarse sand. The lowermost 18 inches is light brownish-gray and grayish-brown coarse sand.

Permeability is moderately rapid in the surface layer and upper part of the substratum and rapid in the lower part of the substratum. The available water capacity is low. The organic-matter content is moderate, and fertility is medium. The water table is within 5 feet of the surface most of the year and just below the surface in spring and early in summer. Tillage is often delayed because of wetness.

These soils are suited to grain crops, grasses, and legumes.

Representative profile of Wyrene sandy loam, in a hay meadow, 220 feet north and 1,450 feet west of the southeast corner of the NE¼ sec. 22, T. 148 N., R. 64 W., Eddy County:

A1—0 to 8 inches, dark-gray (10YR 4/1) sandy loam, black (10YR 2/1) moist; weak, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C1ca—8 to 13 inches, gray (10YR 6/1) sandy loam, dark gray (10YR 4/1) moist; moderate, coarse, prismatic structure parting to moderate, coarse and medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; common roots; violently effervescent; moderately alkaline; gradual, wavy boundary.

C2ca—13 to 21 inches, gray (10YR 6/1) sandy loam, dark gray (10YR 4/1) moist; moderate, coarse and medium, prismatic structure parting to moderate, coarse and medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; few roots; violently effervescent; moderately alkaline; clear, smooth boundary.

IIC3—21 to 29 inches, light yellowish-brown (2.5Y 6/3) coarse sand, light olive brown (2.5Y 5/4) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIC4—29 to 42 inches, light yellowish-brown (2.5Y 6/4)

coarse sand, light olive brown (2.5Y 5/4) moist; common, fine, faint, dark yellowish-brown (10YR 4/4, moist) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIC5—42 to 60 inches, light brownish-gray and grayish-brown (2.5Y 6/2 and 5/2) coarse sand, very dark grayish brown (2.5Y 3/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline.

Depth to the sand and gravel IIC horizon ranges from 20 to 40 inches but typically is 20 to 30 inches. The A horizon ranges from 6 to 14 inches in thickness. It is gray, dark gray, or very dark gray. Typically, the A horizon is calcareous and has an accumulation of lime in the lower part, but it is noncalcareous in some places. The Cca horizon is light-gray, dark-gray, or gray sandy loam, loam, or loamy sand. It is mottled in some places. The Cca horizon has weak to moderate prismatic structure that parts to weak to moderate subangular blocky structure.

The IIC horizon consists of stratified sand and gravel, but it is dominantly coarse sand. Mottles in the IIC horizon are present in most places. Typically, the IIC horizon is slightly calcareous to strongly calcareous. In some places it is noncalcareous, and in other places it has an accumulation of lime in the upper part. Glacial till is below a depth of 40 inches in some places.

Wyrene soils are adjacent to Arveson, Hamar, Totten, and Wyndmere soils in many places. They are better drained than Arveson soils. They are underlain by coarser sand than Wyndmere soils. They have an accumulation of lime within 16 inches of the surface, which Hamar soils do not have. They lack the alkaline B2 horizon, which is a characteristic of Totten soils.

Wyrene sandy loam (Wr).—This soil is nearly level and is in slight depressions on glacial outwash plains and terraces along drainageways and rivers. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Divide, Hamar, and Totten soils in positions similar to those of Wyrene soils. Also included are small areas of Arveson, Fossum, and Marysland soils in slightly lower positions and Lohnes soils and Clontarf soils in slightly higher positions. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–3; windbreak suitability group 1.

Wyrene sandy loam, till substratum (Ws).—This soil is nearly level and is in slight depressions on sand-mantled glacial till. It has a profile similar to the one described as representative of the series, but glacial till is below a depth of 40 inches.

Included with this soil in mapping are small areas of Fram soils and Totten soils in positions similar to those of Wyrene soils. Also included are small areas of Marysland soils and Vallers soils in slightly lower positions and Emrick soils and Lohnes soils in slightly higher positions. Soils in many cultivated areas have a lighter colored surface layer.

Surface runoff is slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. This soil is suited to grain crops, grasses, and legumes. Wetness, soil blowing, and droughtiness caused by the low available water capacity are the main concerns of management. Capability unit IIIs–3; windbreak suitability group 1.

Wyrene-Totten sandy loams (Wt).—These soils are nearly level and are in slight depressions on glacial outwash plains. The Totten soils have a profile similar to the one described as representative of the series, but the surface layer is sandy loam. Wyrene soils make up about 55 percent of this mapping unit, and Totten soils make up about 35 percent.

Included with these soils in mapping are small areas of Marysland soils in slightly lower positions and Osakis soils in slightly higher positions. Soils in many cultivated areas have a lighter colored surface layer. In some cultivated areas the surface layer of the Totten soils is hard and cloddy when dry and sticky when wet, because some of the subsoil has been mixed with the surface layer.

Surface runoff is very slow, and water ponds in low positions. The hazard of soil blowing is very severe.

Most areas are cultivated; some are used for pasture and hay. These soils are suited to grasses and, if drained, to small grains. Growth of most crops is reduced on the Totten soils because of the dense subsoil, alkalinity, and moderately slow permeability. Wetness, soil blowing, droughtiness caused by the low available water capacity, and maintenance of good soil tilth in cultivated areas are the main concerns of management. Capability unit IIIsw–3; Wyrene soil is in windbreak suitability group 1, Totten soil is in windbreak suitability group 9.

Zell Series

The Zell series consists of deep, hilly, well-drained soils that formed in medium-textured glaciofluvial deposits. These soils are on morainic areas on glacial till plains and on a glacial disintegration ridge on the outwash plain north and east of New Rockford. These soils are mapped only with Buse and Sioux soils in this survey area.

In a representative profile the surface layer is gray loam about 6 inches thick. The substratum is 54 inches thick. The upper 4 inches is white, very friable silt loam that has an accumulation of lime. Below this is 14 inches of pale-yellow loam, 8 inches of light brownish-gray very fine sandy loam, and 20 inches of mottled, light brownish-gray very fine sandy loam. The lowermost 6 inches is light-gray fine sand.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, fertility is low.

These soils are better suited to grasses than to most other uses.

Representative profile of Zell loam in an area of Buse, Sioux, and Zell soils, 3 to 30 percent slopes, in a cultivated field, 100 feet north and 110 feet east of the center of sec. 10, T. 151 N., R. 63 W., Benson County:

Ap—0 to 6 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) moist; weak, coarse and medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots; strongly effervescent; neutral; abrupt, smooth boundary.

C1ca—6 to 10 inches, white (2.5Y 8/2) silt loam, light brownish gray (2.5Y 6/2) moist; weak, coarse,

prismatic structure parting to weak, coarse and medium, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots; violently effervescent; mildly alkaline; clear, wavy boundary.

C2—10 to 24 inches, pale-yellow (2.5Y 7/4) loam, light olive brown (2.5Y 5/4) moist; weak, very coarse, prismatic structure parting to weak, very coarse, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; common to few roots; few pebbles; strongly effervescent; mildly alkaline; clear, smooth boundary.

C3—24 to 32 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, olive brown (2.5Y 4/4) moist; weak, very coarse, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; clear, smooth boundary.

C4—32 to 52 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, olive brown (2.5Y 4/4) moist; common, fine, faint, gray (N 5/0, moist) mottles; massive; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; clear, smooth boundary.

IIC5—52 to 60 inches, light-gray (2.5Y 7/2) fine sand, light brownish gray (2.5Y 6/2) moist; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 4 to 10 inches in thickness. It is gray, dark-gray, or very dark gray loam or silt loam. The C horizon is light gray, light brownish gray, pale yellow or white. Typically, it is loam, silt loam, or very fine sandy loam, but in many places fine sandy loam or fine sand are below a depth of about 40 inches. Lime has accumulated in the upper part of the C horizon in most places. Pebbles and stones are on the surface in some places.

Zell soils are adjacent to Buse and Sioux soils in many places. They have profile characteristics similar to those of Buse soils. They contain more silt and sand and less clay than Buse soils. They lack the coarse sand and gravel in the C horizon, which is a characteristic of Sioux soils.

Use and Management of the Soils

This section discussses the use and management of the soils as dryland and irrigated cropland, as wildlife habitat and recreation areas, and as sites for windbreaks. It describes the relative suitability of soils for highway construction and other engineering works.

General Management of Cropland [3]

About 70 percent of the survey area is cultivated. Spring wheat is the principal crop. Flax, oats, and barley are other important crops.

The main considerations in managing cultivated soils in this survey area are conserving moisture, controlling wind and water erosion, and maintaining fertility.

In dryfarmed areas, moisture generally can be conserved by reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Beneficial practices include stubble mulching, contour farming, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, using crop residue, and applying fertilizer. Fallow helps to control weeds and to build up the content of moisture.

Cover crops, stripcropping, buffer strips, windbreaks, contour farming, diversions, waterways, minimum tillage, emergency tillage, and using crop residue help to control erosion. Generally, a combination of several practices is used.

Among the practices that help to maintain fertility are applying chemical fertilizer, green manure, and barnyard manure, including cover crops, grasses, and legumes in the cropping system, and utilizing summer fallow. Controlling erosion also helps to conserve fertility.

Drainage, removing stones, and reducing salinity are needed in places to offset the effects of unfavorable soil characteristics.

Management of irrigated soils

Soil features affecting irrigation (*6*) are given in table 8.

Crop response to irrigation water generally results in proportionally higher yields on soils that have a low available water capacity compared to soils that have a high available water capacity. Also, crop response to irrigation water is greater if such long-growing season crops as alfalfa are grown. Long-season crops have a high demand for water in July and August when normal precipitation often does not take care of plant needs. Yield data of irrigated and non-irrigated crops can be obtained at the Carrington Irrigation Branch Station located 12 miles south of New Rockford.

Decline in soil fertility takes place at a faster rate with irrigation than it does with dryfarmed conditions. Using commercial fertilizers, returning crop residues to the soils, and using legume or legume-grass mixtures in rotation on irrigated cropland help maintain soil fertility and tilth.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of farming. The soils are grouped according to their limitations 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, horticulture crops, or other crops requiring special management.

From the capability classification much about the behavior of soils can be inferred. But this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, forest trees, or engineering.

In the capability system, the kinds of soils are grouped at three levels: the class, the subclass, and the 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.

Class I soils have few limitations that restrict their use. There are no class I soils in this survey area.

Class II soils have moderate limitations that re-

[3] By EDWARD R. WEIMER, agronomist, Soil Conservation Service, Bismarck.

duce 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 subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes. There are no class VIII soils in this survey area.

CAPABILITY SUBCLASSES 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 saline, shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry. For some soils, erosion or wetness and one of the other kinds of limitations have about equal importance, and the subclass symbol shows both kinds; IIIes is an example.

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, although they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, 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 the management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–6 or IIw–6. 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. Arabic numerals are also used to indicate the susceptibility to wind erosion, ranging from 2, which is very severe, to 6, which is slight. The letter P indicates the presence of a sodic claypan in the subsoil, the letter L indicates that the soil is calcareous, and the letter M indicates that the sandy soils have a substratum of loam, clay loam, or clay.

Management by capability units

In the following pages each of the capability units in this survey area is described, and suggestions for use and management are given. The units are not numbered consecutively, because not all of the units in the statewide system are represented in this survey area. The capability designation for each soil in the survey area is given in the "Guide to Mapping Units." Gravel pits and Made land were not placed in a capability unit.

CAPABILITY UNIT IIe–5

This capability unit consists of well drained and moderately well drained, deep, nearly level, gently undulating, and gently rolling soils. These soils are medium textured, but, in some areas, have moderately coarse textured and coarse textured strata in the lower part of the substratum.

Surface runoff is slow to medium. The available water capacity is high, and permeability is moderate. The hazard of soil blowing is moderate. The organic-matter content is high, and fertility is medium or high.

These soils are suited to all crops commonly grown in the area, and most of the acreage is cultivated. Wheat, barley, flax, oats, and rye are the main crops.

Corn, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of cover crops, crop residue, grassed waterways, stripcropping, field windbreaks, contour farming, buffer strips, timely tillage, emergency tillage, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow is used for weed control and storing soil moisture. Draining shallow depressions and removing surface stones aids in tillage.

CAPABILITY UNIT IIe–6

This capability unit consists of well drained and moderately well drained, deep, gently sloping and gently undulating soils. These soils are medium textured or moderately fine textured.

Surface runoff is medium. The available water capacity is high, and permeability is moderate or moderately slow. The hazard of soil blowing is slight. The organic-matter content is high, and fertility is medium or high.

These soils are suited to all crops commonly grown in the survey area, and most of the acreage is cultivated. Wheat, barley, flax, oats, and rye are the main crops.

Corn, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of

water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of grassed waterways, stubble mulching, cover crops, field windbreaks, timely tillage, stripcropping, contour farming, diversions, fertilizer, and buffer strips. These measures control erosion, conserve moisture, and maintain fertility. Fallow is used for controlling weeds and storing soil moisture. Draining shallow depressions and removing surface stones aids in tillage.

CAPABILITY UNIT IIes–4L

This capability unit consists mainly of somewhat poorly drained, deep, nearly level, gently sloping and gently undulating, calcareous soils. These soils have a medium-textured surface layer. They are calcareous and medium textured in the upper part of the substratum, and they are moderately fine textured to coarse textured in the lower part of the substratum. Among the soils in this unit are nearly level, moderately well drained Svea soils that have a noncalcareous, medium-textured surface layer and subsoil.

Surface runoff is slow to medium. The available water capacity is high, and permeability is moderate or moderately slow. The hazard of soil blowing is severe. The organic-matter content is high, and fertility is medium or high. All the soils except the Svea soils have a seasonal high water table.

These soils are suited to all crops commonly grown in the survey area, and most of the acreage is cultivated. Barley, wheat, flax, oats, and rye are the main crops.

Corn, alfalfa, and bromegrass are grown for silage, hay, or pasture on farms where livestock is raised. Sweetclover that is seeded with flax or oats and cut for hay or plowed under the following summer helps remove excess water from the soil and improve tilth. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of crop residue, cover crops, stripcropping, field windbreaks, grassed waterways, buffer strips, timely tillage, emergency tillage, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. The response of crops to phosphate fertilizer is especially good on these soils. Draining shallow depressions and removing surface stones aids in tillage. Fallow is used only when needed for weed control or to follow a crop of sweetclover.

CAPABILITY UNIT IIw–4L

This capability unit consists of poorly drained, deep and moderately deep, nearly level and gently sloping, calcareous soils. These soils have a medium textured or moderately fine textured surface layer. The substratum is calcareous and is medium textured, moderately coarse textured, or moderately fine textured in the upper part, and it is medium textured to coarse textured in the lower part (fig. 16).

The available water capacity ranges from low to high. Permeability ranges from moderately slow to moderately rapid. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table.

Figure 16.—**Hummocky areas are common where soils in capability unit IIw-4L are used for pasture.**

Most of the acreage of these soils is used for hay and pasture. The high water table causes wetness that delays seeding. Late-seeded crops, such as flax, are grown in a few areas. If the water table can be lowered, these soils are suited to most crops commonly grown in the survey area, but outlets for drainage generally are not available. Native vegetation includes prairie cordgrass, northern reedgrass, sartwell sedge, and Rydberg's sunflower. Grazing of native vegetation should be regulated so that about no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing can be used to prevent overgrazing.

The hazard of soil blowing is severe if these soils are drained and tilled. Management should include the use of cover crops, crop residue, stripcropping, timely tillage, buffer strips and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. The response of crops to phosphate fertilizer is especially good on these soils. Sweetclover that is seeded with a nurse crop and cut for hay or plowed under the following summer helps remove excess moisture and improve tilth. Fallow is used only when needed for weed control or to follow sweetclover.

CAPABILITY UNIT IIw–6

This capability unit consists of poorly drained and somewhat poorly drained, deep, nearly level soils. These soils are medium textured or moderately fine textured. In some areas the lower part of the substratum is coarse textured.

The available water capacity is high. Permeability is moderate to slow. The organic-matter content is high, and fertility is medium. Runoff from adjacent areas ponds on these soils.

These soils are suited to such late-seeded crops as flax and millet. They are suited to all crops commonly grown in the survey area if excess water is drained. Most of the acreage of these soils is used for hay and pasture. Native vegetation includes prairie cordgrass, northern reedgrass, Rydberg's sunflower, and sartwell sedge. Reed canarygrass is well suited to soils in underdrained areas. Grazing of native vegetation should be

regulated so that no more than half of the annual growth is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

The hazard of soil blowing is slight if these soils are tilled. Wetness delays seeding in most years, and during wet years tillage operations are not practical because of ponded water. Crops are damaged in places as a result of ponded water after heavy rains during the growing season. These soils are generally in small areas where draining aids tillage operations. Management should include the use of crop residue, cover crops, timely tillage, buffer strips, stripcropping, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIs–4

This capability unit consists of poorly drained, well drained, and moderately well drained, deep, nearly level soils. These soils have a moderately fine textured or fine textured surface layer, subsoil, and substratum.

The available water capacity is high. Permeability is moderate or slow. The organic-matter content is high, and fertility is medium or high. The hazard of soil blowing is severe, especially after freezing and thawing have destroyed surface cloddiness. Some areas are subject to flooding.

These soils are suited to all crops commonly grown in the survey area, and many areas are cultivated. Wheat, barley, flax, oats, and rye are the main crops. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production. Brush control improves forage production in some areas.

Management should include the use of crop residue, buffer strips, cover crops, stripcropping, windbreaks, fertilizer, and timely tillage. These measures control erosion, conserve moisture, and maintain fertility. Fall plowing should be done early enough to allow for regrowth of the weeds that help to control erosion. Draining shallow depressions and diverting runoff from adjacent areas aids in tillage.

CAPABILITY UNIT IIs–6

The only mapping unit in this capability unit is Vang loam. This soil is well drained, moderately deep, and nearly level. It is medium textured in the surface layer, subsoil, and upper part of the substratum, and coarse textured in the lower part of the substratum.

Surface runoff is slow. The available water capacity is moderate. Permeability is moderate in the surface layer, subsoil, and upper part of the substratum and very rapid in the lower part of the substratum. The hazard of soil blowing is slight. The organic-matter content is high, and fertility is medium.

This soil is suited to all crops commonly grown in the survey area, and most areas are cultivated. Wheat, barley, flax, oats, and rye are the main crops. Corn, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of cover crops, crop residue, timely tillage, stripcropping, field windbreaks, buffer strips, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Draining shallow depressions aids in tillage.

CAPABILITY UNIT IIc–6

This capability unit consists of well drained and moderately well drained, deep and moderately deep, nearly level soils. These soils are medium textured or moderately fine textured. In a few areas, bedded shale is within 24 to 36 inches of the surface.

Surface runoff is slow. The available water capacity is moderate or high, and permeability is moderate or moderately slow. The hazard of soil blowing is slight. The organic-matter content is moderate or high, and fertility is medium or high.

These soils are suited to all crops commonly grown in the area, and most of the acreage is cultivated. Wheat, barley, flax, oats, and rye are the main crops. Corn, bromegrass, and alfalfa are grown for silage, hay, or pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed to maintain forage production in areas of native grass.

Low rainfall and a short growing season are the main limitations to use of these soils. Management should include the use of cover crops, crop residue, timely tillage, stripcropping, field windbreaks, buffer strips, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow is used for weed control and for storing soil moisture. Draining shallow depressions and removing surface stones aid in tillage.

CAPABILITY UNIT IIIe–3

This capability unit consists of moderately well drained and well drained, deep and moderately deep, nearly level and gently undulating soils. These soils have a moderately coarse textured surface layer, but below the surface layer, they are moderately coarse textured or coarse textured in the upper part and coarse textured in the lower part.

Surface runoff is slow. The available water capacity is low or moderate, and permeability is moderately rapid or rapid. The hazard of soil blowing is severe. The organic-matter content ranges from low to high, and fertility is low or medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Corn, bromegrass, and alfalfa are grown for silage, hay, or pasture on farms where livestock is raised. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Brush control increases forage production in some areas.

Management should include the use of crop residue, cover crops, stripcropping, buffer strips, field windbreaks, weed control, timely tillage, emergency tillage, minimum tillage, grassed waterways, diversions, contour farming, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIe-3M

This capability unit consists of well drained and moderately well drained, deep, nearly level and gently undulating soils. They have a moderately coarse textured surface layer, a moderately coarse textured and coarse textured subsoil, and a coarse textured to moderately fine textured substratum.

Surface runoff is slow to medium. The available water capacity ranges from low to high. Permeability ranges from rapid to moderate in the upper part of the profile and from rapid to moderately slow in the lower part. The hazard of soil blowing is very severe. The organic-matter content is moderate or high, and fertility is low or medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, or pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed to maintain forage production in areas of native grass.

Management should include the use of crop residue, stripcropping, field windbreaks, buffer strips, cover crops, emergency tillage, timely tillage, grassed waterways, fertilizer, and green-manure crops. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIe-3P

The only mapping unit in this capability unit is Letcher sandy loam. This soil is somewhat poorly drained, nearly level, and deep. It has a sodic claypan. This soil has a moderately coarse textured surface layer and subsoil and a coarse textured substratum. In some areas, the lower part of the substratum is moderately fine textured glacial till.

Surface runoff is slight. The available water capacity is low. Permeability is slow in the subsoil and rapid to moderately slow in the substratum. The hazard of soil blowing is severe. The organic-matter content is moderate, and fertility is low.

This soil is suited to barley, wheat, and oats. Wheatgrasses, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Wetness delays tillage operations. The sodic claypan and low available water capacity reduce plant growth. Tillage that mixes the sodic subsoil with the surface layer causes surface crusting when the soil dries. This surface crust hinders the emergence of seedlings, especially for such crops as flax. A perched water table forms above the sodic subsoil during periods of heavy precipitation, and it causes wetness that delays tillage operations. Management should include the use of cover crops, stripcropping, buffer strips, minimum tillage, timely tillage, fertilizer, and crop residue. These measures control erosion, conserve moisture, and maintain fertility. The use of green-manure crops and barnyard manure improves tilth and permeability. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIe-5

This capability unit consists of well drained and moderately well drained, deep, sloping and gently rolling soils. These soils are medium textured.

Surface runoff is rapid. The available water capacity is high, and permeability is moderate. The hazard of soil blowing is moderate. The organic-matter content is high, except in the Esmond soils in which it is medium. Fertility is medium, except in the Esmond soils in which it is low.

These soils are suited to close-growing crops. Wheat, barley, flax, and oats are the main crops. Bromegrass and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Brush control improves forage production in some areas.

Management should include the use of contour farming, diversions, grassed waterways, cover crops, crop residue, buffer strips, green-manure crops, fertilizer, and barnyard manure. Grasses and legumes should be included in the cropping system. All of these measures help control erosion, conserve moisture, and maintain fertility. Fallow should be used only to help in controlling weeds and in storing soil moisture.

CAPABILITY UNIT IIIe-6

This capability unit consists of well drained and moderately well drained, deep, sloping and gently rolling soils. These soils are medium textured or moderately fine textured.

Surface runoff is rapid. The available water capacity is high, and permeability is moderate or moderately slow. The hazard of soil blowing is slight. The organic-matter content is moderate or high. Fertility is medium or high, except in Buse soils in which it is low.

These soils are suited to close-growing crops. Wheat, barley, flax, and oats are the main crops. Bromegrass and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Grazing of native vegetation should be controlled so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Brush control improves forage production in some areas.

Management should include the use of contour farming, diversions, grassed waterways, crop residue, fertilizer, barnyard manure, and green-manure crops. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIes-3

This capability unit consists of somewhat excessively drained and moderately well drained, shallow and moderately deep, nearly level and undulating soils. These soils have a moderately coarse textured surface layer and subsoil and a coarse textured substratum.

Surface runoff is slow to medium. The available water capacity is low. Permeability is moderately rapid in the surface layer and subsoil and rapid or very rapid in the substratum. The hazard of soil blowing is very severe. The organic-matter content is medium, and fertility is medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of crop residue, stripcropping, field windbreaks, buffer strips, cover crops, timely tillage, minimum tillage, emergency tillage, green-manure crops, and fertilizer. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIes-5

This capability unit consists mainly of well-drained, shallow, gently undulating and gently rolling soils, but in some areas it consists of excessively drained, very shallow, gently undulating and gently rolling soils. In most areas these soils have a medium-textured surface layer and subsoil and a coarse-textured substratum, but in a few areas they are coarse textured, except for the surface layer.

Surface runoff is medium to rapid. The available water capacity is low or very low, and permeability is moderately rapid in the surface layer but very rapid below that. The hazard of soil blowing is moderate. The organic-matter content ranges from moderately low to high, and fertility is medium or low.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

Management should include the use of crop residue, stripcropping, field windbreaks, buffer strips, cover crops, grassed waterways, timely tillage, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIes-6

This capability unit consists of somewhat excessively drained, shallow, gently undulating Renshaw soils. They have a medium-textured surface layer and subsoil and a coarse-textured substratum.

Surface runoff is medium. The available water capacity is low, and permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The hazard of soil blowing is slight. The organic-matter content is moderate, and fertility is medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops. Alfalfa and bromegrass are grown for silage, hay, and pasture on farms where livestock is raised. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

Management (fig. 17) should include the use of crop residue, cover crops, grassed waterways, stripcropping, timely tillage, fertilizer, and barnyard manure. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed to control weeds.

Figure 17.—**Rough tillage on a soil in capability unit IIIes-6. The ridges hold snow and help control soil blowing.**

CAPABILITY UNIT IIIw-3

This capability unit consists of somewhat poorly drained and poorly drained, deep, nearly level soils. These soils have a moderately coarse textured surface layer but are moderately coarse textured or coarse textured below the surface layer. In some areas the upper part of the soil is high in content of lime, and in other areas the lower part of the substratum is glacial till.

The available water capacity is low or moderate. Permeability is moderately rapid or rapid. The organic-matter content is moderate or high, and fertility is medium.

These soils are suited to native grasses. The native vegetation includes big bluestem, little bluestem, switchgrass, prairie dropseed, western wheatgrass, Maximilian sunflower, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If not drained, these soils are too wet for tilled crops, but if drained, they are suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Corn, bromegrass, and alfalfa are grown for silage, hay, or pasture on farms where livestock is raised.

The hazard of soil blowing is very severe if these soils are drained and tilled. Management should include the use of crop residue, cover crops, stripcropping, field windbreaks, buffer strips, timely tillage, emergency tillage, minimum tillage, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIw-4

The only mapping unit in this capability unit is Ludden silty clay. This soil is poorly drained, deep, nearly level and calcareous. It is fine textured through-

out, and lime has accumulated in the upper part of the substratum.

This soil is subject to flooding. The available water capacity is high. Permeability is slow. The organic-matter content is high, and fertility is medium.

This soil is suited to native grasses. Native vegetation includes big bluestem, slender wheatgrass, green needlegrass, western wheatgrass, prairie dropseed, and Maximilian sunflower. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If undrained, this soil is too wet for cultivated crops, but if drained, it is suited to most crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops.

The hazard of soil blowing is severe if this soil is drained and tilled. Tillage operations are delayed in places and some crops are damaged by overflow even where drainage has been provided. Management should include the use of crop residue, stripcropping, cover crops, buffer strips, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIw–5

The only mapping unit in this capability unit is Fossum loam. This soil is poorly drained, deep, and nearly level. It has a medium-textured surface layer and a coarse-textured substratum that is high in content of lime in the upper part.

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

This soil is suited to native grasses. Native vegetation includes prairie cordgrass, big bluestem, indiangrass, Maximilian sunflower, and western wheatgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If not drained, this soil is too wet for tilled crops, but if drained, it is suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Grasses and legumes are grown for silage, hay, and pasture on farms where livestock is raised.

The hazard of soil blowing is moderate if this soil is drained and tilled. Management should include the use of crop residue, cover crops, buffer strips, stripcropping, green-manure crops, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIw–6

The only mapping unit in this capability unit is Tolna loam. This soil is somewhat poorly drained, moderately deep, and nearly level. It has a medium-textured surface layer and subsoil and a coarse-textured substratum.

The available water capacity is low. Permeability is moderately rapid to very rapid. The organic-matter content is high, and fertility is medium.

This soil is suited to native grasses. Native vegetation includes big bluestem, slender wheatgrass, green needlegrass, Canada wildrye, western wheatgrass, prairie dropseed, and Maximilian sunflower. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

If not drained this soil is too wet for tilled crops, but if drained, it is suited to most crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops.

The hazard of soil blowing is slight if this soil is drained and tilled. Management should include the use of crop residue, stripcropping, cover crops, buffer strips, timely tillage, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIw–7

The only mapping unit in this capability unit is Parnell silty clay loam. This soil is very poorly drained, deep, and nearly level. It has a moderately fine textured surface layer, a fine textured subsoil, and a medium textured or moderately fine textured substratum.

The available water capacity is high. Permeability is slow. The organic-matter content is high, and fertility is high.

This soil is suited to native grasses. Native vegetation includes slough sedge, rivergrass, prairie cordgrass, northern reedgrass, American mannagrass, and reed canarygrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Fencing is needed in places to prevent overgrazing of slough sedge and rivergrass.

If not drained, this soil is too wet for tilled crops, but if drained it is suited to most crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops.

The hazard of water erosion is severe if this soil is drained and tilled. Crops are damaged by runoff from adjacent areas during heavy rainstorms. Management should include careful design of drainage ditches and, in places, diversion of runoff received from adjacent areas.

CAPABILITY UNIT IIIws–4L

This capability unit consists of nearly level, deep and moderately deep, somewhat poorly drained to very poorly drained, saline soils. These soils have a medium textured or moderately fine textured surface layer and a medium textured or moderately fine textured substratum. They have a high content of lime in the upper part, and they range from moderately fine textured to coarse textured in the lower part.

These soils contain soluble salts that are harmful to crops. They have a seasonal high water table. The available water capacity ranges from low to high.

Permeability ranges from moderate or very rapid to moderately slow, depending on the texture of the soil. The organic-matter content is high, and fertility is medium.

These soils are suited to native grasses. Native vegetation consists of big bluestem, little bluestem, prairie cordgrass, foxtail farley, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

If not drained, these soils are too wet for tilled crops, but if drained, they can be used for salt-tolerant plants. The main salt-tolerant crops are barley, rye, wheat, sweetclover, and alfalfa. The seedlings, however, have a low tolerance. Tall wheatgrass, slender wheatgrass, and western wheatgrass are salt-tolerant grasses that are used for hay and pasture plantings.

The hazard of soil blowing is severe if these soils are drained and tilled. Management should include the use of crop residue, stripcropping, buffer strips, cover crops, green-manure crops, fertilizer, and barnyard manure. Legumes and grasses should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIs–3

This capability unit consists of somewhat poorly drained, moderately deep and deep, nearly level, calcareous soils. These soils have a moderately coarse textured surface layer and a substratum medium- to coarse-textured that has a high content of lime in the upper part.

Surface runoff is slow. The available water capacity ranges from low to high. Permeability is moderate to moderately rapid in the upper part and moderate to rapid in the lower part. The hazard of soil blowing is very severe. The organic-matter content is moderate or high, and fertility is medium. These soils have a seasonal high water table.

These soils are suited to all crops commonly grown in the survey area, but seeding is delayed in places because of wetness. Barley, wheat, oats, flax, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, and pasture on farms where livestock is raised. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

Management should include the use of crop residue, cover crops, field windbreaks, buffer strips, stripcropping, fertilizer, and barnyard manure to control erosion, conserve moisture, and maintain fertility. Crop response to phosphate fertilizer is especially good on these soils. Including sweetclover in the rotation helps to lower the water table and if plowed under it improves soil tilth. Fallow should be used only when needed to control weeds or to follow a crop of sweetclover. Draining shallow depressions aids in tillage.

CAPABILITY UNIT IIIs–4L

This capability unit consists of somewhat poorly drained, moderately deep, nearly level and gently undulating, calcareous Divide soils. These soils are medium textured in the surface layer and in the upper part of the substratum but coarse textured in the lower part of the substratum. The upper part of the substratum contains a large amount of lime, and in a few areas, the lower part is glacial till.

Surface runoff is slow to medium. The available water capacity is low. Permeability is moderate in the surface layer and in the upper part of the substratum but very rapid in the lower part of the substratum. The hazard of soil blowing is severe. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table.

These soils are suited to most crops commonly grown in the survey area, but seeding is delayed in places because of wetness. Barley, wheat, oats, flax, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, and pasture on farms where livestock is raised. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

Management should include the use of cover crops, crop residue, stripcropping, field windbreaks, buffer strips, timely tillage, green-manure crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Crop response to phosphate fertilizer is especially good on these soils. Fallow should be used only when needed to control weeds or to follow a crop of sweetclover.

CAPABILITY UNIT IIIs–5

This capability unit consists of well drained and moderately well drained, shallow and moderately deep, nearly level soils. These soils have a medium-textured surface layer and subsoil and a coarse-textured substratum.

Surface runoff is slow. The available water capacity is low, and permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The hazard of soil blowing is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, and pasture on farms that raise livestock. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of crop residue, cover crops, field windbreaks, stripcropping, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility.

CAPABILITY UNIT IIIs–5P

This capability unit consists of well drained, moderately well drained, and somewhat poorly drained, deep, nearly level and gently undulating Cathay and Heimdal soils. Cathay soils have a medium-textured surface layer, a moderately fine textured, sodic subsoil, and a medium-textured substratum. Heimdal soils have medium texture throughout.

Surface runoff is slow to medium. The available wa-

ter capacity is high. Permeability is moderate to slow. The hazard of soil blowing is moderate. The organic-matter content is high, and fertility is medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, flax, oats, and rye are the main crops. Corn, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed to maintain forage production in areas of native grass.

Tillage that mixes the sodic subsoil with the surface layer results in surface crusting when the soil dries. This surface crust hinders the emergence of seedlings, especially for such crops as flax. A perched water table forms above the sodic subsoil during periods of heavy precipitation, and it causes wetness that delays tillage. Management should include the use of crop residue, timely tillage, stripcropping, buffer strips, green-manure crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Including grasses and legumes in the cropping system increases soil permeability and improves tilth.

CAPABILITY UNIT IIIs-6

This capability unit consists of well drained, moderately well drained, and somewhat excessively drained, moderately deep and shallow, nearly level soils. These soils have a medium-textured surface layer and subsoil and a coarse-textured substraum. In some areas the lower part of the substratum is glacial till.

Surface runoff is slow. The available water capacity is low or moderate, but a few areas of Svea loam, cobbly variant, have high available water capacity. Permeability is moderate or moderately rapid in the surface layer and subsoil. It is rapid or very rapid in the substratum in the places where the soil material is coarse textured, but it is moderate or moderately slow in the lower part of the substratum in the places where the soil material is glacial till. The hazard of soil blowing is slight. The organic-matter content is moderate or high, and fertility is medium or high.

These soils are suited to all crops commonly grown in the survey area. Wheat, barley, oats, flax, and rye are the main crops. Corn, alfalfa, and bromegrass are grown for silage, hay, and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed in areas of native grass to maintain forage production.

Management should include the use of crop residue, cover crops, stripcropping, buffer strips, field windbreaks, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IIIs-6P

This capability unit consists mainly of somewhat poorly drained to well drained, deep and moderately deep, nearly level and gently undulating soils. These soils have a medium-textured surface layer, a moderately fine textured, sodic subsoil, and a medium textured or moderately fine textured substratum. In many areas, this unit also has well drained and moderately well drained, deep and moderately deep, nearly level and gently undulating Edgeley and Svea soils. The Edgeley and Svea soils have a medium-textured surface layer, a medium-textured or moderatly fine textured, nonsodic subsoil, and a medium-textured or moderately fine textured substratum. Edgeley soils are underlain by shale.

Surface runoff is slow to medium. The available water capacity is moderate or high. Permeability ranges from moderate to very slow. The hazard of soil blowing is slight. The organic-matter content is high, and fertility ranges from low to high.

These soils are suited to most crops commonly grown in the survey area, but the soils that have a sodic subsoil are less suited than other soils. Wheat, barley, oats, and rye are the main crops. Grasses and legumes are grown for hay and pasture on farms where livestock is raised. Deferring grazing and controlling distribution of water and salt are needed to maintain forage production in areas of native grass.

Tillage that mixes the sodic subsoil with the surface layer results in surface crusting when the soil dries. This surface crusting hinders the emergence of seedlings, especially for such crops as flax. A perched water table forms above the sodic subsoil during periods of heavy precipitation, and it causes wetness that delays tillage. Management should include the use of stripcropping, cover crops, crop residue, buffer strips, grassed waterways, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. The use of green-manure crops and barnyard manure, and the inclusion of grasses and legumes in the cropping system help improve tilth and permeability. Fallow should be used only when needed to control weeds or to follow grasses or legumes. Draining shallow depressions aids in tillage.

CAPABILITY UNIT IIIsw-3

The only mapping unit in this capability unit is Wyrene-Totten sandy loams. Wyrene soils are moderately deep, somewhat poorly drained, and calcareous. They have a moderately coarse textured surface layer, and the lower part of their substratum is coarse textured. The upper part of the substratum contains a large amount of lime. Totten soils are moderately deep and are poorly drained and very poorly drained. They have a moderately coarse textured surface layer, a moderately fine textured sodic subsoil, and a coarse-textured substratum.

The available water capacity is low. The organic-matter content is medium, and fertility is low or moderate. For Wyrene soils permeability is moderately rapid in the surface layer and upper part of the substratum and rapid in the lower part of the substratum. For Totten soils it is moderately slow in the sodic subsoil and rapid in the substratum.

These soils are suited to native grasses. Native vegetation includes western wheatgrass, prairie junegrass, inland saltgrass, big bluestem, prairie cordgrass, and sedges. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If not drained, these soils are too wet for tilled crops, but if drained, they are suited to barley, wheat, and

oats. The soils that have a sodic subsoil are less suited to these crops than other soils. Bromegrass and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised.

The hazard of soil blowing is very severe if these soils are drained and tilled. Tillage that mixes the sodic subsoil with the surface layer results in surface crusting when the soil dries. This surface crust hinders the emergence of seedlings, especially for such crops as flax. A perched water table forms above the sodic subsoil during periods of heavy precipitation, and it causes wetness that delays tillage. Management should include the use of stripcropping, cover crops, buffer strips, crop residue, and fertilizer. These measures control erosion, conserve moisture, and maintain fertility. Growing green-manure crops, applying barnyard manure, and including grasses and legumes in the cropping system improve soil tilth and permeability. Fallow should be used only when needed for weed control or to follow grasses and legumes.

CAPABILITY UNIT IVe-2

This capability unit consists of well drained, moderately well drained, and somewhat poorly drained, deep, nearly level and gently sloping soils. These soils are coarse textured throughout the profile.

Surface runoff is slow to medium. The available water capacity is low, and permeability is rapid. The hazard of soil blowing is very severe. The organic-matter content is moderate or low, and fertility is medium or low.

These soils are suited to all crops commonly grown in the survey area. Wheat, oats, barley, flax, and rye are the main crops. Native vegetation includes prairie sandreed, needleandthread, sun sedge, prairie junegrass, and purple prairie-clover. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Wheatgrass, bromegrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised.

Management should include the use of crop residue, buffer strips, stripcropping, field windbreaks, cover crops, minimum tillage, fertilizer, barnyard manure, and green-manure crops. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVe-3

This capability unit consists of well-drained and excessively drained, deep, nearly level to moderately steep soils. These soils have a moderately coarse textured surface layer. They are moderately coarse textured or coarse textured immediately below the surface layer and coarse textured in the lower part of the soil.

Surface runoff ranges from slow to very rapid. The available water capacity ranges from very low to moderate, and permeability is rapid or moderately rapid. The hazard of soil blowing is very severe. The organic-matter content is low or moderate, and fertility ranges from very low to medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, oats, barley, rye, and flax are the main crops. Native vegetation includes prairie sandreed, needleandthread, sun sedge, prairie junegrass, and purple prairieclover. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing. Bromegrass, wheatgrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised.

Management should include the use of crop residue, cover crops, stripcropping, buffer strips, field windbreaks, grassed waterways, minimum tillage, contour farming, fertilizer, barnyard manure, and green-manure crops. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVe-3M

This capability unit consists of well drained and moderately well drained, deep, sloping and moderately steep soils. These soils have a moderately coarse textured surface layer. Below the surface layer, the texture is coarse to medium in the upper part and coarse to moderately fine in the lower part.

Surface runoff is rapid or very rapid. The available water capacity ranges from low to high. Permeability is rapid or moderately rapid in the upper part of the profile, and it is rapid to moderately slow in the lower part of the profile. The hazard of soil blowing is very severe. The organic-matter content is moderate or high, and fertility ranges from low to medium.

These soils are suited to all crops commonly grown in the survey area. Wheat, oats, barley, rye, and flax are the main crops. Native vegetation includes prairie sandreed, needleandthread, sun sedge, prairie junegrass, and purple prairieclover. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Bromegrass, wheatgrass, and alfalfa are grown for silage, hay, and pasture on farms where livestock is raised.

Management should include the use of crop residue, cover crops, stripcropping, buffer strips, field windbreaks, grassed waterways, minimum tillage, contour farming, fertilizer, barnyard manure, and green-manure crops. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVe-5

The only mapping unit in this capability unit is Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes. These soils are well drained and moderately well drained, deep, and moderately steep. They are medium textured throughout the soil profile.

Surface runoff is very rapid. The available water capacity is high, and permeability is moderate. The hazard of soil blowing is moderate. The organic-matter content is moderate or high, and fertility is low or medium.

These soils are suited to close-growing crops, but in most areas only the less sloping soils are tilled. Wheat, barley, oats, and rye are the main crops. Alfalfa, bromegrass, and wheatgrass are included in most crop-

ping systems. Native vegetation includes western wheatgrass, needleandthread, green needlegrass, prairie junegrass, and bearded wheatgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed.

Management should include the use of grassed waterways, diversions, contour farming, crop residue, buffer strips, cover crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVes–3

This capability unit consists of excessively drained and somewhat excessively drained, shallow and very shallow, sloping soils. These soils have a moderately coarse textured surface layer. Below the surface layer, the texture of these soils is moderately coarse or coarse in the upper part and coarse in the lower part.

Surface runoff is rapid. The available water capacity is low or very low. Permeability is moderately rapid or very rapid in the upper part of the soil and very rapid in the lower part. The hazard of soil blowing is very severe. The organic-matter content ranges from low to moderate, and fertility is low or medium.

These soils are suited to close-growing crops. Wheat, oats, barley, and rye are the main crops. Alfalfa, bromegrass, and wheatgrass are grown as a part of most cropping systems. Native vegetation includes little bluestem, needleandthread, blue grama, plains muhly, prairie junegrass, and purple prairieclover. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can be used to prevent overgrazing.

Management should include the use of crop residue, buffer strips, cover crops, grassed waterways, diversions, contour farming, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVw–2

This capability unit consists of somewhat poorly drained, deep, nearly level Hamar soils. These soils are coarse textured.

The available water capacity is low. Permeability is rapid. The organic-matter content is moderate, and fertility is medium. The hazard of soil blowing is very severe.

These soils are suited to native grasses. If not drained, they are too wet for tilled crops, but if drained, these soils are suited to all crops commonly grown in the survey area. Wheat, oats, barley, flax, and rye are the main crops. Native vegetation includes switchgrass, prairie cordgrass, big bluestem, indiangrass, Maximilian sunflower, tall gayfeather, and meadow parsnip. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing can be used to prevent overgrazing. Bromegrass and alfalfa are grown for silage, hay, and pasture on livestock farms.

Management should include the use of crop residue, cover crops, stripcropping, buffer strips, field windbreaks, minimum tillage, green-manure crops, fertilizer, and barnyard manure. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed to control weeds or to follow a crop of grasses or legumes.

CAPABILITY UNIT IVws–3

This capability unit consists of poorly drained and very poorly drained, deep and moderately deep, nearly level soils. They have a moderately coarse textured surface layer, a moderately coarse textured to moderately fine textured, sodic subsoil, and a coarse textured substratum.

The available water capacity is low and permeability is moderately slow in the subsoil and moderately rapid or rapid in the substratum. The organic-matter content is moderate, and fertility is low. The hazard of soil blowing is very severe.

These soils are suited to native grasses. Native vegetation includes switchgrass, prairie cordgrass, big bluestem, indiangrass, Maximilian sunflower, tall gayfeather, meadow parsnip, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If not drained, these soils are too wet for tilled crops, but if drained, they can be used for salt-tolerant crops. The main crops are barley, oats, and wheat. Wheatgrass, bromegrass, and alfalfa are included in most cropping systems.

Tillage is often delayed because of wetness. These soils have a high water table, and they receive runoff from adjacent areas. Tillage that mixes the subsoil with the surface layer results in surface crusting when the soil drys. This surface crust hinders the emergence of seedlings, especially for such crops as flax. Management should include the use of crop residue, buffer strips, cover crops, green-manure crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Grasses or legumes should be included in the cropping system, and the plowing under of sweetclover improves soil tilth and permeability. Fallow should be used only when needed to control weeds or to follow a crop of grasses or legumes.

CAPABILITY UNIT IVws–6

This capability unit consists of poorly drained and very poorly drained, moderately deep, nearly level Totten loam. This soil has a medium-textured surface layer, a moderately fine textured sodic subsoil and mainly a coarse-textured substratum, but in some areas, the lower part of the substratum is glacial till.

The available water capacity is low. Permeability is moderately slow in the subsoil and rapid in the substratum. The organic-matter content is moderate, and fertility is low. The hazard of soil blowing is slight.

This soil is suited to native grasses. Native vegeta-

tion includes switchgrass, prairie cordgrass, big bluestem, indiangrass, Maximilian sunflower, tall gayfeather, meadow parsnips, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

If not drained, this soil is too wet for tilled crops, but if drained, it is suited to barley, oats, wheat, and other salt-tolerant crops. Wheatgrass, bromegrass, and alfalfa are included in most cropping systems.

Wetness caused by a high water table and the ponding of surface runoff often delays tillage. Tillage that mixes the subsoil with the surface layer results in surface crusting when the soil dries. This surface crust hinders the emergence of seedlings, especially for such crops as flax (fig. 18). Management should include the use of crop residue, stripcropping, buffer strips, cover crops, green-manure crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. Growing grasses and legumes and the plowing under of sweetclover improves soil tilth and permeability. Fallow should be used only when needed to control weeds or to follow a crop of grasses or legumes.

CAPABILITY UNIT IVs–2

The only mapping unit in this capability unit is Minnewaukan loamy fine sand, 6 to 9 percent slopes. This soil is poorly drained, deep, sloping and coarse textured.

Surface runoff is rapid. The available water capacity is low, and permeability is rapid. The hazard of soil blowing is very severe. The organic-matter content is low, and fertility is low.

This soil is suited to close-growing crops. Barley, oats, millet, alfalfa, and bromegrass are the main crops. Tillage is often delayed because of wetness. Native vegetation includes prairie cordgrass, little bluestem, Maximilian sunflower, nuttall alkaligrass, inland saltgrass, and bluegrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing.

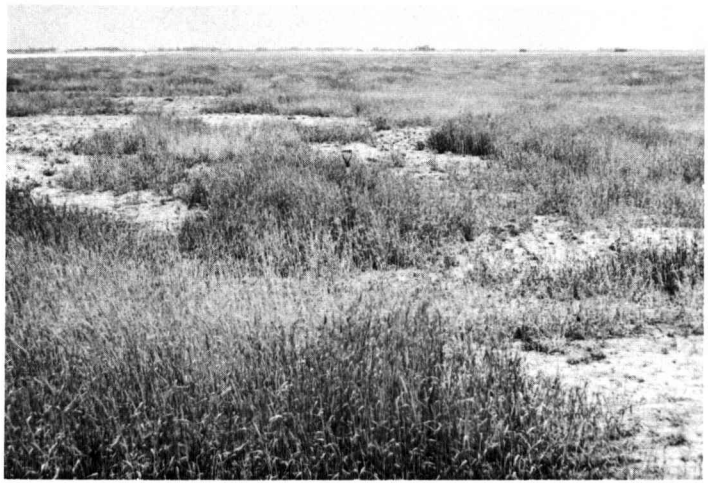

Figure 18.—Because the soil contains salts and has a dense subsoil, the rye has not grown in some spots and has grown unevenly in the rest of this field.

Management should include the use of grassed waterways, diversions, cover crops, crop residue, minimum tillage, buffer strips, green-manure crops, fertilizer, and barnyard manure. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed for weed control.

CAPABILITY UNIT IVs–4L

The only mapping unit in this capability unit is Lallie silty clay loam. This soil is poorly drained and very poorly drained, deep, and nearly level. It has a medium textured or moderately fine textured surface layer and a moderately fine textured or fine textured substratum that has a high content of lime in the upper part.

The available water capacity is moderate. Permeability is slow. The organic-matter content is moderate, and fertility is low. The hazard of soil blowing is severe.

This soil is suited to such salt-tolerant crops as barley, oats, alfalfa, and wheatgrass. Tillage is often delayed because wetness and water ponds in low areas during periods of heavy precipitation. Native vegetation includes prairie cordgrass, little bluestem, Maximilian sunflower, rivergrass, nuttall alkaligrass, inland saltgrass, and bluegrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing to concentrate grazing can be used to prevent overgrazing. Tall wheatgrass, slender wheatgrass, and western wheatgrass are well suited to this soil.

Wetness caused by a high water table and the ponding of runoff often delays tillage. Management should include the use of crop residue, cover crops, buffer strips, timely tillage, green-manure crops, fertilizer, and barnyard manure. Grasses and legumes should be included in the cropping system. These measures control erosion, conserve moisture, and maintain fertility. Fallow should be used only when needed to control weeds or to follow a crop of grass or legumes.

CAPABILITY UNIT IVs–6P

This capability unit consists of moderately well drained, somewhat poorly drained, and poorly drained, deep, nearly level soils. These soils have a medium textured or moderately fine textured surface layer, a moderately fine textured, sodic subsoil, and mainly a medium textured or moderately fine textured substratum, but in a few areas, they are coarse textured in the lower part of the substratum.

Surface runoff is slow. The available water capacity ranges from low to high, and permeability is slow or very slow. The hazard of soil blowing is slight. The organic-matter content is high, and fertility is low or medium.

These soils are suited to salt-tolerant crops. Barley, wheat, and oats are the main crops. Grasses and le-

gumes are grown as part of most cropping systems. Native vegetation includes western wheatgrass, needleandthread, blue grama, sandberg bluegrass, green needlegrass, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing can help prevent overgrazing.

Wetness caused by a high water table and the ponding of surface runoff delays tillage in some areas. Tillage that mixes the sodic subsoil with the surface layer results in surface crusting when the soil dries. This surface crust hinders the emergence of seedlings, especially for such crops as flax. Management should include the use of crop residue, cover crops, buffer strips, green-manure crops, fertilizer, and barnyard manure. These measures control erosion, conserve moisture, and maintain fertility. The plowing under of grasses and legumes improves tilth and permeability. Draining shallow depressions aids in tillage. Fallow should be used only when needed to control weeds or to follow a crop of grasses or legumes.

CAPABILITY UNIT Vw–8

This capability unit consists mainly of very wet, poorly drained and very poorly drained, deep and moderately deep, nearly level soils, but there are areas of very wet marsh and peat. These soils have a medium textured, moderately fine textured, or moderately coarse textured surface layer and a coarse- to fine-textured substratum, but in many places, the upper part of the substratum contains a large amount of lime. In a few areas they have a sodic subsoil. A few inches to several feet of organic matter has accumulated on the surface.

These soils have a high water table. The available water capacity ranges from low to high. Permeability ranges from slow to rapid. The organic-matter content is high in most areas, but it is moderate in other areas where the soils are coarser textured. The fertility is medium or low.

These soils are suited to native grasses. They are too wet for tilled crops, and drainage is not feasible. Native vegetation includes slough sedge, rivergrass, longrooted smartweed, reed canarygrass, prairie cordgrass, asters, bulrushes, and cattails. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing. Larger areas of these soils should be fenced separately to prevent grazing when these soils are very wet and to force grazing of the heavy growth when they are dry enough to be grazed. During wet years these soils are suited only to wildlife habitat.

CAPABILITY UNIT VIe–2

This capability unit consists of moderately well drained, well drained, and excessively drained, deep, moderately steep to very steep and coarse textured soils.

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

These soils are suited to native grasses and are used for pasture and hay. They are too steep for cultivated crops. Areas now tilled should be returned to native vegetation. Native vegetation includes prairie sandreed, sand bluestem, needleandthread, prairie junegrass, and sand dropseed. Grazing should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIe–3

This capability unit consists of well drained and moderately well drained, deep, steep and very steep soils. These soils have a moderately coarse textured surface layer, a moderately coarse textured or medium textured subsoil, and a medium textured to coarse, textured substratum.

The available water capacity is moderate or high. Permeability is moderate or moderately rapid. The organic-matter content is high, and fertility is medium.

These soils are suited to native grasses and are used for pasture and hay. They are too steep for tilled crops. Areas now tilled should be returned to native vegetation. Native vegetation includes prairie sandreed, needleandthread, prairie junegrass, threadleaf sedge, and forbs. Grazing should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIe–5

This capability unit consists of well drained and moderately well drained, deep, steep soils. They are medium textured.

The available water capacity is high. Permeability is moderate. The organic-matter content is moderate or high, and fertility is low or medium.

These soils are suited to native grasses. They are too steep for tilled crops. Areas now tilled should be returned to native vegetation. Native vegetation includes western wheatgrass, needleandthread, green needlegrass, and prairie junegrass. Grazing should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIe–6

The dominant soils in this capability unit are well drained, deep, and sloping to very steep. The minor soils include some that are moderately well drained and deep, and some that are excessively drained and well drained and shallow and very shallow. The dominant soils have a medium-textured surface layer. Below the surface layer they are medium textured or moderately fine textured. The minor soils have a medium textured or moderately coarse textured surface layer, and below the surface layer they are from coarse textured to medium textured in the upper part and coarse textured or bedded shale in the lower part.

The dominant soils have a high available water capacity and moderate or moderately slow permeability. They have moderate or high organic-matter content and low or medium fertility.

These soils are suited to native grasses. They are too steep for tilled crops. Areas now tilled should be returned to native vegetation. Native vegetation includes little bluestem, plains muhly, side-oats grama, plains reedgrass, thickspike wheatgrass, stiff sunflower, and dotted gayfeather. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIes–2

This capability unit consists of moderately well drained, somewhat poorly drained and excessively drained, deep, nearly level and gently sloping, coarse textured soils.

The available water capacity is very low or low. Permeability is rapid. The organic-matter content is low or moderate, and fertility ranges from very low to medium.

These soils are suited to native grasses. They are not suited to tilled crops because of their coarse texture, low or very low available water capacity, and rapid permeability. Because the hazard of soil blowing is very severe, areas that are now tilled should be returned to native grasses. Native vegetation varies with the degree of drainage. On the excessively drained soils, which are dominant in this unit, the vegetation includes sand bluestem, sand dropseed, field sagewort, sun sedge, leadplant amorpha, and Canada wildrye. On the moderately well drained soils, it includes prairie sandreed, needleandthread, sun sedge, prairie junegrass, and purple prairieclover. On the somewhat poorly drained soils, it includes switchgrass, prairie cordgrass, big bluestem, indiangrass, Maxmilian sunflower, and tall gayfeather. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIes–5

The dominant soils in this unit are well drained, shallow, and moderately steep to very steep. Among the minor soils are excessively drained, very shallow soils and well-drained, moderately deep soils. All of these soils have a medium-textured surface layer. Below the surface layer they are medium textured, moderately fine textured, or coarse textured in the upper part and either coarse textured or bedded shale in the lower part.

The dominant soils have a very low available water capacity and moderate permeability. They have high organic-matter content and low fertility.

These soils are suited to native grasses. They are too steep or too shallow for tilled crops. Areas now tilled should be returned to native grass. Native vegetation on the dominant soils includes little bluestem, plains muhly, needleandthread, blue grama, threadleaf sedge, dotted gayfeather, stiff sunflower, purple coneflower, and purple prairieclover. Grazing should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIew–6

The only mapping unit in this capability unit is the La Prairie-Lamoure complex. These soils are deep and nearly level. The La Prairie soil is moderately well drained, and the Lamoure soil is poorly drained. These soils are medium textured or moderately fine textured but in some areas the Lamoure soil has a fine-textured subsoil.

The available water capacity is high. Permeability is moderate. The organic-matter content is high, and fertility is medium or high.

These soils are suited to native grasses. The Lamoure soil is too wet for tilled crops and areas of the La Prairie soil are too small to be tilled separately. Areas now tilled should be returned to native grass. On the La Prairie soil the native vegetation includes western wheatgrass, needleandthread, green needlegrass, prairie junegrass, and bearded wheatgrass. On the Lamoure soil it includes switchgrass, prairie cordgrass, big bluestem, indiangrass, and Maximilian sunflower. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIw–4

This capability unit consists of poorly drained and somewhat poorly drained, deep, nearly level soils. The dominant soils in this unit have a medium textured or moderately fine textured surface layer, a moderately fine textured or fine textured sodic subsoil, and a moderately fine textured or fine textured substratum. Lemert soils have a medium-textured or moderately coarse textured surface layer, a moderately coarse textured, sodic subsoil, and a coarse textured substratum. The minor soils in this unit are poorly drained, deep, nearly level Lamoure soils that have a medium textured or moderately fine textured surface layer, a moderately fine textured or fine textured sodic subsoil, and moderately fine textured substratum.

The dominant soils have a low available water capacity. Permeability is very slow or slow in the subsoil and rapid in the substratum. The organic-matter content is high, and fertility is low.

These soils are suited to native grasses. They are not suited to tilled crops because they have a sodic subsoil, a low available water capacity, very slow or slow permeability, and wetness caused by a high water table. Areas now tilled should be returned to native vegetation. Native vegetation includes blue grama, western wheatgrass, needleandthread, buffalograss, sandberg bluegrass, needleleaf sedge, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing that concentrates grazing can help prevent overgrazing and grazing when the soils are too wet.

CAPABILITY UNIT VIs–3

This capability unit consists of excessively drained and somewhat excessively drained, shallow and very shallow, nearly level to moderately steep soils. These soils have a moderately coarse textured surface layer

and mainly a coarse textured substratum. The Binford soils have a moderately coarse textured subsoil.

The available water capacity is low or very low. Permeability is very rapid, except in Binford soils where it is moderately rapid in the surface layer and subsoil and very rapid in the substratum. The organic-matter content ranges from low to moderate, and fertility is low or medium.

These soils are suited to native grasses. Because of the shallowness and the slope, they are not suited to tilled crops. Areas now tilled should be returned to native vegetation. Native vegetation includes needleandthread, blue grama, threadleaf sedge, red three-awn, plains muhly, common winterfat, and fringed sage. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIs–6P

This capability unit consists of moderately well drained and somewhat poorly drained, deep and moderately deep, nearly level soils. These soils have a medium textured or moderately fine textured surface layer, a moderately fine textured or fine textured, sodic subsoil, and mainly a medium textured to fine textured substratum, but in some areas the lower part of the substratum is bedded shale.

The available water capacity is low or moderate. Permeability is very slow. The organic-matter content is medium or high, and fertility is low.

These soils are suited to native grasses. Because of their sodic subsoil, low available water capacity, and very slow permeability, these soils are not suited to tilled crops. Areas now tilled should be returned to native vegetation. Native vegetation includes western wheatgrass, needleandthread, blue grama, Sandburg bluegrass, green needlegrass, and inland saltgrass. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing, controlling distribution of water and salt, and fencing that concentrates grazing can be used to prevent overgrazing.

CAPABILITY UNIT VIIs–3

This capability unit consists of excessively drained, very shallow, sloping to steep soils. They have a surface layer of sandy loam or gravelly loam and a coarse-textured substratum.

The available water capacity is very low, and permeability is very rapid. The organic-matter content is low or moderately low, and fertility is low.

These soils are suited to native grasses. Because of their coarse texture, very low available water capacity, and very rapid permeability, the soils are not suited to tilled crops. Areas now tilled should be returned to native grass. Native vegetation includes needleandthread, blue grama, threadleaf sedge, red three-awn, plains muhly, and fringed sage. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIIs–8

This capability unit consists of well drained and moderately well drained, deep, gently undulating and gently rolling, stony soils. These soils have a medium-textured surface layer, and below this they are medium textured or moderately fine textured.

The available water capacity is high. Permeability is moderately slow or moderate in the upper part of the profile and moderately slow in the lower part. The organic-matter content is moderate or high, and fertility ranges from low to high.

These soils are suited to native grasses, but they are too stony for tilled crops. Native vegetation includes western wheatgrass, green needlegrass, bearded wheatgrass, needleandthread, prairie junegrass, little bluestem, big bluestem, plains muhly, and sideoats grama. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

CAPABILITY UNIT VIIsw–8

The only mapping unit in this capability unit is Cavour and Vallers stony clay loams. The Cavour soils are moderately well drained, deep, and nearly level. They have a moderately fine textured surface layer, a sodic subsoil, and a medium textured or moderately fine textured substratum. Vallers soils are poorly drained, deep, and nearly level. They have a moderately fine textured surface layer and a medium textured or moderately fine textured substratum that is high in content of lime in the upper part.

Cavour soils have a moderate available water capacity, very slow permeability, high organic-matter content, and low fertility. Vallers soils have a high available water capacity, moderately slow permeability, a high organic-matter content, and medium fertility.

These soils are suited to native grasses, but they are too stony for cultivated crops. On Cavour soils the native vegetation includes western wheatgrass, needleandthread, blue grama, and green needlegrass. On Vallers soils it includes wooly sedge, slim sedge, prairie cordgrass, northern reedgrass, and Rydberg's sunflower. Grazing of native vegetation should be regulated so that no more than half of the annual growth of desirable plants is consumed. Deferring grazing and controlling distribution of water and salt can help prevent overgrazing.

Predicted Yields

Table 2 gives estimated crop yields per acre under two levels of management for each soil mapped in this survey area. The yields shown in columns A are to be expected under average management. This includes some drainage and other yield-improving measures. Those shown in columns B are to be expected if the farmer uses the best techniques and management practices available at the present time.

Some farmers are now exceeding the yields estimated in columns B. It is expected that yields will increase in the future, as improved varieties of plants are grown, new techniques are developed, and additional knowledge is gained from research and experi-

TABLE 2.—*Predicted average yields*

[Dashes indicate that the crop

Soil	Spring wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
Aberdeen loam	22	29	40	61
Aberdeen-Exline loams	15	19	27	40
Arveson sandy loam	14	20	25	42
Arvilla sandy loam	14	18	25	38
Arvilla sandy loam, gravelly substratum, 0 to 3 percent slopes	13	17	23	36
Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes	11	14	20	29
Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes	14	18	25	38
Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes	12	15	22	32
Arvilla-Sioux sandy loams, 6 to 9 percent slopes	7	9	13	19
Barnes loam, 0 to 3 percent slopes	24	34	43	71
Barnes loam, 3 to 6 percent slopes	22	32	40	67
Barnes loam, 6 to 9 percent slopes	17	24	31	50
Barnes-Svea loams, 0 to 3 percent slopes	25	35	45	74
Barnes-Svea loams, 3 to 6 percent slopes	23	33	41	69
Barnes-Svea stony loams, 3 to 6 percent slopes				
Barnes-Svea-Buse loams, 6 to 9 percent slopes	18	24	32	50
Barnes-Svea-Buse stony loams, 6 to 9 percent slopes				
Bearden silt loam, saline	13	16	23	34
Binford sandy loam	14	18	25	38
Binford sandy loam, gravelly substratum, 0 to 3 percent slopes	13	17	23	36
Binford sandy loam, gravelly substratum, 3 to 6 percent slopes	11	14	20	29
Binford sandy loam, sandy substratum, 0 to 3 percent slopes	14	18	25	38
Binford sandy loam, sandy substratum, 3 to 6 percent slopes	12	15	22	32
Binford-Coe sandy loams, 6 to 9 percent slopes	7	9	13	19
Binford-Coe sandy loams, 9 to 12 percent slopes				
Borup silt loam [1]	18	24	32	50
Borup and Marysland silt loams, very wet				
Borup and Vallers loams, 3 to 6 percent slopes				
Brantford loam, 3 to 6 percent slopes	12	15	22	32
Brantford loam, gravelly substratum, 0 to 3 percent slopes	14	18	25	38
Brantford loam, gravelly substratum, 3 to 6 percent slopes	11	14	20	29
Brantford loam, sandy substratum, 0 to 3 percent slopes	15	19	27	40
Brantford loam, sandy substratum, 3 to 6 percent slopes	12	15	22	32
Brantford-Coe loams, 6 to 9 percent slopes	8	10	14	21
Brantford-Kensal loams	16	20	29	42
Buse-Barnes loams, 9 to 30 percent slopes				
Buse-Edgeley loams, 9 to 30 percent slopes				
Buse and Kloten loams, 6 to 25 percent slopes				
Buse, Sioux, and Zell soils, 3 to 30 percent slopes				
Cathay loam	20	27	36	57
Cathay-Heimdal loams, 0 to 3 percent slopes	22	29	40	61
Cathay-Heimdal loams, 3 to 6 percent slopes	21	28	38	59
Cathay-Larson loams	14	19	25	40
Cavour-Cresbard loams	13	17	23	36
Cavour and Vallers stony clay loams				
Cavour clay loam, shaly variant, 3 to 6 percent slopes				
Claire loamy coarse sand, 0 to 3 percent slopes				
Claire loamy coarse sand, 3 to 6 percent slopes				
Claire coarse sandy loam	10	12	18	25
Claire-Lohnes-Hamar loamy coarse sands				
Clontarf sandy loam	18	23	32	48
Coe sandy loam, 0 to 6 percent slopes				
Coe sandy loam, 6 to 25 percent slopes				
Colvin silty clay loam [1]	17	23	31	48
Colvin silty clay loam, saline				
Colvin silty clay loam, very wet				
Cresbard-Cavour loams	15	19	27	40
Divide loam, 0 to 3 percent slopes	18	24	32	50
Divide loam, 3 to 6 percent slopes	17	23	31	48
Divide loam, saline	9	11	16	23
Divide loam, gravelly substratum	17	23	31	48
Divide loam, sandy substratum	18	24	32	50
Divide loam, till substratum	18	24	32	50
Eckman loam, 0 to 3 percent slopes	24	34	43	71
Eckman loam, 3 to 8 percent slopes	20	27	36	57
Edgeley loam	22	28	40	59
Edgeley and Cavour loams, 3 to 6 percent slopes	13	16	23	34

per acre of principal crops

is not suited to the soil]

Barley		Flax		Corn (silage)		Tame hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Tons*	*Tons*
31	46	9	15	4.5	6.0	1.5	2.4
21	30	4	6			1.0	1.6
20	32	7	12			1.6	2.3
20	29	8	13	3.0	4.0	1.0	1.4
18	27	8	13	3.0	4.0	1.0	1.4
15	22	7	12	2.5	3.5	.9	1.3
18	29	8	13	3.0	4.0	1.0	1.4
17	24	7	12	2.5	3.5	.9	1.3
10	14	5	8			.5	.9
34	54	10	16	5.0	6.5	1.6	2.5
31	51	9	15	5.0	6.5	1.5	2.4
24	38	7	11	3.5	5.0	1.1	1.8
35	56	11	17	5.5	7.5	1.7	2.6
32	53	10	16	5.5	7.5	1.6	2.5
25	38	7	11	3.5	5.0	1.1	1.8
18	26	4	6			1.0	1.5
20	29	8	13	3.0	4.0	1.0	1.4
18	27	8	13	3.0	4.0	1.0	1.4
15	22	7	12	2.5	3.5	.9	1.3
20	29	8	13	3.0	4.0	1.0	1.5
17	24	7	12	2.5	4.0	.9	1.3
10	14	5	8			.5	.9
25	38	8	13			1.6	2.5
17	24	7	12	2.5	3.5	1.1	1.4
20	29	8	13	3.0	4.0	1.3	1.6
15	22	7	12	2.5	3.5	1.1	1.4
21	30	8	13	3.0	4.0	1.3	1.6
17	24	7	12	2.5	3.5	1.1	1.4
11	16	5	8			.7	1.0
22	32	8	13	3.0	4.0	1.4	1.7
28	43	9	15	4.0	5.5	1.3	2.3
31	46	9	15	4.5	6.0	1.4	2.4
29	45	8	13	4.5	6.0	1.2	2.1
20	30	4	6			1.0	1.6
18	27	4	5			.9	1.5
						.6	.9
						.8	1.2
						.6	.9
14	19	5	8			1.0	1.4
						1.2	1.6
25	37	8	13	4.0	5.0	1.4	1.7
						.6	1.0
24	37	8	13			1.5	2.4
21	30	8	13			1.1	1.6
25	38	8	13	3.5	4.5	1.4	2.0
24	37	7	12	3.0	4.0	1.3	1.9
13	18	4	6			.9	1.4
24	37	8	13	3.5	4.5	1.4	2.0
25	38	8	13	3.5	4.5	1.4	2.0
25	38	8	13	3.5	4.5	1.4	2.0
34	54	10	16	5.0	7.0	1.6	2.5
28	43	8	13	4.0	5.5	1.3	2.2
31	45	9	15	4.5	6.0	1.4	2.3
18	26	6	10			1.0	1.6

TABLE 2.—*Predicted average yields*

Soil	Spring wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
Edgeley loam, gravelly variant	15	19	27	40
Egeland sandy loam, 0 to 3 percent slopes	20	27	36	57
Egeland sandy loam, 6 to 12 percent slopes	14	18	25	38
Egeland sandy loam, sandy substratum	17	23	31	48
Egeland fine sandy loam, till substratum, 0 to 3 percent slopes	20	27	36	57
Egeland fine sandy loam, till substratum, 3 to 6 percent slopes	17	24	31	50
Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes	15	20	27	42
Embden sandy loam, 0 to 3 percent slopes	21	28	38	59
Embden-Egeland sandy loams, 3 to 6 percent slopes	18	24	32	50
Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes	22	29	40	61
Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes	20	28	36	59
Emrick sandy loam	25	34	45	71
Emrick loam	27	37	49	78
Esmond, Coe, and Embden soils, 6 to 25 percent slopes				
Exline loam				
Fargo and Nutley silty clay loams	24	34	43	71
Fordville loam	17	22	31	46
Fossum sandy loam [1]	15	20	27	42
Fossum loam [1]	16	21	29	44
Fossum and Hamar sandy loams [1]	17	23	31	48
Fram loam, 0 to 3 percent slopes	21	30	38	63
Fram loam, 3 to 6 percent slopes	20	29	36	61
Fram loam, saline	12	15	22	32
Fram and Wyndmere fine sandy loams	19	27	34	58
Gardena loam, 0 to 3 percent slopes	28	38	50	80
Gardena loam, 3 to 6 percent slopes	25	34	45	71
Glyndon loam	25	35	45	74
Glyndon loam, saline	13	16	23	34
Gravel pit				
Hamar loamy coarse sand	11	14	20	29
Hamar loamy sand	14	18	25	38
Hamar coarse sandy loam	14	18	25	38
Hamar sandy loam	17	22	31	46
Hamerly loam, 0 to 3 percent slopes	21	30	38	63
Hamerly loam, 3 to 6 percent slopes	20	29	36	61
Hamerly loam, saline	12	14	22	29
Hamerly-Svea loams, 0 to 3 percent slopes	23	32	41	67
Hamerly-Svea loams, 3 to 6 percent slopes	21	30	38	63
Hecla loamy sand, 0 to 3 percent slopes	14	19	25	40
Hecla loamy sand, 3 to 6 percent slopes	11	14	20	29
Hecla sandy loam, 0 to 3 percent slopes	17	23	31	48
Hecla sandy loam, 3 to 6 percent slopes	14	19	25	40
Hecla-Dickey fine sandy loams, 3 to 6 percent slopes	14	18	25	38
Hecla-Hamar loamy sands	14	19	25	40
Hecla-Maddock loamy sands, 0 to 3 percent slopes	13	17	23	36
Hecla-Maddock loamy sands, 3 to 6 percent slopes	10	13	18	27
Heimdal sandy loam, 0 to 3 percent slopes	22	30	40	63
Heimdal sandy loam, 3 to 6 percent slopes	20	28	36	59
Heimdal sandy loam, 6 to 9 percent slopes	15	21	27	44
Heimdal loam, 0 to 3 percent slopes	24	34	43	71
Heimdal loam, 3 to 6 percent slopes	22	32	40	67
Heimdal loam, 6 to 9 percent slopes	17	24	31	50
Heimdal-Embden fine sandy loams, 9 to 15 percent slopes	12	15	22	32
Heimdal-Embden fine sandy loams, 15 to 25 percent slopes				
Heimdal-Emrick loams, 0 to 3 percent slopes	25	35	45	74
Heimdal-Emrick loams, 3 to 6 percent slopes	23	33	41	69
Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes	17	23	31	48
Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes	13	17	23	36
Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes				
Kensal loam	16	20	29	42
Kensal loam, sandy substratum	17	21	31	44
Kloten loam, 9 to 30 percent slopes				
Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes				
Kratka fine sandy loam [1]	17	23	31	48
LaDelle silty clay loam	28	38	50	80
Lallie silty clay loam [1]	11	14	20	29
Lamoure silty clay loam [1]	18	24	32	50
Lamoure silty clay loam, saline [1]				
La Prairie silt loam	28	38	50	80

per acre of principal crops—Continued

Barley		Flax		Corn (silage)		Tame hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Tons*	*Tons*
21	30	7	12	3.5	4.5	1.2	1.8
28	43	8	13	4.0	5.5	1.3	1.8
20	29	6	10	----	----	.9	1.5
24	37	8	13	4.0	5.5	1.3	1.8
28	43	8	13	4.0	5.5	1.4	1.9
24	38	7	12	3.5	5.0	1.1	1.7
21	32	7	12	4.0	5.5	1.0	1.6
29	45	9	14	6.0	8.0	1.5	2.1
25	38	8	13	5.0	6.5	1.3	1.9
31	46	9	14	6.0	8.0	1.6	2.3
28	45	8	13	5.0	6.5	1.5	2.2
35	54	10	15	6.0	8.0	1.9	2.7
38	59	11	17	6.0	8.0	2.0	3.0
----	----	----	----	----	----	----	----
----	----	----	----	----	----	.7	1.0
34	54	11	17	4.0	5.5	1.8	2.8
24	35	9	14	3.5	4.5	1.3	1.6
21	32	7	12	----	----	1.6	2.3
22	34	7	12	----	----	1.6	2.3
24	37	7	12	----	----	1.6	2.3
29	48	9	15	4.5	6.0	1.9	2.7
28	46	8	13	4.5	6.0	1.9	2.7
17	24	7	6	----	----	.9	1.4
27	43	8	13	4.0	5.0	1.7	2.5
39	61	12	19	6.0	8.0	2.0	3.0
35	54	11	17	5.5	7.5	1.8	2.8
35	56	10	16	4.5	6.0	2.0	2.8
18	36	4	6	----	----	1.0	1.5
----	----	----	----	----	----	----	----
15	22	6	9	3.5	5.0	1.4	1.9
20	29	6	9	4.0	5.5	1.5	2.0
20	29	7	11	4.5	6.0	1.5	2.0
24	35	7	11	5.0	6.5	1.6	2.2
29	48	9	15	4.5	6.0	1.9	2.7
28	46	8	13	4.5	6.0	1.9	2.7
17	22	4	6	----	----	.9	1.4
32	51	10	16	5.0	6.5	1.9	2.7
29	48	9	15	5.0	6.5	1.7	2.5
20	30	6	9	4.0	5.5	1.3	1.8
15	22	5	8	3.0	4.0	1.1	1.6
24	37	7	11	5.0	6.5	1.4	2.0
20	30	6	10	4.0	5.5	1.3	1.8
20	29	6	10	5.0	6.5	1.2	1.7
20	30	6	9	4.0	5.5	1.6	2.2
18	27	6	9	3.5	5.0	1.1	1.6
14	21	5	8	3.0	4.0	.9	1.3
31	48	9	14	5.0	7.0	1.5	2.4
28	45	8	13	4.5	6.5	1.4	2.3
21	34	6	10	----	----	1.0	1.6
34	54	10	16	5.0	7.0	1.6	2.5
31	51	9	15	4.5	6.5	1.5	2.4
24	38	7	11	----	----	1.1	1.8
17	24	5	8	----	----	.9	1.3
----	----	----	----	----	----	----	----
35	56	11	17	5.5	7.5	1.7	2.6
32	53	10	16	5.5	7.5	1.6	2.5
24	37	7	11	3.5	5.0	1.3	2.2
18	27	6	10	----	----	1.0	1.4
----	----	----	----	----	----	----	----
22	32	8	13	3.0	4.0	1.5	2.2
24	34	8	13	3.0	4.0	1.5	2.2
----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----
24	37	7	11	5.0	6.5	1.6	2.2
39	61	12	19	5.5	7.0	2.0	3.0
15	22	4	6	----	----	1.1	1.6
25	38	8	13	----	----	1.5	2.0
----	----	----	----	----	----	----	----
39	61	12	19	6.0	8.0	2.0	3.0

TABLE 2.—*Predicted average yields*

Soil	Spring wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
La Prairie-Lamoure complex				
Larson loam	8	10	14	21
Lemert sandy loam				
Letcher sandy loam	8	10	14	21
Letcher sandy loam, till substratum	8	10	14	21
Lohnes loamy coarse sand	11	14	20	29
Lohnes coarse sandy loam	13	16	23	34
Ludden silty clay [1]	18	24	32	50
Ludden-Lamoure complex				
Maddock loamy sand, 0 to 3 percent slopes	13	16	23	34
Maddock loamy sand, 3 to 6 percent slopes	10	12	18	25
Maddock loamy sand, 6 to 9 percent slopes				
Maddock sandy loam, 0 to 3 percent slopes	15	19	27	40
Maddock sandy loam, 3 to 6 percent slopes	13	17	23	36
Maddock sandy loam, 6 to 9 percent slopes	11	14	20	29
Maddock-Dickey sandy loams, 0 to 6 percent slopes	13	17	23	36
Maddock-Dickey sandy loams, 6 to 9 percent slopes	12	15	22	32
Maddock-Serden loamy fine sands, 9 to 30 percent slopes				
Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes				
Made land				
Marsh				
Marysland loam [1]	18	24	32	50
Marysland and Arveson loams [1]	15	20	27	42
Minnewaukan loamy fine sand, 6 to 9 percent slopes	7	9	13	19
Miranda-Cavour clay loams				
Osakis sandy loam	15	19	27	40
Osakis sandy loam, gravelly substratum	15	19	27	40
Osakis sandy loam, till substratum	15	19	27	40
Overly silty clay loam	28	38	50	80
Parnell silty clay loam [1]	19	29	34	61
Peat				
Perella silty clay loam [1]	21	31	38	65
Rauville silty clay loam				
Renshaw loam, 0 to 3 percent slopes	14	18	25	38
Renshaw loam, 3 to 6 percent slopes	11	14	20	29
Renshaw loam, gravelly substratum	13	17	23	36
Renshaw loam, sandy substratum	14	18	25	38
Renshaw loam, till substratum	13	17	23	36
Ryan silty clay loam	14	19	25	40
Ryan and Lamoure silty clay loams				
Serden-Hamar sands				
Sioux gravelly loam, 0 to 6 percent slopes				
Sioux gravelly loam, 6 to 25 percent slopes				
Spottswood loam	20	26	36	55
Spottswood loam, sandy substratum	20	26	36	55
Stirum sandy loam	8	10	14	21
Svea loam	27	37	49	78
Svea loam, cobbly variant	22	29	40	61
Svea-Barnes loams, 0 to 3 percent slopes	26	36	47	76
Svea-Barnes loams, 3 to 6 percent slopes	25	35	45	74
Svea-Buse-Barnes loams, 6 to 9 percent slopes	18	24	32	50
Svea-Cresbard loams	24	32	43	67
Swenoda-Embden fine sandy loams	22	29	40	61
Tiffany sandy loam [1]	18	25	32	53
Tiffany fine sandy loam, till substratum [1]	18	25	32	53
Tolna loam [1]	18	26	32	55
Tonka silt loam [1]	21	31	38	65
Totten sandy loam	8	12	14	25
Totten loam	8	12	14	25
Totten loam, very wet				
Totten loam, till substratum	8	12	14	25
Towner fine sandy loam, 0 to 3 percent slopes	18	24	32	50
Towner fine sandy loam, 3 to 6 percent slopes	15	20	27	42
Towner-Dickey fine sandy loams	17	23	31	48
Vallers loam [1]	17	23	31	48
Vang loam	17	23	31	48
Venlo sandy loam [1]	14	18	25	38
Wahpeton silty clay	27	37	49	78
Walsh loam, 3 to 6 percent slopes	23	31	41	65

per acre of principal crops—Continued

Barley		Flax		Corn (silage)		Tame hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Tons*	*Tons*
11	16	4	6			1.0	1.5
11	16	4	6			1.0	1.5
11	16	4	6			1.0	1.5
15	22	5	8	3.5	5.0	1.2	1.7
18	26	6	10	4.0	5.5	1.3	1.8
25	38	8	13			1.5	2.0
18	26	5	8	3.0	4.0	.9	1.3
14	19	4	6	2.5	3.0	.7	1.1
21	30	6	9	3.5	4.5	1.1	1.5
18	27	5	8	3.0	4.0	1.0	1.4
15	22	4	6			.6	.9
18	27	5	8	3.0	4.0	1.1	1.5
17	24	4	6			.6	.9
25	38	8	13			1.5	2.3
21	32	7	12			1.5	2.3
10	14	4	6			.9	1.3
21	30	8	13	3.0	4.0	1.2	1.6
21	30	8	13	3.0	4.0	1.2	1.6
21	30	8	13	3.0	4.0	1.2	1.6
39	61	12	19	5.5	7.0	2.0	3.0
27	46	9	15			1.6	2.6
29	50	10	16			1.8	2.8
20	29	8	13	3.0	4.0	1.0	1.4
15	22	7	12	2.5	3.5	.9	1.3
18	27	8	13	3.0	4.0	1.0	1.4
20	29	8	13	3.0	4.0	1.0	1.4
18	27	8	13	3.0	4.0	1.0	1.4
20	30	4	6			1.3	2.0
28	42	10	16	3.5	4.5	1.4	1.8
28	42	10	16	3.5	4.5	1.4	1.8
11	16	4	6			.9	1.4
38	59	11	17	6.0	8.0	2.0	3.0
31	46	10	16	4.0	5.5	1.5	2.1
36	58	11	17	5.5	7.5	1.8	2.8
35	56	10	16	5.5	7.5	1.6	2.5
25	38	8	13			1.2	2.0
34	51	9	15			1.5	2.4
31	46	9	14	6.0	8.0	1.5	2.4
25	40	8	13	5.5	6.5	1.7	2.3
25	40	8	13			1.7	2.3
25	42	8	13	3.5	5.0	1.8	2.4
29	50	10	16	4.0	5.5	1.9	2.5
11	19	4	6			1.0	1.5
11	19	4	6			1.0	1.5
11	19	4	6			1.0	1.5
25	38	7	11	5.0	6.5	1.4	2.0
21	32	6	10	4.0	5.5	1.3	1.8
24	37	7	11	4.5	6.0	1.3	1.8
24	27	7	11			1.5	2.0
24	37	10	16	4.0	5.5	1.5	2.0
20	29	6	9			1.3	1.8
38	59	12	19	5.5	7.0	2.0	3.0
32	50	9	15	4.5	6.0	1.8	2.7

TABLE 2.—*Predicted average yields*

Soil	Spring wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
Walsh loam, 6 to 9 percent slopes	18	24	32	50
Walsh clay loam, 0 to 3 percent slopes	26	35	47	74
Walsh clay loam, 3 to 6 percent slopes	25	33	45	69
Walsh clay loam, 6 to 9 percent slopes	19	25	34	53
Walum sandy loam	15	19	27	40
Walum sandy loam, gravelly substratum	15	19	27	40
Warsing loam	15	20	27	42
Warsing loam, sandy substratum	15	20	27	42
Warsing loam, till substratum	15	20	27	42
Wyard loam [1]	26	36	47	76
Wyndmere sandy loam	16	21	29	44
Wyndmere sandy loam, till substratum	16	21	29	44
Wyrene sandy loam	15	20	27	42
Wyrene sandy loam, till substratum	15	20	27	42
Wyrene-Totten sandy loams	12	15	22	32

[1] Yields given are for drained areas of these soils.

ence. The following are among the management practices used to obtain the yields shown in the B columns:

1. Erosion is effectively controlled.
2. Only the best varieties of seed are selected for planting, and only seed of good quality is planted.
3. A proper planting rate is used.
4. Weeds, insects, and diseases are controlled.
5. Tillage, seeding, and harvest operations are timely.
6. The kind and amounts of fertilizer applied are based on the results of soil tests.
7. The soils are adequately drained.
8. A good cropping system is used.

The estimated yields in table 2 are based on information obtained from farmers and other agricultural workers in the survey area. They are averages for a period long enough to include years of both favorable and unfavorable temperatures and moisture supply during the growing season. The estimates represent the acreage planted rather than only the acreage harvested.

Woodland and Windbreaks [4]

Eddy County has approximately 3,300 acres of native woodland. Most of the tree and shrub species grow on the La Prairie, LaDelle, Lamoure, and Walsh soils on the Sheyenne River bottom lands and adjacent draws and valley slopes. Several groves are on slopes of Borup and Vallers soils along high terraces of the Sheyenne River. About one-third of the trees and shrubs grow on Serden, Hamar, and Rauville soils in the Hamar and Warwick area and on Minnewaukan, Heimdal, Emrick, Towner, and Dickey soils along North and South Washington Lakes, Lake Coe, and Cherry Lake. Several hundred acres of native trees and shrubs are in the parts of Benson and Nelson Counties included in this survey area.

The principal species of trees and shrubs are American elm, green ash, bur oak, cottonwood, chokecherry, juneberry, hawthorn, wild plum, current, redosier dogwood, woods rose, shrub willows, and buffalo berry.

The early settlers used the trees for lumber, fence posts, and fuel. Today, however, the main uses for trees and shrubs are for livestock protection, wildlife habitat, recreation, esthetic purposes, erosion control, and watershed protection.

Windbreaks have been planted in the survey area since the days of the early settlers, mainly for the protection of farmsteads and livestock. Windbreaks are still needed on thousands of acres in the survey area, mainly in cultivated areas where the hazard of soil blowing is severe.

Windbreaks distribute and hold snow and prevent it from drifting around the farmstead. They protect the buildings and livestock from cold winter winds and thus reduce fuel and feed costs. They protect field crops, gardens, and orchards from strong damaging winds, and reduce the hazards of erosion and evaporation. They provide habitat for birds and other wildlife, and they enhance the beauty of a house and its surroundings.

The purpose of planting, the suitability of the soils, and the selection of suitable trees and shrubs are factors to be considered before a windbreak is planted. Proper design of windbreaks is most important.

The establishment of a windbreak and the growth of the trees depend on careful selection of the site, suitability preparation, and adequate maintenance. Grass and weeds need to be eliminated before the trees are planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed during the first 2 years.

[4] By DAVID L. HINTZ, forester, Soil Conservation Service, Huron, South Dakota.

per acre of principal crops—Continued

Barley		Flax		Corn (silage)		Tame hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Tons*	*Tons*
25	38	7	11	----------	----------	1.5	2.4
36	56	12	19	5.5	7.0	2.0	3.0
35	53	10	16	4.5	6.5	1.8	2.8
27	40	8	12	----------	----------	1.5	2.4
21	30	8	13	3.0	4.0	1.4	2.0
21	30	8	13	3.0	4.0	1.4	2.0
21	32	8	13	3.0	4.0	1.4	2.0
21	32	8	13	3.0	4.0	1.4	2.0
21	32	8	13	3.0	4.0	1.4	2.0
36	58	11	17	5.5	8.0	2.0	3.0
22	34	8	13	5.0	6.5	1.5	2.1
22	34	8	13	5.0	6.5	1.5	2.1
21	32	7	12	3.5	5.0	1.2	1.6
21	32	7	12	3.5	5.0	1.2	1.6
17	24	5	8	----------	----------	1.0	1.5

Windbreak groups

Ten windbreak suitability groups are designated in North Dakota. All of these groupings are in this survey area. Under good management the growth response of suitable trees and shrubs is generally the same for all soils within a group.

Several factors are considered in grouping soils. The amount of soil moisture and the seasonal availability are the most critical factors. The soil slope and the soil texture are also important, because they largely determine the degree of water erosion and soil blowing.

Conserving water is most important on soils that have a slope of more than 6 percent. Special site preparation, planting, and cultivation are needed to successfully establish and maintain plantings where soil blowing and water erosion are hazards. Soils in group 2 are ponded and have a high water table. The lack of soil moisture is not a limitation in group 1, but the water table is beyond the reach of tree roots in all soils in groups 3 through 9 and in some soils in group 10. Some soils in group 10 are very wet during part of the year, and a few have additional limitations that are critical for growing trees and shrubs.

Windbreak groups are not designated for mine pits and dumps, riverwash, and made land. These areas are so variable that grouping is not feasible. In selected locations, they are suited to spot plantings for wildlife habitat, recreation, and beautification.

Table 3 lists the species of trees and shrubs commonly used in windbreak plantings in the survey area, and it gives the actual or estimated average height and the vigor, by windbreak group, of the various species at 20 years of age. All height measurements and vigor ratings have been based on well-managed plantings. No data are given for windbreak groups 9 and 10 because the soils in these groups are not suitable for tree and shrub plantings.

The ratings in the table refer to the density of foliage, the freedom from damage from insects or disease, and the general appearance of the tree. A rating of *good* indicates that leaves and needles are normal in color and growth; only a small amount of deadwood, that is, tops, branches, and twigs, occurs within the live crown; little or no disease, insect, or climatic damage is evident and evidence of stagnation or suppression is only slight. A rating of *fair* indicates that leaves and needles are obviously abnormal in color and growth; a substantial amount of deadwood occurs within the live crown; evidence of moderate disease, insect, or climatic damage is apparent; there is definite suppression or stagnation; and the current year's growth is obviously less than normal.

A rating of *poor* indicates that leaves and needles are very abnormal in color and growth; a very large amount of deadwood occurs within the live crown; there is extensive disease, insect, or climatic damage, severe stagnation, suppression or decadence; and the current year's growth is essentially negligible. Plants that are rated poor are unsatisfactory for farmstead, feedlot, or field windbreaks but may be satisfactory as wildlife and beautification plantings.

The windbreak suitability groups in the survey area are described in the following paragraphs. The soil series in each group are listed, but this does not mean that all the soils of the given series are in the group. For the windbreak suitability group of each mapping unit, refer to the Guide to Mapping Units at the back of this survey.

WINDBREAK SUITABILITY GROUP 1

In this group are nearly level and gently undulating soils. These soils are in the Clontarf, Divide, Embden, Emrick, Fargo, Fram, Gardena, Glyndon, Hamerly, Hecla, Kensal, LaDelle, La Prairie, Ludden, Osakis, Overly, Svea, Svea cobbly variant, Swenoda, Towner, Wahpeton, Walsh, Walum, Warsing, Wyard, Wyndmere, and Wyrene series.

These are deep, moderately well drained soils, or shallow and moderately deep soils that have little or

TABLE 3.—*Height and vigor of specified trees*

[Height measurements and vigor ratings are for trees at 20

Windbreak group	Vigor ratings and estimated height of trees in feet					
	Eastern redcedar or Rocky Mountain juniper	Ponderosa pine	Black Hills spruce; Colorado blue spruce	Caragana	Chokeberry	Honeysuckle
1	Good: 11 to 13	Good: 18 to 22	Good: 16 to 20	Good: 9 to 11	Good: 11 to 14	Good: 8 to 10
[1] 2	Good: 11 to 13	Good: 20 to 22	Good: 15 to 18	Fair: 7 to 9	Good: 9 to 11	Good: 7 to 9
3	Good: 12 to 15	Good: 18 to 22	Good: 15 to 18	Good: 8 to 10	Good: 10 to 12	Good: 8 to 10
4	Good: 10 to 12	Good: 17 to 19	Fair: 15 to 18	Good: 6 to 8	Good: 8 to 10	Good: 6 to 8
5	Good: 9 to 11	Good: 15 to 20	Poor	Good: 8 to 10	Good: 8 to 10	Good: 7 to 9
6	Fair: 8 to 10	Fair: 14 to 18	Poor	Fair: 7 to 9	Fair: 7 to 9	Fair: 6 to 8
7	Fair: 7 to 9	Fair: 12 to 15	Poor	Fair: 5 to 7	Poor	Poor
8	Fair: 7 to 9	Fair: 11 to 14	Poor	Fair: 5 to 7	Poor	Fair: 5 to 7

[1] Vigor and height results listed can be obtained only with establishment of adequate drains.

no runoff and have a water table within the reach of tree roots. They are moderately coarse textured to fine textured and have favorable soil moisture for tree and shrub survival and growth. Many of these soils receive extra moisture by runoff from surrounding higher lying areas.

These soils are well suited to all types of windbreaks and plantings.

Except for those soils on which the hazard of soil blowing is severe, there are no serious hazards or limitations to planting trees and shrubs.

WINDBREAK SUITABILITY GROUP 2

In this group are nearly level, drained and undrained soils. These soils are in the Arveson, Borup, Colvin, Fossum, Hamar, Kratka, Lamoure, Marysland, Parnell, Perella, Tiffany, Tolna, Tonka, Vallers, and Venlo series.

These are deep and moderately deep, poorly drained and very poorly drained soils. They are moderately coarse textured to moderately fine textured. They are ponded or have a high water table. Unless drained, they are poorly suited or unsuited to trees and shrubs.

These soils are suited to most plantings if adequate drainage is installed. The number of adapted trees and shrubs is limited.

The hazard of soil blowing is severe on those soils that are limy to the surface and those that have a clayey or sandy surface layer. Wetness is a critical limitation to use; to a lesser extent, the high content of lime is also a limitation.

WINDBREAK SUITABILITY GROUP 3

In this group are nearly level to hilly soils. These soils are in the Barnes, Eckman, Edgeley, Emrick, Fordville, Heimdal, Spottswood, Svea, and Vang series. The Edgeley variant is also in this group.

These are deep or moderately deep, well-drained, and medium-textured soils. Svea soil, however, is moderately well drained. If proper care is taken to conserve moisture, these soils are suited to nearly all adapted trees and shrubs.

These soils are well suited to all types of windbreaks and plantings.

Some areas of Emrick soils and Svea soils are in this group because they have less moisture available for optimum tree growth.

Soils on sloping to hilly sites have a hazard of water erosion, but they have no other serious hazard or limitation to planting of trees and shrubs.

WINDBREAK SUITABILITY GROUP 4

In this group are nearly level soils. These soils are in the Aberdeen, Cathay, Cresbard, and Nutley series.

These are deep, medium textured or moderately fine textured soils that are moderately well drained and somewhat poorly drained. They have a claypan subsoil and a sodic layer that restricts root growth. An exception is Nutley soils, which are well-drained, calcareous, silty clay loam. A limited number of trees and shrubs grow well on these soils. Choosing species for planting requires careful selection.

These soils are suited to all types of windbreaks and plantings if tree and shrub species are properly selected.

Soil blowing is a hazard on these soils. The only critical limitation is the sodic subsoil, which limits the choice of species.

WINDBREAK SUITABILITY GROUP 5

In this group are nearly level to hilly soils in the Dickey and Egeland series, nearly level to sloping soils in the Maddock series, and sloping to steep soils in the Embden and Hecla series.

Some areas of Embden and Hecla soils are in this group because they receive less moisture and therefore tree growth is not so good as it is on areas of these soils in other windbreak groups.

These are deep, coarse textured and moderately coarse textured, well-drained soils, except for the moderately well drained Embden soils and Hecla soils. These soils absorb moisture rapidly. The water table is generally beyond the reach of tree roots. A limited number of trees and shrubs grow well on these soils. Only adapted plants should be planted.

and shrubs by windbreak suitability group

years of age. Dashes indicate that data are not available]

Vigor ratings and estimated height of trees in feet—continued						
Wild plum	American elm	Cottonwood	Green ash	Russian-olive	Siberian elm	White and golden willow
Good: 7 to 9	Good: 22 to 27	Good: 40 to 48	Good: 21 to 26	Fair: 15 to 19	Good: 28 to 35	Good: 28 to 35.
Good: 6 to 7	Good: 20 to 25	Good: 38 to 45	Good: 21 to 26	Fair: 15 to 19	Fair: 28 to 32	Good: 28 to 32.
Good: 8 to 10	Fair: 20 to 25	Poor	Good: 20 to 25	Fair: 14 to 18	Good: 26 to 32	Poor.
Good: 7 to 9	Fair: 15 to 19	Poor	Good: 16 to 20	Fair: 12 to 15	Good: 22 to 26	Poor.
Good: 7 to 9	Fair: 15 to 19	Poor	Fair: 15 to 19	Fair: 11 to 14	Good: 20 to 25	Poor.
Fair: 6 to 8	Fair: 14 to 18	Poor	Fair: 14 to 18	Fair: 11 to 14	Fair: 17 to 22	Poor.
Poor	Poor	Poor	Poor	Poor: 11 to 14	Fair: 14 to 18	Poor.
Poor	Poor	Poor	Fair: 14 to 18	Fair: 11 to 14	Fair: 14 to 18	Poor.

These soils are suited to all types of windbreaks and plantings, if the plants are properly selected.

The hazard of soil blowing is severe, and water erosion is a hazard on sloping and hilly phases of these soils. The main limitation to use of these soils is the low to moderate available water capacity.

WINDBREAK SUITABILITY GROUP 6

In this group are nearly level to sloping soils. These soils are in the Arvilla, Binford, Brantford, and Renshaw series.

These are shallow, moderately coarse textured or medium textured soils overlying coarse sand or gravel. They are well drained and somewhat excessively drained. They absorb most of the precipitation, but water moves rapidly through the underlying sand and gravel. The available water capacity is low.

These soils are poorly suited to all types of windbreaks and plantings. Windbreaks and plantings can be established if the proper plants are selected and if optimum survival, growth, and vigor are not required or expected.

The hazards of soil blowing and water erosion are slight to severe on these soils. The low available water capacity and a restricted rooting zone are critical limitations to the survival and growth of trees and shrubs.

WINDBREAK SUITABILITY GROUP 7

In this group are nearly level soils in the Lohnes series and nearly level to hilly soils in the Serden series.

These are deep, coarse-textured, moderately well drained and excessively drained soils. They absorb most of the precipitation but retain little. The available water capacity is low and very low. A limited number of trees and shrubs grow well on these soils.

These soils are suited to wildlife and beautification plantings if optimum survival, growth, and vigor are not required or expected. They are poorly suited to field windbreaks.

The hazard of soil blowing on these soils is severe. The low or very low available water capacity is the critical limitation to use.

WINDBREAK SUITABILITY GROUP 8

In this group are sloping to steep soils in the Barnes, Buse, Esmond, and Zell series, steep soils in the Heimdal series, and hilly to steep soils in the Edgeley series.

These are moderately deep or deep, medium-textured, and well-drained soils on complex slopes that have rapid to very rapid runoff. They have a moderate to high available water capacity, but excessive runoff restricts the intake of water and the amount of water available to trees and shrubs.

Barnes, Edgeley, and Heimdal soils in this group have steeper slopes and receive less moisture for optimum growth than the same soils in other windbreak groups.

Windbreaks and plantings need special water-conservation measures for satisfactory growth of trees and shrubs. Soils of this group are suited to plantings for wildlife, for recreation areas, and for beautification if optimum survival, growth, and vigor are not required or expected.

The hazards of soil blowing and water erosion on these soils are very severe where they are cultivated. Steepness of slope, which causes excessive runoff and low water intake, is the main limitation to use.

WINDBREAK SUITABILITY GROUP 9

In this group are nearly level and gently sloping soils. These soils are in the Cavour, Exline, Larson, Lemert, Letcher, Miranda, Ryan, Stirum, and Totten series. Also in this group is the Cavour variant.

These are deep and moderately deep, moderately well drained to very poorly drained soils that have a dense sodic claypan subsoil. The available water capacity is low, except for Cavour and Larson soils where it is moderate.

These soils are not suited to any type of windbreak or planting. They generally are mapped in a complex with soils that are suitable for hand planting of trees and shrubs for wildlife, recreation, or beautification.

The hazard of soil blowing on these soils is slight to severe. The main limitations to use are the restricted

root zone, the low or moderate available water capacity, and salinity.

WINDBREAK SUITABILITY GROUP 10

In this group are the stony soils of the Barnes, Buse, Cavour, Svea, and Vallers series; the hilly soils of the Binford series; and the saline soils of the Bearden, Colvin, Divide, Fram, Glyndon, Hamerly, and Lamoure series. Also in this group are the shallow soils of the Claire, Coe, Kloten, and Sioux series; the wet soils of the Borup, Colvin, Lallie, Marysland, Minnewauken, and Rauville series; soils of the Totten series; and the land types Marsh, Peat, and Gravel pit.

Included in this group are soils that have a wide range in depth, texture, drainage, salinity, and slope. They all have one or more limitations, however, that are highly critical to tree and shrub planting, survival, vigor, and growth. Limitations include waterlogging, low available water capacity, stoniness, shallowness, high content of sodium, salinity, hilliness, infertility, restricted root zone, and erodibility.

These soils are not suited to windbreak plantings. Generally the stony soils and the soils mapped in a complex with steeply sloping soils are suited to hand plantings for wildlife, recreation, and beautification. Proper care, however, must be given to selection of planting site and to the selection of adapted trees and shrubs.

The hazard of erosion on these soils is slight to severe.

Use of the Soils for Wildlife [5]

Wildlife provide a source of outdoor recreation for people in the survey area. They also contribute to the economy by furnishing hunting opportunities, by helping to control insects, and as a source of fur. Among the more important wildlife are sharp-tailed grouse, gray partridge, waterfowl, and white-tailed deer. Other wildlife are mourning dove, cottontail rabbit, and fox squirrel. Furbearers of economic importance are mink, beaver, muskrat, weasel, red fox, and jackrabbit, particularly the red fox and jackrabbit. The survey area is an important habitat for waterfowl, but it has a better potential for developing and maintaining a habitat for ducks than for most other waterfowl. A small number of prairie chickens and ringnecked pheasants remain in the survey area, but the lack of tall herbaceous cover limits their number. The range of the greater prairie chicken is also limited by the lack of grass.

Most of the public fishing areas are on the Sheyenne River and the James River, but access to them is limited. The reservoir impounded by Warsing Dam (fig. 19) also provides public fishing and is occasionally managed for trout. The fish most commonly sought are walleye, northern pike, perch, and bullheads.

Table 4 shows the suitability of the soils for openland wildlife, rangeland wildlife, and wetland wildlife. Among the openland wildlife are gray partridge, pheasant, cottontail rabbit, red fox, goldfinch, horned lark, and ground squirrel. These animals, generally, either have been introduced or are dependent on disturbed soil or annual plants. For these wildlife, the habitat elements considered were grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs. Among rangeland wildlife are white-tailed deer, sharp-tailed grouse, coyote, and jackrabbit. These animals are dependent on range for habitat. Among wetland wildlife are ducks, herons, shorebirds, mink, muskrat, geese, and coot. These animals normally use and are dependent on natural wetlands. Woodland wildlife has not been included in the table because, in the survey area, there are only small wooded tracts that provide a habitat for thrush, vireo, fox squirrel, and other birds and small animals that require only small habitat niches.

Figure 19.—Warsing Dam and reservoir near Sheyenne in Eddy County.

Most wildlife habitats are created, improved, or maintained by managing existing vegetation, planting suited vegetation, inducing natural regeneration of desired plants, and by earth moving to improve the habitat. The suitability ratings are based on the ability of the soil to produce the various habitat elements needed for the specified kind of wildlife. Not considered in these ratings are present land use, the relationship of one soil to another, nor the size, shape, and extent of the soil areas. These ratings can be used as an aid in selecting sites for general kinds of wildlife habitat, determining the suitability of the soil for a particular habitat, or learning the degree of management intensity needed to produce satisfactory habitat. They provide a means of grouping soils for broad scale wildlife planning or showing land owners where management practices are best applied.

The elements needed to provide a habitat for a kind of wildlife largely determine the suitability rating of the soil for that particular habitat. The suitability ratings in table 4 are good, fair, poor, and very poor.

Use of the Soils for Recreational Development

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 5, the soils of this survey area are rated accord-

[5] By ERLING B. PODOLL, biologist, Soil Conservation Service, Bismarck.

TABLE 4.—*Suitability of the soils for kinds of wildlife*

Map symbol	Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Ab	Aberdeen loam	Good	Good	Fair.
Ae	Aberdeen-Exline loams:			
	Aberdeen part	Good	Good	Fair.
	Exline part	Poor	Very poor	Fair.
Ar	Arveson sandy loam	Fair	Fair	Good.
As	Arvilla sandy loam	Fair	Poor	Very poor.
AtA	Arvilla sandy loam, gravelly substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
AtB	Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
AvA	Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
AvB	Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
AxC	Arvilla-Sioux sandy loams, 6 to 9 percent slopes:			
	Arvilla part	Fair	Poor	Very poor.
	Sioux part	Very poor	Very poor	Very poor.
BaA	Barnes loam, 0 to 3 percent slopes	Good	Fair	Very poor.
BaB	Barnes loam, 3 to 6 percent slopes	Good	Fair	Very poor.
BaC	Barnes loam, 6 to 9 percent slopes	Good	Fair	Very poor.
BbA	Barnes-Svea loams, 0 to 3 percent slopes	Good	Fair	Very poor.
BbB	Barnes-Svea loams, 3 to 6 percent slopes	Good	Fair	Very poor.
BcB	Barnes-Svea stony loams, 3 to 6 percent slopes	Poor	Fair	Very poor.
BdC	Barnes-Svea-Buse loams, 6 to 9 percent slopes	Good	Fair	Very poor.
BeC	Barnes-Svea-Buse stony loams, 6 to 9 percent slopes	Poor	Fair	Very poor.
Bg	Bearden silt loam, saline	Poor	Poor	Fair.
Bh	Binford sandy loam	Fair	Poor	Very poor.
BkA	Binford sandy loam, gravelly substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
BkB	Binford sandy loam, gravelly substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
BlA	Binford sandy loam, sandy substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
BlB	Binford sandy loam, sandy substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
BmC	Binford-Coe sandy loams, 6 to 9 percent slopes:			
	Binford part	Fair	Poor	Very poor.
	Coe part	Very poor	Very poor	Very poor.
BmD	Binford-Coe sandy loams, 9 to 12 percent slopes:			
	Binford part	Fair	Poor	Very poor.
	Coe part	Very poor	Very poor	Very poor.
Bn	Borup silt loam	Fair	Fair	Good.
Bo	Borup and Marysland silt loams, very wet	Poor	Poor	Good.
BpB	Borup and Vallers loams, 3 to 6 percent slopes	Fair	Fair	Good.
BrB	Brantford loam, 3 to 6 percent slopes	Fair	Poor	Very poor.
BsA	Brantford loam, gravelly substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
BsB	Brantford loam, gravelly substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
BtA	Brantford loam, sandy substratum, 0 to 3 percent slopes	Fair	Poor	Very poor.
BtB	Brantford loam, sandy substratum, 3 to 6 percent slopes	Fair	Poor	Very poor.
BuC	Brantford-Coe loams, 6 to 9 percent slopes:			
	Brantford part	Fair	Poor	Very poor.
	Coe part	Very poor	Very poor	Very poor.
Bv	Brantford-Kensal loams:			
	Brantford part	Fair	Poor	Very poor.
	Kensal part	Fair	Fair	Very poor.
BwE	Buse-Barnes loams, 9 to 30 percent slopes	Fair	Fair	Very poor.
BxD	Buse-Edgeley loams, 9 to 30 percent slopes	Fair	Fair	Very poor.
ByE	Buse and Kloten loams, 6 to 25 percent slopes	Fair	Fair	Very poor.
BzD	Buse, Sioux, and Zell soils, 3 to 30 percent slopes:			
	Buse-Zell part	Fair	Fair	Very poor.
	Sioux part	Very poor	Very poor	Very poor.
Ca	Cathay loam	Fair	Fair	Poor.
ChA	Cathay-Heimdal loams, 0 to 3 percent slopes:			
	Cathay part	Fair	Fair	Poor.
	Heimdal part	Good	Fair	Very poor.
ChB	Cathay-Heimdal loams, 3 to 6 percent slopes:			
	Cathay part	Fair	Fair	Poor.
	Heimdal part	Good	Fair	Very poor.
Cm	Cathay-Larson loams:			
	Cathay part	Fair	Fair	Poor.
	Larson part	Poor	Very poor	Poor.
Cn	Cavour-Cresbard loams:			
	Cavour part	Poor	Very poor	Poor.
	Cresbard part	Fair	Fair	Poor.
Co	Cavour and Vallers stony clay loams	Poor	Poor	Fair.
CpB	Cavour clay loam, shaly variant, 3 to 6 percent slopes	Poor	Very poor	Poor.
CrA	Claire loamy coarse sand, 0 to 3 percent slopes	Fair	Fair	Very poor.
CrB	Claire loamy coarse sand, 3 to 6 percent slopes	Fair	Fair	Very poor.
Cs	Claire coarse sandy loam	Fair	Fair	Very poor.
Ct	Claire-Lohnes-Hamar loamy coarse sands:			
	Claire part	Fair	Fair	Very poor.

TABLE 4.—*Suitability of the soils for kinds of wildlife*—Continued

Map symbol	Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
	Claire-Lohnes-Hamar—continued			
	Lohnes part	Good	Fair	Very poor.
	Hamar part	Good	Good	Poor.
Cu	Clontarf sandy loam	Good	Poor	Very poor.
CvB	Coe sandy loam, 0 to 6 percent slopes	Very poor	Very poor	Very poor.
CvD	Coe sandy loam, 6 to 25 percent slopes	Very poor	Very poor	Very poor.
Cw	Colvin silty clay loam	Good	Fair	Good.
Cx	Colvin silty clay loam, saline	Poor	Poor	Fair.
Cy	Colvin silty clay loam, very wet	Poor	Poor	Good.
Cz	Cresbard-Cavour loams:			
	Cresbard part	Fair	Fair	Poor.
	Cavour part	Poor	Very poor	Fair.
DvA	Divide loam, 0 to 3 percent slopes	Good	Fair	Poor.
DvB	Divide loam, 3 to 6 percent slopes	Good	Fair	Poor.
Dw	Divide loam, saline	Poor	Poor	Fair.
Dx	Divide loam, gravelly substratum	Good	Fair	Poor.
Dy	Divide loam, sandy substratum	Good	Fair	Poor.
Dz	Divide loam, till substratum	Good	Fair	Poor.
EaA	Eckman loam, 0 to 3 percent slopes	Good	Fair	Very poor.
EaB	Eckman loam, 3 to 8 percent slopes	Good	Fair	Very poor.
Eb	Edgeley loam	Good	Fair	Poor.
EcB	Edgeley and Cavour loams, 3 to 6 percent slopes:			
	Edgeley part	Good	Fair	Poor.
	Cavour part	Poor	Very poor	Fair.
Ed	Edgeley loam, gravelly variant	Good	Fair	Poor.
EeA	Egeland sandy loam, 0 to 3 percent slopes	Fair	Fair	Very poor.
EeC	Egeland sandy loam, 6 to 12 percent slopes	Fair	Fair	Very poor.
Eg	Egeland sandy loam, sandy substratum	Fair	Fair	Very poor.
EhA	Egeland fine sandy loam, till substratum, 0 to 3 percent slopes	Fair	Fair	Very poor.
EhB	Egeland fine sandy loam, till substratum, 3 to 6 percent slopes	Fair	Fair	Very poor.
EmC	Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes:			
	Egeland part	Fair	Fair	Very poor.
	Embden part	Good	Fair	Very poor.
EnA	Embden sandy loam, 0 to 3 percent slopes	Good	Fair	Poor.
EoB	Embden-Egeland sandy loams, 3 to 6 percent slopes:			
	Embden part	Good	Fair	Very poor.
	Egeland part	Fair	Fair	Very poor.
EsA	Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes:			
	Embden-Heimdal part	Good	Fair	Poor.
	Swenoda part	Fair	Good	Very poor.
EsB	Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes:			
	Embden-Heimdal part	Good	Fair	Very poor.
	Swenoda part	Fair	Good	Very poor.
Et	Emrick sandy loam	Good	Fair	Poor.
Eu	Emrick loam	Good	Fair	Poor.
EvD	Esmond, Coe, and Embden soils, 6 to 25 percent slopes:			
	Esmond part	Fair	Fair	Very poor.
	Coe part	Very poor	Very poor	Very poor.
	Embden part	Good	Fair	Very poor.
Ew	Exline loam	Poor	Very poor	Fair.
Fa	Fargo and Nutley silty clay loams	Fair	Poor	Poor.
Fd	Fordville loam	Good	Good	Very poor.
Fm	Fossum sandy loam	Fair	Fair	Good.
Fo	Fossum loam	Fair	Fair	Good.
Fp	Fossum and Hamar sandy loams:			
	Fossum part	Fair	Fair	Good.
	Hamar part	Good	Good	Poor.
FrA	Fram loam, 0 to 3 percent slopes	Good	Fair	Poor.
FrB	Fram loam, 3 to 6 percent slopes	Good	Fair	Poor.
Fs	Fram loam, saline	Poor	Poor	Fair.
Fw	Fram and Wyndmere fine sandy loams:			
	Fram part	Good	Fair	Poor.
	Wyndmere part	Fair	Good	Very poor.
GaA	Gardena loam, 0 to 3 percent slopes	Good	Fair	Poor.
GaB	Gardena loam, 3 to 6 percent slopes	Good	Fair	Very poor.
Gd	Glyndon loam	Good	Fair	Poor.
Ge	Glyndon loam, saline	Poor	Poor	Fair.
Gp	Gravel pit			
Ha	Hamar loamy coarse sand	Good	Good	Poor.
Hb	Hamar loamy sand	Good	Good	Poor.
Hc	Hamar coarse sandy loam	Good	Good	Poor.
Hd	Hamar sandy loam	Good	Good	Poor.
HeA	Hamerly loam, 0 to 3 percent slopes	Good	Fair	Poor.
HeB	Hamerly loam, 3 to 6 percent slopes	Good	Fair	Poor.

TABLE 4.—*Suitability of the soils for kinds of wildlife*—Continued

Map symbol	Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Hf	Hamerly loam, saline	Poor	Poor	Fair.
HgA	Hamerly-Svea loams, 0 to 3 percent slopes	Good	Fair	Poor.
HgB	Hamerly-Svea loams, 3 to 6 percent slopes	Good	Fair	Poor.
HhA	Hecla loamy sand, 0 to 3 percent slopes	Fair	Fair	Very poor.
HhB	Hecla loamy sand, 3 to 6 percent slopes	Fair	Fair	Very poor.
HkA	Hecla sandy loam, 0 to 3 percent slopes	Fair	Fair	Very poor.
HkB	Hecla sandy loam, 3 to 6 percent slopes	Fair	Fair	Very poor.
HlB	Hecla-Dickey fine sandy loams, 3 to 6 percent slopes	Fair	Fair	Very poor.
Hm	Hecla-Hamar loamy sands:			
	Hecla part	Fair	Fair	Very poor.
	Hamar part	Good	Good	Poor.
HnA	Hecla-Maddock loamy sands, 0 to 3 percent slopes	Fair	Fair	Very poor.
HnB	Hecla-Maddock loamy sands, 3 to 6 percent slopes	Fair	Fair	Very poor.
HoA	Heimdal sandy loam, 0 to 3 percent slopes	Good	Fair	Very poor.
HoB	Heimdal sandy loam, 3 to 6 percent slopes	Good	Fair	Very poor.
HoC	Heimdal sandy loam, 6 to 9 percent slopes	Good	Fair	Very poor.
HpA	Heimdal loam, 0 to 3 percent slopes	Good	Fair	Very poor.
HpB	Heimdal loam, 3 to 6 percent slopes	Good	Fair	Very poor.
HpC	Heimdal loam, 6 to 9 percent slopes	Good	Fair	Very poor.
HrD	Heimdal-Embden fine sandy loams, 9 to 15 percent slopes	Good	Fair	Very poor.
HrE	Heimdal-Embden fine sandy loams, 15 to 25 percent slopes	Fair	Fair	Very poor.
HsA	Heimdal-Emrick loams, 0 to 3 percent slopes	Good	Fair	Poor.
HsB	Heimdal-Emrick loams, 3 to 6 percent slopes	Good	Fair	Very poor.
HtC	Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes	Good	Fair	Very poor.
HtD	Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes:			
	Heimdal-Emrick part	Good	Fair	Very poor.
	Esmond part	Fair	Fair	Very poor.
HtE	Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes	Fair	Fair	Very poor.
Ke	Kensal loam	Fair	Fair	Very poor.
Kf	Kensal loam, sandy substratum	Fair	Fair	Very poor.
KoE	Kloten loam, 9 to 30 percent slopes	Fair	Fair	Very poor.
KsE	Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes:			
	Kloten-Edgeley part	Fair	Fair	Very poor.
	Sioux part	Very poor	Very poor	Very poor.
Kt	Kratka fine sandy loam	Fair	Fair	Good.
La	LaDelle silty clay loam	Good	Good	Very poor.
Lb	Lallie silty clay loam	Poor	Fair	Good.
Le	Lamoure silty clay loam	Fair	Good	Fair.
Lm	Lamoure silty clay loam, saline	Poor	Poor	Fair.
Ln	La Prairie silt loam	Good	Good	Poor.
Lp	La Prairie-Lamoure complex:			
	La Prairie part	Good	Good	Poor.
	Lamoure part	Fair	Good	Fair.
Lr	Larson loam	Poor	Very poor	Poor.
Ls	Lemert sandy loam	Poor	Very poor	Poor.
Lt	Letcher sandy loam	Fair	Poor	Fair.
Lu	Letcher sandy loam, till substratum	Fair	Poor	Fair.
Lv	Lohnes loamy coarse sand	Good	Fair	Very poor.
Lw	Lohnes coarse sandy loam	Good	Fair	Very poor.
Lx	Ludden silty clay	Fair	Fair	Fair.
Lz	Ludden-Lamoure complex:			
	Ludden part	Fair	Fair	Fair.
	Lamoure part	Poor	Poor	Good.
MaA	Maddock loamy sand, 0 to 3 percent slopes	Fair	Fair	Very poor.
MaB	Maddock loamy sand, 3 to 6 percent slopes	Fair	Fair	Very poor.
MaC	Maddock loamy sand, 6 to 9 percent slopes	Fair	Fair	Very poor.
MbA	Maddock sandy loam, 0 to 3 percent slopes	Fair	Fair	Very poor.
MbB	Maddock sandy loam, 3 to 6 percent slopes	Fair	Fair	Very poor.
MbC	Maddock sandy loam, 6 to 9 percent slopes	Fair	Fair	Very poor.
MdB	Maddock-Dickey sandy loams, 0 to 6 percent slopes	Fair	Fair	Very poor.
MdC	Maddock-Dickey sandy loams, 6 to 9 percent slopes	Fair	Fair	Very poor.
MeD	Maddock-Serden loamy fine sands, 9 to 30 percent slopes:			
	Maddock part	Fair	Fair	Very poor.
	Serden part	Poor	Fair	Very poor.
MfD	Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes:			
	Maddock-Hecla part	Fair	Fair	Very poor.
	Serden part	Poor	Fair	Very poor.
Mg	Made land			
Mh	Marsh			
Mm	Marysland loam	Poor	Fair	Good.
Mn	Marysland and Arveson loams:			
	Marysland part	Poor	Fair	Good.
	Arveson part	Fair	Fair	Good.

TABLE 4.—*Suitability of the soils for kinds of wildlife*—Continued

Map symbol	Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
MwC	Minnewaukan loamy fine sand, 6 to 9 percent slopes	Poor	Good	Very poor.
Mx	Miranda-Cavour clay loams:			
	Miranda part	Poor	Very poor	Poor.
	Cavour part	Poor	Very poor	Fair.
Os	Osakis sandy loam	Fair	Fair	Very poor.
Ot	Osakis sandy loam, gravelly substratum	Fair	Fair	Very poor.
Ou	Osakis sandy loam, till substratum	Fair	Fair	Very poor.
Ov	Overly silty clay loam	Good	Fair	Poor.
Pa	Parnell silty clay loam	Very poor	Poor	Good.
Pe	Peat			
Pr	Perella silty clay loam	Fair	Fair	Fair.
Ra	Rauville silty clay loam	Very poor	Poor	Good.
ReA	Renshaw loam, 0 to 3 percent slopes	Fair	Poor	Very poor.
ReB	Renshaw loam, 3 to 6 percent slopes	Fair	Poor	Very poor.
Rn	Renshaw loam, gravelly substratum	Fair	Poor	Very poor.
Rs	Renshaw loam, sandy substratum	Fair	Poor	Very poor.
Rt	Renshaw loam, till substratum	Fair	Poor	Very poor.
Ry	Ryan silty clay loam	Poor	Very poor	Good.
Rz	Ryan and Lamoure silty clay loams:			
	Ryan part	Poor	Very poor	Good.
	Lamoure part	Poor	Poor	Fair.
Se	Serden-Hamar sands:			
	Serden part	Poor	Fair	Very poor.
	Hamar part	Good	Good	Poor.
SoB	Sioux gravelly loam, 0 to 6 percent slopes	Very poor	Very poor	Very poor.
SoE	Sioux gravelly loam, 6 to 25 percent slopes	Very poor	Very poor	Very poor.
Sp	Spottswood loam	Good	Fair	Very poor.
Sr	Spottswood loam, sandy substratum	Good	Fair	Very poor.
Ss	Stirum sandy loam	Poor	Poor	Fair.
St	Svea loam	Good	Fair	Poor.
Su	Svea loam, cobbly variant	Good	Fair	Poor.
SvA	Svea-Barnes loams, 0 to 3 percent slopes:			
	Svea part	Good	Fair	Poor.
	Barnes part	Good	Fair	Very poor.
SvB	Svea-Barnes loams, 3 to 6 percent slopes	Good	Fair	Very poor.
SwC	Svea-Buse-Barnes loams, 6 to 9 percent slopes	Good	Fair	Very poor.
Sx	Svea-Cresbard loams:			
	Svea part	Good	Fair	Poor.
	Cresbard part	Fair	Fair	Poor.
Sz	Swenoda-Embden fine sandy loams:			
	Swenoda part	Fair	Good	Very poor.
	Embden part	Good	Fair	Poor.
Tf	Tiffany sandy loam	Fair	Fair	Fair.
Tg	Tiffany fine sandy loam, till substratum	Fair	Fair	Fair.
Tn	Tolna loam	Fair	Fair	Fair.
To	Tonka silt loam	Fair	Fair	Fair.
Ts	Totten sandy loam	Poor	Poor	Fair.
Tt	Totten loam	Poor	Poor	Fair.
Tu	Totten loam, very wet	Very poor	Poor	Good.
Tv	Totten loam, till substratum	Poor	Poor	Fair.
TwA	Towner fine sandy loam, 0 to 3 percent slopes	Fair	Fair	Very poor.
TwB	Towner fine sandy loam, 3 to 6 percent slopes	Fair	Fair	Very poor.
Tx	Towner-Dickey fine sandy loams	Fair	Fair	Very poor.
Va	Vallers loam	Fair	Fair	Good.
Vn	Vang loam	Good	Fair	Very poor.
Vo	Venlo sandy loam	Poor	Fair	Good.
Wa	Wahpeton silty clay	Fair	Poor	Poor.
WbB	Walsh loam, 3 to 6 percent slopes	Good	Fair	Very poor.
WbC	Walsh loam, 6 to 9 percent slopes	Good	Fair	Very poor.
WcA	Walsh clay loam, 0 to 3 percent slopes	Good	Fair	Very poor.
WcB	Walsh clay loam, 3 to 6 percent slopes	Good	Fair	Very poor.
WcC	Walsh clay loam, 6 to 9 percent slopes	Good	Fair	Very poor.
Wd	Walum sandy loam	Fair	Fair	Very poor.
We	Walum sandy loam, gravelly substratum	Fair	Fair	Very poor.
Wf	Warsing loam	Fair	Fair	Very poor.
Wg	Warsing loam, sandy substratum	Fair	Fair	Very poor.
Wm	Warsing loam, till substratum	Fair	Fair	Very poor.
Wn	Wyard loam	Good	Good	Fair.
Wo	Wyndmere sandy loam	Fair	Good	Very poor.
Wp	Wyndmere sandy loam, till substratum	Fair	Good	Very poor.
Wr	Wyrene sandy loam	Fair	Fair	Very poor.

TABLE 4.—*Suitability of the soils for kinds of wildlife*—Continued

Map symbol	Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Ws	Wyrene sandy loam, till substratum	Fair	Fair	Very poor.
Wt	Wyrene-Totten sandy loams:			
	Wyrene part	Fair	Fair	Very poor.
	Totten part	Poor	Poor	Fair.

ing to limitations that affect their suitability for playgrounds, camp areas, picnic areas, and paths and trails.

In table 5, the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils used for playgrounds should be able to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage, are not subject to flooding during periods of heavy use, and their surface is firm after rains but not dusty when dry. If grading and leveling are needed, depth to rock is important.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have gentle slopes, good drainage, and a surface free of rocks and coarse fragments. They are not subject to flooding during periods of heavy use, and their surface is firm after rains but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stoniness that greatly increase the cost of leveling or of building access roads.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Engineering Uses of the Soils [6]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who–

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6, 7, 8, and 9, which show estimated soil properties significant in engineering; interpretations for land-use planning and various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6, 7, and 8, and it also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially of small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas

[6] CLINTON JOHNSON, State conservation engineer, and WILTON GRADY, area engineer, Soil Conservation Service, assisted in preparing this section.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Ab—Aberdeen loam	Moderate: somewhat poorly drained or moderately well drained.	Moderate: slow permeability.	Moderate: somewhat poorly drained or moderately well drained.	Moderate: somewhat poorly drained or moderately well drained.
Ae—Aberdeen-Exline loams:				
Aberdeen part	Moderate: somewhat poorly drained or moderately well drained.	Moderate: slow permeability.	Moderate: somewhat poorly drained or moderately well drained.	Moderate: somewhat poorly drained or moderately well drained.
Exline part	Severe: very slow permeability.	Severe: slow permeability.	Moderate: somewhat poorly drained or moderately well drained.	Moderate: somewhat poorly drained or moderately well drained.
Ar—Arveson sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
As—Arvilla sandy loam	Slight	Slight	Slight	Slight.
AtA—Arvilla sandy loam, gravelly substratum, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight.
AtB—Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight.
AvA—Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight.
AvB—Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight.
AxC—Arvilla-Sioux sandy loams, 6 to 9 percent slopes.	Severe: slope	Slight	Slight	Slight.
BaA—Barnes loam, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight.
BaB—Barnes loam, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight.
BaC—Barnes loam, 6 to 9 percent slopes.	Severe: slope	Slight	Slight	Slight.
BbA—Barnes-Svea loams, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight.
BbB—Barnes-Svea loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
BcB—Barnes-Svea stony loams, 3 to 6 percent slopes.	Severe: stoniness	Severe: stoniness	Moderate: stoniness	Severe: stoniness.
BdC—Barnes-Svea-Buse loams, 6 to 9 percent slopes:				
Barnes-Svea part	Severe: slope	None to slight	None to slight	None to slight.
Buse part	Severe: slope	Moderate: moderately slow permeability.	Moderate: slope	None to slight.
BeC—Barnes-Svea-Buse stony loams, 6 to 9 percent slopes.	Severe: stoniness	Severe: stoniness	Moderate: stoniness	Severe: stoniness.
Bg—Bearden silt loam, saline	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Bh—Binford sandy loam	None to slight	None to slight	None to slight	None to slight.
BkA—Binford sandy loam, gravelly substratum, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
BkB—Binford sandy loam, gravelly substratum, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
BlA—Binford sandy loam, sandy substratum, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
BlB—Binford sandy loam, sandy substratum, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
BmC—Binford-Coe sandy loams, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
BmD—Binford-Coe sandy loams, 9 to 12 percent slopes.	Very severe: slope	Moderate: slope	Moderate: slope	None to slight.
Bn—Borup silt loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Bo—Borup and Marysland silt loams, very wet.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
BpB—Borup and Vallers loams, 3 to 6 percent slopes.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
BrB—Brantford loam, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	None to slight.
BsA—Brantford loam, gravelly substratum, 0 to 3 percent slopes.	Slight	Slight	Slight	None to slight.
BsB—Brantford loam, gravelly substratum, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	None to slight.
BtA—Brantford loam, sandy substratum, 0 to 3 percent slopes.	Slight	Slight	Slight	None to slight.
BtB—Brantford loam, sandy substratum, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	None to slight.
BuC—Brantford-Coe loams, 6 to 9 percent slopes.	Severe: slope	Slight	Slight	None to slight.
Bv—Brantford-Kensal loams	Slight	Slight	Slight	None to slight.
BwE—Buse-Barnes loams, 9 to 30 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Moderate to severe: slope.
BxD—Buse-Edgeley loams, 9 to 30 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to severe: slope.
ByE—Buse and Kloten loams, 6 to 25 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to severe: slope.
BzD—Buse, Sioux, and Zell soils, 3 to 30 percent slopes.	Moderate to very severe: slope.	Slight to severe: slope.	Slight to severe: slope.	Slight to severe: slope.
Ca—Cathay loam	Moderate: moderately slow permeability.	Moderate: moderately slow permeability.	None to slight	None to slight.
ChA—Cathay-Heimdal loams, 0 to 3 percent slopes:				
Cathay part	Moderate: moderately slow permeability.	Moderate: moderately slow permeability.	None to slight	None to slight.
Heimdal part	None to slight	None to slight	None to slight	None to slight.
ChB—Cathay-Heimdal loams, 3 to 6 percent slopes:				
Cathay part	Moderate: slope	Moderate: moderately slow permeability.	None to slight	None to slight.
Heimdal part	Moderate: slope	None to slight	None to slight	None to slight.
Cm—Cathay-Larson loams	Moderate: moderately slow and slow permeability, wetness.	Moderate: moderately slow and slow permeability.	Slight to moderate: moderately well drained and somewhat poorly drained.	Slight to moderate: somewhat poorly drained.
Cn—Cavour-Cresbard loams:				
Cavour part	Severe: very slow permeability.	Severe: very slow permeability.	None to slight	Slight.
Cresbard part	Moderate: slow permeability.	Moderate: slow permeability.	None to slight	None to slight.
Co—Cavour and Vallers stony clay loams.	Severe: stoniness	Severe: stoniness	Severe: stoniness	Severe: stoniness.
CpB—Cavour clay loam, shaly variant, 3 to 6 percent slopes.	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
CrA—Claire loamy coarse sand, 0 to 3 percent slopes.	Severe: subject to blowing.	Severe: texture	Severe: texture	Severe: texture.
CrB—Claire loamy coarse sand, 3 to 6 percent slopes.	Severe: subject to blowing.	Severe: texture	Severe: texture	Severe: texture.
Cs—Claire coarse sandy loam	Severe: subject to blowing.	Moderate: texture	Moderate: texture	Moderate: texture.
Ct—Claire-Lohnes-Hamar loamy coarse sands.	Severe: subject to blowing.	Severe: texture	Severe: texture	Severe: texture.
Cu—Clontarf sandy loam	Slight	Slight	Slight	Slight.
CvB—Coe sandy loam, 0 to 6 percent slopes.	Moderate: slope	Slight	Slight	None to slight.
CvD—Coe sandy loam, 6 to 25 percent slopes.	Very severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Cw—Colvin silty clay loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Cx—Colvin silty clay loam, saline	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Cy—Colvin silty clay loam, very wet	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Cz—Cresbard-Cavour loams:				
Cresbard part	Moderate: slow permeability.	Moderate: slow permeability.	None to slight	None to slight.
Cavour part	Severe: very slow permeability.	Severe: very slow permeability.	None to slight	Slight.
DvA—Divide loam, 0 to 3 percent slopes.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
DvB—Divide loam, 3 to 6 percent slopes.	Moderate: slope, somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Dw—Divide loam, saline	Severe: somewhat poorly drained, high water table.	Severe: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Dx—Divide loam, gravelly substratum.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Dy—Divide loam, sandy substratum	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Dz—Divide loam, till substratum	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
EaA—Eckman loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
EaB—Eckman loam, 3 to 8 percent slopes.	Moderate to severe: slopes.	None to slight	None to slight	None to slight.
Eb—Edgeley loam	None to slight	None to slight	None to slight	None to slight.
EcB—Edgeley and Cavour loams, 3 to 6 percent slopes:				
Edgeley part	Moderate: slope	None to slight	None to slight	None to slight.
Cavour part	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Ed—Edgeley loam, gravelly variant	None to slight	None to slight	None to slight	None to slight.
EeA—Egeland sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
EeC—Egeland sandy loam, 6 to 12 percent slopes.	Severe: slope	Slight to moderate: slope.	Slight to moderate: slope.	None to slight.
Eg—Egeland sandy loam, sandy substratum.	None to slight	None to slight	None to slight	None to slight.
EhA—Egeland fine sandy loam, till substratum, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
EhB—Egeland fine sandy loam, till substratum, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
EmC—Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
EnA—Embden sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
EoB—Embden-Egeland sandy loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
EsA—Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
EsB—Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
Et—Emrick sandy loam	None to slight	None to slight	None to slight	None to slight.
Eu—Emrick loam	None to slight	None to slight	None to slight	None to slight.
EvD—Esmond, Coe, and Embden soils, 6 to 25 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to severe: slope.
Ew—Exline loam	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Fa—Fargo and Nutley silty clay loams:				
Fargo part	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Fargo and Nutley—continued				
Nutley part	Moderate: slow permeability, texture.	Moderate: slow permeability.	Moderate: texture	Moderate: texture.
Fd—Fordville loam	Slight	Slight	Slight	None to slight.
Fm—Fossum sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Fo—Fossum loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Fp—Fossum and Hamar sandy loams.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
FrA—Fram loam, 0 to 3 percent slopes.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
FrB—Fram loam, 3 to 6 percent slopes.	Moderate: somewhat poorly drained, slope.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Fs—Fram loam, saline	Severe: somewhat poorly drained.	Severe: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained.
Fw—Fram and Wyndmere fine sandy loams.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
GaA—Gardena loam, 0 to 3 percent slopes.	Slight	None to slight	None to slight	Slight.
GaB—Gardena loam, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	Slight.
Gd—Glyndon loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Ge—Glyndon loam, saline	Severe: somewhat poorly drained.	Severe: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained.
Gp—Gravel pit. Too variable to be rated.				
Ha—Hamar loamy coarse sand	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Hb—Hamar loamy sand	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Hc—Hamar coarse sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Hd—Hamar sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
HeA—Hamerly loam, 0 to 3 percent slopes.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
HeB—Hamerly loam, 3 to 6 percent slopes.	Moderate: somewhat poorly drained, slope.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Hf—Hamerly loam, saline	Severe: somewhat poorly drained.	Severe: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained, high water table.	Moderate: somewhat poorly drained.
HgA—Hamerly-Svea loams, 0 to 3 percent slopes:				
Hamerly part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Svea part	None to slight	None to slight	None to slight	None to slight.
HgB—Hamerly-Svea loams, 3 to 6 percent slopes:				
Hamerly part	Moderate: somewhat poorly drained, slope.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Svea part	Moderate: slope	None to slight	None to slight	None to slight.
HhA—Hecla loamy sand, 0 to 3 percent slopes.	Moderate: texture	Moderate: texture	Moderate: texture	Moderate: texture.
HhB—Hecla loamy sand, 3 to 6 percent slopes.	Moderate: texture, slope.	Moderate: texture	Moderate: texture	Moderate: texture.
HkA—Hecla sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
HkB—Hecla sandy loam, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
HlB—Hecla-Dickey fine sandy loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
Hm—Hecla-Hamar loamy sands:				
Hecla part	Moderate: texture	Moderate: texture	Moderate: texture	Moderate: texture.
Hamar part	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
HnA—Hecla-Maddock loamy sands, 0 to 3 percent slopes.	Moderate: texture	Moderate: texture	Moderate: texture	Moderate: texture.
HnB—Hecla-Maddock loamy sands, 3 to 6 percent slopes.	Moderate: texture, slope.	Moderate: texture	Moderate: texture	Moderate: texture.
HoA—Heimdal sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
HoB—Heimdal sandy loam, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
HoC—Heimdal sandy loam, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
HpA—Heimdal loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
HpB—Heimdal loam, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
HpC—Heimdal loam, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
HrD—Heimdal-Embden fine sandy loams, 9 to 15 percent slopes.	Very severe: slope	Moderate: slope	Moderate: slope	None to slight.
HrE—Heimdal-Embden fine sandy loams, 15 to 25 percent slopes.	Very severe: slope	Severe: slope	Severe: slope	Moderate: slope.
HsA—Heimdal-Emrick loams, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
HsB—Heimdal-Emrick loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
HtC—Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes:				
Heimdal-Emrick part	Moderate to severe: slope.	None to slight	None to slight	None to slight.
Esmond part	Severe: slope	Moderate: slope	Moderate: slope	Slight.
HtD—Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes.	Very severe: slope	Moderate: slope	Moderate: slope	None to slight.
HtE—Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes.	Very severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Ke—Kensal loam	None to slight	None to slight	None to slight	None to slight.
Kf—Kensal loam, sandy substratum	None to slight	None to slight	None to slight	None to slight.
KoE—Kloten loam, 9 to 30 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to severe: slope.
KsE—Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes.	Very severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to moderate: slope.
Kt—Kratka fine sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
La—LaDelle silty clay loam	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Lb—Lallie silty clay loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Le—Lamoure silty clay loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Lm—Lamoure silty clay loam, saline.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Ln—La Prairie silt loam	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Lp—La Prairie-Lamoure complex:				
La Prairie part	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Lamoure part	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Lr—Larson loam	Moderate: slow permeability.	Moderate: slow permeability.	Moderate: moderately well drained and somewhat poorly drained.	Slight to moderate: somewhat poorly drained.
Ls—Lemert sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Lt—Letcher sandy loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Lu—Letcher sandy loam, till substratum.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Lv—Lohnes loamy coarse sand	Severe: subject to blowing.	Severe: texture	Severe: texture	Severe: texture.
Lw—Lohnes coarse sandy loam	Severe: subject to blowing.	Moderate: texture	Moderate: texture	Moderate: texture.
Lx—Ludden silty clay	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Lz—Ludden-Lamoure complex	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
MaA—Maddock loamy sand, 0 to 3 percent slopes.	Moderate: texture	Moderate: texture	Moderate: texture	Moderate: texture.
MaB—Maddock sandy loam, 3 to 6 percent slopes.	Moderate: texture, slope.	Moderate: texture	Moderate: texture	Moderate: texture.
MaC—Maddock loamy sand, 6 to 9 percent slopes.	Severe: texture, slope.	Moderate: texture	Moderate: texture	Moderate: texture.
MbA—Maddock sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
MbB—Maddock sandy loam, 6 to 9 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
MbC—Maddock sandy loam, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
MdB—Maddock-Dickey sandy loams, 0 to 6 percent slopes.	Slight to moderate: slope.	None to slight	None to slight	None to slight.
MdC—Maddock-Dickey sandy loams, 6 to 9 percent slopes.	Severe: slope	None to slight	None to slight	None to slight.
MeD—Maddock-Serden loamy fine sands, 9 to 30 percent slopes:				
Maddock part	Very severe: slope, texture.	Moderate to severe: slope, texture.	Moderate to severe: slope, texture.	Moderate: slope, texture.
Serden part	Very severe: slope, texture.	Severe: slope, texture.	Severe: slope, texture.	Severe: slope, texture.
MfD—Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes:				
Maddock-Hecla part	Very severe: slope, texture.	Moderate to severe: slope, texture.	Moderate to severe: slope, texture.	Moderate: slope, texture.
Serden part	Very severe: slope, texture.	Severe: slope, texture.	Severe: slope, texture.	Severe: slope, texture.
Mg—Made land. Too variable to be rated.				
Mh—Marsh. Too variable to be rated.				
Mm—Marysland loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Mn—Marysland and Arveson loams	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
MwC—Minnewaukan loamy fine sand, 6 to 9 percent slopes.	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding.
Mx—Miranda-Cavour clay loams	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: texture	Moderate: texture.
Os—Osakis sandy loam	None to slight	None to slight	None to slight	None to slight.
Ot—Osakis sandy loam, gravelly substratum.	None to slight	None to slight	None to slight	None to slight.
Ou—Osakis sandy loam, till substratum.	None to slight	None to slight	None to slight	None to slight.
Ov—Overly silty clay loam	Moderate: moderately slow permeability.	Moderate: moderately slow permeability, texture.	Moderate: texture	Moderate: texture.
Pa—Parnell silty clay loam	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Pe—Peat. Too variable to be rated.				
Pr—Perella silty clay loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Ra—Rauville silty clay loam	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
ReA—Renshaw loam, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight.
ReB—Renshaw loam, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight.
Rn—Renshaw loam, gravelly substratum.	Slight	Slight	Slight	Slight.
Rs—Renshaw loam, sandy substratum.	Slight	Slight	Slight	Slight.
Rt—Renshaw loam, till substratum	Slight	Slight	Slight	Slight.
Ry—Ryan silty clay loam	Severe: poorly drained, very slow permeability, flooding.	Severe: poorly drained, very slow permeability, flooding.	Severe: poorly drained, flooding.	Severe: poorly drained.
Rz—Ryan and Lamoure silty clay loams.	Severe: poorly drained, flooding.	Severe: poorly drained, flooding.	Severe: poorly drained, flooding.	Severe: poorly drained.
Se—Serden-Hamar sands:				
Serden part	Severe: texture	Severe: texture	Severe: texture	Severe: texture.
Hamar part	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
SoB—Sioux gravelly loam, 0 to 6 percent slopes.	Moderate: texture, slope.	Slight	Slight	Slight.
SoE—Sioux gravelly loam, 6 to 25 percent slopes.	Very severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Sp—Spottswood loam	Slight	Moderate: flooding	Slight	Slight.
Sr—Spottswood loam, sandy substratum.	Slight	Moderate: flooding	Slight	Slight.
Ss—Stirum sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
St—Svea loam	None to slight	None to slight	None to slight	None to slight.
Su—Svea loam, cobbly variant	Moderate: moderately slow permeability.	Moderate: moderately slow permeability.	None to slight	None to slight.
SvA—Svea-Barnes loams, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
SvB—Svea-Barnes loams, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
SwC—Svea-Buse-Barnes loams, 6 to 9 percent slopes:				
Svea-Barnes part	Severe: slope	None to slight	None to slight	None to slight.
Buse part	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Sx—Svea-Cresbard loams:				
Svea part	None to slight	None to slight	None to slight	None to slight.
Cresbard part	Moderate: slow permeability.	Moderate: slow permeability.	None to slight	None to slight.
Sz—Swenoda-Embden fine sandy loams.	None to slight	None to slight	None to slight	None to slight.
Tf—Tiffany sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Tg—Tiffany fine sandy loam, till substratum.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Tn—Tolna loam	Severe: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
To—Tonka silt loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Ts—Totten sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Tt—Totten loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Tu—Totten loam, very wet	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Tv—Totten loam, till substratum	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
TwA—Towner fine sandy loam, 0 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
TwB—Towner fine sandy loam, 3 to 6 percent slopes.	Moderate: slope	None to slight	None to slight	None to slight.
Tx—Towner-Dickey fine sandy loams.	None to slight	None to slight	None to slight	None to slight.
Va—Vallers loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Vn—Vang loam	None to slight	None to slight	None to slight	None to slight.
Vo—Venlo sandy loam	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Wa—Wahpeton silty clay	Severe: texture	Severe: texture	Severe: texture	Severe: texture.
WbB—Walsh loam, 3 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight.

TABLE 5.—*Degree and kind of soil limitations for recreational uses*—Continued

Symbol and soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
WbC—Walsh loam, 6 to 9 percent slopes.	Severe: slope	Slight	Slight	Slight.
WcA—Walsh clay loam, 0 to 3 percent slopes.	Moderate: texture	Moderate: texture	Moderate: texture	Moderate: texture.
WcB—Walsh clay loam, 3 to 6 percent slopes.	Moderate: texture, slope.	Moderate: texture	Moderate: texture	Moderate: texture.
WcC—Walsh clay loam, 6 to 9 percent slopes.	Severe: slope	Moderate: texture	Moderate: texture	Moderate: texture.
Wd—Walum sandy loam	None to slight	None to slight	None to slight	None to slight.
We—Walum sandy loam, gravelly substratum.	None to slight	None to slight	None to slight	None to slight.
Wf—Warsing loam	None to slight	None to slight	None to slight	None to slight.
Wg—Warsing loam, sandy substratum.	None to slight	None to slight	None to slight	None to slight.
Wm—Warsing loam, till substratum	None to slight	None to slight	None to slight	None to slight.
Wn—Wyard loam	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: flooding.
Wo—Wyndmere sandy loam	Slight	Slight	Slight	Slight.
Wp—Wyndmere sandy loam, till substratum.	Slight	Slight	Slight	Slight.
Wr—Wyrene sandy loam	Slight	Slight	Slight	Slight.
Ws—Wyrene sandy loam, till substratum.	Slight	Slight	Slight	Slight.
Wt—Wyrene-Totten sandy loams:				
Wyrene part	Slight	Slight	Slight	Slight.
Totten part	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.

of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

The "Glossary" defines many terms that are commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*10*) used by SCS engineers, the Department of Defense, and others, and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building material or for the support of structures other than highways. Soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils that are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. There is one class of highly organic soils, Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: 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. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 9; the estimated classification, without group index numbers, is given in table 6; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 6. These estimates are made by layers of representative soil profiles having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experiences with the same kinds of soil in other counties. Depth to bedrock is not shown because with the exception of three soils it is far enough below the surface to be no problem for engineering purposes. The exceptions are Kloten and Edgeley soils and the Cavour variant. Kloten soils are 10 to 20 inches to bedded shale; Edgeley soils are 24 to 36 inches to bedded shale; and the Cavour variant is 25 to 45 inches to bedded shale. Following are explanations of some of the columns in table 6.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

TABLE 6.—*Estimated 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 as indicated in the first column of this table. The symbol

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
*Aberdeen: Ab, Ae For Exline part of Ae, see Exline series.	1–5	0–7	Loam	ML or CL	A–4 or A–6		100	100
		7–11	Very fine sandy loam.	ML	A–4		100	100
		11–35	Clay loam	CL or CH	A–6 or A–7		100	100
		35–60	Very fine sandy loam.	ML	A–4		100	95–100
Arveson: Ar	0–3	0–21	Sandy loam	SM	A–2 or A–4		95–100	95–100
		21–60	Sand, sandy loam	SP–SM, SM	A–2 or A–3		95–100	95–100
*Arvilla:								
As, AtA, AtB, AxC For Sioux part of AxC, see Sioux series.	>5	0–18	Sandy loam	SM	A–2 or A–4		95–100	95–100
		18–60	Gravel and sand	GM or SM	A–1	<5	40–75	20–65
AvA, AvB	>5	0–18	Sandy loam	SM	A–2 or A–4		95–100	95–100
		18–60	Sand	SM	A–1		75–95	70–85
*Barnes: BaA, BaB, BaC, BbA, BbB, BcB, BdC, BeC. For Svea part of BbA, BbB, BcB, BdC, and BeC, see Svea series. For Buse part of BdC and BeC, see Buse series.	>5	0–6	Loam	ML or CL	A–4 or A–6	(2)	90–100	90–100
		6–60	Clay loam	CL or ML–CL	A–4, A–6 or A–7	(2)	90–100	85–100
Bearden: Bg	1–5	0–15	Silt loam	ML or CL	A–4 or A–6		100	100
		15–48	Silty clay loam	CL	A–7 or A–6		100	100
		48–60	Sand and gravel	SM	A–2 or A–1		80–90	70–80
*Binford:								
Bh, BkA, BkB, BmC, BmD. For Coe part of BmC and BmD, see Coe series.	>5	0–13	Sandy loam	SM	A–2 or A–4		95–100	90–100
		13–60	Shaly gravel and sand.	SM	A–1	<5	70–90	60–80
BlA, BlB	>5	0–13	Sandy loam	SM	A–2 or A–4		100	100
		13–60	Shaly sand	SM	A–2	<1	85–100	80–95
*Borup: Bn, Bo, BpB For Marysland part of Bo, see Marysland series. For Vallers part of BpB, see Vallers series.	0–3	0–11	Silt loam and loam.	ML	A–4		100	100
		11–54	Silt loam	ML	A–4		100	100
		54–60	Sand and gravel	SM	A–2 or A–4	<1	80–90	70–80
Brantford: BrB, BsA, BsB, BuC, Bv.	>5	0–15	Loam	ML–CL, ML or CL	A–4 or A–6		95–100	85–100
		15–60	Shaly gravel and sand.	SM	A–2 or A–1	<5	70–95	60–90
BtA, BtB	>5	0–15	Loam	ML or CL	A–4 or A–6		95–100	90–100
		15–60	Shaly sand	SM	A–2	<1	85–100	80–95

properties of the soils

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series
> means more than; the symbol < means less than]

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
85–95	60–75	20–40	4–20	0.6–2.0	0.18–0.22	6.1–6.5		Low	High	Low.
85–95	50–65	20–40	2–10	0.6–2.0	0.18–0.22	7.4–7.8		Low	High	Low.
90–100	70–80	30–60	12–35	0.06–0.2	0.15–0.17	7.9–9.0	8–16	High	High	Moderate.
85–95	50–65	20–40	2–10	0.6–2.0	0.14–0.17	7.4–9.0	4–8	Low	High	Moderate.
60–70	30–40	20–40	2–10	2.0–6.0	0.15–0.18	7.4–8.4		Low	High	Low.
50–75	5–35	[1] NP	[1] NP	2.0–6.0	0.03–0.06	7.4–7.8		Low	High	Low.
60–70	30–40	20–40	2–10	2.0–6.0	0.13–0.18	6.6–7.3		Low	Moderate	Low.
15–40	3–10	NP	NP	>20.0	0.03–0.05	6.6–7.8		Low	Moderate	Low.
60–70	30–40	20–40	2–10	2.0–6.0	0.13–0.18	6.6–7.3		Low	Moderate	Low.
25–40	5–20	NP	NP	>20.0	0.04–0.06	6.6–7.8		Low	Moderate	Low.
80–95	55–75	20–40	4–20	0.6–2.0	0.20–0.22	6.1–6.5		Low to moderate.	Moderate	Low.
75–100	55–80	20–50	4–25	0.2–0.6	0.16–0.18	6.6–8.4	0–4	Moderate to high.	High	Low.
90–100	70–90	25–40	4–20	0.6–2.0	0.18–0.20	7.4–7.8	8–16	Low to moderate.	High	Moderate.
95–100	85–95	35–50	15–30	0.2–0.6	0.17–0.19	7.4–7.8	8–16	High	High	Moderate.
40–60	10–25	NP	NP	2.0–20.0	0.03–0.06	7.4–7.8	4–16	Low	High	Moderate.
60–70	30–40	20–40	2–10	2.0–6.0	0.13–0.18	6.1–6.5		Low	Moderate	Low.
25–40	10–25	NP	NP	>20.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
60–70	30–40	20–40	2–10	2.0–6.0	0.13–0.18	6.1–6.5		Low	Moderate	Low.
50–70	15–30	NP	NP	>20.0	0.03–0.06	7.4–7.8		Low	Moderate	Low.
85–95	70–85	25–40	2–10	0.6–2.0	0.20–0.22	7.4–7.8		Low to moderate.	High	Low.
85–95	70–85	25–40	2–10	0.6–2.0	0.19–0.21	7.4–7.8	0–4	Low to moderate.	High	Low.
40–60	10–25	NP	NP	6.0–20.0	0.03–0.05	7.4–7.8		Low	High	Low.
85–95	55–75	20–40	4–20	2.0–6.0	0.20–0.22	6.6–7.3		Low	Moderate	Low.
25–60	10–25	NP	NP	>20.0	0.03–0.05	7.9–8.4		Low	Moderate	Low.
85–95	60–75	20–40	4–20	2.0–6.0	0.20–0.22	6.6–7.3		Low	Moderate	Low.
50–70	15–30	NP	NP	>20.0	0.03–0.06	7.9–8.4		Low	Moderate	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
*Buse: BwE, BxD, ByE, BzD. For Barnes part of BwE, see Barnes series; for Edgely part of BxD, see Edgely series; for Kloten part of ByE, see Kloten series; and for Sioux and Zell parts of BzD, see Sioux and Zell series.	>5	0–7	Loam	ML or CL	A–4 or A–6	0–25	90–100	80–95
		7–60	Loam	CL	A–6	0–25	90–100	80–95
*Cathay: Ca, ChA, ChB, Cm. For Heimdal part of ChA and ChB, see Heimdal series. For Larson part of Cm, see Larson series.	1–5	0–9	Loam	ML	A–4		100	95–100
		9–32	Clay loam	CL	A–6 or A–7		100	95–100
		32–60	Loam	ML	A–4		100	95–100
*Cavour: Cn, Co For Cresbard part of Cn, see Cresbard series; for Vallers part of Co, see Vallers series.	0–5	0–4	Loam	ML or CL	A–4 or A–6	[3] 0–25	95–100	90–100
		4–19	Clay loam	CH	A–7	[3] 0–25	95–100	95–100
		19–48	Clay loam	CL	A–6 or A–7	[3] 0–25	95–100	90–100
		48–60	Loam	CL	A–6	[3] 0–25	95–100	90–100
Cavour variant: CpB.	>5	0–5	Clay loam	CL	A–6 or A–7	<1	100	95–100
		5–32	Silty clay	CH	A–7	<1	100	100
		32–60	Weathered shale.					
*Claire: CrA, CrB, Cs, Ct. For Lohnes and Hamar part of Ct, see the Lohnes series and Ha in the Hamar series.	>5	0–8	Loamy coarse sand, coarse sandy loam.	SM	A–2		95–100	85–100
		8–48	Coarse sand	SP–SM	A–3		95–100	85–100
		48–60	Fine sand	SM, SW–SM	A–2		100	100
Clontarf: Cu	3–5	0–26	Sandy loam	SM	A–2 or A–4		95–100	90–100
		26–60	Sand	SP–SM or SM	A–2		95–100	90–100
Coe: CvB, CvD	>5	0–6	Sandy loam, shaly loam.	SM	A–2 or A–4	<1	90–100	85–100
		6–16	Coarse sand and gravel.	SM	A–2	<5	80–90	85–95
		16–60	Shaly coarse sand and gravel.	SM or GM	A–1 or A–2	<5	30–90	25–75

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
70–90	60–75	20–40	4–20	0.6–2.0	0.20–0.22	6.6–7.8		Low to moderate.	Moderate	Low.
70–90	60–75	20–40	12–20	0.2–0.6	0.17–0.19	7.9–8.4	0–4	Moderate	Moderate	Low.
80–90	60–75	15–40	2–10	0.6–2.0	0.15–0.18	6.1–6.5		Low to moderate.	Moderate	Low.
85–95	70–80	25–45	12–25	0.06–0.6	0.17–0.20	6.6–8.4	0–4	Moderate	High	Moderate.
80–90	60–75	15–40	2–10	0.6–2.0	0.15–0.18	7.9–8.4	0–4	Low to moderate.	Moderate	Moderate.
85–95	60–75	20–40	4–20	0.06–0.6	0.15–0.18	6.1–6.5		Moderate	Moderate	Low.
90–100	70–80	50–70	25–45	<0.06	0.12–0.14	6.6–7.8	4–8	High	High	Moderate.
90–100	70–80	20–45	12–25	<0.06	0.12–0.14	7.9–8.4	8–16	High	High	Moderate.
85–95	60–75	20–40	12–20	0.06–0.6	0.12–0.15	7.9–8.4	4–8	Moderate	High	Moderate.
90–100	70–80	20–45	12–25	0.06–0.2	0.17–0.20	6.6–7.3		High	High	Low.
95–100	90–95	50–70	25–45	<0.06	0.12–0.15	6.6–8.4	0–8	High	High	Moderate.
50–80	15–40	NP	NP	6.0–20.0	0.06–0.10	6.6–7.3		Low	Moderate	Low.
45–80	<5–10	NP	NP	6.0–20.0	0.03–0.04	6.6–7.8		Low	Moderate	Low.
65–80	10–25	NP	NP	6.0–20.0	0.04–0.05	7.9–8.4		Low	Moderate	Low.
60–70	30–40	20–40	2–10	2.0–6.0	0.13–0.15	6.1–7.8		Low	Moderate	Low.
55–80	5–20	NP	NP	2.0–6.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
50–60	20–40	15–35	2–10	2.0–6.0	0.12–0.14	7.4–7.8		Low	Moderate	Low.
50–60	15–30	NP	NP	>20.0	0.03–0.06	7.9–8.4		Low	Moderate	Low.
20–60	10–30	NP	NP	>20.0	0.02–0.04	7.9–8.4		Low	Moderate	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Colvin: Cw, Cx, Cy	0–3	0–40	Silty clay loam	CL	A–6 or A–7		100	100
		40–60	Sandy clay loam	SC or CL	A–6		100	95–100
*Cresbard: Cz	1–5	0–7	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
For Cavour part of Cz, see Cavour series.		7–36	Clay loam	CL or CH	A–6 or A–7	<1	95–100	90–100
		36–60	Loam	CL	A–6	<1	95–100	90–100
Dickey	>5	0–6	Fine sandy loam, loamy fine sand.	SM	A–2 or A–4		100	95–100
Mapped only with Maddock, Hecla, and Towner soils.		6–24	Loamy fine sand	SM	A–2		100	95–100
		24–60	Loam	CL	A–6	<1	95–100	90–100
Divide:								
DvA, DvB, Dw, Dx	1–5	0–22	Loam	ML or CL	A–4 or A–6		95–100	95–100
		22–60	Sand and gravel	SM or GM	A–1	<3	40–75	25–65
Dy	1–5	0–22	Loam	ML or CL	A–4 or A–6		95–100	95–100
		22–60	Coarse sand	SM	A–2		95–100	80–90
Dz	1–5	0–22	Loam	ML or CL	A–4 or A–6		95–100	95–100
		22–40	Sand and gravel	SM or GM	A–1	<3	40–75	25–65
		40–60	Loam	CL	A–6	<1	95–100	90–100
Eckman: EaA, EaB	>5	0–6	Loam	ML	A–4		100	100
		6–60	Silt loam	ML	A–4		100	100
*Edgeley: Eb, EcB	>5	0–6	Loam	ML or CL	A–4 or A–6		95–100	90–100
For Cavour part of EcB, see Cavour series.		6–15	Silt loam	ML or CL	A–4 or A–6		95–100	90–100
		15–32	Silty clay loam	CL or CH	A–7	<1	95–100	90–100
		32–60	Weathered and bedded shale.					
Edgeley variant: Ed.	>5	0–16	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		16–30	Gravel and sand	SM or GM	A–1 or A–2	<3	40–75	25–65
		30–60	Weathered shale.					
*Egeland:								
EeA, EeC	>5	0–20	Sandy loam	SM	A–2 or A–4		95–100	95–100
		20–30	Loamy fine sand	SM	A–2		95–100	95–100
		30–60	Fine sand	SM	A–2		95–100	90–100
Eg	>5	0–20	Sandy loam	SM	A–2 or A–4		95–100	95–100
		20–30	Loamy sand	SM	A–2		95–100	95–100
		30–60	Medium and coarse sand.	SP–SM or SM	A–2	<1	95–100	90–100
EhA, EhB, EmC	>5	0–20	Sandy loam	SM	A–2 or A–4		95–100	95–100
For Embden part of EmC, see EsA in the Embden series.		20–30	Loamy sand	SM	A–2		95–100	95–100
		30–48	Sand	SP–SM or SM	A–2	<1	95–100	90–100
		48–60	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
*Embden:								
EnA, EoB	3–5 (0 to 1 percent slope).	0–5	Sandy loam	SM	A–2 or A–4		100	100
For Egeland part of EoB, see EeA in the Egeland series.	>5 (more than 2 percent slope).	5–48	Fine sandy loam	SM or ML	A–2 or A–4		100	100
		48–60	Fine sand	SM	A–2		95–100	90–100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
90–100	80–95	20–45	12–25	0.2–0.6	0.16–0.21	6.6–7.8	[3] 0–16	Moderate	High	Low to moderate.[3]
80–90	35–55	20–40	12–20	0.2–0.6	0.15–0.18	6.6–7.8	[3] 0–16	Moderate	High	Low to moderate.[3]
85–95	60–75	20–40	4–20	0.2–0.6	0.19–0.22	6.1–7.3		Moderate	Moderate	Low.
85–95	70–80	30–70	12–45	0.06–0.2	0.15–0.18	6.6–8.4	4–16	High	High	Moderate.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.4–8.4	4–8	Moderate	High	Moderate.
55–85	20–50	20–35	2–10	6.0–20.0	0.10–0.18	6.1–6.5		Low	Moderate	Low.
55–75	15–35	NP	NP	6.0–20.0	0.08–0.10	6.6–7.3		Low	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.4–8.4	0–4	Moderate	High	Low.
75–85	60–75	20–40	4–20	0.6–2.0	0.18–0.20	7.4–8.4	[3] 0–16	Low	High	Low to moderate.[3]
15–40	10–25	NP	NP	>20.0	0.03–0.04	7.9–8.4	[3] 0–16	Low	High	Low to moderate.[3]
75–85	60–75	20–40	4–20	0.6–2.0	0.18–0.20	7.4–8.4	0–4	Low	High	Low.
55–70	15–25	NP	NP	>20.0	0.03–0.04	7.9–8.4	0–4	Low	High	Low.
75–85	60–75	20–40	4–20	0.6–2.0	0.18–0.20	7.4–8.4	0–4	Low	High	Low.
15–40	10–25	NP	NP	>20.0	0.03–0.04	7.9–8.4	0–4	Low	High	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.9–8.4	0–4	Moderate	High	Low.
85–95	60–75	15–40	2–10	0.6–2.0	0.17–0.20	6.6–7.3		Low	Moderate	Low.
90–100	70–90	15–40	2–10	0.6–2.0	0.17–0.20	6.6–8.4		Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.6–2.0	0.18–0.22	6.1–6.5		Moderate	Moderate	Low.
80–90	65–80	20–40	4–20	0.6–2.0	0.20–0.22	6.6–7.3		Moderate	Moderate	Low.
85–95	80–90	45–70	20–45	0.6–2.0	0.20–0.22	7.4–7.8		Moderate	Moderate	Low.
85–95	65–75	20–40	4–20	0.6–2.0	0.20–0.22	6.1–7.3		Moderate	Moderate	Low.
15–40	15–30	NP	NP	6.0–20.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
60–70	30–40	15–35	2–10	2.0–6.0	0.15–0.18	6.1–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	2.0–6.0	0.12–0.13	6.6–7.3		Low	Moderate	Low.
65–80	20–35	NP	NP	2.0–6.0	0.07–0.08	7.4–8.4		Low	Moderate	Low.
60–70	30–40	15–35	2–10	2.0–6.0	0.15–0.18	6.1–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	2.0–6.0	0.12–0.13	6.6–7.3		Low	Moderate	Low.
55–80	5–20	NP	NP	6.0–20.0	0.06–0.07	7.4–8.4		Low	Moderate	Low.
60–70	30–40	15–35	2–10	2.0–6.0	0.15–0.18	6.1–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	2.0–6.0	0.12–0.13	6.6–7.3		Low	Moderate	Low.
55–80	5–20	NP	NP	6.0–20.0	0.06–0.07	7.4–7.8		Low	Moderate	Low.
85–95	60–75	NP	NP	0.2–0.6	0.16–0.18	7.4–8.4	0–4	Moderate	High	Low.
60–70	30–40	20–40	2–10	2.0–6.0	0.12–0.16	6.1–6.5		Low	Moderate	Low.
70–85	40–55	10–30	0–5	2.0–6.0	0.12–0.16	6.1–6.5		Low	Moderate	Low.
65–80	25–35	NP	NP	2.0–6.0	0.05–0.08	6.1–6.5		Low	Moderate	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Embden—continued								
EsA, EsB	3–5 (0 to 1 percent slope).	0–48	Sandy loam, fine sandy loam.	SM or ML	A–2 or A–4		100	100
For Swenoda part of EsA see Swenoda series. For Heimdal part of EsB, see Heimdal series.	>5 (more than 2 percent slope).	48–60	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
Emrick: Et, Eu	>3	0–9	Loam, sandy loam	ML or SM	A–4	0	100	100
		9–60	Loam	ML	A–4	<1	100	100
*Esmond: EvD	>5	0–60	Loam	ML	A–4	<5	95–100	90–100
For Coe and Embden parts of EvD, see Coe series and EnA in the Embden series.								
Exline: Ew	0–3	0–4	Loam	CL	A–6		100	100
		4–24	Clay loam	CL	A–7 or A–6		100	100
		24–60	Sandy clay loam	SC or CL	A–6	1	95–100	95–100
*Fargo: Fa	3–5	0–8	Silty clay loam	CH	A–7		100	100
For Nutley part of Fa, see Nutley series.		8–60	Silty clay	CH	A–7		100	100
Fordville: Fd	>5	0–22	Loam	ML	A–4		95–100	90–100
		22–60	Sand and gravel	SM or GM	A–1	5	40–75	25–65
*Fossum: Fm, Fo, Fp.	1–3	0–16	Sandy loam	SM	A–2 or A–4		95–100	90–100
		16–34	Loamy sand	SM	A–2		95–100	90–100
For Hamar part of Fp, see Hd in the Hamar series.		34–60	Sand	SP–SM	A–3		95–100	90–100
*Fram: FrA, FrB, Fs, Fw.	1–5	0–60	Loam, fine sandy loam.	SM, ML–CL, ML, or CL	A–4 or A–6	1	95–100	95–100
For Wyndmere part of Fw, see Wo in the Wyndmere series.								
Gardena: GaA, GaB	>5	0–18	Loam	ML	A–4		100	100
		18–53	Silt loam	ML	A–4		100	100
		53–60	Fine sandy loam	SM or ML	A–4		100	100
Glyndon: Gd, Ge	2–4	0–6	Loam	ML	A–4		100	100
		6–30	Silt loam	ML	A–4		100	100
		30–42	Very fine sandy loam.	ML	A–4		100	100
		42–60	Loamy fine sand	SM	A–2	1	100	100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
60–85	30–55	20–40	2–10	2.0–6.0	0.12–0.15	6.6–7.3		Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.13–0.15	7.9–8.4	0–4	Moderate	Moderate	Low.
65–90	35–70	20–40	2–10	0.6–2.0	0.17–0.20	6.6–7.3		Low to moderate.	Moderate	Low.
85–95	60–75	15–40	2–10	0.6–2.0	0.16–0.20	7.4–8.4	0–4	Low to moderate.	Moderate	Low.
85–95	60–75	15–40	2–10	0.6–2.0	0.16–0.19	6.6–8.4		Low to moderate.	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.15–0.17	6.6–7.3	0–4	Moderate	High	Low.
90–100	70–80	20–45	12–25	<0.06	0.07–0.09	7.9–9.0	4–16	High	High	Moderate.
80–90	35–55	20–35	12–20	0.06–0.2	0.07–0.09	8.5–9.0	4–16	High	High	Moderate.
95–100	85–95	50–70	25–45	0.06–0.2	0.15–0.23	6.1–7.3		High	High	Low.
95–100	90–95	50–75	25–50	0.06–0.2	0.15–0.17	7.4–8.4	0–4	High	High	Low.
85–95	55–65	15–40	2–10	0.6–2.0	0.20–0.22	6.6–7.8		Low	Moderate	Low.
15–40	10–25	NP	NP	>20.0	0.04–0.06	7.4–7.8		Low	Moderate	Low.
60–70	30–40	15–35	2–10	6.0–20.0	0.13–0.15	7.4–7.8		Low	High	Low.
50–75	15–35	NP	NP	6.0–20.0	0.09–0.11	7.4–7.8		Low	High	Low.
50–70	5–10	NP	NP	6.0–20.0	0.04–0.06	7.4–7.8		Low	High	Low.
75–95	50–75	20–40	4–20	0.6–2.0	0.16–0.20	7.4–9.0	[3] 0–16	Low to moderate.	High	Low to moderate.[3]
85–95	60–75	15–40	2–10	0.6–2.0	0.18–0.24	7.4–7.8		Low	Moderate	Low.
90–100	70–90	15–40	2–10	0.6–2.0	0.16–0.19	7.4–8.4	0–4	Low	Moderate	Low.
70–85	40–55	NP	NP	2.0–6.0	0.08–0.14	7.9–8.4	0–4	Low	High	Low.
85–95	60–75	15–40	2–10	0.6–2.0	0.22–0.24	6.6–7.3	[3] 0–16	Low to moderate.	High	Low to moderate.[3]
90–100	70–90	15–40	2–10	0.6–2.0	0.22–0.24	7.4–7.8	[3] 0–16	Low to moderate.	High	Low to moderate.[3]
85–95	50–65	2–8	20–35	0.6–2.0	0.17–0.19	7.4–7.8	[3] 0–16	Low	High	Low to moderate.[3]
50–75	15–30	NP	NP	2.0–6.0	0.07–0.10	7.4–7.8	[3] 0–16	Low	High	Low to moderate.[3]

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Gravel pit: Gp. Properties are too variable to be estimated.								
Hamar:								
Hb, Hd	1–5	0–13	Loamy sand, sandy loam.	SM	A–2		100	100
		13–20	Sand	SM, SP–SM	A–2		100	90–100
		20–60	Loamy sand	SM	A–2		100	95–100
Ha, Hc	1–5	0–13	Loamy coarse sand, coarse sandy loam.	SM	A–2 or A–4		95–100	85–95
		13–20	Coarse sand	SP–SM	A–3		95–100	85–95
		20–60	Loamy coarse sand.	SM	A–2		95–100	85–95
*Hamerly: HeA, HeB, Hf, HgA, HgB. For Svea part of HgA and HgB, see Svea series.	1–5	0–60	Loam	ML or CL	A–4 or A–6	<1	90–100	90–100
*Hecla: HhA, HhB, HkA, HkB, HlB, Hm, HnA, HnB. For Dickey part of HlB, see Dickey series; for Hamar part of Hm, see Hb in the Hamar series; and for Maddock part of HnA and HnB, see Maddock series.	>4	0–16	Loamy sand, sandy loam.	SM	A–2		100	95–100
		16–32	Loamy sand	SM	A–2		100	95–100
		32–50	Fine sand	SM	A–2		100	90–100
		50–60	Loamy sand	SM	A–2		100	95–100
*Heimdal: HoA, HoB, HoC, HpA, HpB, HpC, HrD, HrE, HsA, HsB, HtC, HtD, HtE. For Embden part of HrD and HrE, see EsA in the Embden series; for Emrick part of HsA, HsB, HtC, HtD, and HtE, see Emrick series; and for Esmond part of HtC, HtD, and HtE, see Esmond series.	>5	0–12	Loam, sandy loam, fine sandy loam.	ML or SM	A–4		95–100	95–100
		12–60	Loam	ML or CL	A–4 or A–6	<1	95–100	85–100
Kensal:								
Ke	>5	0–18	Loam	ML	A–4	<1	95–100	90–100
		18–24	Sandy loam	SM	A–2 or A–4	<1	95–100	90–100
		24–30	Loamy sand	SM	A–2	<1	95–100	90–100
		30–60	Shaly sand and gravel.	SM	A–1	<5	70–90	60–80

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
55–75	15–35	15–35	2–10	6.0–20.0	0.10–0.12	6.1–6.5		Low	High	Low.
50–70	10–15	NP	NP	6.0–20.0	0.05–0.06	6.1–6.5		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.08–0.10	6.1–6.5		Low	High	Low.
60–75	15–40	NP	NP	6.0–20.0	0.09–0.11	6.1–6.5		Low	High	Low.
45–80	5–10	NP	NP	6.0–20.0	0.04–0.05	6.1–6.5		Low	High	Low.
65–80	15–25	NP	NP	6.0–20.0	0.07–0.09	6.1–6.5		Low	High	Low.
85–95	55–75	20–40	4–20	0.2–0.6	0.16–0.20	7.4–8.4	[3] 0–16	Low to moderate.	High	Low to moderate.[3]
55–75	15–35	15–35	2–10	6.0–20.0	0.08–0.16	6.1–6.5		Low	Moderate	Low.
50–75	15–30	NP	NP	6.0–20.0	0.09–0.11	6.1–6.5		Low	Moderate	Low.
65–80	20–35	NP	NP	6.0–20.0	0.05–0.06	6.1–6.5		Low	Moderate	Low.
50–75	15–30	NP	NP	6.0–20.0	0.04–0.05	6.6–7.3		Low	Moderate	Low.
65–95	35–80	15–35	2–10	0.6–2.0	0.17–0.22	6.6–7.3		Low to moderate.	Moderate	Low.
75–95	50–75	20–40	4–20	0.6–2.0	0.16–0.19	6.6–8.4	0–4	Low to moderate.	Moderate	Low.
85–95	60–75	15–40	2–10	2.0–6.0	0.16–0.18	6.6–7.3		Low to moderate.	High	Low.
60–70	30–40	NP	NP	2.0–6.0	0.12–0.14	6.6–7.3		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.04–0.06	7.4–7.8		Low	High	Low.
25–40	10–25	NP	NP	>20.0	0.03–0.04	7.4–7.8		Low	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Kensal—continued								
Kf	>5	0–18	Loam	ML	A–4		95–100	90–100
		18–24	Sandy loam	SM	A–2 or A–4		95–100	90–100
		24–32	Loamy sand	SM	A–2		95–100	95–100
		32–60	Shaly sand	SM	A–2	<1	85–100	80–95
*Kloten: KoE, KsE — For Sioux and Edgeley part of KsE, see those series.	>5	0–16	Loam	ML or CL	A–4 or A–6	<3	95–100	90–100
		16–60	Bedded shale					
Kratka: Kt	1–3	0–13	Fine sandy loam	SM or ML	A–4		100	100
		13–23	Loamy fine sand	SM	A–2		100	100
		23–31	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		31–45	Coarse sand	SM	A–2 or A–1	<1	85–100	80–90
		45–60	Clay loam	CL	A–6 or A–7	<1	95–100	90–100
LaDelle: La	>5	0–60	Silty clay loam	CL, MH or CH	A–7 or A–6		100	100
Lallie: Lb	1–5	0–24	Silty clay loam	CL or CH	A–6 or A–7		100	100
		24–60	Silty clay	CH	A–7		100	100
Lamoure: Le, Lm	2–5	0–60	Silty clay loam	CL, MH or CH	A–7		100	100
*La Prairie: Ln, Lp — For Lamoure part of Lp, see Lamoure series.	>5	0–21	Silt loam	ML or CL	A–4, A–6		100	95–100
		21–60	Silty clay loam	CL, MH or CH	A–7		100	95–100
Larson: Lr	1–5	0–7	Loam	ML or CL	A–4 or A–6		100	95–100
		7–16	Clay loam	CH	A–7		100	95–100
		16–60	Clay loam	CL	A–6 or A–7		100	95–100
Lemert: Ls	2–5	0–12	Sandy loam	SM or SC	A–2 or A–4	<1	95–100	90–100
		12–22	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		22–49	Medium and coarse sand.	SP–SM or SM	A–2	<1	90–100	85–95
		49–60	Clay loam	CL	A–6 or A–7		100	95–100
Letcher: Lt, Lu	2–5	0–9	Sandy loam	SM	A–2 or A–4		95–100	95–100
		9–28	Sandy loam	SM or SC	A–2 or A–4		100	100
		28–60	Medium to very coarse sand.	SP–SM or SM	A–2		90–100	80–90
Lohnes: Lv, Lw	>5	0–16	Loamy coarse sand, coarse sandy loam.	SM	A–2		95–100	85–100
		16–30	Loamy coarse sand.	SM	A–2		95–100	85–100
		30–60	Coarse sand	SP–SM	A–3		95–100	85–100
*Ludden: Lx, Lz — For Lamoure part of Lz, see Lamoure series.	0–3	0–7	Silty clay	CH	A–7		100	100
		7–60	Clay	CH	A–7		100	100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
85–95	60–75	15–40	2–10	2.0–6.0	0.18–0.20	6.6–7.3		Low to moderate.	High	Low.
60–70	30–40	NP	NP	2.0–6.0	0.12–0.14	6.6–7.3		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.04–0.06	7.4–7.8		Low	High	Low.
50–70	15–30	NP	NP	>20.0	0.03–0.05	7.4–7.8		Low	High	Low.
85–95	60–75	20–40	4–20	0.6–2.0	0.16–0.18	6.6–7.3		Moderate	Moderate	Low.
70–85	40–55	NP	NP	6.0–20.0	0.13–0.18	6.1–7.3		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.08 0.10	6.1–7.5		Low	High	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.15–0.19	6.1–6.5		Moderate	High	Low.
35–65	15–25	NP	NP	6.0–20.0	0.02–0.04	6.1–7.3		Low	High	Low.
85–95	70–80	20–45	12–25	0.2–0.6	0.03–0.05	7.4–7.8	0–4	Moderate	High	Low.
95–100	85–100	20–70	12–30	0.6–2.0	0.19–0.20	6.6–7.8		Moderate	High	Low.
95–100	85–95	30–70	15–40	0.06–0.2	0.13–0.15	7.4–7.8	4–8	High	High	Moderate.
95–100	90–95	50–75	25–45	0.06–0.2	0.09–0.11	7.4–8.4	4–8	High	High	Moderate.
95–100	85–95	45–75	20–45	0.6–2.0	0.19–0.20	6.6–8.4	[3] 0–16	High	High	Low to moderate.[3]
90–100	65–90	20–35	4–15	0.6–2.0	0.18–0.22	6.6–7.3		Low	Moderate	Low.
90–100	65–95	45–75	20–45	0.6–2.0	0.16–0.19	7.4–8.4	0–4	Moderate	Moderate	Low.
85–95	60–75	20–40	4–20	0.6–2.0	0.16–0.20	6.6–7.3		Low	Moderate	Low.
85–95	70–80	50–75	25–45	0.06–0.2	0.12–0.15	7.4–7.8	0–4	Moderate	High	Low.
80–90	70–80	20–45	12–25	0.06–0.2	0.10–0.12	7.9–8.4	0–8	Moderate	High	Low.
60–70	30–40	15–35	4–10	0.06–0.2	0.12–0.15	6.6–>9.0	4–8	Low	High	Moderate.
70–90	60–75	20–40	4–20	0.06–0.2	0.13–0.17	>9.0	8–16	Low	High	Moderate.
50–75	5–20	NP	NP	6.0–20.0	0.04–0.06	7.9–9.0	0–8	Low	High	Moderate.
80–90	70–80	20–45	12–25	0.06–0.2	0.10–0.12	7.9–8.4	0–4	Moderate	High	High.
60–70	30–40	15–35	2–10	0.6–2.0	0.13–0.17	6.1–7.3		Low	High	Low.
60–90	30–50	20–35	2–10	0.06–0.2	0.11–0.15	6.6–8.4	0–8	Low	High	Moderate.
50–75	5–20	NP	NP	6.0–20.0	0.03–0.05	7.9–8.4	0–8	Low	High	Moderate.
50–80	15–40	NP	NP	6.0–20.0	0.07–0.13	6.6–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	6.0–20.0	0.07–0.10	6.6–7.3		Low	Moderate	Low.
50–75	5–10	NP	NP	6.0–20.0	0.03–0.04	7.4–8.4		Low	Moderate	Low.
95–100	90–95	50–75	25–45	0.06–0.2	0.16–0.18	7.4–7.8	0–4	High	High	Moderate.
90–100	75–95	50–70	25–40	0.06–0.2	0.15–0.18	7.4–7.8	0–4	High	High	Moderate.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
*Maddock: MaA, MaB, MaC, MbA, MbB, MbC, MdB, MdC, MeD, MfD. For Dickey part of MdB and MdC, see Dickey series; for Serden part of MeD and MfD, see Serden series; and for Hecla part of MfD, see Hecla series.	>5	0–7	Sandy loam, loamy sand.	SM	A–2 or A–4		100	95–100
		7–40	Loamy sand	SM	A–1 or A–2		95–100	95–100
		40–60	Sand	SM	A–1 or A–2		95–100	95–100
Made land: Mg. Properties are too variable to be estimated.								
Marsh: Mh. Properties are too variable to be estimated.								
*Marysland: Mm, Mn. For Arveson part of Mn, see Arveson series.	0–4	0–7	Loam	ML or CL	A–4 or A–6		100	100
		7–24	Silt loam	CL	A–6		100	100
		24–29	Sandy clay loam	SC	A–6		100	100
		29–60	Medium and coarse sand.	SP–SM	A–2 or A–3		95–100	90–100
Minnewaukan: MwC.	1–5	0–3	Loamy fine sand	SM	A–2	<1	90–100	85–95
		3–28	Loamy sand	SM	A–1 or A–2	<1	95–100	95–100
		28–60	Fine sand	SM	A–2	<1	100	95–100
*Miranda: Mx For Cavour part of Mx, see Cavour series.	1–4	0–8	Clay loam	CL	A–6 or A–7	<1	95–100	95–100
		8–60	Clay loam	CL	A–6 or A–7	<1	95–100	95–100
Nutley Mapped only with Fargo soils.	>5	0–40	Silty clay loam	CH	A–7		100	100
		40–50	Clay loam	CL	A–6 or A–7		100	100
		50–56	Medium sand	SM	A–2		100	95–100
		56–60	Silty clay loam	CH	A–7		100	100
Osakis:								
Os	>5	0–18	Sandy loam	SM	A–2 or A–4		95–100	90–100
		18–30	Loamy coarse sand.	SM.	A–2		95–100	80–90
		30–60	Sand and gravel	SM	A–1	<1	70–90	40–80
Ot	>5	0–18	Sandy loam	SM	A–2 or A–4		95–100	90–100
		18–30	Loamy coarse sand.	SM	A–2		95–100	80–90
Ou	>5	30–60	Gravel	GM or SM	A–1	<5	40–75	20–65
		0–18	Sandy loam	SM	A–2 or A–4		95–100	90–100
		18–30	Loamy coarse sand.	SM	A–2		95–100	80–90
		30–48	Sand and gravel	GM or SM	A–1	<5	40–75	20–65
		48–60	Loam	CL	A–6	<3	95–100	90–100
Overly: Ov	>5	0–25	Silty clay loam	CL	A–7 or A–6		100	100
		25–60	Silty clay loam	CL	A–7 or A–6		100	100
Parnell: Pa	0–5	0–18	Silty clay loam	CL	A–7		100	100
		18–40	Silty clay	CH	A–7		100	100
		40–60	Silty clay loam	CL	A–7		100	95–100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
55–75	15–35	NP	NP	6.0–20.0	0.10–0.15	6.1–6.5		Low	Moderate	Low.
45–75	10–30	NP	NP	6.0–20.0	0.08–0.10	6.6–7.8		Low	Moderate	Low.
45–70	10–15	NP	NP	6.0–20.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
85–95	60–75	20–40	4–20	2.0–6.0	0.20–0.24	7.9–8.4		Low	High	Low.
90–100	70–90	20–40	12–20	2.0–6.0	0.20–0.24	7.9–8.4		Low to moderate.	High	Low.
80–90	35–50	20–40	12–20	2.0–6.0	0.17–0.20	7.9–8.4		Low	High	Low.
45–70	5–10	NP	NP	2.0–20.0	0.03–0.05	7.9–8.4		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.10–0.14	7.4–7.8		Low	Moderate	Low.
45–75	10–30	NP	NP	6.0–20.0	0.08–0.10	7.4–7.8		Low	Moderate	Low.
65–80	20–35	NP	NP	6.0–20.0	0.04–0.06	7.4–8.4		Low	Moderate	Low.
85–95	60–80	35–50	15–30	<0.06	0.12–0.15	7.4–8.4	0–4	Moderate	High	Moderate.
75–95	55–80	35–50	15–30	<0.06	0.06–0.08	8.5–9.0	4–16	Moderate	High	Moderate.
95–100	85–95	50–70	25–45	0.06–0.2	0.15–0.23	7.4–8.4		High	High	Low.
90–100	70–80	35–50	15–30	0.06–0.2	0.13–0.19	7.9–8.4		High	High	Low.
50–75	5–15	NP	NP	2.0–6.0	0.04–0.07	7.9–8.4		Low	High	Low.
95–100	85–95	50–70	25–45	0.06–0.2	0.10–0.15	7.9–8.4	0–4	High	High	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.18	6.6–7.8		Low	Moderate	Low.
50–60	15–25	NP	NP	6.0–20.0	0.07–0.10	7.4–7.8		Low	Moderate	Low.
25–40	5–20	NP	NP	6.0–20.0	0.03–0.05	7.9–8.4		Low	Moderate	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.18	6.6–7.8		Low	Moderate	Low.
50–60	15–25	NP	NP	6.0–20.0	0.07–0.10	7.4–7.8		Low	Moderate	Low.
15–40	3–10	NP	NP	6.0–20.0	0.03–0.04	7.9–8.4		Low	Moderate	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.18	6.6–7.8		Low	Moderate	Low.
50–60	15–25	NP	NP	6.0–20.0	0.07–0.10	7.4–7.8		Low	Moderate	Low.
15–40	3–10	NP	NP	6.0–20.0	0.03–0.04	7.9–8.4		Low	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.9–8.4	0–4	Moderate	High	Low.
95–100	85–95	20–45	12–25	0.2–0.6	0.18–0.23	6.6–7.8		Moderate	High	Low.
95–100	85–95	20–45	12–25	0.2–0.6	0.13–0.18	7.4–7.8	0–4	Moderate	High	Low.
95–100	85–95	20–45	12–25	0.2–0.6	0.19–0.21	6.6–7.4		High	High	Low.
95–100	90–95	50–70	25–40	0.06–0.2	0.15–0.18	6.6–7.4		High	High	Low.
95–100	85–95	20–45	12–25	0.2–0.6	0.18–0.20	6.6–7.4		High	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Peat: Pe. Properties are too variable to be estimated.								
Perella: Pr	0–3	0–60	Silty clay loam	CL	A–7		100	100
Rauville: Ra	0–3	0–21	Silty clay loam	CL	A–7		100	100
		21–36	Sandy clay loam, loam and sand.	SC, CL or SM	A–2 or A–6		95–100	90–100
		36–60	Sand	SM	A–2	<1	100	95–100
Renshaw:								
ReA, ReB, Rn	>5	0–15	Loam	SC or CL	A–6		95–100	90–100
		15–60	Sand and gravel	GM or SM	A–1	<5	30–70	15–50
Rs	>5	0–15	Loam	SC or CL	A–6		95–100	90–100
		15–60	Coarse sand	SM	A–2		90–100	80–90
Rt	>5	0–15	Loam	SC or CL	A–6		95–100	90–100
		15–48	Sand and gravel	GM or SM	A–1	<5	70–90	40–80
		48–60	Loam	CL	A–6	<3	95–100	90–100
*Ryan: Ry, Rz. For Lamoure part of Rz, see the Lamoure series.	0–5	0–7	Silty clay loam	CH or MH	A–7		100	100
		7–60	Silty clay loam	CH	A–7		100	100
*Serden: Se. For Hamar part of Se, see Hb in the Hamar series.	>5	0–2	Loamy fine sand	SM	A–2		100	100
		2–50	Fine sand	SM	A–2		100	100
		50–60	Loamy fine sand	SM	A–2		100	100
Sioux: SoB, SoE	>5	0–7	Gravelly loam	ML	A–4	<1	70–90	65–80
		7–60	Sand and gravel	GM or SM	A–1	<5	25–75	20–50
Spottswood:								
Sp	3–5	0–20	Loam	ML or CL	A–4 or A–6		95–100	95–100
		20–25	Sandy clay loam	SC or CL	A–6	<1	100	95–100
		25–60	Sand and gravel	GM or SM	A–1 or A–2	<5	40–75	20–65
Sr	3–5	0–20	Loam	ML or CL	A–6 or A–4		100	95–100
		20–25	Sandy clay loam	SC or CL	A–6		100	100
		25–60	Sand	SP–SM	A–3	<1	95–100	90–100
Stirum: Ss	0–5	0–40	Sandy loam, sandy clay loam.	SM	A–2 or A–4		95–100	90–100
		40–60	Sandy loam, loamy sand and sand.	SM or SC	A–2, A–4 or A–6		95–100	90–100
*Svea: St, SvA, SvB, SwC, Sx. For Barnes part of SvA, SvB, and SwC, see Barnes series; for Buse part of SwC, see Buse series; and for Cresbard part of Sx, see Cresbard series.	>5	0–6	Loam	ML or CL	A–4 or A–6	(2)	100	100
		6–19	Silt loam	CL	A–6	(2)	100	100
		19–60	Loam	CL	A–6	(2)	95–100	90–100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
95–100	85–95	20–45	12–25	0.2–0.6	0.19–0.20	6.6–7.8		High	High	Low.
90–100	75–95	20–45	12–25	0.06–0.2	0.19–0.22	7.9–8.4		Moderate	High	Low.
80–90	35–60	0–30	0–15	0.06–0.2	0.18–0.20	7.9–8.4		Moderate	High	Low.
55–70	5–15	NP	NP	6.0–20.0	0.03–0.06	7.9–8.4		Low	High	Low.
75–90	45–70	20–40	12–25	2.0–6.0	0.18–0.20	6.6–7.3		Low	Moderate	Low.
10–40	5–20	NP	NP	>20.0	0.02–0.04	7.4–7.8		Low	Moderate	Low.
75–90	45–70	20–40	12–25	2.0–6.0	0.18–0.20	6.6–7.3		Low	Moderate	Low.
50–70	15–25	NP	NP	>20.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
75–90	45–70	20–40	12–25	2.0–6.0	0.18–0.20	6.6–7.3		Low	Moderate	Low.
20–40	5–20	NP	NP	>20.0	0.02–0.04	7.4–7.8		Low	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.4–7.8	0–4	Moderate	High	Low.
95–100	85–95	50–70	15–45	<0.06	0.13–0.18	7.9–9.0	0–8	High	High	Low.
95–100	85–100	50–70	25–45	<0.06	0.06–0.08	8.5–9.0	4–16	High	High	Moderate.
65–80	15–25	15–35	2–10	6.0–20.0	0.05–0.07	6.6–7.3		Low	Moderate	Low.
65–80	20–35	NP	NP	6.0–20.0	0.03–0.05	6.6–7.8		Low	Moderate	Low.
65–80	20–35	NP	NP	6.0–20.0	0.03–0.04	6.6–7.3		Low	Moderate	Low.
60–75	55–70	25–40	2–10	2.0–6.0	0.13–0.17	6.6–7.3		Low	Moderate	Low.
10–35	5–25	NP	NP	>20.0	0.02–0.03	7.4–7.8		Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.6–2.0	0.19–0.22	6.6–7.3		Low	Moderate to high.	Low.
75–90	35–55	20–40	12–25	0.6–2.0	0.18–0.20	6.6–7.3		Low	Moderate to high.	Low.
15–40	3–15	NP	NP	>20.0	0.03–0.06	6.6–7.8		Low	Moderate to high.	Low.
75–95	50–75	20–40	4–20	0.6–2.0	0.19–0.22	6.6–7.3		Low	Moderate to high.	Low.
80–95	35–60	20–40	12–25	0.6–2.0	0.18–0.20	6.6–7.3		Low	Moderate to high.	Low.
50–70	5–10	NP	NP	>20.0	0.03–0.06	6.6–7.8		Low	Moderate to high.	Low.
60–70	30–40	15–30	0–5	0.2–6.0	0.08–0.14	7.9–8.4	4–16	Low	High	Moderate.
60–85	20–50	0–40	0–25	2.0–6.0	0.03–0.05	7.4–7.8	4–16	Low	High	Moderate.
85–95	60–75	20–40	4–20	0.6–2.0	0.20–0.22	6.1–6.5		Moderate	Moderate	Low.
90–100	70–90	20–40	12–20	0.6–2.0	0.20–0.22	6.6–7.3		Moderate	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.16–0.18	7.4–8.4	0–4	Moderate	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Svea variant: Su	>5	0–20	Loam	ML or CL	A–4 or A–6	<1	100	100
		20–25	Sand and gravel	GM or GC				
		25–44	Stratified sandy clay loam, sand and clay loam.	SM or SC	A–1	5–25	40–50	25–40
					A–2, A–4 or A–6	1	95–100	90–100
		44–60	Clay loam	CL	A–6 or A–7	<1	95–100	90–100
*Swenoda: Sz For Embden part of Sz, see EsA in the Embden series.	>5	0–8	Fine sandy loam	SM	A–4		100	100
		8–30	Sandy loam	SM	A–2		100	100
		30–60	Clay loam	CL	A–6 or A–7	<1	95–100	90–100
Tiffany:								
Tf	0–5	0–25	Sandy loam	SM	A–2 or A–4		100	100
		25–40	Loamy sand	SM	A–2		100	100
		40–60	Fine sand and sand.	SM	A–2		100	100
Tg	0–5	0–25	Fine sandy loam	SM or ML	A–2 or A–4		100	100
		25–40	Loamy sand	SM	A–2		100	100
		40–60	Loam, clay loam	ML or CL	A–4 or A–6	<1	100	95–100
Tolna: Tn	2–5	0–17	Loam	ML	A–4		95–100	90–100
		17–30	Fine sandy loam	SM	A–4	<1	95–100	90–100
		30–60	Shaly coarse sand and gravel.	SM	A–1	<5	70–90	60–80
Tonka: To	0–5	0–7	Silt loam	ML	A–4		100	100
		7–11	Very fine sandy loam.	ML	A–4		100	100
		11–28	Clay loam	CL	A–6 or A–7		100	100
		28–60	Loam	ML or CL	A–4 or A–6		100	95–100
Totten:								
Ts, Tt, Tu	1–3	0–5	Loam, sandy loam	SM or ML	A–4		100	95–100
		5–26	Sandy clay loam	CL or SC	A–6	<1	95–100	90–100
		26–60	Coarse sand, gravelly coarse sand.	SM	A–2	<1	90–100	85–95
Tv	1–3	0–5	Loam	ML	A–4		100	95–100
		5–26	Sandy clay loam, loam.	CL or SC	A–6	<1	95–100	90–100
		26–44	Coarse sand, gravelly coarse sand.	SM	A–2	<1	90–100	85–95
		44–60	Loam, clay loam	CL	A–6	<1	95–100	90–100
*Towner: TwA, TwB, Tx. For Dickey part of Tx, see Dickey series.	>2	0–18	Fine sandy loam	SM or ML	A–4		100	100
		18–27	Loamy fine sand	SM	A–2		100	95–100
		27–46	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		46–56	Sand	SM	A–2	<1	95–100	90–100
		56–60	Loam	CL	A–6	<1	95–100	90–100
Vallers: Va	1–3	0–8	Loam	ML or CL	A–4 or A–6	[3] 0–25	95–100	90–100
		8–19	Clay loam	CL	A–6 or A–7	[3] 0–25	95–100	90–100
		19–60	Loam	ML or CL	A–4 or A–6	[3] 0–25	95–100	90–100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
85–95	60–75	20–40	4–20	0.2–0.6	0.20–0.22	6.1–7.3		Moderate	Moderate	Low.
15–25	10–20	0–35	0–5	2.0–6.0	0.04–0.07	7.4–7.9		Low	Moderate	Low.
60–85	20–50	0–40	0–25	0.2–0.6	0.14–0.18	7.4–7.9		Moderate	Moderate	Low.
85–95	70–80	35–50	15–30	0.2–0.6	0.14–0.17	7.4–7.9	0–4	Moderate	High	Low.
70–85	40–50	NP	NP	2.0–6.0	0.16–0.18	6.6–7.3		Low	Moderate	Low.
55–70	20–35	15–30	0–5	2.0–6.0	0.10–0.15	6.6–7.8		Low	Moderate	Low.
85–95	70–80	35–50	15–30	0.2–0.6	0.12–0.14	7.9–8.4	0–4	Moderate	High	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.14	6.1–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	2.0–6.0	0.09–0.10	6.6–7.3		Low	Moderate	Low.
55–75	10–25	NP	NP	2.0–6.0	0.03–0.04	6.6–7.3		Low	Moderate	Low.
70–85	40–55	NP	NP	2.0–6.0	0.13–0.14	6.1–7.3		Low	Moderate	Low.
50–75	15–30	NP	NP	2.0–6.0	0.08–0.09	6.6–7.3		Low	Moderate	Low.
85–95	60–80	20–40	4–20	0.2–0.6	0.04–0.05	6.6–7.8		Moderate	High	Low.
85–95	60–75	20–35	2–8	2.0–6.0	0.16–0.18	5.6–6.0		Moderate	High	Moderate.
65–80	35–50	NP	NP	2.0–6.0	0.13–0.15	5.6–6.0		Low	High	Moderate.
25–40	10–25	NP	NP	>20.0	0.02–0.03	6.1–7.8		Low	High	Low.
90–100	70–90	15–40	2–10	0.2–0.6	0.18–0.22	6.6–7.3		Low to moderate.	High	Low.
85–95	50–65	15–40	2–10	0.6–2.0	0.16–0.18	6.6–7.3		Low	High	Low.
90–100	70–80	35–50	15–30	0.06–0.2	0.15–0.19	6.6–7.3		High	High	Low to moderate.
85–95	60–75	20–40	4–20	0.06–0.2	0.17–0.19	6.6–7.3		Moderate	High	Low.
65–90	35–70	20–35	2–8	0.2–0.6	0.13–0.20	7.9–8.4	0–8	Low to moderate.	High	Moderate.
80–95	40–70	20–40	12–25	0.2–0.6	0.12–0.14	7.9–8.4	4–16	Moderate	High	Moderate.
55–65	15–25	NP	NP	6.0–20.0	0.02–0.04	7.4–8.4	0–4	Low	High	Moderate.
85–95	60–75	20–35	2–8	0.2–0.6	0.13–0.20	7.9–8.4	0–8	Low to moderate.	High	Moderate.
80–95	40–70	20–40	12–25	0.2–0.6	0.12–0.14	7.9–8.4	4–16	Moderate	High	Moderate.
55–65	15–25	NP	NP	6.0–20.0	0.02–0.04	7.4–8.4	0–4	Low	High	Moderate.
85–95	60–75	20–40	12–25	0.2–0.6	0.14–0.17	7.4–8.4	0–4	Moderate	High	Moderate.
70–85	40–55	15–40	2–10	6.0–20.0	0.16–0.18	6.6–7.3		Low	Moderate	Low.
55–75	15–35	NP	NP	6.0–20.0	0.08–0.10	7.4–7.8		Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.13–0.15	7.9–8.4		Low to moderate.	Moderate	Low.
50–70	15–25	NP	NP	2.0–6.0	0.03–0.05	7.9–8.4		Low	Moderate	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.10–0.12	7.9–8.4	0–4	Moderate	Moderate	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.20–0.22	7.4–7.8	0–4	Moderate	High	Low.
85–95	70–80	35–50	15–30	0.2–0.6	0.15–0.19	7.9–8.4	0–8	Moderate	High	Moderate.
85–95	60–75	20–40	4–20	0.2–0.6	0.17–0.19	7.4–8.4	0–8	Moderate	High	Moderate.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
Vang: Vn	>5	0–18	Loam	ML	A–4		100	100
		18–33	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		33–60	Shaly gravel and sand.	SM	A–1	<5	70–90	60–80
Venlo: Vo	0–3	0–7	Sandy loam	SM	A–2 or A–4		100	95–100
		7–21	Loamy sand	SM	A–2		100	95–100
		21–24	Sand	SM	A–2		100	95–100
		24–32	Sandy loam	SM	A–2 or A–4		100	95–100
		32–60	Sand	SM	A–2		100	95–100
Wahpeton: Wa	>5	0–21	Silty clay	CH	A–7		100	100
		21–60	Clay	CH	A–7		100	100
Walsh: WbB, WbC, WcA, WcB, WcC.	>5	0–30	Loam, clay loam	ML or CL	A–4 or A–6		100	95–100
		30–60	Loam, clay loam	CL	A–6		100	95–100
Walum:								
Wd	>5	0–16	Sandy loam	SM	A–2 or A–4		95–100	90–100
		16–30	Loamy sand	SM	A–2	<1	95–100	90–100
		30–60	Shaly sand and gravel.	SM	A–2	<1	85–100	80–95
We	>5	0–16	Sandy loam	SM	A–2 or A–4		95–100	90–100
		16–30	Loamy sand	SM	A–2	<1	95–100	90–100
		30–60	Shaly gravel	SM or GM	A–1	<5	40–70	20–65
Warsing:								
Wf	>5	0–18	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		18–60						
Wg	>5	0–18	Sand and gravel	SM	A–1	<5	75–95	70–85
		18–60	Loam	ML or CL	A–4 or A–6		100	100
Wm	>5	0–18	Sand	SP–SM	A–3	<1	95–100	90–100
			Loam	ML or CL	A–4 or A–6	<1	95–100	90–100
		18–44	Sand and gravel	SM	A–1	<5	75–95	70–85
		44–60	Loam	CL	A–6	<1	95–100	90–100
Wyard: Wn	0–3	0–32	Loam	ML	A–4		95–100	95–100
		32–60	Loam	ML or CL	A–4 or A–6		95–100	95–100
Wyndmere:								
Wo	1–3	0–26	Sandy loam	SM	A–2 or A–4		95–100	95–100
		26–60	Sand	SM	A–2		95–100	90–100
Wp	1–3	0–26	Sandy loam	SM	A–2 or A–4		95–100	95–100
		26–44	Sand, fine sandy loam.	SM	A–2		95–100	90–100
		44–60	Loam	ML or CL	A–4 or A–6	<1	95–100	90–100

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
85–95	60–75	20–35	2–8	0.6–2.0	0.20–0.22	6.1–7.3		Low	High	Low.
85–90	60–75	20–40	4–20	0.6–2.0	0.17–0.19	7.4–7.8		Low	High	Low.
25–40	10–25	NP	NP	>20.0	0.03–0.05	7.9–8.4		Low	High	Low.
60–70	30–40	15–30	0–5	6.0–20.0	0.13–0.15	5.6–6.0		Low	Moderate	Low.
50–75	15–30	NP	NP	6.0–20.0	0.09–0.11	6.1–7.3		Low	Moderate	Low.
55–75	10–25	NP	NP	6.0–20.0	0.05–0.07	6.6–7.3		Low	Moderate	Low.
60–70	30–40	15–30	0–5	6.0–20.0	0.11–0.13	6.6–7.3		Low	Moderate	Low.
55–75	10–25	NP	NP	6.0–20.0	0.03–0.05	7.4–7.8		Low	Moderate	Low.
95–100	90–95	50–75	25–45	0.6–2.0	0.16–0.19	6.1–7.3		High	High	Low.
90–100	75–95	50–75	25–45	0.6–2.0	0.14–0.18	7.4–7.8	0–4	High	High	Low.
85–95	60–75	20–40	4–20	0.6–2.0	0.18–0.21	6.1–7.3		Moderate	Moderate to high.	Low.
85–95	60–80	20–40	12–25	0.6–2.0	0.17–0.19	7.4–7.8		Moderate	Moderate to high.	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.17	6.6–7.3		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.10–0.12	7.4–8.4		Low	High	Low.
50–70	15–30	NP	NP	>20.0	0.03–0.05	7.9–8.4		Low	High	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.17	6.6–7.3		Low	High	Low.
50–75	15–30	NP	NP	6.0–20.0	0.10–0.12	7.4–8.4		Low	High	Low.
15–40	5–20	NP	NP	>20.0	0.02–0.04	7.9–8.4		Low	High	Low.
85–95	60–75	20–40	4–20	2.0–6.0	0.18–0.21	6.6–7.8		Low to moderate.	High	Low.
25–40	5–20	NP	NP	>20.0	0.02–0.04	7.9–8.4		Low	High	Low.
85–95	60–75	20–40	4–20	2.0–6.0	0.18–0.21	6.6–7.8		Low to moderate.	High	Low.
50–70	5–10	NP	NP	>20.0	0.03–0.05	7.9–8.4		Low	High	Low.
85–95	60–75	20–40	4–20	2.0–6.0	0.18–0.21	6.6–7.8		Low to moderate.	High	Low.
25–40	5–20	NP	NP	>20.0	0.02–0.04	7.9–8.4		Low	High	Low.
85–95	60–75	20–40	12–20	0.2–0.6	0.14–0.17	7.9–8.4		Moderate	High	Low.
85–95	60–75	20–35	2–8	0.6–2.0	0.20–0.22	6.6–7.3		Low to moderate.	High	Low.
85–95	60–80	20–40	4–20	0.6–2.0	0.16–0.17	7.9–8.4	0–4	Low to moderate.	High	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.14–0.17	7.9–8.4	0–4	Low	Moderate	Low.
65–80	20–35	NP	NP	>20.0	0.08–0.10	7.9–8.4	0–4	Low	Moderate	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.14–0.17	7.9–8.4	0–4	Low	Moderate	Low.
65–80	20–35	NP	NP	>20.0	0.08–0.10	7.9–8.4	0–4	Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.12–0.15	7.9–8.4	0–4	Moderate	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification			Fraction greater than 3 inches	Percentage passing sieve—	
			USDA texture	Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*				*Percent*		
*Wyrene:								
Wr, Wt	1–5	0–21	Sandy loam	SM	A–2 or A–4		95–100	95–100
		21–60	Coarse sand	SM or SP–SM	A–1		75–95	70–85
For Totten part of Wt, see Ts in the Totten series.								
Ws	1–5	0–21	Sandy loam	SM	A–2 or A–4		95–100	95–100
		21–44	Coarse sand	SM or SP–SM	A–1		75–95	70–85
		44–60	Loam	ML or CL	A–4 or A–6	1	95–100	90–100
Zell	5	0–24	Loam, silt loam	ML	A–4		100	100
		24–52	Very fine sandy loam.	ML	A–4		100	95–100
Mapped only with Buse and Sioux soils.		52–60	Fine sand	SM	A–2		100	95–100

[1] NP means nonplastic.
[2] Fragments coarser than 3 inches make up 25 percent of some phases of this series.
[3] Some phases of this series have moderate to high salinity.

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in the less than 2 millimeter fraction of the soil. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the "Glossary" of this soil survey.

Liquid limit and plasticity index are water contents obtained by specified operations. As the water content of a clayey soil from which the particles coarser than 0.5 millimeter have been removed is increased from a dry state, the material changes from a semisolid to a plastic. If the moisture content is further increased, the material changes from a plastic to a liquid. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic; and the liquid limit, from a plastic to a liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. In table 9 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability, as used here, is an estimate of the rate at which saturated soil transmits water in a vertical direction under a unit head of pressure. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or such transient soil features as plowpans and surface crusts are not considered.

Available water capacity is an estimate of the capacity of soils to hold water for use by most plants. It is defined here as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

Reaction refers to the acidity or alkalinity of a soil, expressed in pH values for a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the "Glossary."

Salinity refers to the amount of salts more soluble than gypsum in the soil. It is expressed as the electrical conductivity of a saturation extract, in millimhos per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils may damage building foundations, roads, and other structures. Soils having a *high* shrink-swell potential are the most hazardous.

Shrink-swell potential is not indicated for organic soils or certain soils which shrink markedly on drying but do not swell quickly when rewetted.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one

properties of the soils—Continued

Percentage passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 40 (0.42 mm)	No. 200 (0.047 mm)								Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
60–70	30–40	15–30	0–5	2.0–6.0	0.12–0.15	7.9–8.4		Low	Moderate	Low.
25–40	5–20	NP	NP	6.0–20.0	0.03–0.05	7.9–8.4		Low	Moderate	Low.
60–70	30–40	15–30	0–5	2.0–6.0	0.13–0.17	7.9–8.4		Low	Moderate	Low.
25–40	5–20	NP	NP	6.0–20.0	0.03–0.05	7.9–8.4		Low	Moderate	Low.
85–95	60–75	20–40	4–20	0.2–0.6	0.12–0.15	7.9–8.4	0–4	Moderate	High	Low.
85–95	60–85	20–40	2–10	0.6–2.0	0.20–0.22	6.6–7.8		Low	Moderate	Low.
85–95	50–65	20–35	2–8	0.6–2.0	0.17–0.19	7.4–7.8		Low	Moderate	Low.
65–80	20–35	NP	NP	2.0–6.0	0.05–0.10	7.4–7.8		Low	Moderate	Low.

kind of soil or in one soil horizon. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for uncoated steel and more resistant concrete should be used to reduce damage.

Engineering interpretations of the soils

The estimated interpretations in tables 7 and 8 are based on the engineering properties of soils shown in table 6, on test data for soils in this survey area and others nearby or adjoining, and on the experiences of engineers and soil scientists with the soils of the survey area. In table 7, ratings are used to summarize limitations or suitability of the soils for all listed purposes. Table 8 rates the suitability of the soils as sources of construction materials and lists those soil features not to be overlooked in planning, installation, and maintenance for ponds and reservoirs, embankments, drainage of crops and pasture, and irrigation.

In table 7, soil limitations are indicated by the ratings *slight, moderate,* and *severe. Slight* means soil properties generally favorable for the rated use, or in other words, limitations that are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special design, or intensive maintenance.

Following are explanations of the columns in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope; and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes,

TABLE 7.—*Soil interpretations for land-use planning*

[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 such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series as indicated in the first column of this table. Some of the soil characteristics in this table are described in computer-adapted terms that differ from those in the Soil Survey Manual (*8*). Refer to the Explanation of Key Phrases, page 190, for the definition of "shrink-swell" and other terms that describe soil characteristics]

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
*Aberdeen: Ab, Ae. For Exline part of Ae, see Exline series.	Severe: slow permeability.	Slight	Moderate to severe: wet.	Severe: shrink-swell.	Severe: seasonal water table.	Severe: shrink-swell.
Arveson: Ar	Severe: wet [1]	Severe: wet; moderately rapid permeability.	Severe: wet	Severe: wet	Severe: wet; too sandy.	Severe: wet.
*Arvilla: As, AtA, AtB, AvA, AvB, AxC. For Sioux part of AxC, see SoB in the Sioux series.	Slight [1]	Severe: very rapid permeability.	Severe: cutbanks cave.	Slight	Severe: very rapid permeability.[1]	Slight.
*Barnes: BaA, BaB, BaC, BbA, BbB, BdC. For Svea part of BbA, BbB, and BdC, see Svea series. For Buse part of BdC, see Buse series.	Severe: moderately slow permeability in substratum.	Slight where slopes are less than 3 percent. Moderate where slopes are 3 to 6 percent. Severe where slopes are more than 6 percent.	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.
BcB, BeC	Severe: large stones.	Severe: large stones.	Severe: large stones.	Severe: large stones.	Severe: large stones.	Moderate to severe: large stones.
Bearden: Bg	Severe: moderately slow permeability; seasonal water table.	Moderate to severe: seasonal water table.	Severe: wet	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: shrink-swell.
*Binford: Bh, BkA, BkB, BlB, BmC, BmD. For Coe part of BmC and BmD, see Coe series.	Slight where slopes are less than 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: very rapid permeability.	Severe: cutbanks cave.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: very rapid permeability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.
*Borup: Bn, Bo, BpB. For Marysland part of Bo, see Marysland series. For Vallers part of BpB, see Vallers series.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: wet.
*Brantford: BrB, BsA, BsB, BtA, BtB, BuC, Bv. For Coe part of BuC, see Coe series. For Kensal part of Bv, see Kensal series.	Slight [1]	Severe: very rapid permeability.	Severe: cutbanks cave.	Slight	Severe: very rapid permeability.	Slight.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
*Buse: BwE, BxD, ByE, BzD. For Barnes part of BwE, see BoA in the Barnes series; for Edgeley part of BxD, see Edgeley series; for Kloten part of ByE, see Kloten series; and for Sioux and Zell parts of BzD, see SoE in the Sioux and Zell series.	Severe: moderately slow permeability.	Severe: slope	Moderate where slopes are 9 to 15 percent. Severe where slopes are less than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are less than 15 percent.	Slight where slopes are less than 15 percent. Moderate where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
*Cathay: Ca, ChA, ChB, Cm. For Heimdal part of ChA and ChB, see HoA in the Heimdal series. For Larson part of Cm, see Larson series.	Severe: slow permeability in subsoil.	Moderate: moderate permeability in substratum.	Moderate to severe: wet.	Moderate to severe: wet.	Moderate: wet.	Moderate: wet, shrink-swell.
*Cavour: Cn For Cresbard part of Cn, see Cresbard series.	Severe: very slow permeability.	Slight	Moderate: seasonal water table.	Severe: shrink-swell.	Severe: wet	Severe: shrink-swell.
Co For Vallers part of Co, see Vallers series.	Severe: very slow permeability; large stones.	Moderate to severe: large stones.	Severe: large stones.	Severe: large stones.	Severe: large stones.	Severe: shrink-swell; large stones.
Cavour variant: CpB	Severe: very slow permeability; shale bedrock.	Severe: shale bedrock.	Severe: wet; shale bedrock.	Severe: wet; shrink-swell; shale bedrock.	Severe: shale bedrock.	Severe: shrink-swell.
*Claire: CrA, CrB, Cs, Ct. For Lohnes and Hamar parts of Ct, see those series respectively.	Slight [1]	Severe: rapid permeability.	Severe: cutbanks cave; too sandy.	Slight	Severe: rapid permeability.	Slight.
Clontarf: Cu	Slight [1]	Severe: moderately rapid permeability.	Severe: cutbanks cave.	Moderate: wet.	Severe: moderately rapid permeability.	Slight.
Coe: CvB, CvD	Slight where slopes are less than 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are less than 15 percent.	Severe: very rapid permeability.	Severe: cutbanks cave.	Slight where slopes are less than 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: very rapid permeability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
Colvin: Cw, Cx, Cy	Severe: seasonal water table; moderately slow permeability.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: wet.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
*Cresbard: Cz For Cavour part of Cz, see Cn in the Cavour series.	Severe: slow permeability.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table; shrink-swell.	Severe: seasonal water table.	Severe: shrink-swell.
Dickey Mapped only with Maddock, Hecla, and Towner soils.	Severe: moderately slow permeability in substratum.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 6 percent. Severe where slopes are 6 to 9 percent.	Slight	Moderate: shrink-swell in substratum.	Slight	Moderate: shrink-swell in substratum.
Divide:						
DvA, DvB, Dw, Dx, Dy	Severe: seasonal water table.[1]	Severe: very rapid permeability in substratum.	Severe: wet; cutbanks cave.	Severe: wet; seasonal water table.	Severe: seasonal water table.[1]	Moderate: wet.
Dz	Severe: seasonal water table; moderately slow permeability below a depth of 40 inches.	Slight	Severe: wet	Severe: wet; seasonal water table.	Severe: seasonal water table.[1]	Moderate: wet.
Eckman: EaA, EaB	Slight	Moderate: moderate permeability.	Slight	Slight	Slight	Moderate: low strength.
*Edgeley: Eb, EcB For Cavour part of EcB, see Cn in the Cavour series.	Severe: shale bedrock.	Severe: shale bedrock.	Moderate: shale bedrock.	Moderate: shale bedrock.	Moderate: shale bedrock.	Moderate: shrink-swell.
Edgeley variant: Ed	Severe: shale bedrock.	Severe: shale bedrock.	Moderate: shale bedrock.	Moderate: shale bedrock.	Moderate: shale bedrock.	Slight.
Egeland:						
EeA, EeC	Slight[1]	Severe: moderately rapid permeability.	Slight	Slight	Severe: moderately rapid permeability.	Slight.
Eg	Slight[1]	Severe: moderately rapid permeability.	Severe: substratum too sandy.	Slight	Severe: moderately rapid and rapid permeability.[1]	Slight.
EhA, EhB, EmC	Severe: moderately slow permeability in substratum.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 6 percent. Severe where slopes are 6 to 9 percent.	Slight	Moderate: shrink-swell in substratum.	Slight	Moderate: shrink-swell in substratum.
Embden:						
EnA, EoB	Moderate: seasonal water table.[1]	Severe: moderately rapid permeability.	Moderate: moderately well drained.	Moderate: moderately well drained.	Severe: moderately rapid permeability.	Slight.
EsA, EsB	Severe: moderately slow permeability in substratum.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 6 percent.	Moderate: moderately well drained.	Moderate: moderately well drained.	Slight	Moderate: shrink-swell in substratum.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Emrick: Et, Eu	Slight	Moderate: moderate permeability.	Moderate: moderately well drained.	Moderate: moderately well drained.	Slight	Slight to moderate: shrink-swell.
*Esmond: EvD For Coe and Embden parts of EvD, see the Coe series and EnA in the Embden series.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: slope	Moderate where slopes are 6 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 6 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are less than 15 percent. Moderate where slopes are more than 15 percent.	Moderate where slopes are 6 to 15 percent. Severe where slopes are more than 15 percent.
Exline: Ew	Severe: very slow permeability; seasonal water table.	Moderate: seasonal water table.	Severe: wet	Severe: wet; shrink-swell.	Severe: seasonal water table.	Severe: shrink-swell.
*Fargo: Fa For Nutley part of Fa, see Nutley series.	Severe: slow permeability.	Slight	Severe: wet; too clayey.	Severe: wet; shrink-swell.	Severe: wet; too clayey.	Severe: wet; shrink-swell.
Fordville: Fd	Slight[1]	Severe: very rapid permeability in substratum.	Severe: cut-banks cave.	Slight	Severe: very rapid permeability in substratum.	Slight.
*Fossum: Fm, Fo, Fp For Hamar part of Fp, see Hamar series.	Severe: seasonal water table.[1]	Severe: seasonal water table; rapid permeability.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; rapid permeability.	Severe: wet.
*Fram: FrA, FrB, Fs, Fw. For Wyndmere part of Fw, see Wp in the Wyndmere series.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Moderate: wet.
Gardena: GaA, GaB	Slight	Moderate: moderate permeability.	Moderate: moderately well drained.	Moderate: moderately well drained.	Slight	Moderate: low strength.
Glyndon: Gd, Ge	Severe: seasonal water table.	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Moderate: wet.
Gravel pit: Gp. Too variable for interpretations to be made.						
Hamar: Ha, Hb, Hc, Hd.	Severe: seasonal water table.	Severe: seasonal water table; rapid permeability.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: seasonal water table.[1]	Moderate: wet.
*Hamerly: HeA, HeB, Hf, HgA, HgB. For Svea part of HgA and HgB, see Svea series.	Severe: moderately slow permeability.	Moderate: seasonal water table.	Severe: wet	Severe: wet	Severe: seasonal water table.	Moderate: wet.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
*Hecla: HhA, HhB, HkA, HkB, HlB, Hm, HnA, HnB. For Hamar and Maddock parts of Hm, HnA and HnB, see those series. For Dickey part of HlB, see Dickey series.	Slight[1]	Severe: rapid permeability.	Severe: cut-banks cave.	Moderate: moderately well drained.	Severe: rapid permeability.	Slight.
*Heimdal: HoA, HoB, HoC, HpA, HpB, HpC, HsA, HsB, HtC. For Emrick part of HsA and HsB and Emrick and Esmond parts of HtC, see those series.	Slight	Moderate: moderate permeability.	Slight	Slight to moderate: shrink-swell.	Slight	Slight to moderate: shrink-swell.
HrD, HrE, HtD, HtE For Embden part of HrD and HrE, see EsA in the Embden series. For Emrick and Esmond parts of HtD and HtE, see Emrick and Esmond series.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: slope	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are 9 to 15 percent. Moderate where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
Kensal: Ke, Kf	Slight[1]	Severe: very rapid permeability in substratum.	Severe: cut-banks cave.	Moderate: moderately well drained.	Severe: very rapid permeability in substratum.	Slight.
*Kloten: KoE, KsE For Sioux and Edgeley parts of KeE, see SoE in the Sioux series and the Edgeley series.	Severe: slope; shale bedrock.	Severe: slope	Severe: shale bedrock; slope.	Severe: shale bedrock; slope.	Severe: shale bedrock; slope.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
Kratka: Kt	Severe: wet; seasonal water table; moderately slow permeability in substratum.	Severe: seasonal water table.[1]	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: seasonal water table; wet.	Severe: wet.
LaDelle: La	Severe: floods	Moderate: floods.	Severe: floods	Severe: floods	Severe: floods	Moderate: shrink-swell.
Lallie: Lb	Severe: wet; seasonal water table; slow permeability.	Moderate: seasonal water table.[1]	Severe: wet; seasonal water table.	Severe: wet	Severe: wet; seasonal water table.	Severe: wet; shrink-swell.
Lamoure: Le, Lm	Severe: wet; seasonal water table.	Severe: floods	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; floods.	Severe: wet; seasonal water table; floods.	Severe: wet; shrink-swell.
*La Prairie: Ln, Lp For Lamoure part of Lp, see Lamoure series.	Severe: floods	Moderate: moderate permeability.	Severe: floods	Severe: floods	Severe: floods	Severe: floods.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Larson: Lr	Severe: slow permeability; seasonal water table.	Moderate: seasonal water table.[1]	Moderate to severe: wet; seasonal water table; too clayey.	Severe: seasonal water table.	Severe: seasonal water table.	Moderate: shrink-swell.
Lemert: Ls	Severe: seasonal water table.[1]	Severe: seasonal water table; rapid permeability in substratum.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: seasonal water table.	Moderate to severe: wet.
Letcher: Lt, Lu	Severe: seasonal water table.[1]	Severe: seasonal water table; rapid permeability in substratum.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: seasonal water table.	Moderate: wet.
Lohnes: Lv, Lw	Slight[1]	Severe: rapid permeability.	Severe: cutbanks cave; too sandy.	Moderate: moderately well drained.	Severe: rapid permeability; too sandy; cutbanks cave.	Slight.
*Ludden: Lx, Lz For Lamoure part of Lz, see Lamoure series.	Severe: slow permeability; floods.	Severe: wet	Severe: wet; seasonal water table; floods.	Severe: wet; seasonal water table; floods; shrink-swell.	Severe: wet; seasonal water table; floods.	Severe: wet; floods; shrink-swell.
*Maddock: MaA, MaB, MaC, MbA, MbB, MbC, MdB, MdC, MeD, MfD. For Dickey part of MdB and MdC, Serden part of McD, and Serden and Hecla parts of MfD, see those series.	Slight where slopes are 0 to 9 percent.[1] Moderate where slopes are 9 to 15 percent.	Severe: rapid permeability.	Severe: cutbanks cave; too sandy.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: rapid permeability; too sandy.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.
Made land: Mg. Too variable for interpretations to be made.						
Marsh: Mh. Too variable for interpretations to be made.						
*Marysland: Mm, Mn For Arveson part of Mn, see Arveson series.	Severe: wet; seasonal water table.	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet.
Minnewaukan: MwC	Severe: wet; seasonal water table.[1]	Severe: seasonal water table; rapid permeability.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: seasonal water table.	Severe: wet.
*Miranda: Mx For Cavour part of Mx, see Cn in the Cavour series.	Severe: very slow permeability; seasonal water table.	Moderate: seasonal water table.	Severe: seasonal water table; too clayey.	Severe: seasonal water table.	Severe: seasonal water table.	Moderate: shrink-swell.
Nutley Mapped only with Fargo soils.	Severe: slow permeability.	Slight	Moderate: too clayey.	Severe: shrink-swell.	Moderate: too clayey.	Severe: shrink-swell.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Osakis:						
Os, Ot	Slight[1]	Severe: rapid permeability in substratum.	Severe: cutbanks cave.	Moderate: moderately well drained.	Severe: rapid permeability in substratum.	Slight.
Ou	Severe: moderately slow permeability in substratum.	Slight	Severe: cutbanks cave.	Moderate: moderately well drained.	Slight	Slight.
Overly: Ov	Severe: moderately slow permeability.	Slight	Moderate: moderately well drained.	Moderate: shrink-swell.	Moderate: too clayey.	Moderate: shrink-swell.
Parnell: Pa	Severe: slow permeability; floods.	Severe: floods	Severe: wet; too clayey.	Severe: wet; floods; shrink-swell.	Severe: wet; floods; too clayey.	Severe: wet; floods.
Peat: Pe. Too variable for interpretations to be made.						
Perella: Pr	Severe: moderately slow permeability; seasonal water table.	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; floods.	Severe: wet; seasonal water table; floods.
Rauville: Ra	Severe: slow permeability; floods; seasonal water table.	Severe: floods; seasonal water table.	Severe: floods; seasonal water table.	Severe: floods; seasonal water table.	Severe: wet; seasonal water table; floods.	Severe: wet; floods.
Renshaw:						
ReA, ReB, Rn, Rs	Slight[1]	Severe: very rapid permeability in substratum.	Moderate: cutbanks cave.	Slight	Severe: very rapid permeability in substratum.[1]	Slight.
Rt	Severe: moderately slow permeability in substratum.	Slight	Slight	Moderate: shrink-swell in substratum.	Slight	Slight.
*Ryan: Ry, Rz. For Lamoure part of Rz, see Lamoure series.	Severe: very slow permeability; seasonal water table.	Slight	Severe: seasonal water table; too clayey.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet.
*Serden: Se. For Hamar part of Se, see Hamar series.	Slight[1]	Severe: rapid permeability.	Severe: cutbanks cave; too sandy.	Slight	Severe: rapid permeability;[1] cutbanks cave; too sandy.	Slight.
Sioux:						
SoB	Slight[1]	Severe: very rapid permeability.	Moderate: cutbanks cave.	Slight	Severe: very rapid permeability.[1]	Slight.
SoE	Moderate where slopes are 9 to 15 percent.[1] Severe where slopes are more than 15 percent.	Severe: very rapid permeability.	Severe: cutbanks cave; slope.	Slight where slopes are 6 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: very rapid permeability.	Slight where slopes are 6 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Spottswood: Sp, Sr	Moderate: seasonal water table.[1]	Severe: very rapid permeability in substratum.	Severe: cutbanks cave.	Moderate: moderately well drained.	Severe: very rapid permeability in substratum.	Slight.
Stirum: Ss	Severe: seasonal water table.[1]	Severe: seasonal water table; moderately rapid permeability in substratum.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; moderately rapid permeability in substratum.[1]	Severe: wet.
*Svea: St, SvA, SvB, SwC, Sx. For Barnes part of SvA, SvB, and SwC, see BoA in the Barnes series; for Buse part of SwC, see Buse series; and for Cresbard part of Sx, see Cresbard series.	Severe: moderately slow permeability in substratum.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 5 percent. Severe where slopes are 6 to 9 percent.	Moderate: moderately well drained.	Moderate: moderately well drained.	Slight	Moderate: shrink-swell.
Svea variant: Su	Severe: moderately slow permeability.	Slight	Moderate: moderately well drained.	Moderate: moderately well drained.	Slight	Moderate: shrink-swell.
*Swenoda: Sz For Embden part of Sz, see EsA in the Embden series.	Severe: moderately slow permeability in substratum.	Slight	Moderate: moderately well drained.	Moderate: moderately well drained.	Moderate: too clayey in substratum.	Moderate: shrink-swell.
Tiffany: Tf, Tg	Severe: seasonal water table.[1]	Severe: seasonal water table; moderately rapid permeability.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; moderately rapid permeability.[1]	Severe: wet.
Tolna: Tn	Severe: floods	Severe: very rapid permeability in substratum; floods.	Severe: floods	Severe: floods	Severe: floods; very rapid permeability in substratum.	Severe: floods.
Tonka: To	Severe: floods; slow permeability.	Slight	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.
Totten: Ts, Tt, Tu	Severe: wet; seasonal water table.[1]	Severe: wet; seasonal water table; rapid permeability in substratum.	Severe: wet; cutbanks cave.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table; too sandy.	Severe: wet.
Tv	Severe: wet; seasonal water table; moderately slow permeability in substratum.	Severe: wet; seasonal water table.	Severe: wet	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet.
*Towner: TwA, TwB, Tx. For Dickey part of Tx, see Dickey series.	Severe: moderately slow permeability in substratum.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 6 percent.	Moderate: too clayey in substratum.	Moderate: shrink-swell.	Moderate: too clayey in substratum.	Moderate: shrink-swell.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Vallers: Va	Severe: seasonal water table; moderately slow permeability.	Severe: seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet.
Vang: Vn	Slight [1]	Severe: very rapid permeability in substratum.	Severe: cutbanks cave.	Slight	Severe: very rapid permeability in substratum.	Slight.
Venlo: Vo	Severe: wet; seasonal water table.[1]	Severe: wet; seasonal water table; rapid permeability.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.	Severe: wet; seasonal water table.[1]	Severe: wet.
Wahpeton: Wa	Severe: floods	Moderate: floods.	Severe: floods	Severe: floods; shrink-swell.	Severe: floods	Severe: floods; shrink-swell.
Walsh: WbB, WbC, WcA, WcB, WcC.	Slight	Moderate: moderate permeability. Severe where slopes are 6 to 9 percent.	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.
Walum: Wd, We	Slight [1]	Severe: very rapid permeability in substratum.	Severe: cutbanks cave.	Moderate: moderately well drained.	Severe: very rapid permeability in substratum.[1]	Slight.
Warsing: Wf, Wg	Slight [1]	Severe: very rapid permeability in substratum.	Severe: cutbanks cave.	Moderate: moderately well drained.	Severe: very rapid permeability in substratum.	Slight.
Wm	Severe: moderately slow permeability in substratum.	Slight	Severe: cutbanks cave.	Moderate: moderately well drained.	Slight	Moderate: shrink-swell in substratum.
Wyard: Wn	Severe: floods	Moderate: moderate permeability.	Severe: wet; floods.	Severe: wet; floods.	Severe: floods	Severe: floods.
Wyndmere: Wo	Severe: seasonal water table.[1]	Severe: moderately rapid permeability; seasonal water table.	Severe: seasonal water table; wet.	Severe: seasonal water table; wet.	Severe: seasonal water table; moderately rapid permeability.	Moderate: wet.
Wp	Severe: moderately slow permeability in substratum; seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table; wet.	Severe: seasonal water table; rapid permeability in upper part.	Moderate: wet.
*Wyrene: Wr, Wt. For Totten part of Wt, see the Totten series.	Severe: seasonal water table.[1]	Severe: rapid permeability in substratum; seasonal water table.	Severe: seasonal water table; wet.	Severe: seasonal water table; wet.	Severe: seasonal water table; rapid permeability in substratum.	Moderate: wet.
Ws	Severe: moderately slow permeability in substratum; seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table.	Severe: seasonal water table; wet.	Severe: seasonal water table; rapid permeability in upper part.	Moderate: wet.

TABLE 7.—*Soil interpretations for land-use planning*—Continued

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Zell Mapped only with Buse and Sioux soils.	Moderate: moderate permeability. Severe where slopes are more than 15 percent.	Moderate where slopes are 3 to 6 percent. Severe where slopes are more than 15 percent.	Slight where slopes are 3 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 3 to 15 percent. Severe where slopes are more than 15 percent.	Slight where slopes are 3 to 15 percent. Moderate where slopes are 15 to 25 percent. Severe where slopes are more than 25 percent.	Moderate where slopes are 3 to 15 percent. Severe where slopes are more than 15 percent.

[1] Pollution is a hazard because of permeability.

absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings, as rated in table 7, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under loam, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated the ratings in table 7 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 to 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth of hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

In table 8, soil suitability is rated by the terms *good*, *fair*, and *poor*. Following are explanations of some of the columns in table 8.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and (2) the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or its response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material

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 as indicated in the first column of this table. Some of the soil characteristics in this table are described in computer-adapted terms "shrink-swell" and other terms that

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
*Aberdeen: Ab, Ae For Exline part of Ae, see Exline series.	Poor: shrink-swell	Unsuited	Fair: thin layer; too clayey.
Arveson: Ar	Poor: wet	Poor to fair for sand	Poor: wet
*Arvilla: As, AtA, AtB, AvA, AvB, AxC For Sioux part of AxC, see SoB in the Sioux series.	Good	Fair: excessive fines	Poor: thin layer
*Barnes: BaA, BaB, BaC, BbA, BbB, BdC For Svea part of BbA, BbB, and BdC, see Svea series. For Buse part of BdC, see Buse series.	Fair: shrink-swell	Unsuited	Good
BcB, BeC	Fair to poor: large stones.	Unsuited	Poor: large stones
Bearden: Bg	Poor: shrink-swell	Unsuited	Poor: excess salt
*Binford: Bh, BkA, BkB, BlB, BmC, BmD For Coe part of BmC and BmD, see Coe series.	Good	Poor: high shale content.	Poor: thin layer
*Borup: Bn, Bo, BpB For Marysland part of Bo, see Marysland series. For Vallers part of BpB, see Vallers series.	Poor: wet	Unsuited	Poor: wet
*Brantford: BrB, BsA, BsB, BtA, BtB, BuC, Bv For Coe part of BuC, see Coe series. For Kensal part of Bv, see Kensal series.	Good	Poor: high shale content.	Fair: thin layer
*Buse: BwE, BxD, ByE, BzD For Barnes part of BwE, see BoA in the Barnes series; for Edgeley part of BxD, see Edgeley series; for Kloten part of ByE, see Kloten series; and for Sioux and Zell parts of BzD, see SoE in the Sioux and Zell series.	Fair: slope; shrink-swell.	Unsuited	Poor: thin layer
*Cathay: Ca, ChA, ChB, Cm For Heimdal part of ChA and ChB, see HoA in the Heimdal series. For Larson part of Cm, see Larson series.	Fair: shrink-swell	Unsuited	Fair: thin layer; excess salt.
*Cavour:			
Cn For Cresbard part of Cn, see Cresbard series.	Poor: shrink-swell	Unsuited	Poor: thin layer; excess salt.
Co For Vallers part of Co, see Vallers series.	Poor: shrink-swell; large stones.	Unsuited	Poor: large stones; excess salt.
Cavour variant: CpB	Poor: shrink-swell	Unsuited	Poor: thin layer; excess salt.

interpretations of the soils

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series that differ from those in the Soil Survey Manual (*8*). Refer to the Explanation of Key Phrases, page 190, for the definition of describe soil characteristics]

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Favorable	Shrink-swell; low strength; medium compressibility.	Slow permeability	Slow permeability; alkalinity; seasonal water table; salinity.	Waterlogging; salinity.
Wet; moderately rapid permeability; seasonal water table.	Moderately rapid permeability; low compressibility.	Wet; poor outlets	Low available water capacity; salinity; seasonal water table.	Erosion; percolation loss; drain stability; gravity-distributing water.
Very rapid permeability.	Medium to high shear strength.	Not needed	Low available water capacity; shallow soil; high infiltration rate; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.
Favorable	Low strength; medium compressibility.	Not needed	Moderately slow permeability; salinity; topography in places.	Waterlogging; salinity; gravity-distributing water; erosion in places.
Favorable	Large stones	Not needed	Unsuited	Large stones.
Seasonal water table	Low strength	Excess salt; poor outlets.	Moderately slow permeability; seasonal water table; salinity; alkalinity.	Waterlogging; salinity.
Very rapid permeability.	Medium strength; susceptible to piping.	Not needed	Low available water capacity; shallow soil; high infiltration rate; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table	Low strength	Seasonal water table; poor outlets.	Moderate permeability; salinity; seasonal water table; seepage in places.	Waterlogging; salting.
Very rapid permeability.	Medium strength; susceptible to piping.	Not needed	Low available water capacity; shallow soil; topography in places.	Percolation loss; drain stability; gravity-distributing water; water erosion in places.
Slope	Low strength; medium compressibility.	Not needed	Moderately slow permeability; topography; salinity.	Gravity-distributing water; water erosion; waterlogging; salting.
Seasonal water table	Low strength; medium compressibility.	Slow permeability in subsoil.	Slow permeability in subsoil; alkalinity; salinity; seasonal water table; topography in places.	Waterlogging; salting; gravity-distributing water; water erosion in places.
Favorable	Low strength; high compressibility.	Very slow permeability; excess salt.	Very slow permeability; alkalinity; salinity; seasonal water table.	Waterlogging; salting.
Favorable	Large stones; low strength.	Large stones	Unsuited	Large stones.
Favorable	Low strength; high compressibility.	Very slow permeability; shale bedrock.	Very slow permeability; alkalinity; salinity; seepage; topography.	Waterlogging; salting; gravity-distributing water.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
*Claire: CrA, CrB, Cs, Ct For Lohnes and Hamar parts of Ct, see those series.	Good	Fair: sand	Poor: too sandy
Clontarf: Cu	Good	Fair: sand	Good
Coe: CvB, CvD	Good where slopes are less than 15 percent. Fair where slopes are more than 15 percent.	Poor: high shale content.	Poor: thin layer
Colvin: Cw, Cx, Cy	Poor: wet	Unsuited	Poor: wet
*Cresbard: Cz For Cavour part of Cz, see Cn in the Cavour series.	Poor: shrink-swell	Unsuited	Poor: thin layer
Dickey Mapped only with Maddock, Hecla, and Towner soils.	Fair: shrink-swell in substratum.	Unsuited	Fair to poor: too sandy.
Divide: DvA, DvB, Dw, Dx, Dy	Fair: wet	Fair to poor: sand and gravel.	Good [1]
Dz	Fair: wet; shrink-swell below a depth of 40 inches.	Poor: thin layer of sand and gravel.	Good
Eckman: EaA, EaB	Fair: low strength	Unsuited	Good
*Edgeley: Eb, EcB For Cavour part of EcB, see Cn in the Cavour series.	Fair: shrink-swell	Unsuited	Poor: thin layer
Edgeley variant: Ed	Fair: thin layer	Poor: thin layer	Fair: thin layer
Egeland: EeA, EeC	Good	Unsuited	Good
Eg	Good	Poor to fair: sand	Good
EhA, EhB, EmC	Good in upper 40 inches. Fair: shrink-swell below 40 inches.	Unsuited	Good

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Rapid permeability	Medium strength; susceptible to piping.	Not needed	Very low available water capacity; rapid infiltration; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.
Moderately rapid permeability.	Medium strength; susceptible to piping.	Cutbanks cave	Low available water capacity; moderately deep soil; rapid infiltration.	Erosion; percolation loss; drain stability; gravity-distributing water.
Very rapid permeability.	Low to medium compressibility; subject to piping.	Not needed	Very low available water capacity; very shallow soil; rapid infiltration; topography.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table	Low strength	Moderately slow permeability; poor outlets.	Moderately slow permeability; seasonal water table; salinity; alkalinity in places.	Waterlogging; salting.
Favorable	Low strength; medium compressibility.	Slow permeability; excess alkali.	Slow permeability in subsoil; alkalinity; salinity; seasonal water table.	Waterlogging; salting.
Slope	Medium to low shear strength.	Not needed	Moderately slow permeability in substratum; rapid infiltration; topography.	Erosion; percolation loss; drain stability; waterlogging; gravity-distributing water.
Very rapid permeability in substratum.	Medium strength; subject to piping.	Cutbanks cave;[1] seasonal water table.	Low available water capacity; moderately deep soil; salinity; seasonal water table; topography in places.	Percolation loss; drain stability; gravity-distributing water; water erosion.
Seasonal water table; rapid permeability above a depth of 40 inches.	Medium strength	Seasonal water table	Low available water capacity; moderately deep soil; salinity; seasonal water table.	Percolation loss; drain stability.
Moderate permeability	Low strength; piping hazard.	Not needed	Moderate permeability; topography in places.	Waterlogging; gravity-distributing water; water erosion.
Moderate permeability; shale bedrock.	Shale bedrock; low strength.	Not needed	Moderately deep soil; topography in places; shale bedrock.	Waterlogging; gravity-distributing water.
Moderate permeability; shale bedrock.	Shale bedrock; percs rapidly.	Not needed	Moderately deep soil; shale bedrock.	Waterlogging.
Moderately rapid permeability.	Medium strength	Not needed	Moderate available water capacity; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water in places.
Moderately rapid and rapid permeability.	Medium strength; susceptible to piping.	Not needed	Moderate available water capacity; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water in places.
Moderately rapid permeability in upper part.	Low to medium strength.	Not needed	Moderate available water capacity; moderately slow permeability in substratum; topography in places.	Erosion; percolation loss; drain stability; waterlogging; gravity-distributing water in places.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
Embden: EnA, EoB	Good	Unsuited	Good
EsA, EsB	Fair: shrink-swell in substratum.	Unsuited	Good
Emrick: Et, Eu	Good to fair: shrink-swell.	Unsuited	Good
*Esmond: EvD For Coe and Embden parts of EvD, see the Coe series and EnA in the Embden series.	Fair: shrink-swell; slope.	Unsuited	Poor: too thin
Exline: Ew	Poor: shrink-swell	Unsuited	Poor: excess salt
*Fargo: Fa For Nutley part of Fa, see Nutley series.	Poor: shrink-swell; wet.	Unsuited	Poor: wet; too clayey
Fordville: Fd	Good	Fair: sand and gravel.	Good
*Fossum: Fm, Fo, Fp For Hamar part of Fp, see Hamar series.	Poor: wet	Unsuited	Poor: wet
*Fram: FrA, FrB, Fs, Fw For Wyndmere part of Fw, see Wp in the Wyndmere series.	Fair: wet	Unsuited	Good [1]
Gardena: GaA, GaB	Fair: low strength	Unsuited	Good
Glyndon: Gd, Ge	Fair: wet	Unsuited	Good [1]
Gravel pit: Gp. Too variable for interpretations to be made.			
Hamar: Ha, Hb, Hc, Hd	Fair: wet	Unsuited	Fair to poor: thin layer; too sandy.
*Hamerly: HeA, HeB, Hf, HgA, HgB For Svea part of HgA and HgB, see Svea series.	Fair: wet	Unsuited	Fair: thin layer [1]
*Hecla: HhA, HhB, HkA, HkB, HlB, Hm, HnA, HnB For Hamar and Maddock parts of Hm, HnA, and HnB, see those series, and for Dickey part of HlB, see Dickey series.	Good	Unsuited	Good to poor: too sandy.

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Moderately rapid permeability.	Medium strength; susceptible to piping.	Not needed	Moderate available water capacity; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water in places.
Moderately rapid permeability in upper part.	Medium strength; susceptible to piping.	Not needed	Moderately slow permeability in substratum; topography in places.	Erosion; percolation loss; drain stability; waterlogging; gravity-distributing water in places.
Moderate permeability	Low strength; piping hazard.	Not needed	Moderate permeability; salinity; complex slope in places.	Waterlogging; salting; erosion; gravity-distributing water in places.
Slope; moderate permeability.	Low strength; hard to pack; piping nazard.	Not needed	Topography; moderate permeability; salinity.	Gravity-distributing water; waterlogging; salinity; erosion.
Favorable	Low strength	Very slow permeability; excess salt.	Very slow permeability in subsoil; low available water capacity; seasonal water table; alkalinity; salinity.	Waterlogging; salting.
Favorable	Low strength; hard to pack; high compressibility.	Slow permeability	Slow permeability; salinity.	Waterlogging; salting.
Very rapid permeability in substratum.	Medium strength; fair to good compaction characteristics.	Not needed	Moderately deep soil	Percolation loss; drain stability.
Wet; seasonal water table; rapid permeability.	Medium strength; piping hazard.	Wet; seasonal water table; poor outlets.	Low available water capacity; salinity; seasonal water table.	Erosion; percolation loss; drain stability.
Seasonal water table	Low strength; hard to pack.	Seasonal water table [1]	Moderate permeability; salinity; seasonal water table;[1] topography in places.	Waterlogging; salting; erosion; gravity-distributing water in places.
Moderate permeability	Low strength; hard to pack.	Not needed	Moderate permeability; topography in places.	Waterlogging; gravity-distributing water; water erosion.
Moderate permeability	Low strength; hard to pack.	Seasonal water table [1]	Moderate permeability; salinity; seasonal water table.[1]	Waterlogging; salting.
Rapid permeability; seasonal water table.	Medium strength; susceptible to piping.	Wet; seasonal water table; cutbanks cave; poor outlets.	Low available water capacity; rapid infiltration; seasonal water table.	Erosion; percolation loss; drain stability.
Seasonal water table	Medium to low strength; medium compressibility.	Seasonal water table; moderately slow permeability.[1]	Moderately slow permeability; salinity; seasonal water table;[1] topography in places.	Waterlogging; salting; erosion; gravity-distributing water in places.
Rapid permeability	Medium strength; susceptible to piping.	Not needed	Low available water capacity; rapid infiltration; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
*Heimdal: HoA, HoB, HoC, HpA, HpB, HpC, HsA, HsB, HtC --- For Emrick part of HsA and HsB and for Emrick and Esmond parts of HtC, see those series.	Good to fair: low strength; shrink-swell.	Unsuited	Fair: thin layer
HrD, HrE, HtD, HtE For Embden part of HrD and HrE, see EsA in the Embden series. For Emrick and Esmond parts of HtD and HtE, see Emrick and Esmond series.	Good to fair: shrink-swell.	Unsuited	Fair to poor: slope
Kensal: Ke, Kf	Good	Poor: high shale content.	Fair: thin layer
*Kloten: KoE, KsE For Sioux and Edgeley parts of KsE, see SoE in the Sioux series and the Edgeley series.	Poor: slope; shale bedrock; thin layer.	Unsuited	Poor: thin layer
Kratka: Kt	Poor: wet	Unsuited	Poor: wet
LaDelle: La	Fair: shrink-swell	Unsuited	Fair: too clayey
Lallie: Lb	Poor: wet; shrink-swell.	Unsuited	Poor: wet
Lamoure: Le, Lm	Poor: wet; shrink-swell.	Unsuited	Poor: wet[1]
*La Prairie: Ln, Lp For Lamoure part of Lp, see Lamoure series.	Fair: shrink-swell	Unsuited	Good
Larson: Lr	Fair: shrink-swell	Unsuited	Poor: thin layer; excess salt.
Lemert: Ls	Fair to poor: wet	Unsuited	Poor: excess salt; wet.
Letcher: Lt, Lu	Fair: wet	Unsuited	Fair: excess salt
Lohnes: Lv, Lw	Good	Fair: sand	Fair to poor: too sandy.
*Ludden: Lx, Lz For Lamoure part of Lz, see Lamoure series.	Poor: wet; shrink-swell; too clayey.	Unsuited	Poor: wet; too clayey

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Moderate permeability; slope.	Low strength; susceptible to piping.	Not needed	Moderate permeability; salinity; topography in places.	Waterlogging; salting; erosion; gravity-distributing water in places.
Slope; moderate permeability.	Low strength; susceptible to piping.	Not needed	Topography	Gravity-distributing water.
Very rapid permeability in substratum.	Medium strength; susceptible to piping.	Not needed	Low available water capacity; moderately deep soil.	Percolation loss; drain stability.
Slope; shale bedrock	Shale bedrock	Not needed	Very low available water capacity; topography; shallow soil.	Gravity-distributing water and water erosion; waterlogging; salting.
Seasonal water table	Medium to low strength; hard to pack.	Moderately slow permeability in substratum; poor outlets; seasonal water table.	Moderately slow permeability in substratum; seasonal water table; rapid infiltration.	Waterlogging; erosion; percolation loss; drain stability.
Favorable	Medium to low strength; medium compressibility.	Not needed	Moderate permeability	Waterlogging.
Seasonal water table	Low strength; hard to pack.	Slow permeability; seasonal water table; salinity.	Slow permeability; seasonal water table; salinity; alkalinity.	Waterlogging; salting.
Seasonal water table	Medium to low strength.	Moderate permeability; seasonal water table; floods.[1]	Moderate permeability; salinity; seasonal water table.[1]	Waterlogging; salting.
Moderate permeability	Medium to low strength.	Not needed	Moderate permeability	Waterlogging.
Seasonal water table	Low strength; medium compressibility.	Slow permeability; seasonal water table; excess salt.	Slow permeability in subsoil; alkalinity; salinity; seasonal water table; topography in places.	Waterlogging; salting; gravity-distributing water and water erosion in places.
Seasonal water table; rapid permeability in substratum.	Low strength	Seasonal water table; excess salt.	Low available water capacity; slow permeability in subsoil; alkalinity; seasonal water table; salinity.	Waterlogging; salting; drain stability.
Seasonal water table	Low strength	Seasonal water table; excess salt.	Low available water capacity; slow permeability in subsoil; alkalinity; salinity; seasonal water table.	Waterlogging; salting; drain stability.
Rapid permeability	Medium strength; susceptible to piping.	Not needed	Low available water capacity; rapid infiltration.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table; floods.	Low strength; high compressibility; hard to pack.	Seasonal water table; floods; poor outlets; slow permeability.	Slow permeability; salinity; seasonal water table; alkalinity in places.	Waterlogging; salting.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
*Maddock: MaA, MaB, MaC, MbA, MbB, MbC, MdB, MdC, MeD, MfD. For Dickey part of MdB and MdC, Serden part of McD, and Serden and Hecla parts of MfD, see those series.	Good	Poor: sand	Poor: thin layer
Made land: Mg. Too variable for interpretations to be made.			
Marsh: Mh. Too variable for interpretations to be made.			
*Marysland: Mm, Mn. For Arveson part of Mn, see Arveson series.	Poor: wet	Unsuited	Poor: thin layer
Minnewaukan: MwC	Poor: wet	Poor: sand	Poor: thin layer; too sandy.
*Miranda: Mx. For Cavour part of Mx, see Cn in the Cavour series.	Fair: shrink-swell	Unsuited	Poor: thin layer; excess salt.
Nutley. Mapped only with Fargo soils.	Poor: shrink-swell	Unsuited	Fair: too clayey
Osakis: Os, Ot	Good	Poor to fair: sand and gravel.	Good
Ou	Good	Poor: thin layer	Good
Overly: Ov	Fair: shrink-swell	Unsuited	Fair: too clayey
Parnell: Pa	Poor: shrink-swell; wet.	Unsuited	Poor: wet; too clayey
Peat: Pe. Too variable for interpretations to be made.			
Perella: Pr	Poor: shrink-swell; wet.	Unsuited	Poor: wet
Rauville: Ra	Poor: wet	Unsuited	Poor: wet
Renshaw: ReA, ReB, Rn, Rs	Good	Fair: sand and gravel.	Fair: thin layer

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Rapid permeability; slope.	Medium strength; susceptible to piping.	Not needed	Low available water capacity; rapid infiltration; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table	Low strength	Wet; seasonal water table.	Moderately deep soil; salinity; seasonal water table.	Percolation loss; drain stability.
Rapid permeability	Medium strength; susceptible to piping.	Wet; seasonal water table; poor outlets.	Low available water capacity; rapid infiltration; salinity in places; seasonal water table; topography.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table	Low strength; medium compressibility.	Very slow permeability; excess salt.	Low available water capacity; very slow permeability; alkalinity; salinity; seasonal water table.	Waterlogging; salting.
Favorable	Low strength; high compressibility; hard to pack.	Not needed	Slow permeability	Waterlogging; salting.
Rapid permeability in substratum.	Low strength; susceptible to piping.	Not needed	Low available water capacity; shallow soil; high infiltration rate.	Erosion; percolation loss; drain stability; gravity-distributing water.
Rapid permeability in upper part.	Low strength	Not needed	Low available water capacity; shallow soil; high infiltration rate; moderately slow permeability in substratum.	Erosion; percolation loss; drain stability; gravity-distributing water.
Moderately slow permeability.	Medium to low strength; medium compressibility.	Not needed	Moderately slow permeability.	Waterlogging.
Floods	Low strength; medium compressibility; hard to pack.	Wet; floods; slow permeability; poor outlets.	Slow permeability; seasonal water table; depressed positions.	Waterlogging.
Seasonal water table; floods.	Low strength; medium compressibility; hard to pack.	Wet; floods; moderately slow permeability; poor outlets.	Moderately slow permeability; seasonal water table.	Waterlogging.
Seasonal water table; floods.	Low strength; medium compressibility.	Wet; floods; slow permeability; poor outlets.	Slow permeability in subsoil; salinity; seasonal water table.	Waterlogging.
Very rapid permeability in substratum.	Medium to high strength.	Not needed	Low available water capacity; shallow soil; topography in places.	Percolation loss; drain stability; gravity-distributing water; water erosion.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
Renshaw—continued Rt	Good to fair: thin layer; shrink-swell in lower part.	Poor: thin layer; sand and gravel.	Fair: thin layer
*Ryan: Ry, Rz For Lamoure part of Rz, see Lamoure series.	Poor: wet; shrink-swell.	Unsuited	Poor: wet; excess salt.
*Serden: Se For Hamar part of Se, see Hamar series.	Good	Fair to poor: sand	Poor: too sandy
Sioux: SoB	Good	Fair: sand and gravel.	Poor: thin layer
SoE	Good where slopes are 6 to 15 percent. Fair where slopes are more than 15 percent.	Fair: sand and gravel.	Poor: thin layer
Spottswood: Sp, Sr	Good	Fair to poor: sand and gravel.	Fair: thin layer
Stirum: Ss	Poor: wet	Unsuited	Poor: excess salt; wet.
*Svea: St, SvA, SvB, SwC, Sx For Barnes part of SvA, SvB, and SwC, see BaA in the Barnes series; for Buse part of SwC, see Buse series; and for Cresbard part of Sx, see Cresbard series.	Fair: shrink-swell	Unsuited	Good
Svea variant: Su	Fair: shrink-swell	Unsuited	Good
*Swenoda: Sz For Embden part of Sz, see EsA in the Embden series.	Fair: shrink-swell	Unsuited	Good
Tiffany: Tf, Tg	Poor: wet	Unsuited	Poor: wet
Tolna: Tn	Fair: wet	Poor: high shale content.	Good
Tonka: To	Poor: wet	Unsuited	Poor: wet
Totten: Ts, Tt, Tu	Poor: wet	Unsuited	Poor: wet; excess salt.

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Moderately rapid permeability in upper part.	Medium to low strength.	Not needed	Low available water capacity; shallow soil; moderately slow permeability in substratum.	Percolation loss; drain stability; waterlogging.
Seasonal water table; nearly level.	Medium to low strength; hard to pack.	Very slow permeability.	Low available water capacity; very slow permeability; alkalinity; salinity; seasonal water table.	Waterlogging; salting.
Rapid permeability	Medium strength; susceptible to piping.	Not needed	Very low available water capacity; rapid infiltration; topography.	Erosion; percolation loss; drain stability; gravity-distributing water.
Very rapid permeability.	Medium to high strength.	Not needed	Very low available water capacity; very shallow soil; rapid infiltration.	Erosion; percolation loss; drain stability; gravity-distributing water.
Slope; very rapid permeability.	Medium to high strength.	Not needed	Topography	Gravity-distributing water.
Very rapid permeability in substratum.	Medium to high strength.	Poor outlets	Moderately deep soil	Percolation loss; drain stability.
Moderately rapid permeability in substratum.	Low strength; susceptible to piping.	Excess salt; seasonal water table; poor outlets.	Low available water capacity; seasonal water table; moderately slow permeability in subsoil; alkalinity; salinity.	Waterlogging; salting; drain stability.
Favorable	Low strength; medium compressibility.	Not needed	Moderately slow permeability in substratum; salinity; topography in places.	Waterlogging; salting; gravity-distributing water; water erosion in places.
Favorable	Low strength; medium compressibility.	Not needed	Moderately slow permeability; salinity.	Waterlogging; salting.
Moderately slow permeability in substratum.	Low strength	Not needed	Moderately slow permeability in substratum.	Erosion; percolation loss; drain stability; waterlogging.
Seasonal water table; moderately rapid permeability.	Medium strength; susceptible to piping.	Seasonal water table; wet; poor outlets.	Seasonal water table; low available water capacity.	Erosion; percolation loss; drain stability.
Very rapid permeability in substratum.	Low strength	Floods; poor outlets	Low available water capacity; seasonal water table; moderately deep soil; depressed positions.	Percolation loss; drain stability.
Floods; slow permeability.	Low strength; high compressibility.	Floods; poor outlets; slow permeability.	Slow permeability; depressed positions.	Waterlogging.
Seasonal water table; rapid permeability in substratum.	Medium to low strength.	Seasonal water table; excess salt.	Low available water capacity; seasonal water table; alkalinity; salinity.	Salting; drain stability.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
Totten—continued Tv	Poor: wet	Unsuited	Poor: wet; excess salt.
*Towner: TwA, TwB, Tx For Dickey part of Tx, see Dickey series.	Fair: shrink-swell	Unsuited	Good
Vallers: Va	Poor: wet	Unsuited	Poor: wet
Vang: Vn	Good	Poor: high shale content.	Fair: thin layer
Venlo: Vo	Poor: wet	Unsuited	Poor: wet
Wahpeton: Wa	Poor: shrink-swell; too clayey.	Unsuited	Poor: too clayey
Walsh: WbB, WbC, WcA, WcB, WcC	Fair: shrink-swell	Unsuited	Good
Walum: Wd, We	Good	Poor: high shale content.	Poor: thin layer
Warsing: Wf, Wg	Good	Fair to poor: sand and gravel.	Fair: thin layer
Wm	Good in upper 40 inches	Unsuited	Fair: thin layer
Wyard: Wn	Fair: wet	Unsuited	Good
Wyndmere: Wo	Fair: wet	Unsuited	Good
Wp	Fair: wet	Unsuited	Good
*Wyrene: Wr, Wt For Totten part of Wt, see Ts in the Totten series.	Fair: wet	Unsuited	Fair: thin layer

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Seasonal water table	Low to medium compressibility.	Seasonal water table; excess salt.	Low available water capacity; seasonal water table; alkalinity; salinity; moderately slow permeability in substratum.	Waterlogging; salting; drain stability.
Moderately slow permeability in substratum.	Medium to low strength; fair to good compaction characteristics.	Not needed	Moderately slow permeability in substratum; rapid infiltration; topography in places.	Erosion; percolation loss; drain stability; gravity-distributing water.
Seasonal water table; moderately slow permeability.	Low strength; medium compressibility.	Wet; seasonal water table; poor outlets; moderately slow permeability.	Moderately slow permeability; salinity; seasonal water table.	Waterlogging; salting.
Very rapid permeability in substratum.	Low to medium compressibility.	Not needed	Moderately deep soil	Percolation loss; drain stability.
Seasonal water table; rapid permeability.	Medium strength; low to medium compressibility.	Wet; seasonal water table; poor outlets.	Low available water capacity; rapid infiltration; seasonal water table.	Erosion; percolation loss; drain stability.
Floods; moderate permeability.	Low strength; high compressibility; hard to pack.	Not needed	Moderate permeability	Waterlogging; salting.
Slope	Low strength; medium compressibility.	Not needed	Moderate permeability; topography in places.	Waterlogging; salting; gravity-distributing water; water erosion.
Very rapid permeability in substratum.	Medium to high strength; low to medium compressibility.	Not needed	Low available water capacity; moderately deep soil; high infiltration rate.	Erosion; percolation loss; drain stability.
Very rapid permeability in substratum.	Medium strength; low to medium compressibility.	Not needed	Low available water capacity; shallow soil.	Percolation loss; drain stability.
Moderately rapid permeability in upper part.	Medium to low strength; low to medium compressibility.	Not needed	Low available water capacity; shallow soil; moderately slow permeability in substratum.	Percolation loss; drain stability; waterlogging.
Floods	Low strength; medium compressibility.	Floods	Moderate permeability; seasonal water table; depressed positions.	Waterlogging.
Moderately rapid permeability; seasonal water table.	Medium strength; low to medium compressibility.	Seasonal water table	Salinity; seasonal water table.	Erosion; percolation loss; drain stability.
Moderately rapid permeability in upper part.	Medium to low strength.	Seasonal water table	Seasonal water table; moderately slow permeability in substratum.	Erosion; percolation loss; drain stability.
Rapid permeability in substratum.	Medium strength; low to medium compressibility.	Seasonal water table	Low available water capacity; high infiltration rate; salinity; seasonal water table.	Erosion; percolation loss; drain stability.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—		
	Road fill	Sand and gravel	Topsoil
Wyrene—continued Ws	Fair: wet	Unsuited	Fair: thin layer
Zell Mapped only with Buse and Sioux soils.	Fair: slope	Unsuited	Poor: thin layer

[1] Some phases of this series have a moderate to severe limitation because of salinity.

in a soil are among factors that are unfavorable.

Drainage for crops and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope and stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer or other layers that restrict movement of water; amount of water held available to plants; and need for drainage or depth to water table or bedrock.

EXPLANATION OF KEY PHRASES

Some of the soil characteristics in tables 7 and 8 are expressed in computer-adapted terms that differ from those used in the Soil Survey Manual (*8*). Following are definitions of the computer-adapted terms used to describe soil characteristics in these tables.

Complex slope	Slopes short and irregular.
Cutbanks cave	Walls of cuts not stable.
Excess salt	Soluble salts restrict plant growth.
Favorable	Features of soil favorable.
Floods	Soil floods by stream overflow, runoff, or high tides.
Hard to pack	Difficult to compact.
Large stones	Rock fragments 10 inches or more across.
Low strength	Not enough strength to adequately support the load.
Not needed	Practice not applicable.
Percs rapidly	Water moves through soil too fast.
Poor outlets	Difficult or expensive to install outlets for drainage.
Shrink-swell	Soil expands significantly on wetting and shrinks on drying.
Slope	Slope is too great.
Thin layer	Inadequate thickness of suitable soil.
Too clayey	Soil slippery and sticky when wet and slow to dry.
Too sandy	Soil soft and loose; droughty and low in fertility.
Wet	Soil wet during period of use.

Soil test data

Table 9 contains engineering test data for some of the major soil series in this survey area. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as explained for table 6.

Formation and Classification of the Soils

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Eddy, Benson, and Nelson Counties; the second explains the system of soil classification currently used and places each soil series in the classes of that system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting 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 material, the climate under which the soil material has accumulated and existed since accumulation, the plant and animal life on and

of the soils—Continued

Soil features affecting—				
Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Irrigation management concerns
Rapid permeability in upper part.	Medium to low strength.	Seasonal water table	Seasonal water table; moderately slow permeability in substratum.	Erosion; drain stability.
Slope	Low strength; hard to pack; medium compressibility; piping hazard.	Not needed	Topography	Gravity-distributing water; water erosion.

in the soil, the relief, or lay of the land, and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Most of the soils in this survey area formed in glacial material derived from preglacial granite, gneiss, sandstone, shale, limestone, and basalt. The glacier picked up these materials, ground and mixed them as it transported them across country, and then deposited them as it melted. Some deposits consist of unsorted material, or glacial till; others consist of material sorted either by water when it was being deposited or by wind and water afterward. Some soils along the Sheyenne River Valley formed in weathered Pierre shale, and other soils formed in thin layers of glacial till or local colluvium overlying the shale at depths of less than five feet.

The calcareous till in the survey area is mainly of a type that contains 18 percent clay or less and much fine sand and silt. Pockets of fine sand, silt, and pebbles or stones are common. The Heimdal, Emrick, Esmond, Fram, Cathay, and Larson series formed in this type of glacial till. The Barnes, Svea, Buse, Hamerly, Cresbard, and Cavour series formed in glacial till that contains 20 to 30 percent clay. The total thickness of the till ranges from 20 to 200 feet thick over preglacial sediments, except where glacial meltwater has washed away all but a trace of till, especially along the Sheyenne Valley.

The outwash areas are of two types—pitted and dissected topography that is similar to glacial moraines and plains that are smooth and nearly level. The outwash consists of gravel or coarse and medium sand that has content of shale that ranges from nearly zero to 75 percent by volume. The soils in these areas formed in medium textured and moderately coarse textured sediments overlying gravel and sand. These sediments are 14 to 26 inches thick in most areas, but they range from 4 inches thick on slope crests to 40 inches thick on foot slopes and in swales. The Renshaw, Arvilla, Divide, Brantford, Sioux, Coe, Kensal, Walum, Warsing, Osakis, Marysland, and Totten soils are the main soils in these areas. Some areas of the outwash are less than 5 feet thick.

Many soils formed in medium and fine sands that have been sorted by glacial meltwater and reworked by wind. These deposits range in depth from about 2 to 20 feet. In some areas the soils formed mainly in coarse sands, and some areas are underlain by glacial till at a depth of 15 to 40 inches. These soils are moderately coarse textured and coarse textured and are underlain by sands at a depth of less than 1 foot to more than 5 feet. The soils in these areas are in the Embden, Egeland, Hecla, Maddock, Lohnes, Claire, Towner, Dickey, Wyndmere, Hamar, Tiffany, Fossum, Borup, Stirum, and Letcher series.

The soils of the Sheyenne and James River Valleys formed in colluvium derived from glacial till and Pierre shale of the higher slopes and from alluvium. These deposits are medium to fine in texture. The soils are in the La Prairie, Lamoure, LaDelle, Ludden, Ryan, and Walsh series.

Some minor soil areas are those in which the soils formed in recent lake or beach sediments, ranging from sands to silty clay. These soils are in the Minnewaukan and Lallie series. Other minor soil areas are

TABLE 9.—*Engineering*

[Tests performed by North Dakota State University in cooperation with the North Dakota State Highway Department and the State Highway and Transportation

Soil name and location	Parent material	North Dakota SCS report No.	Depth from surface	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb per cu ft*	*Percent*
Barnes loam:					
150 feet west and 150 feet north of the SE corner of NE¼ sec. 26, T. 149 N., R. 62 W.; 8 miles north and 2 miles east of McHenry. (Modal)	Glacial till.	49	0–6	94.5	23.5
		50	8–16	103.6	18.5
		51	23–60	105.0	18.5
Borrow pit, north end; 1,940 feet south of intersection (not section line) and 400 feet east; 1,750 feet south and 680 feet east of NW corner of sec. 27, T. 150 N., R. 66 W.; 6 miles north and 1 mile east of New Rockford. (Coarse-textured subsoil)	Glacial till.	55	0–7	92.5	22.0
		56	7–16	116.0	14.0
		57	31–60	107.0	18.4
Brantford loam:					
80 feet north and 1,350 feet west of SE corner of sec. 28, T. 150 N., R. 65 W.; 6 miles north and 7 miles east of New Rockford. (Modal)	Shaly outwash sand and gravel.	1	0–6	97.0	19.5
		2	6–11	107.0	17.5
		3	13–60	107.0	17.3
500 feet south and 125 feet east of NW corner of NE¼ sec. 25, T. 150 N., R. 65 W.; 7.5 miles north and 9.5 miles east of New Rockford. (Shaly sand substratum)	Shaly outwash sand and gravel.	4	0–6	104.0	17.7
		5	6–13	109.0	15.0
		6	20–60	100.0	20.5
320 feet north and 210 feet west of SE corner of NE¼ sec. 7, T. 149 N., R. 64 W.; 11 miles east and 4 miles north of New Rockford. (Shallow)	Shaly outwash sand and gravel.	10	0–6	106.0	17.5
		11	6–10	112.0	14.0
		12	10–60	108.0	16.8
Claire loamy coarse sand:					
285 feet north and 250 feet east of SW corner of sec. 10, T. 150 N., R. 63 W.; 2½ miles south of Warwick. (Modal)	Glacial meltwater deposits.	46	0–7	112.0	14.0
		47	11–18	114.5	10.5
		48	18–58	108.0	14.4
Fram loam:					
150 feet south and 162 feet east of NW corner of SW¼ sec. 32, T. 148 N., R. 67 W.; 6 miles south and 6 miles west of New Rockford. (Modal)	Glacial till.	25	0–6	106.5	17.0
		26	10–22	119.0	13.0
		27	22–60	120.0	12.0
Hamerly loam:					
132 feet north of Traill and 550 feet west of SE corner of NE¼ sec. 33, T. 150 N., R. 67 W.; 6 miles north and 5 miles west of New Rockford. (Modal)	Glacial till.	22	0–7	102.0	19.0
		23	7–20	111.6	16.4
		24	36–60	120.0	12.5
168 feet north and 852 feet east of SW corner of sec. 36, T. 148 N., R. 66 W.; 6½ miles south and 4 miles east of New Rockford. (Thinner surface)	Glacial till.	28	0–5	109.0	16.0
		29	13–30	119.5	12.0
		30	30–60	122.2	11.5
Heimdal loam:					
430 feet west and 276 feet north of SE corner of SW¼ sec. 17, T. 150 N., R. 67 W.; 1½ miles south and 6½ miles west of Sheyenne. (Modal)	Glacial till.	52	0–7	97.0	21.0
		53	10–18	106.0	16.0
		54	20–60	116.0	14.0
LaDelle silty clay loam:					
30 feet NW of approach 105 feet north of road and 465 feet SW of bridge on Sheyenne River sec. 2, T. 150 N., R. 65 W.; 8½ miles east of Sheyenne. (Modal)	Local alluvium.	34	0–7	79.0	33.9
		35	21–30	89.0	26.4
		36	35–60	89.0	27.6
La Prairie silt loam:					
2,350 feet north and 60 feet west of the SE corner of NE¼ sec. 23, T. 150 N., R. 63 W.; and 3 miles south of Hamar. (Modal)	Local alluvium.	37	0–10	81.2	31.5
		38	21–32	85.7	30.0
		39	32–60	93.9	24.0
Lohnes loamy sand:					
100 feet north and 150 feet east of the center of sec. 8, T. 150 N., R. 66 W.; ¾ mile west of Sheyenne. (Modal)	Glacial meltwater deposits.	43	0–5	117.0	12.4
		44	17–22	122.8	10.7
		45	22–52	108.5	14.0

test data

U.S. Department of Commerce, Bureau of Public Roads, in accordance with standard procedures of the American Association of Officials (AASHTO) (*1*)]

Mechanical analysis [2]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—							
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			AASHTO [3]	Unified [4]
									Percent			
[5] 94	93	92	85	59	48	32	19	13	40	12	A–6	ML
100	98	96	89	71	60	44	35	29	46	24	A–7–6(14)	CL
100	92	87	76	55	47	31	19	12	34	10	A–4(4)	CL–ML
100	98	96	89	55	37	17	8	6	NP	NP	A–4(4)	ML
100	93	88	80	41	32	19	13	11	NP	NP	A–4(1)	SM
100	100	98	97	90	78	56	28	19	36	15	A–6(10)	CL
100	100	98	81	58	48	30	13	8	42	12	A–7–5(6)	CL–ML
100	99	97	80	59	50	31	20	15	34	12	A–6(6)	CL–ML
[5] 96	80	63	29	13	11	8	5	4	NP	NP	A–1–b(0)	SM
100	100	100	85	45	39	25	15	10	30	6	A–4(2)	ML–CL
100	100	100	88	52	44	31	19	16	29	12	A–6(4)	CL
100	95	90	59	25	21	15	12	10	NP	NP	A–2–4(0)	SM
100	99	97	77	35	29	19	11	8	33	5	A–2–4(0)	SM
100	100	97	82	38	32	22	14	12	28	8	A–4(1)	SM–SC
100	86	77	40	13	9	6	4	3	NP	NP	A–1–b(0)	SM
100	100	100	77	20	18	12	7	5	NP	NP	A–2–4(0)	SM
100	100	100	79	13	12	9	7	4	NP	NP	A–2–4(0)	SM
100	100	98	76	6	5	4	3	3	NP	NP	A–3(0)	SW–SM
100	99	98	94	71	48	22	14	11	34	11	A–6(8)	CL–ML
100	97	95	90	69	60	41	28	22	26	8	A–4(7)	CL
100	98	96	92	70	57	33	21	16	23	7	A–4(7)	CL–ML
100	98	96	91	75	54	28	20	14	39	9	A–4(8)	ML
100	94	91	86	72	63	44	35	28	32	12	A–6(8)	CL
100	95	93	85	58	50	35	26	20	31	13	A–6(6)	CL
100	98	97	90	63	53	36	24	18	34	6	A–4(6)	ML
[5] 97	95	93	87	61	55	43	30	25	29	12	A–6(6)	CL
100	99	97	89	60	53	39	25	19	26	6	A–4(5)	CL–ML
100	100	99	95	79	59	32	23	19	39	11	A–6(8)	ML
100	100	99	97	86	64	33	22	17	35	15	A–6(10)	CL
100	95	91	79	50	43	32	21	14	29	10	A–4(3)	SC
100	100	100	98	88	78	60	39	29	67	25	A–7–5(18)	MH
100	100	100	100	98	92	80	52	41	57	24	A–7–5(17)	MH
100	100	100	100	94	87	73	49	38	57	28	A–7–6(19)	CH
100	100	100	97	84	70	47	30	23	63	24	A–7–5(18)	MH
100	100	100	98	88	78	56	41	31	58	24	A–7–5(17)	MH
100	100	100	98	86	74	50	35	28	52	28	A–7–6(18)	CH
100	100	99	76	23	19	12	8	6	NP	NP	A–2–4(0)	SM
100	99	97	75	21	19	14	9	8	NP	NP	A–2–4(0)	SM
100	98	94	65	7	7	6	5	4	NP	NP	A–3(0)	SW–SM

TABLE 9.—*Engineering*

Soil name and location	Parent material	North Dakota SCS report No.	Depth from surface	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb per cu ft*	*Percent*
Maddock loamy sand:					
114 feet north and 624 feet west of SE corner of sec. 31, T. 148 N., R. 63 W.; 1 mile south and 9 miles east of Brantford. (Modal)	Glacial meltwater deposits.	40	0–5	114.5	12.3
		41	11–21	17.5	10.0
		42	21–60	12.7	13.0
Miranda silt loam:					
80 feet north and 135 feet east of SW corner of sec. 23, T. 148 N., R. 67 W.; 4½ miles south and 2 miles west of New Rockford. (Modal)	Glacial till.	61	2–8	102.0	18.5
		62	8–30	117.0	13.0
		63	30–60	112.0	15.0
Renshaw loam:					
210 feet west and 1,100 feet north of the SE corner of sec. 26, T. 150 N., R. 66 W.; 6½ miles north and 3 miles east of New Rockford. (Modal)	Outwash sand and gravel.	19	0–5	106.0	17.5
		20	8–14	117.0	12.0
		21	18–60	131.0	9.0
150 feet north and 780 feet east of the S¼ corner of sec. 25, T. 149 N., R. 66 W.; (north of third pole with stub post); 3¾ miles east of New Rockford on Highway 15. (Gravel substratum)	Outwash sand and gravel.	13	0–5	108.4	16.0
		14	5–11	113.8	14.7
		15	22–60	141.0	7.0
West of the NE corner to the cemetery vault, 105 feet south of road, sec. 29, T. 149 N., R. 66 W.; 1½ miles north of New Rockford, and ⅓ mile west of Highway 281. (Sand substratum)	Outwash sand and gravel.	16	0–6	100.6	20.8
		17	6–13	122.0	11.0
		18	22–60	119.5	11.0
Ryan silt loam:					
240 feet north of Sheyenne River, 135 feet east of road on the west side of sec. 8, T. 150 N., R. 67 W.; 7 miles west and ½ mile south of Sheyenne. (Modal)	Local alluvium.	58	0–3	86.6	27.0
		59	3–7	90.4	26.0
		60	23–60	102.0	19.2
Totten loam:					
1,320 feet east and 53 feet north of SW corner of sec. 29, T. 150 N., R. 65 W.; 20 feet west of railroad tie in fence; 6½ miles north and 5 miles east of New Rockford. (Modal)	Stratified sand and gravel, glacial outwash.	7	0–8	84.5	28.5
		8	8–20	113.0	14.6
		9	32–48	118.8	11.0

[1] Based on AASHTO designation T 99–57, Methods A and C (*1*).

[2] Analysis according to AASHTO Designation T 88 (*1*). Results by this procedure frequently differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO 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 coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for use in naming textural classes of soil.

old abandoned glacial outwash channels in which the soils formed in medium textured and moderately fine textured sediments. These soils are in the Colvin and Borup series.

Climate

This survey area has a cool, dry-subhumid, continental climate characterized by long cold winters and a short growing season, during which the distribution of rainfall is erratic. The climate does not vary much from place to place in the survey area and probably has not changed much during the period of soil formation. It has not been too severe for the growth of prairie vegetation.

Temperature and moisture affect the growth of plants, the activity of micro-organisms, and the speed of chemical reactions, particularly during the growing season. Rainfall has not been sufficient for the deep leaching of the soils, nor has it caused more than a minor amount of erosion. Freezing and thawing help to disintegrate parts of the glacial debris, and frost heaving helps mix soil materials, thus affecting soil structure. The cool temperatures slow the decay of plant and animal materials, thus promoting the accumulation of organic matter. This process is responsible for the large amount of organic matter in Svea, Emrick, and Hecla soils. In these ways, climate has had an effect on soil formation in this area.

Plant and animal life

Soil formation started in this survey area when plants began to grow in the unconsolidated materials

test data—Continued

Mechanical analysis [2]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—							
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			AASHTO [3]	Unified [4]
									Percent			
100	100	95	64	22	19	12	8	6	NP	NP	A–2–4(0)	SM
100	100	99	75	19	17	14	10	8	NP	NP	A–2–4(0)	SM
100	97	95	48	11	9	6	6	4	NP	NP	A–1–b(0)	SW–SM
100	97	95	87	69	56	36	28	23	45	23	A–7–6(13)	CL
100	99	97	79	59	56	45	37	34	43	29	A–7–6(15)	CL
100	98	96	91	67	65	59	45	40	47	29	A–7–6(15)	CL
100	99	97	81	53	43	26	15	10	33	12	A–6(4)	CL
100	93	81	65	43	35	21	14	12	31	13	A–6(2)	SC
[5] 99	72	54	20	6	5	4	3	2	NP	NP	A–1–b(0)	SW–SM
100	99	97	75	50	39	24	14	12	36	11	A–6(3)	SC
100	100	99	79	58	45	27	19	15	35	8	A–4(8)	ML
[7] 64	41	33	17	3	3	2	2	1	NP	NP	A–1–a(0)	GP
100	98	95	68	40	30	15	9	6	39	3	A–4(1)	SM
100	98	93	63	33	27	17	11	8	27	5	A–2–4(0)	SM–SC
100	93	82	32	4	3	3	3	2	NP	NP	A–1–b(0)	SP
100	100	100	99	89	70	38	23	16	50	14	A–7–5(12)	MH
100	100	100	98	95	78	53	35	29	66	36	A–7–5(20)	CH
100	100	100	100	98	91	79	76	73	58	35	A–7–6(20)	CH
100	100	99	84	56	37	16	11	9	63	9	A–5(6)	MH
100	99	98	77	47	36	23	18	15	34	12	A–6(3)	SC
100	99	96	62	18	13	8	7	6	NP	NP	A–2–4(0)	SM

[3] Based on AASHTO Designation M 145–49 (*1*).

[4] Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. An example of a borderline classification so obtained is CL–ML.

[5] 100 percent passed the 1-inch sieve.

[6] NP means nonplastic.

[7] 100 percent passed the 2-inch sieve.

deposited by the glacier. Well-drained soils formed under dominantly cool-season, drought-resistant grasses. Tall, warm-season grasses grow where the soils receive extra moisture.

Plant roots loosen the soil material and bring minerals from the parent material upward toward the surface. As the plants die and decay, they contribute organic matter, which bacteria and other microorganisms help to decompose. Thus, nutrients leached out of the surface layer are replaced, and a good supply is maintained for the growth of other plants.

The activity of animals seems to be of less importance to soil formation in this survey area than the growth of plants. Earthworms and burrowing animals help to mix the soil materials from various horizons and bring some fresh parent material to the surface layer. Man's activities, particularly in altering drainage conditions, maintaining fertility, and changing the kinds of vegetation, will have an important effect on the rate and direction of soil formation in the future.

Relief

Relief influences the formation of soils through its effect on runoff and drainage. If other soil-forming factors are equal, relief largely determines the degree of profile development, mainly because it controls the amount of moisture in the soil. Because of excessive drainage, the more sloping and coarser textured soils have only a little water in them and the vegetation is sparse; consequently, profile development is slow. Among the soils affected in this way are Buse and Sioux soils. In areas of poorly drained soils, such as

Parnell and Ludden soils, excessive water disturbs the process of soil formation.

Time

Time is necessary for the factors of soil formation to act on parent material. Generally, length of time determines whether the soil has reached an equilibrium with its environment.

The degree of profile development in most of the soils in the survey area has been affected more by differences in the other soil-forming factors than by differences in the length of time, because, except for the Lamoure, La Prairie, Lallie, Minnewaukan, and LaDelle soils, the length of time has been about the same. In terms of geologic time, the soils are young because they formed from materials deposited in late Pleistocene time, which ended about 11,000 years ago.

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 the soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; 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.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (*7, 9*). Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*5*).

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 genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 10, the soil series of the survey area are placed in categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is subdivided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth, soil climate, the accumulation of clay, iron, or organic carbon in the upper solum, cracking of soils caused by a decrease in soil moisture, and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu,* meaning water or wet, and *oll,* from Mollisol).

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil compaction, and soil color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Haplaquoll* (*Hapl,* meaning simple horizons, *aqu,* for wetness or water, and *oll,* from Mollisol).

SUBGROUP. Great groups are subdivided 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. Other subgroups may have soil properties unlike those 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. An example is *Typic Haplaquolls* (a typical Haplaquoll).

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 10). An example is the coarse-loamy, mixed, frigid family of Typic Haplaquolls.

Environmental Factors Affecting Soil Use

The first settlers came to the area that is now Eddy County in 1882. They raised livestock and produced grain. The population increased rapidly, particularly between 1890 and 1900, reached a peak in 1930, and gradually declined after 1930. For Eddy County, it was 6,341 in 1930 and 4,103 in 1970. For the parts of Benson and Nelson Counties in this survey area, population figures are not available.

The number of farms and ranches in Eddy County is about 445. The number for those in the parts of the survey area that are in Benson and Nelson Counties is not available.

Supplying transportation in this survey area are railroads, one U.S. Highway, three State Highways,

TABLE 10.—*Soil series classified according to the current system of classification*

[Classification as of April 1973]

Series	Family	Subgroup	Order
Aberdeen [1]	Fine, montmorillonitic	Glossic Udic Natriborolls	Mollisols.
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Arvilla	Sandy, mixed	Udic Haploborolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Bearden [1]	Fine-silty, frigid	Aeric Calciaquolls	Mollisols.
Binford	Sandy, mixed	Udic Haploborolls	Mollisols.
Borup [1]	Coarse-silty, frigid	Typic Calciaquolls	Mollisols.
Brantford	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Cathay	Fine-loamy, mixed	Glossic Udic Natriborolls	Mollisols.
Cavour	Fine, mixed	Udic Natriborolls	Mollisols.
Cavour variant	Fine, mixed	Udic Natriborolls	Mollisols.
Claire	Mixed, frigid	Typic Udipsamments	Entisols.
Clontarf	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Coe	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Cresbard	Fine, mixed	Glossic Udic Natriborolls	Mollisols.
Dickey	Sandy over loamy, mixed	Udic Haploborolls	Mollisols.
Divide	Fine-loamy over sandy or sandy-skeletal, frigid	Aeric Calciaquolls	Mollisols.
Eckman	Coarse-silty, mixed	Udic Haploborolls	Mollisols.
Edgeley	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Edgeley variant	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Egeland	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Emrick	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Esmond	Coarse-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Exline	Fine, montmorillonitic	Leptic Natriborolls	Mollisols.
Fargo	Fine, montmorillonitic, frigid	Vertic Haplaquolls	Mollisols.
Fordville	Fine-loamy over sandy or sandy-skeletal, mixed	Pachic Udic Haploborolls	Mollisols.
Fossum	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Fram	Coarse-loamy, frigid	Aeric Calciaquolls	Mollisols.
Gardena	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Glyndon	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Hamar [1]	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Hamerly	Fine-loamy, frigid	Aeric Calciaquolls	Mollisols.
Hecla	Sandy, mixed	Udic Haploborolls	Mollisols.
Heimdal	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
Kensal	Fine-loamy over sandy or sandy-skeletal, mixed	Aquic Haploborolls	Mollisols.
Kloten	Loamy, mixed	Lithic Haploborolls	Mollisols.
Kratka	Sandy over loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
LaDelle	Fine-silty, mixed	Cumulic Udic Haploborolls	Mollisols.
Lallie	Fine, montmorillonitic (calcareous), frigid	Typic Fluvaquents	Entisols.
Lamoure	Fine-silty, mixed (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
La Prairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols.
Larson	Fine-loamy, mixed	Udic Natriborolls	Mollisols.
Lemert	Coarse-loamy, mixed	Leptic Natriborolls	Mollisols.
Letcher	Coarse-loamy, mixed	Udic Natriborolls	Mollisols.
Lohnes	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Ludden	Fine, montmorillonitic (calcareous), frigid	Vertic Haplaquolls	Mollisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Marysland	Fine-loamy over sandy or sandy-skeletal, frigid	Typic Calciaquolls	Mollisols.
Minnewaukan	Mixed, frigid	Typic Psammaquents	Entisols.
Miranda	Fine-loamy, mixed	Leptic Natriborolls	Mollisols.
Nutley	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Osakis	Sandy, mixed	Aquic Haploborolls	Mollisols.
Overly	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Parnell	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Perella [1]	Fine-silty, mixed, frigid	Typic Haplaquolls	Mollisols.
Rauville [1]	Fine-silty, mixed (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Ryan	Fine, montmorillonitic, frigid	Typic Natraquolls	Mollisols.
Serden	Mixed, frigid	Typic Udipsamments	Entisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Spottswood	Fine-loamy over sandy or sandy-skeletal, mixed	Pachic Udic Haploborolls	Mollisols.
Stirum	Coarse-loamy, mixed, frigid	Typic Natraquolls	Mollisols.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Svea variant	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Tolna	Fine-loamy over sandy or sandy-skeletal, mixed	Aquic Haploborolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Totten	Fine-loamy over sandy or sandy-skeletal, mixed, frigid	Typic Natraquolls	Mollisols.

TABLE 10.—*Soil series classified according to the current system of classification*—Continued

[Classification as of April 1973]

Series	Family	Subgroup	Order
Towner	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Vallers	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Vang	Fine-loamy over sandy or sandy-skeletal, mixed	Pachic Udic Haploborolls	Mollisols.
Venlo	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Wahpeton	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Walsh	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Walum	Sandy, mixed	Aquic Haploborolls	Mollisols.
Warsing	Fine-loamy over sandy or sandy-skeletal, mixed	Aquic Haploborolls	Mollisols.
Wyard	Fine-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Wyndmere	Coarse-loamy, frigid	Aeric Calciaquolls	Mollisols.
Wyrene	Sandy, frigid	Aeric Calciaquolls	Mollisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

[1] All or part of these soils are taxadjuncts. The reasons for excluding them from the series with which they are here identified are as follows:

Aberdeen, Bearden, Borup, Perella, and Rauville soils have a higher content of sand than is defined for their series.

Hamar loamy coarse sand and Hamar coarse sandy loam have a higher content of coarse sand than is defined for the series.

and numerous county roads. The railroads were important in the early development of this area, and they now serve communities in the southwestern part of Eddy County and in the parts of Benson and Nelson Counties that are in this survey area. Most of the county roads are graveled or paved and are well maintained.

Physiography, Relief, and Drainage

This survey area is nearly level to steep and in most areas has short irregular slopes, but in the Sheyenne River Valley the side slopes are sloping to steep and 400 to 800 feet long. The slopes are uniform except where drainageways enter the valley.

In the smooth areas of outwash and ground moraine the slopes are generally less than 4 percent, but in the pitted and dissected areas of outwash and recessional moraines, they range from less than 4 to 30 percent. Relief ranges from less than 5 feet to about 160 feet within the survey area, but not including the Sheyenne River Valley.

The elevation in the survey area ranges from about 1,420 feet on the flood plain of the Sheyenne River in the northwest corner of Eddy County to about 1,370 feet downstream near the eastern boundary of the survey area. It is 1,680 feet at a high point of the Continental Divide north of New Rockford, about 1,520 feet at New Rockford, and 1,470 feet at Hamar.

The Continental Divide runs through the southwestern part of Eddy County. It separates the watershed of the James River, which flows into the Missouri River, from that of the Sheyenne River, which flows into the Red River of the North. The James River is not so deeply entrenched as the Sheyenne River, which flows in a channel about 10 to 30 feet deep.

The drainage pattern is not well developed in most of the survey area. Much of the runoff collects in depressions. Consequently there is little runoff from most areas until water fills the depressions and overflows into the poorly developed drainageways. As a result, the Sheyenne and James Rivers carry less water than is normal for the size of their watersheds. Rocky Run and Robinson Coulee also provide outlets for runoff. Numerous shallow salt lakes are in the survey area. The north edge of the area borders on Stump Lake and East Devils Lake, remnants of old glacial Lake Minnewaukan.

Water Supply

Wells are the main source of water for domestic use on farms and in most communities. The water comes from gravel and sand aquifers within the glacial material. The wells generally are less than 100 feet deep, but many are less than 15 feet deep and some are more than 200 feet deep. A few deep wells penetrate bedrock, and water is obtained from the Pierre Formation and from the sand of the Dakota Formation, but the quality of the water is poor (*2*). A few flowing wells are in the southwestern corner of Eddy County, but most of this water is not suitable for domestic use.

Local sources of ground water generally are sufficient for domestic use, but some farmers have to truck water to their farms. New Rockford obtains water from wells drilled in the Heimdal aquifer, and Devils Lake is supplied by wells drilled near Hamar.

Farm wells generally are adequate for domestic use, but the supply may not be adequate for livestock. Consequently, dugouts where the soils are shallow to ground water, and natural sloughs are used to water livestock on many farms. Springs have been developed to supply water on some farms.

Climate [7]

The climate of Eddy County is marked by large annual and day-to-day ranges of temperature. The relative humidity is moderate, and rainfall is light and irregular. Most of the precipitation falls during spring and summer. Local flooding along the Sheyenne River

[7] By MORTON BAILEY, climatologist for North Dakota, National Weather Service, U.S. Department of Commerce.

and headwaters of the James River is minor. Summers are warm, and winters are long and cold.

Table 11 shows temperature and precipitation, based on records kept at McHenry; table 12 shows the probability of low temperatures on specified dates; and table 13 shows the probability of receiving specified amounts of precipitation during various periods of the growing season, based on records kept at Napoleon. The probabilities for Napoleon should be representative for Eddy County.

Frontal passages occur throughout the year, and they are occasionally accompanied by large and rapid fluctuations in temperature. Cold fronts sometimes lower the temperature by as much as 40 degrees or 50 degrees within a 24-hour period. The daily range in temperature averages about 20 degrees in winter and 27 degrees in midsummer. In an average year, the maximum temperature is 90° F or higher on about 11 days, mostly during July and August. Temperatures above 100° occur in only about 1 year in 3 and are of short duration. The minimum temperature is 32° or below on about 200 days each year and is zero or below zero on about 60 days each year.

The average length of the freeze-free period is about 120 days (*3*). No time of the year can be considered absolutely frost free or freeze free. Freezing temperatures have occurred in every month, except July when a minimum of 35° has been recorded.

Average annual precipitation for the period 1941–70 was 17.70 inches at McHenry, and surrounding stations indicate that only slightly less was received in other parts of the survey area. Yearly precipitation varies widely, however, and at McHenry annual rainfall has ranged from 11.08 inches to 26.63 inches. Normally, 0.10 inch or more on about 10 days. On the average in at least 1 year out of 5 (*4*), the following amounts of rainfall can be expected: 1.2 inches in 30 minutes, 1.5 inches in 1 hour, 1.8 inches in 3 hours, 2.2 inches in 6 hours, 2.5 inches in 12 hours, and 2.8 inches in 24 hours.

Average seasonal snowfall is about 28 inches. Since 1937–38, average winter snowfall at McHenry has ranged from 11.2 to 47.8 inches. Four or five inches of snow is the average amount for November through March when snowfall is heaviest. In April, snowfall averages nearly 3 inches, but yearly amounts vary considerably. In about 1 year in 5, 1 inch or more of snow falls in May and October. Blizzards occur nearly every year, and restricted visibility because of blowing snow occurs several times each winter.

Thunderstorms occur in the area on an average of about 30 days per year. Hail occurs on about 2 days each year in any part of the survey area, and most hailstorms occur in June and July.

The annual evaporation from class A pans averages about 40 inches in the northeastern part of the survey area and 42 inches in the southwestern part. About 85 percent of the evaporation takes place in the period May to October. The annual evaporation from lakes is 30 inches.

Eddy County receives 59 percent of the possible annual sunshine. July, averaging 71 percent of the possible sunshine, is the sunniest month; November and December, averaging only 44 percent and 45 percent of the possible sunshine, are the cloudiest.

The prevailing wind direction in Eddy County is

TABLE 11.—*Temperature and precipitation*

[All data from McHenry, Eddy County]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average monthly total	One year in 10 will have—		Days with snow cover	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		Inches
January	14	−6	36	−28	0.46	0.10	0.94	28	8
February	19	−2	37	−24	.37	.09	.75	27	10
March	31	11	54	−12	.71	.12	1.53	22	11
April	52	28	72	14	1.25	.31	2.48	6	5
May	66	39	83	26	2.24	.88	3.89	(1)	
June	74	49	87	38	3.47	1.76	5.45	0	
July	81	55	92	45	2.67	1.19	4.43	0	
August	80	53	94	42	2.44	.70	4.67	0	
September	69	42	88	27	2.01	.60	3.79	0	
October	57	32	73	19	1.09	.15	2.43	1	(1)
November	35	16	57	− 6	.53	.09	1.13	7	2
December	22	2	40	−20	.46	.10	.93	25	5
Year	50	26	[2] 98	[3] −33	17.70	12.62	23.25	116	8

[1] Less than half a day.

[2] Average annual highest temperature.

[3] Average annual lowest temperature.

TABLE 12.—*Probability of low temperatures in spring and fall*

[All data from McHenry, Eddy County]

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
Spring:					
1 year in 10 later than	May 4	May 13	May 22	May 30	June 11
2 years in 10 later than	April 28	May 8	May 16	May 25	June 6
5 years in 10 later than	April 17	April 27	May 6	May 16	May 28
Fall:					
1 year in 10 earlier than	October 6	September 27	September 13	September 8	September 7
2 years in 10 earlier than	October 12	October 3	September 19	September 12	September 7
5 years in 10 earlier than	October 23	October 14	September 29	September 21	September 15

TABLE 13.—*Probability of receiving specified amounts of precipitation during three periods of the growing season*

[The symbol < means less than]

Period	Probability of receiving—						
	4 inches or less	More than—					
		4 inches	6 inches	8 inches	10 inches	12 inches	14 inches
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
77-day period:							
March 15–May 30	50	50	15	----------	----------	<10	----------
March 22–June 6	40	60	25	----------	----------	<10	----------
March 29–June 13	30	70	35	15	----------	<10	----------
April 5–June 20	20	80	45	20	----------	<10	----------
April 12–June 27	15	85	55	25	----------	<10	----------
April 19–July 4	10	90	60	30	10	<10	----------
April 26–July 11	10	90	60	30	10	<10	----------
May 3–July 18	10	90	60	30	15	<10	----------
May 10–July 25	5	95	65	35	15	<10	----------
May 17–August 1	5	95	70	35	15	<10	----------
May 24–August 8	10	90	65	35	15	<10	----------
May 31–August 15	10	90	65	30	10	<10	----------
June 7–August 22	10	90	60	30	----------	----------	----------
June 14–August 29	15	85	50	20	----------	----------	----------
91-day period:							
March 15–June 13	20	80	45	20	----------	----------	<10
March 22–June 20	15	85	50	25	----------	----------	<10
March 29–June 27	10	90	65	30	10	----------	<10
April 5–July 4	5	95	70	40	15	----------	<10
April 12–July 11	5	95	75	45	20	----------	<10
April 19–July 18	5	95	80	50	25	----------	<10
April 26–July 25	5	95	80	50	25	----------	<10
May 3–August 1	5	95	80	50	25	10	<10
May 10–August 8	5	95	80	50	25	10	<10
May 17–August 15	5	95	80	50	20	----------	<10
May 24–August 22	5	95	80	50	25	10	<10
May 31–August 29	5	95	80	50	25	10	<10
June 7–September 5	5	95	70	40	20	----------	<10
June 14–September 12	5	95	70	35	15	----------	<10
119-day period:							
April 26–August 22	1	99	95	75	50	25	10
May 3–August 29	1	99	95	75	50	25	10
May 10–September 5	1	99	95	75	50	30	10
May 17–September 12	1	99	95	75	50	25	10
May 24–September 19	1	99	90	70	45	25	10
May 31–September 26	1	99	90	70	40	20	<10

northwesterly from September through May and southeasterly during June, July, and August. Wind directions are quite variable, however, and the wind blows from each direction part of the time during each month. Wind speeds are also quite variable, and periods of strong wind are followed by relative calm. April is the windiest month, during which the average wind speed is about 12 miles per hour. Wind speeds generally are strongest in early afternoon.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms are called peds. Clods are aggregates produced by tillage or logging.

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

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.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

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.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice; the deposits are stratified and occur in the form of kames, eskers, deltas, and outwash plains.

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 resides.

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.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types are these: Terminal, lateral, medial, ground.

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.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

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

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter 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.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

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.

Slope. The incline of the surface of the soil. The summit is the top of the land form. A shoulder is the convexly rounded part of the slope between the summit and the backslope. Backslope is the linear part of the slope between the shoulder and foot slope. Foot slope is the concave part of the slope between the backslope and toe slope that is partly erosional and partly depositional. Toe slope is the part of the slope commonly formed on depositional debris that extends from the base of the slope.

Stone line. A concentration of coarse rock fragments in soils that generally represents an old weathering surface. In a cross section, the line may be one stone or more thick. The line generally overlies material that weathered in place, and is ordinarily overlain by sediment of variable thickness.

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 either *single grain* (each grain by itself, as in dune sand) or *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.

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."

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.

Varves. Distinctly marked annual deposits of sediments, regardless of their origin.

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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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, page 14.
Predicted average yields, table 2, page 120.
Soil interpretations for wildlife, table 4, page 131.
Soil interpretations for recreation, table 5, page 136.
Engineering uses of the soils, tables 6, 7, 8, and 9, pages 144 through 195.

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ab	Aberdeen loam	18	IIIs-6P	113	4	128
Ae	Aberdeen-Exline loams	18	IVs-6P	116	--	---
	Aberdeen part	--	---	---	4	128
	Exline part	--	---	---	9	129
Ar	Arveson sandy loam	19	IIIw-3	110	2	128
As	Arvilla sandy loam	19	IIIes-3	109	6	129
AtA	Arvilla sandy loam, gravelly substratum, 0 to 3 percent slopes	19	IIIes-3	109	6	129
AtB	Arvilla sandy loam, gravelly substratum, 3 to 6 percent slopes	20	IIIes-3	109	6	129
AvA	Arvilla sandy loam, sandy substratum, 0 to 3 percent slopes	20	IIIes-3	109	6	129
AvB	Arvilla sandy loam, sandy substratum, 3 to 6 percent slopes	20	IIIes-3	109	6	129
AxC	Arvilla-Sioux sandy loams, 6 to 9 percent slopes	20	IVes-3	115	--	---
	Arvilla part	--	---	---	6	129
	Sioux part	--	---	---	10	130
BaA	Barnes loam, 0 to 3 percent slopes	21	IIc-6	108	3	128
BaB	Barnes loam, 3 to 6 percent slopes	21	IIe-6	106	3	128
BaC	Barnes loam, 6 to 9 percent slopes	21	IIIe-6	109	3	128
BbA	Barnes-Svea loams, 0 to 3 percent slopes	22	IIc-6	108	--	---
	Barnes part	--	---	---	3	128
	Svea part	--	---	---	1	127
BbB	Barnes-Svea loams, 3 to 6 percent slopes	22	IIe-6	106	--	---
	Barnes part	--	---	---	3	128
	Svea part	--	---	---	1	127
BcB	Barnes-Svea stony loams, 3 to 6 percent slopes	22	VIIs-8	119	10	130
BdC	Barnes-Svea-Buse loams, 6 to 9 percent slopes	22	IIIe-6	109	--	---
	Barnes part	--	---	---	3	128
	Svea part	--	---	---	3	128
	Buse part	--	---	---	10	130
BeC	Barnes-Svea-Buse stony loams, 6 to 9 percent slopes	22	VIIs-8	119	10	130
Bg	Bearden silt loam, saline	23	IIIws-4L	111	10	130
Bh	Binford sandy loam	24	IIIes-3	109	6	129
BkA	Binford sandy loam, gravelly substratum, 0 to 3 percent slopes	24	IIIes-3	109	6	129
BkB	Binford sandy loam, gravelly substratum, 3 to 6 percent slopes	24	IIIes-3	109	6	129
BlA	Binford sandy loam, sandy substratum, 0 to 3 percent slopes	24	IIIes-3	109	6	129
BlB	Binford sandy loam, sandy substratum, 3 to 6 percent slopes	24	IIIes-3	109	6	129
BmC	Binford-Coe sandy loams, 6 to 9 percent slopes	25	IVes-3	115	--	---
	Binford part	--	---	---	6	129
	Coe part	--	---	---	10	130
BmD	Binford-Coe sandy loams, 9 to 12 percent slopes	25	VIs-3	118	10	130
Bn	Borup silt loam	26	IIw-4L	107	2	128
Bo	Borup and Marysland silt loams, very wet	26	Vw-8	117	10	130
BpB	Borup and Vallers loams, 3 to 6 percent slopes	26	Vw-8	117	2	128
BrB	Brantford loam, 3 to 6 percent slopes	27	IIIes-5	110	6	129
BsA	Brantford loam, gravelly substratum, 0 to 3 percent slopes	27	IIIs-5	112	6	129
BsB	Brantford loam, gravelly substratum, 3 to 6 percent slopes	27	IIIes-5	110	6	129
BtA	Brantford loam, sandy substratum, 0 to 3 percent slopes	27	IIIs-5	112	6	129
BtB	Brantford loam, sandy substratum, 3 to 6 percent slopes	28	IIIes-5	110	6	129

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
BuC	Brantford-Coe loams, 6 to 9 percent slopes	28	IIIes-5	110	--	---
	Brantford part	--	---	---	6	129
	Coe part	--	---	---	10	130
Bv	Brantford-Kensal loams	28	IIIs-5	112	--	---
	Brantford part	--	---	---	6	129
	Kensal part	--	---	---	1	127
BwE	Buse-Barnes loams, 9 to 30 percent slopes	29	VIe-6	117	8	129
BxD	Buse-Edgeley loams, 9 to 30 percent slopes	29	VIe-6	117	8	129
ByE	Buse and Kloten loams, 6 to 25 percent slopes	29	VIe-6	117	--	---
	Buse part	--	---	---	8	129
	Kloten part	--	---	---	10	130
BzD	Buse, Sioux, and Zell soils, 3 to 30 percent slopes	30	VIe-6	117	--	---
	Buse part	--	---	---	8	129
	Sioux part	--	---	---	10	130
	Zell part	--	---	---	8	129
Ca	Cathay loam	30	IIIs-5P	112	4	128
ChA	Cathay-Heimdal loams, 0 to 3 percent slopes	31	IIIs-5P	112	--	---
	Cathay part	--	---	---	4	128
	Heimdal part	--	---	---	3	128
ChB	Cathay-Heimdal loams, 3 to 6 percent slopes	31	IIIs-5P	112	--	---
	Cathay part	--	---	---	4	128
	Heimdal part	--	---	---	3	128
Cm	Cathay-Larson loams	31	IVs-6P	116	--	---
	Cathay part	--	---	---	4	128
	Larson part	--	---	---	9	129
Cn	Cavour-Cresbard loams	32	IVs-6P	116	--	---
	Cavour part	--	---	---	9	129
	Cresbard part	--	---	---	4	128
Co	Cavour and Vallers stony clay loams	32	VIIsw-8	119	10	130
CpB	Cavour clay loam, shaly variant, 3 to 6 percent slopes	33	VIs-6P	119	9	129
CrA	Claire loamy coarse sand, 0 to 3 percent slopes	34	VIes-2	118	10	130
CrB	Claire loamy coarse sand, 3 to 6 percent slopes	34	VIes-2	118	10	130
Cs	Claire coarse sandy loam	34	IVe-3	114	10	130
Ct	Claire-Lohnes-Hamar loamy coarse sands	34	VIes-2	118	--	---
	Claire part	--	---	---	10	130
	Lohnes part	--	---	---	7	129
	Hamar part	--	---	---	2	128
Cu	Clontarf sandy loam	35	IIIe-3	108	1	127
CvB	Coe sandy loam, 0 to 6 percent slopes	36	VIs-3	118	10	130
CvD	Coe sandy loam, 6 to 25 percent slopes	36	VIIs-3	119	10	130
Cw	Colvin silty clay loam	37	IIw-4L	107	2	128
Cx	Colvin silty clay loam, saline	37	IIIws-4L	111	10	130
Cy	Colvin silty clay loam, very wet	37	Vw-8	117	10	130
Cz	Cresbard-Cavour loams	38	IIIs-6P	113	--	---
	Cresbard part	--	---	---	4	128
	Cavour part	--	---	---	9	129
DvA	Divide loam, 0 to 3 percent slopes	40	IIIs-4L	112	1	127
DvB	Divide loam, 3 to 6 percent slopes	40	IIIs-4L	112	1	127
Dw	Divide loam, saline	40	IIIws-4L	111	10	130
Dx	Divide loam, gravelly substratum	40	IIIs-4L	112	1	127
Dy	Divide loam, sandy substratum	41	IIIs-4L	112	1	127
Dz	Divide loam, till substratum	41	IIIs-4L	112	1	127
EaA	Eckman loam, 0 to 3 percent slopes	42	IIe-5	106	3	128
EaB	Eckman loam, 3 to 8 percent slopes	42	IIe-5	106	3	128
Eb	Edgeley loam	42	IIc-6	108	3	128
EcB	Edgeley and Cavour loams, 3 to 6 percent slopes	42	IIIs-6P	113	--	---
	Edgeley part	--	---	---	3	128
	Cavour part	--	---	---	9	129

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ed	Edgeley loam, gravelly variant	43	IIIs-6	113	3	128
EeA	Egeland sandy loam, 0 to 3 percent slopes	44	IIIe-3	108	5	128
EeC	Egeland sandy loam, 6 to 12 percent slopes	44	IVe-3	114	5	128
Eg	Egeland sandy loam, sandy substratum	44	IIIe-3	108	5	128
EhA	Egeland fine sandy loam, till substratum, 0 to 3 percent slopes	44	IIIe-3M	109	5	128
EhB	Egeland fine sandy loam, till substratum, 3 to 6 percent slopes	44	IIIe-3M	109	5	128
EmC	Egeland-Embden sandy loams, till substratum, 6 to 9 percent slopes	45	IVe-3M	114	5	128
EnA	Embden sandy loam, 0 to 3 percent slopes	45	IIIe-3	108	1	127
EoB	Embden-Egeland sandy loams, 3 to 6 percent slopes	45	IIIe-3	108	--	---
	Embden part	--	---	---	1	127
	Egeland part	--	---	---	5	128
EsA	Embden, Swenoda, and Heimdal fine sandy loams, 0 to 3 percent slopes	46	IIIe-3M	109	--	---
	Embden part	--	---	---	1	127
	Swenoda part	--	---	---	1	127
	Heimdal part	--	---	---	3	128
EsB	Embden, Swenoda, and Heimdal fine sandy loams, 3 to 6 percent slopes	46	IIIe-3M	109	--	---
	Embden part	--	---	---	1	127
	Swenoda part	--	---	---	1	127
	Heimdal part	--	---	---	3	128
Et	Emrick sandy loam	47	IIIe-3M	109	1	127
Eu	Emrick loam	47	IIe-5	106	1	127
EvD	Esmond, Coe, and Embden soils, 6 to 25 percent slopes	47	VIe-6	117	--	---
	Esmond part	--	---	---	8	129
	Coe part	--	---	---	10	130
	Embden part	--	---	---	5	128
Ew	Exline loam	49	VIw-4	118	9	129
Fa	Fargo and Nutley silty clay loams	49	IIs-4	108	--	---
	Fargo part	--	---	---	1	127
	Nutley part	--	---	---	4	128
Fd	Fordville loam	50	IIIs-6	113	3	128
Fm	Fossum sandy loam	51	IIIw-3	110	2	128
Fo	Fossum loam	51	IIIw-5	111	2	128
Fp	Fossum and Hamar sandy loams	51	IIIw-3	110	2	128
FrA	Fram loam, 0 to 3 percent slopes	52	IIes-4L	107	1	127
FrB	Fram loam, 3 to 6 percent slopes	52	IIes-4L	107	1	127
Fs	Fram loam, saline	52	IIIws-4L	111	10	130
Fw	Fram and Wyndmere fine sandy loams	52	IIIs-3	112	1	127
GaA	Gardena loam, 0 to 3 percent slopes	53	IIe-5	106	1	127
GaB	Gardena loam, 3 to 6 percent slopes	53	IIe-5	106	1	127
Gd	Glyndon loam	54	IIes-4L	107	1	127
Ge	Glyndon loam, saline	54	IIIws-4L	111	10	130
Gp	Gravel pit	54	---	---	10	130
Ha	Hamar loamy coarse sand	55	IVw-2	115	2	128
Hb	Hamar loamy sand	55	IVw-2	115	2	128
Hc	Hamar coarse sandy loam	55	IIIw-3	110	2	128
Hd	Hamar sandy loam	55	IIIw-3	110	2	128
HeA	Hamerly loam, 0 to 3 percent slopes	56	IIes-4L	107	1	127
HeB	Hamerly loam, 3 to 6 percent slopes	56	IIes-4L	107	1	127
Hf	Hamerly loam, saline	56	IIIws-4L	111	10	130
HgA	Hamerly-Svea loams, 0 to 3 percent slopes	56	IIes-4L	107	1	127
HgB	Hamerly-Svea loams, 3 to 6 percent slopes	56	IIes-4L	107	1	127
HhA	Hecla loamy sand, 0 to 3 percent slopes	57	IVe-2	114	1	127

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
HhB	Hecla loamy sand, 3 to 6 percent slopes	57	IVe-2	114	1	127
HkA	Hecla sandy loam, 0 to 3 percent slopes	57	IIIe-3	108	1	127
HkB	Hecla sandy loam, 3 to 6 percent slopes	58	IIIe-3	108	1	127
HlB	Hecla-Dickey fine sandy loams, 3 to 6 percent slopes	58	IIIe-3M	109	--	---
	Hecla part	--	---	---	1	127
	Dickey part	--	---	---	5	128
Hm	Hecla-Hamar loamy sands	58	IVe-2	114	--	---
	Hecla part	--	---	---	1	127
	Hamar part	--	---	---	2	128
HnA	Hecla-Maddock loamy sands, 0 to 3 percent slopes	58	IVe-2	114	--	---
	Hecla part	--	---	---	1	127
	Maddock part	--	---	---	5	128
HnB	Hecla-Maddock loamy sands, 3 to 6 percent slopes	58	IVe-2	114	--	---
	Hecla part	--	---	---	1	127
	Maddock part	--	---	---	5	128
HoA	Heimdal sandy loam, 0 to 3 percent slopes	59	IIIe-3M	109	3	128
HoB	Heimdal sandy loam, 3 to 6 percent slopes	59	IIIe-3M	109	3	128
HoC	Heimdal sandy loam, 6 to 9 percent slopes	59	IVe-3M	114	3	128
HpA	Heimdal loam, 0 to 3 percent slopes	60	IIe-5	106	3	128
HpB	Heimdal loam, 3 to 6 percent slopes	60	IIe-5	106	3	128
HpC	Heimdal loam, 6 to 9 percent slopes	60	IIIe-5	109	3	128
HrD	Heimdal-Embden fine sandy loams, 9 to 15 percent slopes	60	IVe-3M	114	--	---
	Heimdal part	--	---	---	3	128
	Embden part	--	---	---	5	128
HrE	Heimdal-Embden fine sandy loams, 15 to 25 percent slopes	60	VIe-3	117	--	---
	Heimdal part	--	---	---	8	129
	Embden part	--	---	---	5	128
HsA	Heimdal-Emrick loams, 0 to 3 percent slopes	60	IIe-5	106	--	---
	Heimdal part	--	---	---	3	128
	Emrick part	--	---	---	1	127
HsB	Heimdal-Emrick loams, 3 to 6 percent slopes	61	IIe-5	106	--	---
	Heimdal part	--	---	---	3	128
	Emrick part	--	---	---	1	127
HtC	Heimdal-Emrick-Esmond loams, 3 to 9 percent slopes	61	IIIe-5	109	--	---
	Heimdal part	--	---	---	3	128
	Emrick part	--	---	---	3	128
	Esmond part	--	---	---	8	129
HtD	Heimdal-Emrick-Esmond loams, 9 to 15 percent slopes	61	IVe-5	114	--	---
	Heimdal part	--	---	---	3	128
	Emrick part	--	---	---	3	128
	Esmond part	--	---	---	8	129
HtE	Heimdal-Emrick-Esmond loams, 15 to 25 percent slopes	61	VIe-5	117	--	---
	Heimdal part	--	---	---	8	129
	Emrick part	--	---	---	3	128
	Esmond part	--	---	---	8	129
Ke	Kensal loam	62	IIIs-5	112	1	127
Kf	Kensal loam, sandy substratum	62	IIIs-5	112	1	127
KoE	Kloten loam, 9 to 30 percent slopes	63	VIes-5	118	10	130
KsE	Kloten, Sioux, and Edgeley soils, 12 to 25 percent slopes	63	VIes-5	118	--	---
	Kloten part	--	---	---	10	130
	Sioux part	--	---	---	10	130
	Edgeley part	--	---	---	8	128
Kt	Kratka fine sandy loam	64	IIIw-3	110	2	128
La	LaDelle silty clay loam	64	IIc-6	108	1	127
Lb	Lallie silty clay loam	65	IVs-4L	116	10	130
Le	Lamoure silty clay loam	65	IIw-4L	107	2	128
Lm	Lamoure silty clay loam, saline	66	IIIws-4L	111	10	130

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ln	La Prairie silt loam	66	IIc-6	108	1	127
Lp	La Prairie-Lamoure complex	66	VIew-6	118	--	---
	La Prairie part	--	---	---	1	127
	Lamoure part	--	---	---	2	128
Lr	Larson loam	67	IVs-6P	116	9	129
Ls	Lemert sandy loam	68	VIw-4	118	9	129
Lt	Letcher sandy loam	69	IIIe-3P	109	9	129
Lu	Letcher sandy loam, till substratum	69	IIIe-3P	109	9	129
Lv	Lohnes loamy coarse sand	70	IVe-2	114	7	129
Lw	Lohnes coarse sandy loam	70	IIIe-3	108	7	129
Lx	Ludden silty clay	71	IIIw-4	110	1	127
Lz	Ludden-Lamoure complex	71	Vw-8	117	--	---
	Ludden part	--	---	---	1	127
	Lamoure part	--	---	---	2	128
MaA	Maddock loamy sand, 0 to 3 percent slopes	72	IVe-2	114	5	128
MaB	Maddock loamy sand, 3 to 6 percent slopes	72	IVe-2	114	5	128
MaC	Maddock loamy sand, 6 to 9 percent slopes	72	VIe-2	117	5	128
MbA	Maddock sandy loam, 0 to 3 percent slopes	72	IIIe-3	108	5	128
MbB	Maddock sandy loam, 3 to 6 percent slopes	73	IIIe-3	108	5	128
MbC	Maddock sandy loam, 6 to 9 percent slopes	73	IVe-3	114	5	128
MdB	Maddock-Dickey sandy loams, 0 to 6 percent slopes	73	IIIe-3M	109	5	128
MdC	Maddock-Dickey sandy loams, 6 to 9 percent slopes	73	IVe-3M	114	5	128
MeD	Maddock-Serden loamy fine sands, 9 to 30 percent slopes	73	VIe-2	117	--	---
	Maddock part	--	---	---	5	128
	Serden part	--	---	---	7	129
MfD	Maddock-Serden-Hecla loamy fine sands, 9 to 25 percent slopes	74	VIe-2	117	--	---
	Maddock part	--	---	---	5	128
	Serden part	--	---	---	7	129
	Hecla part	--	---	---	5	128
Mg	Made land	74	---	---	--	---
Mh	Marsh	74	Vw-8	117	10	130
Mm	Marysland loam	75	IIw-4L	107	2	128
Mn	Marysland and Arveson loams	75	IIw-4L	107	2	128
MwC	Minnewaukan loamy fine sand, 6 to 9 percent slopes	76	IVs-2	116	10	130
Mx	Miranda-Cavour clay loams	77	VIs-6P	119	9	129
Os	Osakis sandy loam	78	IIIes-3	109	1	127
Ot	Osakis sandy loam, gravelly substratum	78	IIIes-3	109	1	127
Ou	Osakis sandy loam, till substratum	78	IIIes-3	109	1	127
Ov	Overly silty clay loam	79	IIc-6	108	1	127
Pa	Parnell silty clay loam	80	IIIw-7	111	2	128
Pe	Peat	80	Vw-8	117	10	130
Pr	Perella silty clay loam	80	IIw-6	107	2	128
Ra	Rauville silty clay loam	81	Vw-8	117	10	130
ReA	Renshaw loam, 0 to 3 percent slopes	82	IIIs-6	113	6	129
ReB	Renshaw loam, 3 to 6 percent slopes	82	IIIes-6	110	6	129
Rn	Renshaw loam, gravelly substratum	82	IIIs-6	113	6	129
Rs	Renshaw loam, sandy substratum	83	IIIs-6	113	6	129
Rt	Renshaw loam, till substratum	83	IIIs-6	113	6	129
Ry	Ryan silty clay loam	83	IVs-6P	116	9	129
Rz	Ryan and Lamoure silty clay loams	84	VIw-4	118	--	---
	Ryan part	--	---	---	9	129
	Lamoure part	--	---	---	2	128
Se	Serden-Hamar sands	84	VIes-2	118	--	---
	Serden part	--	---	---	7	129
	Hamar part	--	---	---	2	128
SoB	Sioux gravelly loam, 0 to 6 percent slopes	85	VIIs-3	119	10	130

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
SoE	Sioux gravelly loam, 6 to 25 percent slopes	85	VIIs-3	119	10	130
Sp	Spottswood loam	86	IIIs-6	113	3	128
Sr	Spottswood loam, sandy substratum	86	IIIs-6	113	3	128
Ss	Stirum sandy loam	87	IVws-3	115	9	129
St	Svea loam	88	IIc-6	108	1	127
Su	Svea loam, cobbly variant	89	IIIs-6	113	1	127
SvA	Svea-Barnes loams, 0 to 3 percent slopes	88	IIc-6	108	--	---
	Svea part	--	---	---	1	127
	Barnes part	--	---	---	3	128
SvB	Svea-Barnes loams, 3 to 6 percent slopes	88	IIe-6	106	--	---
	Svea part	--	---	---	1	127
	Barnes part	--	---	---	3	128
SwC	Svea-Buse-Barnes loams, 6 to 9 percent slopes	88	IIIe-6	109	--	---
	Svea part	--	---	---	3	128
	Buse part	--	---	---	8	129
	Barnes part	--	---	---	3	128
Sx	Svea-Cresbard loams	88	IIIs-6P	113	--	---
	Svea part	--	---	---	1	127
	Cresbard part	--	---	---	4	128
Sz	Swenoda-Embden fine sandy loams	90	IIIe-3M	109	1	127
Tf	Tiffany sandy loam	91	IIIw-3	110	2	128
Tg	Tiffany fine sandy loam, till substratum	91	IIIw-3	110	2	128
Tn	Tolna loam	92	IIIw-6	111	2	128
To	Tonka silt loam	92	IIw-6	107	2	128
Ts	Totten sandy loam	93	IVws-3	115	9	129
Tt	Totten loam	94	IVws-6	115	9	129
Tu	Totten loam, very wet	94	Vw-8	117	10	130
Tv	Totten loam, till substratum	94	IVws-6	115	9	129
TwA	Towner fine sandy loam, 0 to 3 percent slopes	95	IIIe-3M	109	1	127
TwB	Towner fine sandy loam, 3 to 6 percent slopes	95	IIIe-3M	109	1	127
Tx	Towner-Dickey fine sandy loams	95	IIIe-3M	109	--	---
	Towner part	--	---	---	1	127
	Dickey part	--	---	---	5	128
Va	Vallers loam	96	IIw-4L	107	2	128
Vn	Vang loam	97	IIs-6	108	3	128
Vo	Venlo sandy loam	97	Vw-8	117	2	128
Wa	Wahpeton silty clay	98	IIs-4	108	1	127
WbB	Walsh loam, 3 to 6 percent slopes	99	IIe-6	106	1	127
WbC	Walsh loam, 6 to 9 percent slopes	99	IIIe-6	109	1	127
WcA	Walsh clay loam, 0 to 3 percent slopes	99	IIc-6	108	1	127
WcB	Walsh clay loam, 3 to 6 percent slopes	99	IIe-6	106	1	127
WcC	Walsh clay loam, 6 to 9 percent slopes	99	IIIe-6	109	1	127
Wd	Walum sandy loam	100	IIIes-3	109	1	127
We	Walum sandy loam, gravelly substratum	100	IIIes-3	109	1	127
Wf	Warsing loam	101	IIIs-6	113	1	127
Wg	Warsing loam, sandy substratum	101	IIIs-6	113	1	127
Wm	Warsing loam, till substratum	101	IIIs-6	113	1	127
Wn	Wyard loam	102	IIw-6	107	1	127
Wo	Wyndmere sandy loam	103	IIIs-3	112	1	127
Wp	Wyndmere sandy loam, till substratum	103	IIIs-3	112	1	127
Wr	Wyrene sandy loam	104	IIIs-3	112	1	127
Ws	Wyrene sandy loam, till substratum	104	IIIs-3	112	1	127
Wt	Wyrene-Totten sandy loams	104	IIIsw-3	113	--	---
	Wyrene part	--	---	---	1	127
	Totten part	--	---	---	9	129

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