SOIL SURVEY OF

Burleigh County, North Dakota

United States Department of Agriculture
Soil Conservation Service
in cooperation with
North Dakota Agricultural Experiment Station

Issued December 1974

Major fieldwork for this soil survey was done in the period 1956–64. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the South Burleigh Soil and Water Conservation District and the North Burleigh Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

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

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Soils and Engineering," 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 Burleigh County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

Cover: **Straw soils along Burnt Creek. Trees and brush are growing along the stream channel. Hayfields and cultivated fields are on the flood plain.**

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SOIL SURVEY OF BURLEIGH COUNTY, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

BURLEIGH COUNTY is in the south-central part of the State (fig. 1). It has a land area of 1,648 square miles, or about 1,054,720 acres. The Missouri River, flowing in a southerly to southeasterly direction, forms the western boundary. Bismarck, the county seat and State capital, is in the southwestern part of the county.

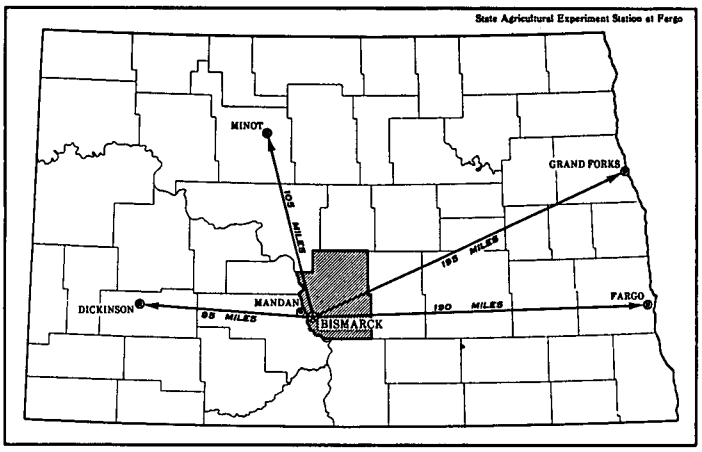

Figure 1.—**Location of Burleigh County in North Dakota.**

The county has a dry-subhumid, continental climate that is characterized by cold winters and warm summers. The physiography consists of glacial landforms, steep residual plains of several geologic formations, loess deposits, windblown sands, glaciafluvial deposits, and recent alluvial bottom lands. The county is drained by the Missouri River, Apple Creek, and Burnt Creek. Most of the runoff collects in depressions and does not reach the streams.

In 1964, about 97 percent of the land area was in farms, and about half was cultivated. Spring wheat, alfalfa, oats, flax, and corn silage are the principal crops. Feed crops, sugar beets, and potatoes are irrigated. The livestock are mainly beef cattle.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Burleigh County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

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

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

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases (*6*).[1] The name of a soil phase indicates a feature that affects management. For example, Williams loam, rolling, is one of several phases within the Williams series.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on

[1] Italic numbers in parentheses refer to Literature Cited, page 110.

such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

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

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Daglum-Belfield-Harriet complex 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." Arnegard and Grassna silt loams, level, 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. Riverwash is a land type in Burleigh County.

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

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

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

General Soil Map

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

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational areas, or community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The 13 soil associations in Burleigh County are described in the following pages.

1. Havrelon-Lohler-Banks association

Nearly level, moderately well drained and somewhat excessively drained, fine-textured to coarse-textured soils on bottom lands

This association is on bottom land of the Missouri River. It is mostly nearly level. There are a few short, gentle slopes on the edges of benches and along drainage channels.

This association occupies about 2 percent of the county. Havrelon soils make up about 70 percent of the association, Lohler soils about 11 percent, and Banks soils about 10 percent. Less extensive in this association are Lallie soils, which are in low areas, and Riverwash, which is adjacent to the river.

Havrelon soils, in the slightly higher lying areas, are mainly medium textured, moderately well drained, and calcareous. The surface layer is loam, silty clay loam, or very fine sandy loam. Underlying layers are silt loam and silty clay loam that contain thin lenses of coarser and finer textured material.

The level Lohler soils, in the lower lying areas, are mainly fine textured, moderately well drained, and calcareous. The surface layer is light brownish-gray silty clay, silty clay loam, or silt loam. The underlying material is mostly clay or silty clay.

Banks soils, in the higher lying areas, are mainly coarse textured and somewhat excessively drained. The surface layer is light brownish-gray loamy fine sand, fine sandy loam, or loam. Below this is loamy sand or sand.

Lallie soils are very poorly drained. Riverwash, which is near the river, is frequently flooded, and the water table is close to the surface.

Small grain, corn, and alfalfa grow well on most of this association. Fertility is low to medium, and the organic-matter content is low to moderate. Available water capacity is low to high. Major concerns in management are improving drainage and maintaining tilth and fertility.

More than half of this association is used for cultivated crops, and part of this is irrigated. The rest is wooded, brushy grassland that is used for grazing. The more heavily wooded areas are used mostly as wildlife habitat. Most farming is a combination livestock and small grain enterprise.

2. *Roseglen-Tansem-Savage association*

Nearly level to rolling, well-drained, mainly medium-textured soils on lake plains and terraces

This association is on a glacial lake plain. The soils are deep. Slopes are typically short, and changes in elevation are less than 20 feet.

This association occupies about 6 percent of the county. Roseglen and Tansem soils are about equally extensive and together make up about 40 percent of the association. Savage soil make up about 15 percent, Daglum and Belfield soils about 8 percent, and Lihen and Parshall soils about 7 percent. Temvik, Rhoades, Arnegard, Lehr, Straw, and Werner soils make up the rest.

Roseglen and Tansem soils have a surface layer of dark grayish-brown silt loam or loam that overlies grayish-brown or brown silt loam. Roseglen soils have a thicker surface layer than Tansem soils and occupy a lower position on the landscape.

Savage soils have a surface layer of dark-gray silt loam or silty clay loam that overlies dark-gray or dark grayish-brown silty clay loam or silty clay.

Belfield, Daglum, and Rhoades soils have a claypan. They are in swales and concave areas. The coarse textured and moderately coarse textured Lihen and Parshall soils occupy slightly higher lying convex slopes. The nearly level Temvik soils are in smooth areas mantled with silty material. Arnegard soils are on colluvial fans and in swales. Lehr soils are in smooth glacial outwash areas. Straw soils are on low terraces and bottom land along drainageways. Werner soils occupy the higher, steeper parts of the landscape.

Most of this association is well suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is medium to high, and the organic-matter content is moderate to high. Available water capacity is moderate to high. The main hazard is soil blowing.

More than 75 percent of this association is used for cultivated crops. Most of the farming is a cash crop or a combination cash crop and livestock enterprise.

3. *Heil-Rhoades association*

Level, poorly drained and moderately well drained, mainly fine-textured soils in lake basins and outwash channels

This association consists of deep, level soils that have a claypan. These soils formed in glacial lake and outwash material. Slopes are smooth except for slight microdepressions. Many of the lower lying areas and depressions are flooded for short periods.

This association occupies about 1 percent of the county. Heil soils make up about 35 percent of the association, Rhoades soils about 25 percent, and Savage soils about 20 percent. Tansem, Roseglen, Parshall, Daglum, and Belfield soils make up the rest.

Heil soils are in depressions and are poorly drained. Their surface layer typically is very dark gray or dark-gray silt loam about three-fourths of an inch thick. The subsoil is clay. It is black in the upper part and very dark gray in the lower part. It is underlain by olive, calcareous clay at a depth of about 20 inches.

Rhoades soils are on the outer edges of depressions, sloughs, and low-lying lake terraces. They are moderately well drained. Their surface layer is gray silt loam about one-fourth inch thick. The subsoil is dark grayish-brown silty clay loam about 6 inches thick. It is underlain by olive silty clay and silty clay loam that is calcareous and contains a large amount of salt in the upper part.

Savage soils have a surface layer of dark-gray silt loam about 8 inches thick. The subsoil is dark-gray silty clay. It is underlain by light olive-gray silty clay at a depth of about 26 inches.

Tansem, Roseglen, and Parshall soils are well drained. They occupy the higher parts of the landscape. Daglum and Belfield soils are in swales and narrow drainageways.

Small grain is the principal crop. Fertility is low to high, and the organic-matter content is moderate or high. Available water capacity is low to high. Major concerns of management are poor tilth and ponded water in depressions.

Only about 25 percent of this association is used for cultivated crops. The rest is in native grass. Most farming is a combination livestock and small grain enterprise. The wet depressions provide wildlife habitat.

4. *Parshall-Lihen-Flaxton association*

Nearly level to rolling, well-drained, mainly moderately coarse textured soils on outwash plains and sand-mantled uplands

This association consists of deep soils that formed in moderately coarse textured and coarse textured glacial outwash material. It is mainly nearly level to rolling but includes a few steeper areas.

This association occupies about 8 percent of the county. Parshall soils make up about 40 percent of the association, Lihen soils about 20 percent, and Flaxton soils about 10 percent. Livona, Harriet, Straw, and Rhoades soils make up the rest.

Parshall and Lihen soils are in lower lying, smooth, slightly concave positions. Parshall soils have a surface layer of very dark grayish-brown fine sandy loam that is underlain by very dark grayish-brown and dark grayish-brown, calcareous fine sandy loam. Lihen soils have a surface layer of dark-gray loamy fine sand or fine sandy loam. Below this is dark grayish-brown loamy fine sand that grades to olive-gray fine sand at a depth of about 34 inches.

Flaxton and Livona soils are in the higher lying, convex positions. Flaxton soils have a surface layer of very dark grayish-brown to grayish-brown fine sandy loam, about 22 inches thick, that is underlain by grayish-brown clay loam. Livona soils have a surface layer of dark grayish-brown fine sandy loam, about 8 inches thick, that is underlain by a light brownish-gray clay loam subsoil.

Straw, Harriet, and Rhoades soils are along the bottoms of shallow drainageways. They are finer textured than the other soils in this association.

Most of this association is suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is medium, and the organic-matter content is moderate to high. Available water capacity is

moderate. Major concerns in management are controlling soil blowing and maintaining tilth and fertility.

About 65 percent of this association is used for cultivated crops. Farming is mostly a small grain or a combination small grain and livestock enterprise.

5. *Telfer-Lihen-Seroco association*

Nearly level to hilly, well-drained and excessively drained, mainly coarse-textured soils on sand-mantled uplands

This association consists mainly of deep soils that formed in material deposited by wind. Slopes are typically short and complex. Scattered hummocks, dunes, and blowouts are common.

This association occupies about 4 percent of the county. Telfer soils make up about 35 percent of the association, Lihen soils about 35 percent, and Seroco soils about 10 percent. Flaxton, Livona, Arveson, Temvik, and Heil soils make up the rest.

Telfer soils occupy the higher lying, convex slopes. They are excessively drained. Their surface layer typically is dark grayish-brown loamy sand. It is underlain by grayish-brown and light olive-brown fine sand.

The well-drained Lihen soils are in lower lying, smooth, slightly concave positions. Their surface layer is dark-gray loamy fine sand. It is underlain by dark grayish-brown loamy fine sand that grades to olive-gray fine sand at a depth of about 34 inches.

The excessively drained Seroco soils are in the highest parts of the landscape. They have a surface layer of dark grayish-brown loamy sand that is underlain by light olive-brown fine sand.

The well-drained Flaxton and Livona soils occupy convex slopes. The nearly level to sloping Temvik soils are on smooth slopes and in areas that are mantled with silty material. The wet Arveson and Heil soils are in swales, depressions, and low concave areas.

Small grain and alfalfa are the principal crops. Fertility is low to medium, and the organic-matter content is low to moderate. Available water capacity is very low to moderate. The main hazard is soil blowing.

Only about 30 percent of this association is used for cultivated crops. The rest is mostly in native grass. Livestock raising is the main enterprise.

6. *Flasher-Vebar association*

Rolling to steep, well-drained and excessively drained, mainly moderately coarse textured soils on sandstone uplands

This association (fig. 2) consists of shallow and moderately deep soils that formed in material weathered from soft sandstone. Slopes are irregular and vary in length. Sandstone crops out on the upper slopes and ridges.

This association occupies about 3 percent of the

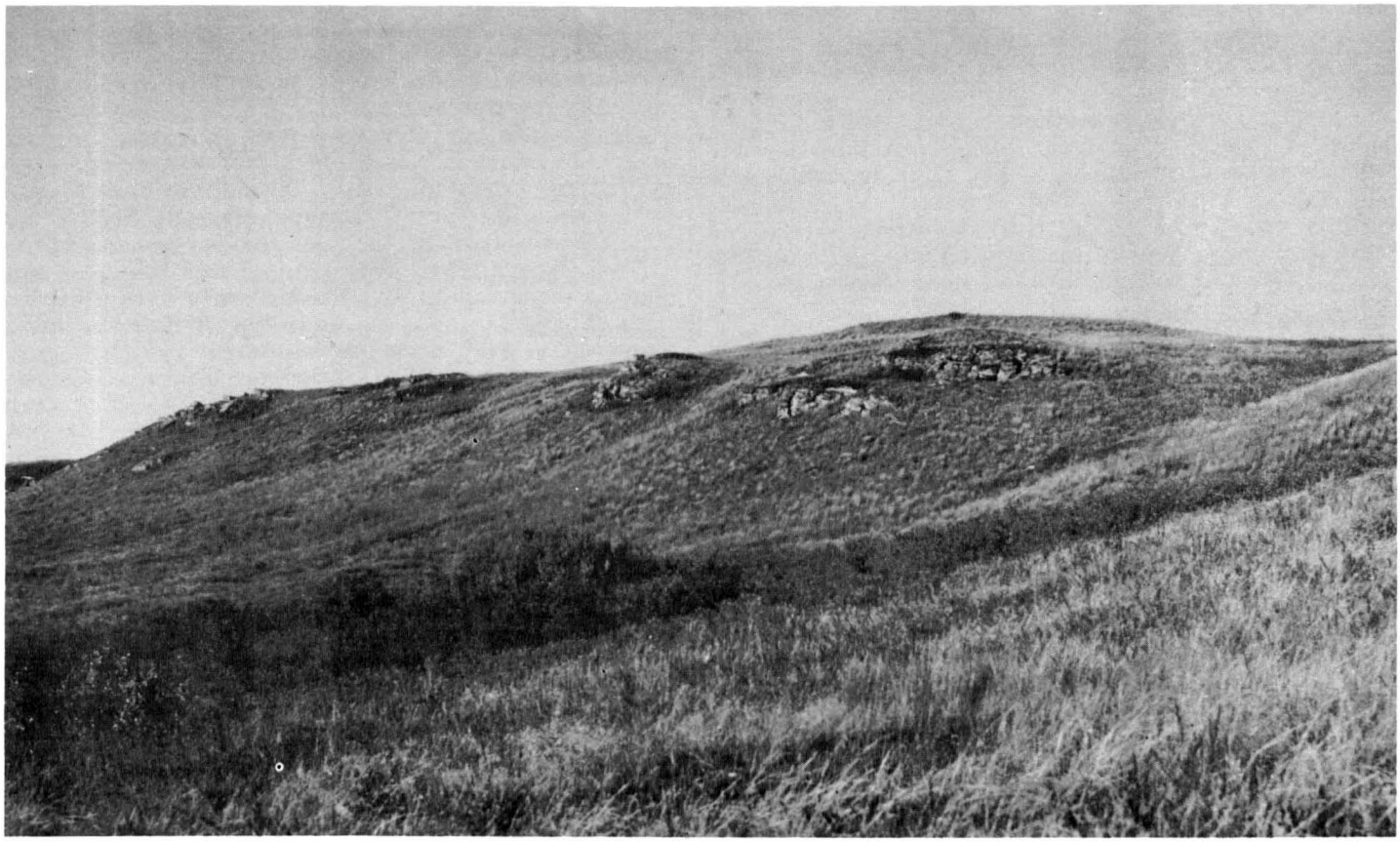

***Figure 2.*—Area in Flasher-Vebar association. Flasher soils and sandstone ledgerock are on the upper slopes. Vebar soils and the denser vegetation are on the lower slopes.**

county. It is about 55 percent Flasher soils, 25 percent Vebar soils, and 20 percent soils of minor extent.

Flasher soils, on the higher lying slopes and ridges, are excessively drained. The surface layer typically is dark grayish-brown fine sandy loam. It is underlain by grayish-brown fine sandy loam and loamy fine sand that grades to soft, bedded sandstone within a depth of about 19 inches.

Vebar soils, on smooth slopes and in rolling areas, are well drained. Their surface layer typically is dark grayish-brown fine sandy loam. It is underlain by light brownish-gray and light yellowish-brown fine sandy loam that grades to soft, bedded sandstone within a depth of about 36 inches.

Less extensive in this association are the Sen, Werner, and Williams soils. The shallow Werner soils are on the upper slopes and ridges. Sen soils occupy smooth slopes. Williams soils occupy smooth slopes mantled with glacial till.

Small grain and alfalfa are the principal crops. Fertility is low to medium, and the organic-matter content is low to moderate. Available water capacity is very low to moderate. The main hazard is water erosion.

Most of this association is in native grass. Livestock raising is the main enterprise. Some of the smoother, less sloping areas are used for small grain and alfalfa.

7. *Williams-Noonan association*

Nearly level to undulating, well-drained, medium-textured soils and moderately well drained claypan soils on glacial till plains

This association consists mainly of deep soils that formed in glacial till. The undulating areas are characterized by short, irregular slopes. Potholes and depressions are common. Stones are common in some areas.

This association occupies about 2 percent of the county. It is about 70 percent Williams soils, 10 percent Noonan soils, and 5 percent Niobell soils. Lehr, Parshall, Miranda, Parnell, and Tonka soils are of minor extent.

Williams soils, in the higher lying positions, are well drained. Their surface layer typically is very dark grayish-brown loam about 4 inches thick. The subsoil is dark grayish-brown to brown and dark-brown clay loam. It is underlain by olive-gray and light olive-brown clay loam that contains a large amount of lime in the upper part.

Noonan soils, in the lower lying positions, are moderately well drained. Their surface layer is loam that typically is dark gray in the upper part and gray in the lower part. The subsoil is dark grayish-brown clay loam. It is underlain by pale-brown and light brownish-gray clay loam that contains a large amount of segregated lime and salt in the upper part.

The moderately well drained Niobell soils are in slight microdepressions in close association with Noonan soils. Lehr soils, on smooth glacial outwash, have sand and gravel within a depth of 40 inches. The smooth, gently sloping Parshall soils are moderately coarse textured. Miranda soils are fine textured and occupy low spots adjacent to Noonan soils. The wet Parnell and Tonka soils are in depressions and potholes.

Most of this association is suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is medium to high, and the organic-matter content is moderate. Available water capacity is moderate to high. Major concerns in management are controlling water erosion, improving drainage, and maintaining tilth and fertility.

About 65 percent of this association is used for cultivated crops. Farming is mostly a combination livestock and small grain enterprise.

8. *Williams-Max-Zahl association*

Nearly level to steep, well-drained, medium-textured soils on glacial till plains

This association consists mainly of deep, rolling soils that formed in glacial till. Slopes are short and irregular. Depressions are common. Stones are common in many areas.

This association occupies about 27 percent of the county. It is about 50 percent Williams soils, 25 percent Max soils, and 10 percent Zahl soils. The rest is Arnegard, Parnell, Tonka, and Regan soils.

Williams soils occupy the smooth, less sloping parts of the landscape and the midslopes in steeper areas. Their surface layer typically is very dark grayish-brown loam about 4 inches thick. The subsoil is dark grayish-brown to brown and dark-brown clay loam. It is underlain by olive-gray and light olive-brown clay loam that has a large amount of lime in the upper part.

Max soils occupy the upper slopes above Williams soils. Their surface layer typically is very dark grayish-brown loam about 6 inches thick. The subsoil is dark-brown and grayish-brown loam. It is underlain by light olive-brown, dark grayish-brown, and light brownish-gray, calcareous loam that has a large amount of lime in the upper part.

Zahl soils occupy the highest parts of the landscape. They have a thin surface layer of very dark grayish-brown loam. This layer is underlain by a thin transition layer of grayish-brown loam that grades to olive-gray and light brownish-gray glacial till of clay loam texture.

Arnegard soils are in swales and on foot slopes. The wet Parnell and Tonka soils are in depressions and basins. The very poorly drained Regan soils are in shallow stream valleys and basins.

The less sloping soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is low to high, and the organic-matter content is moderate. Available water capacity is high. The main hazard is water erosion. The topography, the numerous depressions, and the stones are concerns in management.

About 75 percent of this association is in native grass. Livestock raising is the main enterprise. Most of the cultivated acreage is on the milder slopes.

9. *Williams-Max association*

Nearly level to rolling, well-drained, medium-textured soils on glacial till plains

This association consists of deep soils that formed in glacial till. Slopes are short and irregular. Depressions are common, and many are flooded for extended periods.

This association occupies about 27 percent of the county. It is about 55 percent Williams soils and 25 percent Max soils. Less extensive are the Arnegard, Lehr, Parnell, Tonka, and Colvin soils.

The well-drained Williams soils occupy the lower slopes and midslopes in some areas. Their surface layer is very dark grayish-brown loam about 4 inches thick. The subsoil is dark grayish-brown to brown and dark-brown clay loam. It is underlain by olive-gray and light olive-brown clay loam that has a large amount of lime in the upper part.

The well-drained Max soils occupy the upper slopes and the ridgetops. They have a surface layer of very dark grayish-brown loam about 6 inches thick. The subsoil is dark-brown and grayish-brown loam. It is underlain by light olive-brown, dark grayish-brown, and light brownish-gray, calcareous loam that has a large amount of lime in the upper part.

Arnegard soils are in swales and on foot slopes. The wet Parnell and Tonka soils are in depressions and basins. Lehr soils, on terraces, are underlain by sand and gravel within a depth of 40 inches. The poorly drained Colvin soils are in sloughs and basins.

Most of this association is suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is high to medium, and the organic-matter content is moderate. Available water capacity is high. Major concerns in management are controlling water erosion, improving drainage, and maintaining tilth and fertility.

About 65 percent of this association is used for cultivated crops. Some farms specialize in cash grain crops, and others in feed grain and livestock enterprises.

10. Sen-Werner-Morton association

Gently sloping to hilly, well-drained, medium-textured soils on soft shale and siltstone uplands

This association consists of moderately deep and shallow soils that formed in material weathered from soft shale and siltstone. It is on uplands near the Missouri River Valley. Slopes are irregular. In some areas they are long and gently sloping. In others they are short and steep.

This association occupies about 4 percent of the county. It is about 55 percent Sen soils, 20 percent Werner soils, and 10 percent Morton soils. Arnegard, Daglum, Flasher, and Rhoades soils are of minor extent.

The gently sloping to steep, well-drained Sen soils occupy the upper slopes in the less sloping areas and the lower slopes and midslopes in the steeper areas. Their surface layer is dark grayish-brown silt loam about 6 inches thick. The subsoil is dark grayish-brown and brown silt loam. It is underlain by pale-brown, calcareous silt loam that grades to bedded silty shale at a depth of about 38 inches.

The well-drained Werner soils occupy the upper slopes and the crests of ridges. They have a surface layer of dark grayish-brown loam. This layer is underlain by grayish-brown loam that grades to bedded sandstone and shale at a depth of less than 20 inches.

The gently sloping to sloping Morton soils are well drained. Their surface layer is dark grayish-brown silt loam. The subsoil is dark grayish-brown silt loam in the upper part and olive silty clay loam in the lower part. It is underlain by light olive-gray silty clay loam.

Arnegard soils are in swales and on foot slopes. The moderately well drained Daglum and Rhoades soils are in swales and on foot slopes along shallow drainageways. The excessively drained, shallow Flasher soils are on ridges and crests of slopes.

Most of this association is in native grass. Livestock raising is the main enterprise. Fertility is low to medium, and the organic-matter content is moderate. Available water capacity is low to high.

11. Williams-Vebar Flasher association

Gently undulating to steep, well-drained, medium-textured soils on glacial till and excessively drained, moderately coarse textured soils on sandstone uplands

This association consists of deep soils that formed in glacial till and moderately deep and shallow soils that formed in material derived from soft sandstone. These soils are undulating to rolling in the glacial till areas and hilly to steep in the sandstone areas.

This association occupies about 3 percent of the county. It is about 45 percent Williams soils, 15 percent Vebar soils, and 15 percent Flasher soils. The rest is Arnegard, Grail, Regan, Sen, and Werner soils.

Williams soils are gently undulating to rolling and are well drained. Their surface layer is very dark grayish-brown loam about 4 inches thick. The subsoil is dark grayish-brown to brown and dark-brown clay loam. It is underlain by olive-gray and light olive-brown clay loam that has a large amount of lime in the upper part.

The well-drained Vebar soils are on smooth slopes below the Flasher soils. Their surface layer typically is dark grayish-brown fine sandy loam. It is underlain by light brownish-gray and light yellowish-brown fine sandy loam that grades to soft, bedded sandstone within a depth of about 36 inches.

Flasher soils, on higher lying slopes and ridges, are excessively drained. Their surface layer is typically dark grayish-brown fine sandy loam. It is underlain by grayish-brown fine sandy loam that grades to yellowish-brown loamy fine sand over soft, bedded sandstone within a depth of about 19 inches.

Arnegard and Grail soils are in swales and on foot slopes. Regan soils are very poorly drained and are in shallow stream valleys and basins. Sen soils are on smooth slopes and are well drained. Werner soils are shallow and occupy the upper slopes and ridgetops.

In the shallow soils, fertility and the organic-matter content are low and the available water capacity is very low to low. In the deeper soils, fertility is medium to high and the organic-matter content and available water capacity are moderate to high. The main hazards are soil blowing and water erosion.

About 65 percent of this association is in native grass. Livestock raising is the main enterprise. Some of the smoother, less sloping areas are used for growing small grain and alfalfa.

12. Temvik-Mandan-Werner association

Nearly level to steep, well-drained, medium-textured soils on terraces and uplands

This association consists of deep, nearly level to rolling soils that formed in material deposited by wind and shallow, steep soils that formed in material derived from soft shale and siltstone.

This association occupies about 6 percent of the county. It is about 35 percent Temvik soils, 20 percent Mandan soils, and 15 percent Werner soils. The rest is Linton, Sen, Arnegard, Flasher, Williams, and Vebar soils.

Temvik soils are nearly level to gently rolling and are well drained. Their surface layer is dark-gray silt loam about 6 inches thick. The subsoil is dark grayish-brown and brown silt loam. It is underlain by light-gray, calcareous loam at a depth of about 22 inches.

Mandan soils are on smooth benches and terraces adjacent to the steep breaks of the Missouri River. Their surface layer is dark grayish-brown silt loam about 13 inches thick. The subsoil is grayish-brown silt loam. It is underlain by light brownish-gray, calcareous silt loam.

Werner soils are steep, shallow, and well drained. Their surface layer is dark grayish-brown loam. It is underlain by grayish-brown loam that grades to bedded sandstone and shale at a depth of 20 inches or less.

Linton soils are well drained. They occupy the slightly higher positions in the landscape, in close association with Mandan soils. The Sen and Vebar soils are on smooth slopes and have soft, bedded sandstone and siltstone at a depth of less than 40 inches. Arnegard soils are in swales and on foot slopes. The excessively drained Flasher soils are on ridges and crests of slopes. The sloping to rolling Williams soils are well drained.

The less sloping soils in this association are suited to the field crops, hay crops, and pasture plants commonly grown in the county. In the deeper soils, fertility is medium to high and the organic-matter content and available water capacity are moderate to high. In the shallow soils fertility is low, the organic-matter content is moderate, and available water capacity is low. The main hazards on this association are soil blowing and water erosion.

About 50 percent of this association is used for cultivated crops. Some farmers specialize in cash grain crops, and others in feed grain and livestock enterprises.

13. Lehr-Wabek-Manning association

Nearly level to steep, somewhat excessively drained and excessively drained, medium-textured and moderately coarse textured soils on outwash plains

This association consists of moderately deep and shallow soils on terraces and in glacial outwash areas.

This association occupies about 7 percent of the county. It is about 55 percent Lehr soils, 13 percent Wabek soils, and 12 percent Manning soils. Less extensive are the Tansem, Roseglen, Regan, Colvin, Harriet, and Williams soils.

Lehr soils, in the smooth, less sloping parts of the landscape, are somewhat excessively drained. Their surface layer is dark grayish-brown loam about 6 inches thick. The subsoil is dark grayish-brown and grayish-brown loam. It is underlain by light brownish-gray gravelly coarse sandy loam that grades to gravel at a depth of about 22 inches.

Wabek soils, in the steeper parts of the landscape, are excessively drained. Their surface layer is very dark grayish-brown loam. It is underlain by light brownish-gray, calcareous gravelly loam that grades to gravel and sand at a depth of less than 10 inches.

Manning soils, in the smooth, less sloping parts of the landscape, are somewhat excessively drained. Their surface layer is dark grayish-brown fine sandy loam about 8 inches thick. The subsoil is dark-brown or brown fine sandy loam. It is underlain by light yellowish-brown fine sandy loam that grades to sand and gravel at a depth of about 25 inches.

Tansem and Roseglen soils are silty and nearly level to gently sloping. The poorly drained Colvin soils and the very poorly drained Regan soils are in shallow stream valleys and basins. The poorly drained Harriet soils are in swales and along bottoms of shallow drainageways. Williams soils are well drained and gently sloping to rolling.

Most of this association is suited to the field crops, hay crops, and pasture plants commonly grown in the county. Fertility is low to medium, and the organic-matter content is moderate. Available water capacity is very low to low. Major concerns in management are soil blowing and very low to low available water capacity.

About 65 percent of this association is used for cultivated crops. The shallow soils are used mainly for livestock production. They are also a source of sand and gravel.

Descriptions of the Soils

This section describes the soil series and mapping units in Burleigh County. Each soil series is described in considerable detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that 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. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless it is otherwise stated, the colors given in the descriptions are those of a dry soil.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Riverwash, for example, does not belong to a soil series, but nevertheless, is 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, range site, and windbreak group in which the mapping unit has been placed. The page for the description of each capability unit and range site can be found by re-

ferring to the "Guide to Mapping Units" at the back of this survey.

The 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 (*6*).

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

Soil	Area	Extent
	Acres	*Percent*
Arnegard and Grassna silt loams, level	33, 070	3. 1
Arnegard and Grassna silt loams, gently sloping	5, 806	. 6
Arveson-Stirum loams	1, 343	. 1
Arveson-Stirum loams, very poorly drained	473	(1)
Banks loamy fine sand	2, 044	. 2
Banks fine sandy loam	482	(1)
Banks loam	567	. 1
Belfield-Rhoades silty clay loams, nearly level	11, 143	1. 1
Belfield-Rhoades silty clay loams, gently sloping	880	. 1
Belfield-Rhoades-Grail silty clay loams	4, 139	. 4
Blown-out land	254	(1)
Colvin silty clay loam	5, 353	. 5
Daglum-Belfield-Harriet complex	1, 342	. 1
Daglum-Rhoades silty clay loams	983	. 1
Dimmick silty clay	3, 307	. 3
Flasher soils, sloping	184	(1)
Flasher-Vebar complex, hilly	17, 552	1. 7
Flasher-Vebar-Rock outcrop complex, steep	10, 719	1. 0
Flaxton fine sandy loam	1, 471	. 1
Flaxton-Livona loamy fine sands, undulating	2, 721	. 3
Flaxton-Livona fine sandy loams, undulating	7, 787	. 7
Grail silt loam, level	8, 159	. 8
Grail silt loam, gently sloping	1, 500	. 1
Grail silty clay loam, level	2, 943	. 3
Grail silty clay loam, gently sloping	619	. 1
Harriet complex	3, 319	. 3
Harriet and Regan soils, strongly saline	14, 630	1. 4
Havrelon fine sandy loam	2, 732	. 3
Havrelon loam	8, 306	. 8
Havrelon loam, clay subsoil variant	633	. 1
Havrelon silty clay loam	6, 725	. 6
Heil soils	8, 202	. 8
Lallie silty clay loam	1, 452	. 1
Lehr loam, nearly level	35, 502	3. 3
Lehr loam, undulating	15, 990	1. 5
Lehr loam, sloping	1, 313	. 1
Lihen loamy fine sand, nearly level	18, 592	1. 8
Lihen loamy fine sand, clay subsoil variant	422	(1)
Lihen, Livona, and Parshall fine sandy loams, hilly	2, 202	. 2
Lihen, Parshall, and Telfer fine sandy loams, rolling	4, 603	. 4
Lihen-Telfer loamy fine sands, undulating	8, 975	. 9
Lihen-Telfer loamy fine sands, rolling	1, 475	. 1
Linton-Mandan silt loams, hilly	1, 034	. 1
Linton-Mandan silt loams, steep	1, 573	. 1
Livona-Flaxton loamy fine sands, rolling	816	. 1
Livona-Flaxton fine sandy loams, rolling	3, 719	. 4
Livona and Lihen loamy fine sands, hilly	809	. 1
Livona, Lihen, and Flasher fine sandy loams, steep	1, 224	. 1
Livona-Williams fine sandy loams, hilly	5, 703	. 5
Lohler silt loam	664	. 1
Lohler silty clay loam	1, 382	. 1
Lohler silty clay	1, 101	. 1
Magnus silty clay loam	1, 159	. 1
Makoti silty clay loam, level	2, 646	. 3
Makoti-Williams silty clay loams, gently sloping	588	. 1
Mandan silt loam, level	4, 835	. 5
Mandan-Linton silt loams, undulating	4, 784	. 5
Mandan-Linton silt loams, rolling	2, 975	. 3
Manning fine sandy loam, nearly level	2, 660	. 3
Manning fine sandy loam, undulating	5, 406	0. 5
Manning fine sandy loam, sloping	860	. 1
Max-Zahl loams, rolling	775	. 1
Mine pits and dumps	1, 414	. 1
Miranda-Noonan complex	1, 618	. 2
Morton silt loam, gently sloping	491	(1)
Morton silt loam, sloping	686	. 1
Niobell-Noonan loams, nearly level	6, 495	. 6
Niobell-Noonan loams, undulating	5, 009	. 5
Parnell silty clay loam, very poorly drained	10, 176	1. 0
Parshall fine sandy loam, nearly level	517	(1)
Parshall fine sandy loam, gently sloping	626	. 1
Parshall fine sandy loam, clay subsoil variant	333	(1)
Parshall and Lihen fine sandy loams, nearly level	22, 053	2. 1
Parshall, Lihen, and Telfer fine sandy loams, undulating	21, 619	2. 0
Regan silty clay loam	12, 572	1. 2
Regent silty clay loam, sloping	1, 430	. 1
Regent-Grail silty clay loams, gently sloping	1, 589	. 2
Rhoades complex	11, 466	1. 1
Rhoades-Daglum complex	1, 607	. 2
Riverwash	1, 730	. 2
Roseglen-Tansem silt loams, nearly level	34, 679	3. 3
Savage silt loam, level	5, 579	. 5
Savage silt loam, gently sloping	1, 766	. 2
Savage silt loam, sloping	364	(1)
Savage silty clay loam, level	3, 432	. 3
Savage silty clay loam, gently sloping	917	. 1
Sen silt loam, gently sloping	9, 893	. 9
Sen silt loam, sloping	11, 330	1. 1
Sen silt loam, hilly	1, 304	. 1
Straw silt loam	5, 367	. 5
Straw, Arnegard, and Colvin soils, channeled	4, 347	. 4
Tansem loam, sloping	1, 632	. 2
Tansem-Lehr loams, nearly level	4, 641	. 4
Tansem-Roseglen silt loams, gently sloping	9, 917	. 9
Telfer-Lihen loamy sands, nearly level	412	(1)
Telfer-Lihen loamy fine sands, hilly	1, 041	. 1
Telfer-Seroco loamy sands	11, 047	1. 1
Temvik silt loam, nearly level	8, 281	. 8
Temvik silt loam, undulating	16, 466	1. 6
Temvik silt loam, rolling	5, 352	. 5
Tiffany loam	252	(1)
Tonka and Parnell soils	5, 007	. 5
Vebar fine sandy loam, gently sloping	4, 098	. 4
Vebar fine sandy loam, sloping	7, 961	. 8
Wabek soils, undulating	4, 072	. 4
Wabek soils, hilly	12, 102	1. 1
Werner complex, steep	15, 615	1. 5
Werner-Morton-Sen complex, hilly	18, 110	1. 7
Werner-Sen loams, sloping	332	(1)
Werner-Shale outcrop complex	1, 041	. 1
Williams stony loam, rolling	3, 754	. 4
Williams loam, nearly level	46, 438	4. 4
Williams loam, undulating	218, 455	20. 7
Williams loam, rolling	100, 606	9. 5
Williams loam, hilly	8, 645	. 8
Williams-Zahl loams, hilly	54, 700	5. 1
Williams-Zahl loams, steep	2, 157	. 2
Lake	3, 655	. 4
Saline intermittent lake	3, 895	. 3
Total	1, 054, 720	100. 0
Inland water	31, 808	--------

[1] Less than 0.05 percent.

Arnegard Series

The Arnegard series consists of deep, nearly level and gently sloping, well-drained soils in swales, small valleys, and concave fans. These soils formed in local alluvium. Slopes are long.

In a representative profile, the surface layer is dark-gray silt loam about 14 inches thick. The subsoil, about 28 inches thick, is dark grayish-brown, friable loam in the upper part, dark-gray loam in the middle part, and grayish-brown clay loam in the lower part. The underlying material is light brownish-gray clay loam to a depth of 48 inches and light brownish-gray gravelly clay loam and sand below. It is moderately limy.

Permeability is moderate. Available water capacity, organic-matter content, and fertility are high.

These soils are well suited to small grain, grasses, legumes, and trees. Most areas are cropland.

Representative profile of Arnegard silt loam in a cultivated field in an area of Arnegard and Grassna silt loams, level, 880 feet north and 350 feet east of the southwest corner of sec. 1, T. 140 N., R. 80 W.:

Ap—0 to 6 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; cloddy; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A1—6 to 14 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; coarse prismatic structure to weak, coarse, angular blocky; slightly sticky and slightly plastic when wet; clear, wavy boundary.

B21—14 to 20 inches, dark grayish-brown (2.5Y 4/2) loam, very dark gray (10YR 3/1) when moist; moderate, medium, prismatic structure to moderate, medium and fine, angular blocky; hard when dry, very friable when moist, sticky and plastic when wet; coatings on vertical faces of peds, very dark gray (10YR 3/1) when moist; gradual, wavy boundary.

B22—20 to 38 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) when moist; strong, medium, prismatic structure to strong, medium and fine, angular blocky; hard when dry, very friable when moist, sticky and plastic when wet; continuous distinct coatings on faces of peds, black (10YR 2/1) when moist; clear, wavy boundary.

B3ca—38 to 42 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse, prismatic structure; hard when dry, sticky and plastic when wet; strong effervescence; few nodules of segregated lime; clear, wavy boundary.

C1ca—42 to 48 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; hard when moist, sticky and plastic when wet; strong effervescence; many soft masses of segregated lime; abrupt, wavy boundary.

IIC2—48 to 53 inches, light brownish-gray (2.5Y 6/2) gravelly clay loam, dark grayish brown (2.5Y 4/2) when moist; sticky and plastic when wet; moderate effervescence; gradual, wavy boundary.

IIIC3—53 to 72 inches, light brownish-gray (2.5Y 6/2) sand, dark grayish brown (2.5Y 4/2) when moist; loose when dry, nonsticky and nonplastic when wet; moderate effervescence.

The depth to which these soils are darkened by organic matter ranges from 25 to more than 60 inches. The A1 horizon ranges from 9 to 18 inches in thickness. It is black, very dark gray, or very dark grayish brown when moist and dark gray and very dark grayish brown when dry. The upper part of the B horizon is dark grayish brown or very dark grayish brown when moist and dark gray or dark grayish brown when dry. With increasing depth the color grades to dark grayish brown. The depth to lime is commonly more than 30 inches. Most profiles have a prominent lime zone in the lower part of the B horizon or in the upper part of the C horizon.

Arnegard soils are associated with Grail, Grassna, and Parshall soils. They are coarser textured than Grail soils and do not have a B2t horizon, which is characteristic of Grail soils. They have a lower silt content than Grassna soils. They are finer textured than Parshall soils.

Arnegard and Grassna silt loams, level (0 to 3 percent slopes) (AgA).—These soils are in swales and small valleys. Some areas are Arnegard silt loam, some are Grassna silt loam, and others contain both soils. The Arnegard soil is commonly associated with soils formed in glacial till. The Grassna soil is on eolian silt deposits adjacent to breaks along the Missouri River.

Each soil has the profile described as representative for its respective series. The Grassna soil is described under the heading "Grassna Series."

Surface runoff is slow. Fertility is high. Soil blowing and water erosion are moderate hazards. Controlling soil blowing is the major concern in management.

These soils are well suited to small grain, corn, and alfalfa. Most of the acreage is cultivated. Areas not under cultivation are in native grass. The trees and shrubs commonly grown do well on these soils. Capability unit IIc-6; Silty range site; windbreak group 1.

Arnegard and Grassna silt loams, gently sloping (3 to 6 percent slopes) (AgB).—These soils are in concave positions on glacial till, residual plains, and eolian silt deposits. Some areas are Arnegard silt loam, some are Grassna silt loam, and others contain both soils. The Arnegard soil is more commonly in the glacial till and residual areas, and the Grassna soil is in areas of eolian silt deposits and adjacent to the Missouri River.

Surface runoff is medium. Fertility is high. The erosion hazard is moderate. Controlling water erosion and soil blowing is the major concern in management.

These soils are well suited to small grain, corn, and alfalfa. About 75 percent of the acreage is cultivated, and the rest is in native grass. The commonly grown trees and shrubs do well. Capability unit IIe-6; Silty range site; windbreak group 1.

Arveson Series

The Arveson series consists of deep, level, poorly drained and very poorly drained soils that are limy at or near the surface. These soils are in basins, sloughs, and seep areas. They formed in moderately coarse textured deposits of glacial origin. They have a seasonal high water table that contributes to the accumulation of lime near the surface.

In a representative profile, the surface layer is loam about 5 inches thick, is very dark gray when moist, is moderately limy, and contains a few yellowish-red mottles. It is underlain by a layer about 9 inches thick that is similar to the surface layer but of fine sandy loam texture. Below this is friable fine sandy loam that is about 22 inches thick, is very dark grayish brown when moist, and is strongly limy. The underlying material is dark grayish-brown fine sandy loam in the upper part, grayish-brown loamy fine sand in the middle part, and strong-brown loamy fine sand in the lower part. The upper part of this material is strongly limy. The colors designated are for moist soil.

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

These soils are used mainly for grass. Some of the better drained areas are used for small grain and corn.

Representative profile of Arveson loam under native grass in an area of Arveson-Stirum loams, 180 feet north and 2,590 feet east of the southwest corner of sec. 29, T. 138 N., R. 78 W.:

A11—0 to 5 inches, gray (N 5/0) loam, very dark gray (10YR 3/1) when moist; few, fine, distinct, yellowish-red (5YR 5/6) mottles; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; clear, smooth boundary.

A12—5 to 14 inches, gray (2.5Y 5/1) fine sandy loam, very dark gray (2.5Y 3/1) when moist; weak, medium, granular to prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; gradual, wavy boundary.

C1ca—14 to 36 inches, gray (5Y 5/1) fine sandy loam, very dark grayish brown (2.5Y 3/2) when moist; single grain; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; strong effervescence; gradual, wavy boundary.

C2gca—36 to 41 inches, gray (5Y 6/1) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; strong effervescence; clear, wavy boundary.

C3g—41 to 52 inches, gray (2.5Y 6/1) loamy fine sand, grayish brown (2.5Y 5/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; moderate effervescence; clear, wavy boundary.

C4g—52 to 60 inches, reddish-yellow (7.5YR 6/6) loamy fine sand, strong brown (7.5YR 5/6) when moist; common, fine, distinct, light-gray (2.5Y 7/2) mottles; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; moderate effervescence.

The A1 horizon is loam or fine sandy loam 10 to 16 inches thick. It is very dark gray or black when moist. It is slightly to moderately limy. The Cca horizon is very dark grayish brown, dark grayish brown, or dark gray when moist, is fine sandy loam or loam, and is moderately to strongly limy. In places the lower part is loamy fine sand. The C horizon is loamy fine sand or fine sandy loam. In places salt crystals are common in the C1ca and Cg horizons, and the soil is moderately to strongly saline.

Arveson soils are similar to Colvin, Regan, and Tiffany soils. They are more sandy than Colvin and Regan soils. They are more limy than Tiffany soils.

Arveson-Stirum loams (0 to 3 percent slopes) (Ar).—This complex is in basins and seep areas. It is about 50 percent Arveson loam, 30 percent Stirum loam, and 20 percent Tiffany and Regan soils. The Stirum soil is in the slightly lower positions.

The Arveson soil has the profile described as representative for the Arveson series. Stirum soils are described under the heading "Stirum Series."

These soils are poorly drained and receive surface runoff and seepage from adjacent areas. Fertility is medium in the Arveson soil and low in the Stirum soil. Wetness is the major concern in management. Soil blowing is a moderate hazard when the surface layer is dry.

Most of the acreage is in native grass. Some of the better drained areas are cultivated, but wetness delays tillage each year, and in some wet periods either seeding or harvesting has to be abandoned. Capability unit IIIwe-3; Arveson soil in Subirrigated range site and windbreak group 2; Stirum soil in Saline Subirrigated range site and windbreak group 9.

Arveson-Stirum loams, very poorly drained (0 to 3 percent slopes) (As).—This complex occurs in basins and seep areas that are very poorly drained. It is about 55 percent Arveson loam, 25 percent Stirum loam, and 20 percent Tiffany and Regan soils. Included in mapping are a few small areas that are moderately to strongly saline.

The Arveson soil has a profile similar to the one described as representative for the Arveson series, but it is more mottled and more poorly drained. The Stirum soil has the profile described as representative for the Stirum series.

Surface runoff is slow. Fertility is medium in the Arveson soil and low in the Stirum soil. Surface ponding and the high water table are the major concerns in management.

The drier areas are used for native hay and pasture. The wetter areas are suitable for wildlife. Capability unit VIs-SS; Saline Subirrigated range site; windbreak group 10.

Banks Series

The Banks series consists of deep, level and gently sloping, somewhat excessively drained soils that formed in recently deposited sandy alluvium on bottom land along the Missouri River. These soils are adjacent to the river and are on islands in the river.

In a representative profile, the surface layer is light brownish-gray very fine sandy loam about 4 inches thick. In areas where the surface layer has been mixed with the underlying material, the texture is loamy fine sand. The underlying material is slightly limy. It is light brownish-gray fine sand to a depth of 30 inches and light brownish-gray loamy fine sand below.

Permeability is rapid. Available water capacity, organic-matter content, and fertility are low.

These soils are suitable for pasture, wildlife habitat, and recreation. Most of the acreage is either wooded and brushy or covered with native tall grasses and scattered cottonwood trees. A few small areas are cultivated.

Representative profile of Banks loamy fine sand in an area of tame grass and cottonwood trees, 1,585 feet south and 2,165 feet east of the northwest corner of sec. 5, T. 140 N., R. 81 W.:

A1—0 to 4 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; abrupt, wavy boundary.

IIC1—4 to 30 inches, light brownish-gray (2.5Y 6/2) fine sand, grayish brown (2.5Y 5/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slight effervescence; gradual, wavy boundary.

IIIC2—30 to 60 inches, light brownish-gray (2.5Y 6/2) loamy fine sand, dark grayish brown (2.5Y 4/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slight effervescence.

In most places, the A horizon layer is loamy fine sand or fine sandy loam. In some it is very fine sandy loam or loam.

Sands and loamy sands dominate in the underlying layers. Color throughout the profile ranges from grayish brown or light brown to light gray or pale yellow. Variations in color and texture relate to stratification.

Banks soils are associated with Havrelon, Lohler, and Seroco soils. Their underlying material is coarser textured than that of Havrelon and Lohler soils. In contrast with Seroco soils, they are limy and subject to overflow. They are commonly higher above the river level than Riverwash.

Banks loamy fine sand (0 to 6 percent slopes) (Ba).—This soil is on bottom land adjacent to the Missouri River. It is about 85 percent Banks loamy fine sand. The rest is Havrelon soils, which have a surface layer of fine sandy loam.

This soil has the profile described as representative for the Banks series.

This soil is droughty and moderately susceptible to soil blowing. Surface runoff is slow. Fertility is low. Controlling soil blowing and conserving moisture are the main concerns of management.

Most areas of this soil are used for grazing and wildlife. The native vegetation is mixed grasses, brush, and cottonwoods. Capability unit VIe–Sa; Sands range site; windbreak group 7.

Banks fine sandy loam (0 to 3 percent slopes) (Bf).—This soil is on bottom land of the Missouri River, adjacent to the channel. It is about 65 percent Banks fine sandy loam and 25 percent Banks loamy fine sand. The rest is Havrelon soils, which have a coarse-textured surface layer.

The profile of this soil is similar to the one described as representative for the Banks series, but the surface layer is fine sandy loam to a depth of 10 inches.

This soil is droughty and moderately susceptible to soil blowing. Surface runoff is slow. Fertility is low. Controlling soil blowing and conserving moisture are the main concerns of management.

Most areas are wooded and brushy, or are covered with native grass and scattered trees and are used for grazing. A few small areas are cultivated. Capability unit IVe–3; Sandy range site; windbreak group 7.

Banks loam (0 to 3 percent slopes) (Bk).—This soil is on bottom land of the Missouri River, close to the channel. It is mostly level, but is undulating in one small area. It is about 75 percent Banks loam and 25 percent Havrelon soil and a coarser textured Banks soil.

Except for the loam surface layer, the profile of this soil is similar to the one described as representative for the Banks series.

This soil is droughty and susceptible to soil blowing. Surface runoff is slow. Fertility is low. Conserving moisture and controlling erosion are the main concerns of management.

About 15 percent of the acreage is cultivated and used for feed crops. The rest is brushy and wooded or covered with native grass and is used for grazing. Capability unit IIIs–5; Silty range site; windbreak group 7.

Belfield Series

The Belfield series consists of deep, nearly level to gently sloping, well-drained soils. These soils formed in material derived from soft shale and siltstone. Slopes are plain or concave, and the gradient is 0 to 9 percent.

In a representative profile, the upper 7 inches of the surface layer is very dark grayish-brown silty clay loam. The lower 5 inches is very dark grayish-brown silt loam. A transition layer between the surface layer and the subsoil is gray silt loam about 4 inches thick. The subsoil is firm and about 32 inches thick. In sequence from the top, the upper 9 inches of this layer is very dark grayish-brown silty clay loam, the next 11 inches is dark grayish-brown clay loam, the next 8 inches is very dark gray clay loam, and the lower 4 inches is light yellowish-brown silty clay. The underlying material is light yellowish-brown silty clay.

Permeability is moderately slow. Available water capacity is high. The organic-matter content is moderate, and fertility is medium.

These soils are suited to small grain, grasses, and legumes. They are only fair for trees. Most of the acreage is cropland.

Representative profile of a Belfield silty clay loam in a cultivated field within an area of Belfield-Rhoades silty clay loams, nearly level, 1,160 feet north and 70 feet west of the southeast corner of sec. 6, T. 138 N., R. 77 W.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A12—7 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) when moist; weak, thick, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

A&B—12 to 16 inches, gray (10YR 5/1) silt loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic structure separating to moderate, medium, angular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; tongues extend to a depth of 18 inches; gradual, wavy boundary.

B21t—16 to 25 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; tops of blocks coated with gray silt loam; moderate, coarse and medium, prismatic structure separating to strong, medium, angular blocky; clay films on all ped faces; hard when dry, firm when moist, sticky and plastic when wet; gradual, wavy boundary.

B22t—25 to 36 inches, dark grayish-brown (10YR 4/2) clay loam, very dark brown (10YR 2/2) when moist; strong, medium and fine, prismatic structure separating to strong, medium and fine, angular blocky; clay films on all ped faces; hard when dry, firm when moist, sticky and plastic when wet; gradual, wavy boundary.

B23t—36 to 44 inches, very dark gray (10YR 3/1) and grayish-brown (2.5Y 5/2) clay loam, black (10YR 2/1) and dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure separating to weak, coarse, angular blocky; clay films on all ped faces; hard when dry, firm when moist, sticky and plastic when wet; gradual, wavy boundary.

Bca—44 to 48 inches, light yellowish-brown (2.5Y 6/3) and very dark grayish-brown (2.5Y 3/2) silty clay, dark grayish brown (2.5Y 4/2) and black (2.5Y 2/1) when moist; weak, coarse, prismatic structure separating to weak, coarse, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence; gradual, wavy boundary.

Cca—48 to 60 inches, light yellowish-brown (2.5Y 6/3) silty clay, olive brown (2.5Y 4/3) when moist; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence.

The solum ranges from 18 to 50 inches in thickness. The A horizon ranges from loam to silty clay loam. The Ap horizon ranges from 4 to 10 inches in thickness and from very dark grayish brown when dry to black when moist. The A12 ranges from 3 to 9 inches in thickness. It is gray or very dark grayish brown when dry and very dark brown or very dark grayish brown when moist. The gray or dark-gray color of the A&B horizon covers the tops of prisms or columns of the B21t horizon. In most places the upper part of the B21t is prismatic, but in places there are round-topped columns that separate to blocks. The B21t and B22t horizons range from very dark brown to dark brown when moist. In places, weathered shale, soft sandstone, or siltstone is below a depth of 36 inches.

Belfield soils are associated with Daglum, Niobell, and Rhoades soils. They differ from Daglum and Rhoades soils in having prismatic or weak columnar structure in the B2t horizon. In contrast with Niobell soils, they have a thicker A horizon and formed in material derived from soft shale and siltstone.

Belfield-Rhoades silty clay loams, nearly level (0 to 3 percent slopes) (BrA).—This complex is on terraces and outwash plains. It is about 60 percent Belfield silty clay loam and 20 percent Rhoades silty clay loam. Included in mapping were small areas of Daglum and Savage soils.

The Belfield soil has the profile described as representative for the Belfield series. The Rhoades soil is described under the heading "Rhoades Series."

Surface runoff is medium to slow. Natural fertility is medium in the Belfield and Daglum soils and low in the Rhoades soil.

More than half the acreage is cultivated. The rest is mainly in native grass. A shallow claypan in the Rhoades soil and in some areas of the Daglum soil makes it difficult to prepare a suitable seedbed. Capability unit IIIs–P6; Belfield soil in Silty range site and windbreak group 4; Rhoades soil in Claypan range site and windbreak group 9.

Belfield-Rhoades silty clay loams, gently sloping (3 to 6 percent slopes) (BrB).—This complex is on terraces and outwash plains. It is about 60 percent Belfield silty clay loam and 20 percent Rhoades silty clay loam. Included in mapping were small areas of Daglum and Savage soils.

Surface runoff is medium. Moisture penetration is somewhat less and the water erosion hazard greater on steeper slopes than on milder slopes.

More than half the acreage is cultivated. The rest is mainly in native grass. Keeping the Rhoades soil and the Daglum soil in good tilth is a concern in management. Small grain grows fairly well. Corn and alfalfa are poorly suited in areas where the surface layer is shallow over the claypan. Capability unit IIIe–P6; Belfield soil in Silty range site and windbreak group 4; Rhoades soil in Claypan range site and windbreak group 9.

Belfield-Rhoades-Grail silty clay loams (0 to 3 percent slopes) (Bs).—This complex is in swales. It is about 55 percent Belfield soils, 25 percent Rhoades soils, and 20 percent Grail and Daglum soils. The microrelief in some areas is less than 5 inches. Rhoades soils are in the low spots.

Surface runoff is medium to slow. Fertility is medium on the Belfield soil, low on the Rhoades soil, and high on the Grail soil. These soils receive additional moisture from surrounding areas.

About half the acreage is cultivated. The rest is used mostly for pasture or hay. Keeping the Rhoades soil in good tilth is difficult because it has a shallow surface layer and a claypan.

Small grains are suited. Corn and alfalfa are poorly suited in areas where the surface layer is shallow over a claypan. Capability unit IIIs–P6; Belfield soil in Silty range site and windbreak group 4; Rhoades soil in Claypan range site and windbreak group 9; Grail soil in Clayey range site and windbreak group 1.

Blown-out Land

Blown-out land (0 to 9 percent slopes) (Bt) consists of soils that have been severely eroded by wind. In most areas the original surface layer was loamy fine sand. In some, soil blowing removed the sandy material and exposed the clay loam subsoil. Most areas are gently sloping, but some are hummocky or dunelike and have steeper, irregular slopes. Nearly all were tilled and then abandoned. Vegetation has been reestablished in many areas, and erosion is no longer a hazard.

Surface runoff is slow, and the available water capacity is low. Fertility is low. Soil blowing is the main hazard.

The areas now in grass have some grazing value. Unless disturbed, most barren areas revert to native grass. Capability unit VIIe–CS: Choppy Sands range site; windbreak group 10.

Colvin Series

The Colvin series consists of deep, nearly level, poorly drained soils. These soils formed in moderately fine textured materials in basins, sloughs, and stream bottoms where the water table is seasonally within a depth of 1 foot.

In a representative profile, the surface layer is dark gray and about 12 inches thick. It is slightly limy. It is silty clay loam in the upper part and silty clay in the lower part. Below the surface layer is very limy silty clay loam about 20 inches thick. This layer is olive gray in the upper part and light olive gray in the lower part. The underlying material to a depth of about 48 inches is gray silty clay loam. It is strongly limy. The next layer extends to a depth of about 60 inches. It is light yellowish-brown coarse sand and is moderately limy.

Permeability is moderate. Available water capacity and organic-matter content are high. Fertility is medium.

These soils should be used for native pasture or hay. Most of the acreage is in native grass. Some of the better drained areas are cultivated.

Representative profile of a Colvin silty clay loam in a cultivated field, 1,900 feet north and 1,280 feet east of the southwest corner of sec. 13, T. 140 N., R. 76 W.:

Ap—0 to 8 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) when moist; weak, fine and medium, granular structure; soft when dry, slightly sticky and slightly plastic when wet; slight effervescence; abrupt, smooth boundary.

A12—8 to 12 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) when moist; weak, fine and medium, granular structure; soft when dry, slightly sticky and slightly plastic when wet; moderate effervescence; clear, wavy boundary.

C1ca—12 to 20 inches, olive-gray (5Y 5/2) silty clay loam, olive gray (5Y 4/2) when moist; moderate, coarse and medium, prismatic structure separating to moderate, medium, angular blocky; very hard when dry, sticky and plastic when wet; strong effervescence and many soft masses of segregated lime; clear, smooth boundary.

C2cacs—20 to 29 inches, light olive-gray (5Y 6/2) silty clay loam, olive gray (5Y 5/2) when moist; weak, medium, granular structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; strong effervescence and many soft masses of segregated lime; horizon is 50 to 70 percent fine, uniform gypsum crystals; gradual, smooth boundary.

C3g—29 to 35 inches, gray (5Y 5/1) silty clay loam, dark gray (5Y 4/1) when moist; many, coarse, prominent mottles, yellowish brown (10YR 5/8) when dry; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strong effervescence and many soft masses of segregated lime; horizon is more than 20 percent fine, uniform gypsum crystals; gradual, wavy boundary.

C4g—35 to 48 inches, gray (5Y 5/1) silty clay loam, dark gray (5Y 4/1) when moist; many, fine and medium, prominent mottles, yellowish brown (10YR 5/8) when dry; massive; hard when dry, friable when moist, sticky and plastic when wet; strong effervescence and many soft lime masses; horizon is more than 5 percent fine, uniform gypsum crystals; clear, wavy boundary.

IIC5—48 to 60 inches, light yellowish-brown (10YR 6/4) coarse sand, yellowish brown (10YR 5/4) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; moderate effervescence.

The A horizon is black or very dark gray when moist. Gravel, sand, or gravelly loam is common below a depth of 40 inches. These soils are limy at or near the surface and have a concentration of lime at a depth of 8 to 16 inches. Some of these soils are slightly saline.

Colvin soils are associated with Arveson, Parnell, Regan, and Tonka soils. They are finer textured than Arveson soils. In contrast with Parnell and Tonka soils, they are limy. They have a thicker, darker colored A1 horizon than Regan soils.

Colvin silty clay loam (0 to 3 percent slopes) (Ch).—This soil is in basins and along stream bottoms. Included in mapping and making up about 20 percent of the acreage are areas of Regan, Parnell, and Dimmick soils.

This soil has the profile described as representative for the series.

Surface runoff is very slow. Water runs in from surrounding areas and ponds occasionally.

Most of the acreage is in native grass for hay or pasture. Some of the better drained or artificially drained areas are suited to small grain, corn, tame grasses, and trees.

The seasonal high water table and the resulting excess water are the main limitations. The additional water, however, is beneficial to crops in dry years. The lime content makes the surface layer slake and also makes it susceptible to soil blowing if the soil is clean fallowed or fall plowed. Crop residue management, stubble mulch tillage, and the use of cover crops help control soil blowing. Tilth and workability are favorable if tillage is done when soil moisture is not excessive. Capability unit IIw–4L; Subirrigated range site; windbreak group 2.

Daglum Series

The Daglum series consists of deep, nearly level and gently undulating, moderately well drained soils in shallow depressions and swales. These soils formed in alluvium derived from soft shale or siltstone.

In a representative profile, the surface layer is dark-gray silty clay loam about 4 inches thick. The subsurface layer is friable silty clay loam about 4 inches thick. It is grayish brown when dry and dark grayish brown when moist. The subsoil is olive silty clay. It is about 20 inches thick, is firm when moist, and is strongly limy in the lower part. The underlying material is pale-olive silty clay. At a depth of 54 inches it grades to silty clay loam, residual shale, and siltstone, all of which are strongly limy.

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

Most areas are in native grass, to which the soils are well suited. Small acreages are used for small grain, corn, alfalfa, and hay.

Representative profile of Daglum silty clay loam under native grass in an area of Daglum-Rhoades silty clay loams, 60 feet north and 1,265 feet east of the southwest corner of sec. 17, T. 141 N., R. 80 W.:

A1—0 to 4 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

A2—4 to 8 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, subangular blocky structure separating to weak, medium, granular; slightly hard when dry, friable when moist, sticky and plastic when wet; very slight effervescence; abrupt, wavy boundary.

B2t—8 to 13 inches, olive (5Y 5/3) silty clay, tongues of dark gray (10YR 4/1), olive (5Y 4/3) when moist; moderate, medium and fine, columnar structure separating to strong, medium, angular blocky; clay films on all faces of peds; very hard when dry, firm when moist, sticky and plastic when wet; slight effervescence; few lime spots; gradual, wavy boundary.

B3ca—13 to 28 inches, olive (5Y 5/3) silty clay, olive gray (5Y 4/2) when moist; moderate, medium and fine, angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; strong effervescence; few lime spots; gradual, wavy boundary.

C1—28 to 38 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 4/3) when moist; massive; slight effervescence; moderate soft lime masses; few salt crystals; gradual, wavy boundary.

C2—38 to 60 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 4/3) when moist, grading to silty clay loam at a depth of 54 inches; strong effervescence; moderate soft lime masses.

The solum ranges from 15 to 32 inches in thickness. The depth to soft shale and siltstone is commonly more than 40 inches. The A horizon ranges from loam to silty clay loam. The B2t horizon is silty clay or clay 4 to 12 inches thick. It is dark grayish brown, dark brown, olive, or very dark gray. The darker colors occur in swales. In places there is a B3ca horizon. The C horizon contains few to many soluble salt crystals. It is moderately limy in the upper part and strongly limy in the lower part.

Daglum soils are associated with Belfield, Noonan, and Rhoades soils. Their surface layer is thinner than that of Belfield soils. They are more clayey throughout the profile than Noonan soils. They have a thicker A horizon and solum than Rhoades soils.

Daglum-Belfield-Harriet complex (0 to 3 percent slopes) (Da).—This mapping unit is about 45 percent Daglum silt loam, 35 percent Belfield silt loam, and 10 percent Harriet soils. The other 10 percent is Straw soils. The soils of this mapping unit are on the flood plains of creeks. They have microrelief of 1 to 6 inches. Harriet soils are in the lower lying positions.

The Daglum, Belfield, and Harriet soils are described under the headings "Daglum Series," "Belfield Series," and "Harriet Series."

Runoff is slow to medium. The water table is high in spring and during other periods of heavy rainfall.

Most of the acreage is in native range. Small grain and alfalfa are the main crops. Capability unit IIIs–P6; Belfield soil in Silty range site and windbreak group 4; Daglum soil in Claypan range site and windbreak group 9; Harriet soil in Claypan range site and windbreak group 10.

Daglum-Rhoades silty clay loams (3 to 6 percent slopes) (Dg).—This mapping unit is about 50 percent Daglum silty clay loam and 30 percent Rhoades soils. The rest is mostly Belfield, Regent, Werner, and Grail soils. The soils of this mapping unit are in swales and on the lower slopes. In swales, Daglum soils make up a large part of the acreage.

This Daglum soil has the profile described as representative for the Daglum series. Except for a more clayey surface layer, the profile of the Rhoades soil is similar to the one described as representative for the Rhoades series. The Rhoades soil is described under the heading "Rhoades Series."

Surface runoff is medium, and the erosion hazard is moderate. The major concern in management is the mixing of the subsoil and the surface soil, which results in poor tilth and adversely affects seed germination. To prepare a good seedbed, tilling must be performed at an optimum moisture level, particularly in areas of Rhoades soils.

In areas that are predominantly Rhoades soils, native grass is the main crop. In other areas, much of the acreage is cultivated. Small grain and alfalfa are the main crops. Capability unit IIIe–P6; Claypan range site; windbreak group 9.

Dimmick Series

The Dimmick series consists of deep, level, very poorly drained soils that formed in fine-textured local alluvium. These soils are in closed depressions and glacial outwash areas.

In a representative profile, a mat of fibrous organic matter about one-half inch thick overlies the surface layer. The surface layer is mainly silty clay. It is dark gray, friable, and about 5 inches thick. The subsoil is dark-gray and gray, firm silty clay about 26 inches thick. The upper part has some dark reddish-brown mottles. The substratum is gray, firm silty clay loam and olive-gray, friable sandy clay loam. It is slightly to moderately limy.

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

These soils are suited to hayland and pasture. Most of the acreage is in native grass. Cattails are common in wet areas.

Representative profile of a Dimmick silty clay in an area of native grass, 635 feet north and 1,690 feet west of the southeast corner of sec. 29, T. 138 N., R. 77 W.:

O—½ inch to 0, mat of fibrous organic matter, black (N 2/0) when moist; abrupt, smooth boundary.

A11—0 to 1½ inches, dark-gray (10YR 4/1) silt loam, black when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

A12—1½ to 5½ inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) when moist; few, fine, faint mottles, reddish brown (5YR 4/4) when dry; weak, medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B21g—5½ to 13 inches, dark-gray (N 4/0) silty clay, very dark gray (2.5Y 3/1) when moist; continuous dark reddish-brown (5YR 3/4) films on all faces of peds; moderate, medium, prismatic structure to strong, fine and very fine, angular blocky; very hard when dry, firm when moist, sticky and plastic when wet; gradual, wavy boundary.

B22g—13 to 17 inches, dark-gray (N 4/0) silty clay, very dark gray (2.5Y 3/1) when moist; patches of dark reddish-brown (5YR 3/4) films on vertical faces of peds; moderate, medium, prismatic structure separating to moderate, fine, angular blocky; very hard when dry, very firm when moist, very sticky and very plastic when wet; gradual, wavy boundary.

B3g—17 to 32 inches, gray (2.5Y 5/1) silty clay, very dark gray (2.5Y 3/1) when moist; massive parting to weak, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; gradual, wavy boundary.

C1ca—32 to 50 inches, gray (2.5Y 5/1) silty clay loam, dark gray (2.5Y 4/1) when moist; weak, fine and very fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; moderate effervescence; many masses of segregated lime; abrupt, wavy boundary.

IIC2g—50 to 60 inches, olive-gray (5Y 4/2) sandy clay loam, dark olive (5Y 3/3) when moist; high content of white salt mycelia; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; common masses of segregated lime.

The A horizon ranges from 2 to 9 inches in thickness. In most places it is silty clay and clay, but in a few it is silt loam. The B horizon ranges from 13 to 27 inches in thickness. It is black and very dark gray silty clay loam or silty clay in the upper part and black to olive-gray silty clay loam or silty clay in the lower part. The reddish-brown and dark yellowish-brown staining on the uncrushed subsoil is distinct to prominent; thus, the material appears to be lighter colored. The C horizon is dark-gray to light olive-brown silty clay loam or silty clay. It is slightly to strongly limy. The depth to which these soils are darkened by organic matter ranges from 18 to more than 60 inches. The depth to lime ranges from 25 to 50 inches.

Dimmick soils are associated with Heil, Lallie, and Parnell soils. In contrast with Heil soils, they do not have an A2 horizon and a columnar B2t horizon. They have a thicker A1 horizon and are dark colored to a greater depth than Lallie soils. In contrast with Parnell soils, they have reddish-brown staining in the upper subsoil and are more clayey throughout the profile.

Dimmick silty clay (0 to 3 percent slopes) (Dk).—This nearly level soil is in flat-bottom basins. Areas are generally more than 100 acres in size. Dimmick soils make up about 65 percent of this mapping unit and Parnell soils about 20 percent. The rest is Regan, Colvin, and Heil soils. On about half the acreage, the surface layer of the Dimmick soil is silty clay loam. In a few areas it is clay.

The Dimmick soil has the profile described as representative for the series. In areas, however, where the 1½ inches of silt loam has been mixed with the finer textured underlying material, the plow layer is silty clay. In a few areas it is clay.

Surface runoff is very slow. Flooding is the main limitation.

Most of the acreage is used for native hay and pasture. An entire field of hay can be cut during dry seasons, but only the outer edges can be cut during wet seasons. Capability unit IIIw–4; Wetland range site; windbreak group 2.

Flasher Series

The Flasher series consists of sloping to steep, excessively drained soils that are shallow over soft sandstone. These soils are on high ridges and buttes. They formed in material weathered from soft sandstone.

In a representative profile, the surface layer is dark grayish-brown fine sandy loam about 6 inches thick. It is moderately limy. The next layer is grayish-brown, friable, moderately limy fine sandy loam about 3 inches thick. The underlying material consists of light yellowish-brown, loose loamy fine sand that grades to brownish-yellow, soft sandstone below a depth of about 19 inches.

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

Most areas are in native grass, to which the soils are suited.

Representative profile of a Flasher fine sandy loam under native grass in an area of Flasher-Vebar-Rock outcrop complex, steep, 132 feet south and 185 feet east of the northwest corner of sec. 20, T. 140 N., R. 79 W.:

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; gradual, wavy boundary.

AC—6 to 9 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; moderate effervescence; gradual, wavy boundary.

C1—9 to 19 inches, light yellowish-brown (2.5Y 6/3) loamy fine sand, light olive brown (2.5Y 5/4) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; strong effervescence, and a few masses of segregated lime; gradual, wavy boundary.

C2—19 to 60 inches, brownish-yellow (10YR 6/7) soft sandstone, yellowish brown (10YR 5/8) when moist; moderate effervescence.

The A horizon is dark grayish brown or very dark grayish brown and ranges from fine sandy loam to loamy sand. In most places, the soil is darkened by organic matter to a depth of less than 10 inches. The depth to lime ranges from 0 to 9 inches.

Flasher soils are associated with Vebar and Werner soils. They are shallower over soft bedrock than Vebar soils. They are coarser textured than Werner soils.

Flasher soils, sloping (6 to 9 percent slopes) (FhC).—This mapping unit is about 70 percent Flasher soils and about 30 percent Vebar fine sandy loam. The Flasher soil is on ridges and the upper slopes. The Vebar soil is on the lower slopes.

These soils are droughty. Fertility is low. Runoff is rapid, and water erosion is a hazard. The low available water capacity and shallowness are the major concerns in management.

Most of the acreage is in native grass. Capability unit VIe–TSy; Thin Sandy range site; windbreak group 10.

Flasher-Vebar complex, hilly (9 to 15 percent slopes) (FmE).—This mapping unit is about 45 percent Flasher soils and 30 percent Vebar soils. The rest is Werner, Parshall, Sen, and Arnegard soils. The Flasher soil is on ridges, and the Vebar fine sandy loam occupies the less sloping areas.

The solum of the most sloping Vebar soils is slightly shallower than that of the soil described as representative for the series (see Vebar Series). Otherwise, their profiles are similar.

Surface runoff is rapid, and the erosion hazard is severe. Fertility is low in the Flasher soil and medium in the Vebar soil. Conserving moisture and controlling erosion are the main concerns in management.

Most areas are in native grass. Capability unit VIe-TSy; Flasher soil in Thin Sandy range site and windbreak group 10; Vebar soil in Sandy range site and windbreak group 5.

Flasher-Vebar-Rock outcrop complex, steep (FrF).—This mapping unit is about 45 percent Flasher soils, 35 percent Vebar fine sandy loam, and 20 percent sandstone outcrops. The Flasher soil is on the upper slopes, and the Vebar soil is on the lower slopes. Slope gradient is more than 15 percent. Included in mapping were areas of Werner, Zahl, and Arnegard soils. In the south-central part of the county, some areas are 25 to 50 percent Flaxton soils.

The Flasher soil has the profile described as representative for the Flasher series. The Vebar soil is described under the heading "Vebar Series."

Surface runoff is rapid, and the erosion hazard is severe. Fertility is low in the Flasher soil and medium in the Vebar soil. Conserving moisture and controlling erosion are major concerns in management.

Most areas are in native grass. Capability unit VIe-TSy; Flasher soil in Thin Sandy range site and windbreak group 10; Vebar soil in Sandy range site and windbreak group 5. No capability, range site, or windbreak classification for Rock outcrop.

Flaxton Series

The Flaxton series consists of deep, nearly level to gently sloping, well-drained soils. These soils are on the smoother parts of sand-mantled glacial till plains. They formed in moderately sandy material and the underlying glacial till.

In a representative profile, the surface layer is very dark grayish-brown fine sandy loam about 15 inches thick. The upper part of the subsoil is grayish-brown, friable fine sandy loam about 7 inches thick. The lower part is grayish-brown, firm clay loam about 13 inches thick over about 7 inches of light brownish-gray clay loam. The underlying glacial till is pale-olive, firm clay loam that has few to many lime segregations and a few stones.

474-504—74——2

Permeability is moderately rapid in the material above the clay loam glacial till and moderately slow in the till. The available moisture capacity and the organic-matter content are moderate. Fertility is medium.

These soils are well suited to crops, grass, and trees. Most of the acreage is cultivated. A few areas are in native grass, and some are in tame grasses or alfalfa.

Representative profile of Flaxton fine sandy loam under native grass in an area of Flaxton-Livona fine sandy loams, undulating, 190 feet south of the northeast corner of sec. 24, T. 137 N., R. 79 W.:

A1—0 to 15 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist, dark grayish brown (10YR 4/2) in the upper 2 inches; very weak, medium and coarse, prismatic structure parting to weak, fine, subangular blocky and crumb; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; many roots; natural; gradual, smooth boundary.

B1—15 to 22 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; thin stains on ped faces, very dark brown (10YR 2/2) when moist; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; neutral; clear, wavy boundary.

IIB21t—22 to 25 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; thin continuous clay films on ped faces, very dark grayish brown (2.5Y 3/2) when moist; a few pebbles; mildly alkaline; clear boundary.

IIB22t—25 to 30 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse and medium, prismatic structure; thin continuous films on prism faces; hard when dry, firm when moist, sticky and plastic when wet; few roots; a few tongues (or filled cracks) of fine sandy loam; mildly alkaline; moderate effervescence, a few soft lime masses; gradual, wavy boundary.

IIB31ca—30 to 35 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse and medium, prismatic structure, very hard when dry, firm when moist, sticky and plastic when wet; moderate effervescence, many soft lime spots which give a mottled appearance to soil mass; moderately alkaline; gradual boundary.

IIB32ca—35 to 42 inches, light brownish-gray (2.5Y 6/2) clay loam, olive brown (2.5Y 4/3) when moist; moderate, medium, prismatic structure; very hard when dry, firm when moist, sticky and plastic when wet; moderate effervescence; few, large, soft lime spots; moderately alkaline; gradual boundary.

IICca—42 to 60 inches, pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) when moist; massive, but breaks into irregular flakes and blocks characteristic of glacial till; very hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; moderately alkaline.

The solum ranges from 25 to more than 48 inches in thickness. The A horizon is 10 to 24 inches thick and is neutral or mildly alkaline. It is dark grayish-brown or very dark grayish-brown fine sandy loam or loamy fine sand. The upper B horizon is 6 to 14 inches thick and is neutral or mildly alkaline. It is fine sandy loam. The IIBt horizon is clay loam or loam. It is mildly alkaline in the upper part and mildly or moderately alkaline in the lower part. The IIC horizon is light brownish-gray, grayish-brown, or pale-olive loam or clay loam glacial till. It is strongly limy.

Flaxton soils are associated with Lihen, Livona, Parshall, and Williams soils. In contrast with Lihen and Parshall soils, they have a two storied profile of sandy material in the upper part and clayey material within a depth of 40 inches in the lower part. In contrast with Livona soils they have a dark-colored surface layer that is more than 20 inches thick. They are more sandy in the surface layer than Williams soils.

Flaxton fine sandy loam (0 to 3 percent slopes) (Fs).—This soil is on the sand-mantled glacial till plain. Included in the mapping were areas of Flaxton loamy fine sand and a few small areas of Livona and Parshall soils.

This soil is highly susceptible to soil blowing. Cultivated fields are moderately eroded. Surface runoff is slow. Fertility is medium. Conserving moisture and controlling erosion are the major concerns in management.

About half the acreage is cultivated. Most of the rest is in native grass. Capability unit IIIe–3M; Sandy range site; windbreak group 5.

Flaxton-Livona loamy fine sands, undulating (0 to 6 percent slopes) (FtB).—This complex is about equal parts of Flaxton loamy fine sand and Livona loamy fine sand. The Flaxton soil occupies concave positions, and the Livona soil convex positions. About 25 percent of the cultivated areas are moderately eroded.

Except for a coarser textured surface layer, the Flaxton soil has a profile similar to the one described as representative for the Flaxton series. The Livona soil is described under the heading "Livona Series."

These soils are very highly susceptible to soil blowing. Surface runoff is slow. Fertility is medium. Controlling erosion, maintaining fertility, and conserving moisture are the major concerns in management.

About 40 percent of the acreage is cultivated. The rest is in native grass. Capability unit IVe–2; Sands range site; windbreak group 5.

Flaxton-Livona fine sandy loams, undulating (3 to 6 percent slopes) (FvB).—This complex is about 50 percent Flaxton fine sandy loam, 40 percent Livona fine sandy loam, and 10 percent Parshall, Lihen, and Williams soils. Livona soils are on the upper slopes. Small areas are moderately eroded.

Each soil has the profile described as representative for its respective series.

These soils are highly susceptible to soil blowing. Surface runoff is slow. Fertility is medium. Scattered glacial stones occur on the surface. Conserving moisture, controlling erosion, and maintaining fertility are the major concerns in management.

About half the acreage is cultivated. The rest is in native grass. Capability unit IIIe–3M; Sandy range site; windbreak group 5.

Grail Series

The Grail series consists of deep, nearly level and gently sloping, well-drained soils. These soils are in swales and small valleys. They formed in alluvium derived from soft shale and glacial till.

In a representative profile, the surface layer is very dark grayish-brown silty clay loam about 16 inches thick. The subsoil is dark grayish-brown, very firm silty clay about 14 inches thick. The underlying material is firm silty clay. It is dark grayish brown in the upper part and grayish brown in the lower part.

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

These soils are well suited to small grain, grasses, legumes, and trees. Most of the acreage is cropland.

Representative profile of Grail silty clay loam, gently sloping, in an area of native grass, 50 feet south and 1,320 feet west of the northeast corner of sec. 16, T. 139 N., R. 79 W.:

A11—0 to 4 inches, very dark grayish-brown (10YR 3/2) silty clay loam, black (10YR 2/1) when moist; weak, medium and fine, subangular blocky structure parting to weak, medium and fine, granular; slightly hard when dry, friable when moist, sticky and plastic when wet; clear, smooth boundary.

A12—4 to 12 inches, very dark grayish-brown (10YR 3/2) silty clay loam, black (10YR 2/1) when moist; weak, fine, prismatic structure parting to moderate, medium, subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; gradual, smooth boundary.

A13—12 to 16 inches, very dark grayish-brown (10YR 3/2) silty clay loam, black (10YR 2/1) when moist; weak, medium, prismatic structure parting to moderate, fine and medium, subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; gradual, smooth boundary.

B2t—16 to 30 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, coarse and medium, prismatic structure parting to moderate, coarse and medium, angular blocky; very hard when dry, very firm when moist, very sticky and very plastic when wet; continuous clay film on vertical faces of peds and patches of clay film on horizontal faces of peds; clear, smooth boundary.

C1—30 to 48 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; massive; hard when dry, firm when moist, very sticky and very plastic when wet; gradual, smooth boundary.

C2ca—48 to 60 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; massive; hard when dry, firm when moist, very sticky and very plastic when wet; strong effervescence, few masses of segregated lime.

The solum ranges from 20 to more than 40 inches in thickness. The A horizon is silt loam or silty clay loam and ranges from 7 to 18 inches in thickness. It is very dark brown or black when moist. The B horizon is very dark grayish brown or very dark brown when moist. The C2ca horizon is strongly limy.

Grail soils are associated with Arnegard, Grassna, and Savage soils. In contrast with Arnegard and Grassna soils, they have strong blocky structure in the B2t horizon and are finer textured in the B and C horizons. In contrast with Savage soils, they are dark colored to a depth of more than 20 inches.

Grail silt loam, level (0 to 3 percent slopes) (GlA).—This soil is in swales and small valleys. Included with this soil in mapping were small areas of Arnegard silt loam and of Williams, Regent, and Belfield soils.

The profile of this soil is less clayey throughout than the one described as representative for the series.

This soil receives runoff from surrounding areas. Surface runoff is slow. Otherwise there are no major concerns in management.

Most areas are cultivated. All locally grown crops are suited. Capability unit IIc–6; Silty range site; windbreak group 1.

Grail silt loam, gently sloping (3 to 6 percent slopes) (GlB).—This soil is on the foot slopes of higher surrounding areas and in concave swales. Included in mapping were small areas of Arnegard silt loam and of Williams, Regent, and Belfield soils.

The profile of this soil is less clayey throughout than the one described as representative for the series.

Surface runoff is medium. Fertility is high. Runoff from surrounding areas cuts gullies through areas of this soil. Grassed waterways are needed for control of water erosion. Other management needed is usually determined by the needs of the associated soils.

Most areas are cultivated. Capability unit IIe–6; Silty range site; windbreak group 1.

Grail silty clay loam, level (0 to 3 percent slopes) (GrA).—This soil is in swales and small valleys. Included in mapping were a few small areas of Grail silt loam and of Daglum, Regent, Rhoades, and Savage soils.

Surface runoff is slow. A few areas are only moderately well drained. Fertility is high. Runoff from surrounding soils ponds on this soil for short periods. The management needed is usually determined by the needs of the associated soils.

Most areas are cultivated. All locally grown crops are suited. Capability unit IIc–7; Clayey range site; windbreak group 1.

Grail silty clay loam, gently sloping (3 to 6 percent slopes) (GrB).—This soil is in swales and small valleys. Slopes are mainly 3 to 6 percent, but in a few small areas they are 6 to 9 percent. Included in mapping were a few small areas of Grail silt loam and of Daglum, Regent, and Savage soils.

This soil has the profile described as representative for the Grail series.

Surface runoff is medium. Fertility is high. Runoff from adjacent areas cuts gullies in areas of this soil. Grass waterways help reduce water erosion.

Most areas are cultivated. Capability unit IIe–7; Clayey range site; windbreak group 1.

Grassna Series

The Grassna series consists of deep, nearly level, well-drained soils that formed in local alluvium washed from adjacent loess-mantled slopes. These soils are in swales and on the lower slopes.

In a representative profile, the surface layer is dark-gray silt loam about 17 inches thick. The subsoil, a friable silt loam, extends to a depth of more than 60 inches and grades from dark gray and dark grayish brown to grayish brown. It is slightly limy in the lower part.

Permeability is moderate. Available water capacity, organic-matter content, and fertility are high.

These soils are well suited to small grain, grass, legumes, and trees. Most areas are cropland.

Representative profile of a Grassna silt loam in a cultivated field within an area of Arnegard and Grassna silt loams, level, 1,740 feet south and 135 feet west of the northeast corner of sec. 2, T. 137 N., R. 80 W.:

A1—0 to 17 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; gradual, wavy boundary.

B21—17 to 33 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, coarse, prismatic structure parting to weak, coarse, angular blocky; soft when dry, friable when moist, slightly sticky and nonplastic when wet; gradual, wavy boundary.

B22—33 to 50 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, coarse and medium, prismatic structure parting to moderate, coarse and medium, angular blocky; soft when dry, friable when moist, slightly sticky and nonplastic when wet; gradual, wavy boundary.

B3ca—50 to 62 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, coarse and medium, angular blocky structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; weak effervescence; gradual boundary.

IICca—62 to 68 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, angular blocky structure; soft when dry, friable when moist, sticky and plastic when wet; weak effervescence, few masses of segregated lime; gradual boundary.

The A1 horizon is very dark gray or very dark grayish brown when moist and dark gray or grayish brown when dry. Silt loam texture predominates throughout the upper 40 inches or more of the profile. The depth to which these soils are darkened by organic matter ranges from 20 to 60 inches. The depth to lime is 18 to 60 inches.

Grassna soils are associated with Arnegard, Grail, Linton, and Mandan soils. They are more silty than Arnegard soils. They have a thicker solum than Grail soils, but do not have the clayey B2t horizon characteristic of those soils. In contrast with Linton soils, they are dark colored to a depth of more than 20 inches and have a thicker, noncalcareous solum. They are finer textured than Mandan soils, and the depth to lime is greater. The Grassna soils in this county are mapped only with Arnegard soils.

Harriet Series

The Harriet series consists of deep, nearly level, poorly drained soils that formed in clayey alluvium. These soils have a claypan. They are on low terraces and bottom lands along streams.

In a representative profile, the surface layer is gray loam about 2 inches thick. The upper part of the subsoil, a claypan, is dark-gray firm heavy clay loam about 4 inches thick. The lower part is grayish-brown, firm clay loam about 12 inches thick. It is moderately to strongly limy and has some accumulation of salts. The upper 10 inches of the underlying material is grayish-brown and light brownish-gray, firm loam. It is strongly limy. Below this is light yellowish-brown and dark-gray, stratified very fine sandy loam, loam, and clay loam.

Permeability is slow. Available water capacity and the organic-matter content are moderate. Fertility is low.

These soils are suited to native grasses and hay. Most areas are in native grass.

Representative profile of Harriet loam under native grass within an area of Harriet complex, 1,690 feet east and 40 feet north of the southwest corner of sec. 34, T. 139 N., R. 79 W.:

A2—0 to 2 inches, gray (2.5Y 5/1 and 6/1) loam, very dark gray (2.5Y 3/1) when moist; weak, thick and medium, platy structure; friable when moist; many fine roots, common fine pores; few salt crystals visible when dry; moderately alkaline; abrupt, wavy boundary.

B21t—2 to 6 inches, dark-gray (2.5Y 4/1) heavy clay loam, black (2.5Y 2/1) when moist; moderate, medium, columnar structure; extremely hard when dry, firm when moist; common roots; coatings on column tops and sides, gray (2.5Y 5/1) when dry, very dark gray (2.5Y 3/1) when moist; slightly calcareous in columns; strongly alkaline; clear, wavy boundary.

B22t—6 to 18 inches, grayish-brown (2.5Y 5/2) clay loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, coarse, prismatic structure and weak, medium, subangular blocky; very hard when dry, firm when moist; few roots; common medium pores; common, fine, white salt crystals; calcareous, strongly alkaline; gradual, wavy boundary.

C1—18 to 28 inches, grayish-brown and light brownish-gray (2.5Y 5/2 and 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure; very hard when dry, firm when moist; occasional fine roots; few medium and fine pores; fine salt crystals visible when dry; strongly calcareous, strongly alkaline; abrupt, smooth boundary.

IIC2—28 to 38 inches, light yellowish-brown (2.5Y 6/3) very fine sandy loam, light olive brown (2.5Y 5/3) when moist; very weak, coarse, prismatic structure and weak, coarse and medium, subangular blocky; very hard when dry, friable when moist; few fine pores; common very fine salt crystals visible when dry; calcareous, strongly alkaline; abrupt, smooth boundary.

IIAb—38 to 40 inches, dark-gray (2.5Y 4/1) clay loam, very dark gray (2.5Y 3/1) when moist; few, medium, distinct mottles, olive brown (2.5Y 4/3) when moist; weak, coarse, prismatic structure; very hard when dry, firm when moist; few fine roots; calcareous, strongly alkaline; abrupt boundary.

IIC3—40 to 60 inches, light yellowish-brown (2.5Y 6/3) stratified loam and clay loam, olive brown (2.5Y 4/3) when moist; massive breaking to weak, coarse and medium, subangular blocky structure; very hard when dry, friable when moist; calcareous, strongly alkaline.

The solum ranges from 10 to 20 inches in thickness. The A2 horizon ranges from 1 to 4 inches in thickness and from loam to clay loam in texture. In many places, the lower part of this horizon is a silty layer that when dry is grayer than the overlying part. It ranges from a film to a layer 3 inches thick and, in places, includes all of the soil above the claypan. The B21t horizon, or claypan, ranges from 3 to 6 inches in thickness and from clay loam to clay in texture. The B22t horizon is highly variable in texture, but is commonly clay loam or clay. Colors are very dark grayish brown, dark grayish brown, or dark gray when moist. The stratified underlying material ranges in texture from fine sandy loam to clay.

Harriet soils are associated with Dimmick, Heil, and Rhoades soils. In contrast with Dimmick soils, they have a claypan. They are coarser textured than Heil soils and are calcareous throughout. In contrast with Rhoades soils, they are stratified and poorly drained.

Harriet complex (0 to 3 percent slopes) (Hh).—This mapping unit is along the bottom land of small streams. It is about 70 percent Harriet soils of clay loam, loam, and clay textures. The rest is Daglum and Regan soils. Microrelief of 1 to 5 inches is common. Harriet soils are in depressions. Daglum soils occupy the high spots, and Regan soils the basins or seeps.

The Harriet soil has the profile described as representative for the series.

Surface runoff is slow. Fertility is low. The shallow claypan, the hazard of flooding, and the seasonal high water table are major concerns in management.

The Harriet soils are suited only to native grass, which is their major use. Capability unit VIs–SS; Saline Subirrigated range site; windbreak group 10.

Harriet and Regan soils, strongly saline (0 to 3 percent slopes) (Hk).—These soils are on creek bottoms and low lake terraces and in basins. Some areas are Regan soils, some are Harriet soils, and others contain both soils. Included in mapping were a few small areas of Colvin, Heil, and Rhoades soils. The Harriet soil occurs mainly on the terraces and bottom land, and the Regan soil in

the basins. White salts have accumulated on the surface (fig. 3).

The profiles of these soils are more saline but are otherwise similar to those described as representative for their respective series. (For Regan soil, see Regan Series.)

Surface runoff is slow. Fertility is low. Wetness and the dense claypan are the major concerns in management.

Most areas are in native grass. Saltgrass is the dominant vegetation. Thin vegetation and barren areas are common. A few basins, too wet to graze, are suited to wildlife. Capability unit VIs–SS; Saline Subirrigated range site; windbreak group 10.

Havrelon Series

The Havrelon series consists of deep, nearly level, moderately well drained soils that formed on flood plains along the Missouri River.

In a representative profile, the surface layer is light brownish-gray loam about 13 inches thick. The underlying material is stratified (fig. 4), grayish-brown, light olive-gray, light-gray, olive-gray, and pale-yellow, friable very fine sandy loam, silt loam, and silty clay loam. It is slightly limy in the upper part and strongly limy in the lower part.

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

These soils are suited to small grain, corn, and alfalfa (fig. 5). They are also used for native and tame pasture and hay and for recreation and wildlife habitat. Most of the acreage is cropland, and part is woodland.

Representative profile of a Havrelon loam in a cultivated field, 1,440 feet south and 50 feet east of the northwest corner of sec. 2, T. 139 W., R. 81 W.:

Ap—0 to 13 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, mildly alkaline; abrupt, smooth boundary.

IIC1—13 to 18 inches, grayish-brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium, granular structure and a lens of strong, very thin, platy or very fine angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; slight effervescence, mildly alkaline; clear, smooth boundary.

IIIC2—18 to 26 inches, light olive-gray (5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, mildly alkaline; clear, smooth boundary.

IVC3—26 to 40 inches, pale-yellow and light brownish-gray (2.5Y 7/3 and 2.5Y 6/2) very fine sandy loam stratified with fine sandy loam and silty clay loam, dark grayish brown (2.5Y 4/2) when moist; massive with strata separating to weak or moderate, thin, platy structure; very friable when moist; calcareous, mildly alkaline.

Figure 3.—**Regan soils, strongly saline. The light colored spots are surface salt accumulations.**

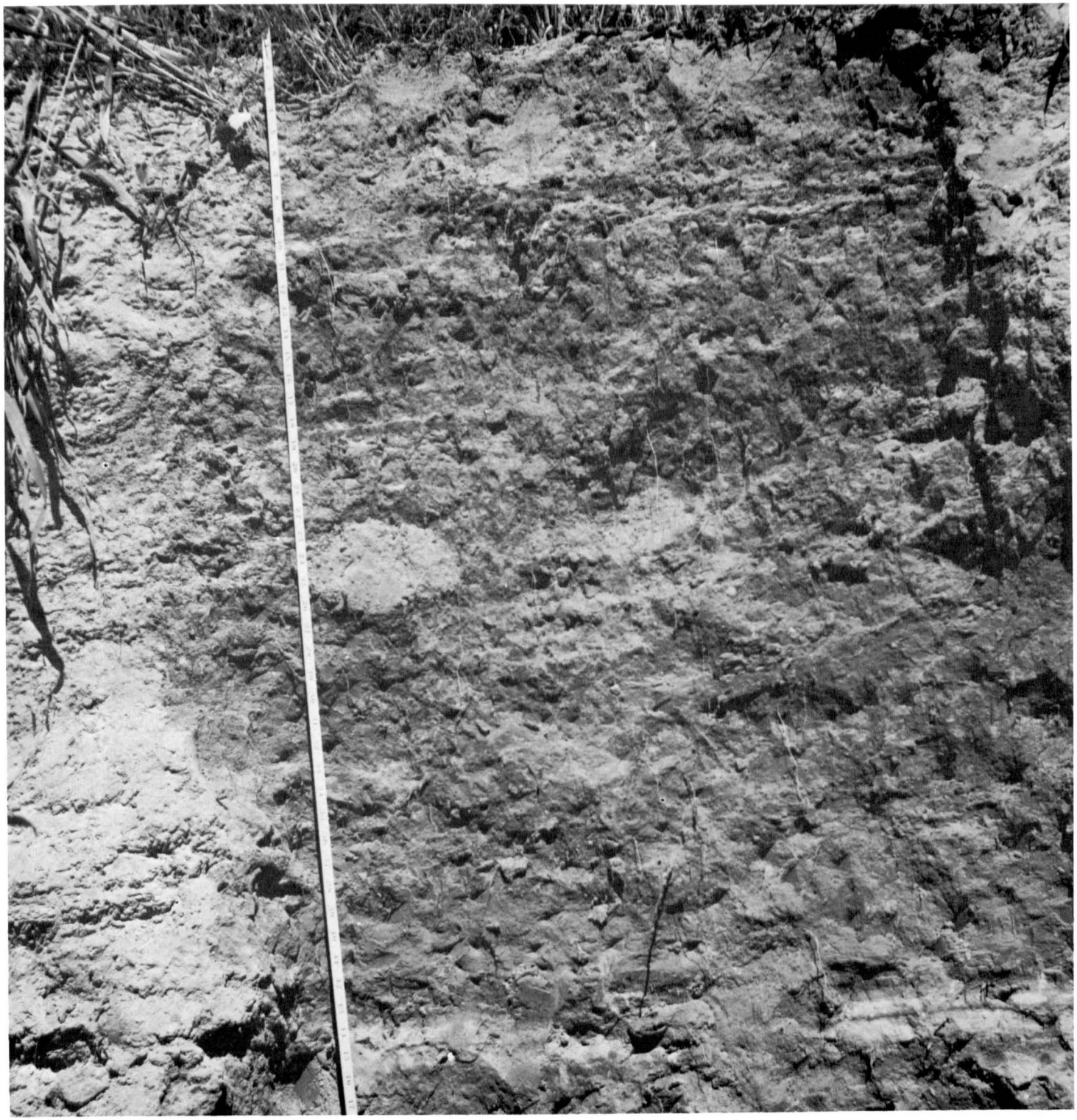

Figure 4.—Profile of Havrelon silty clay loam showing thin stratification.

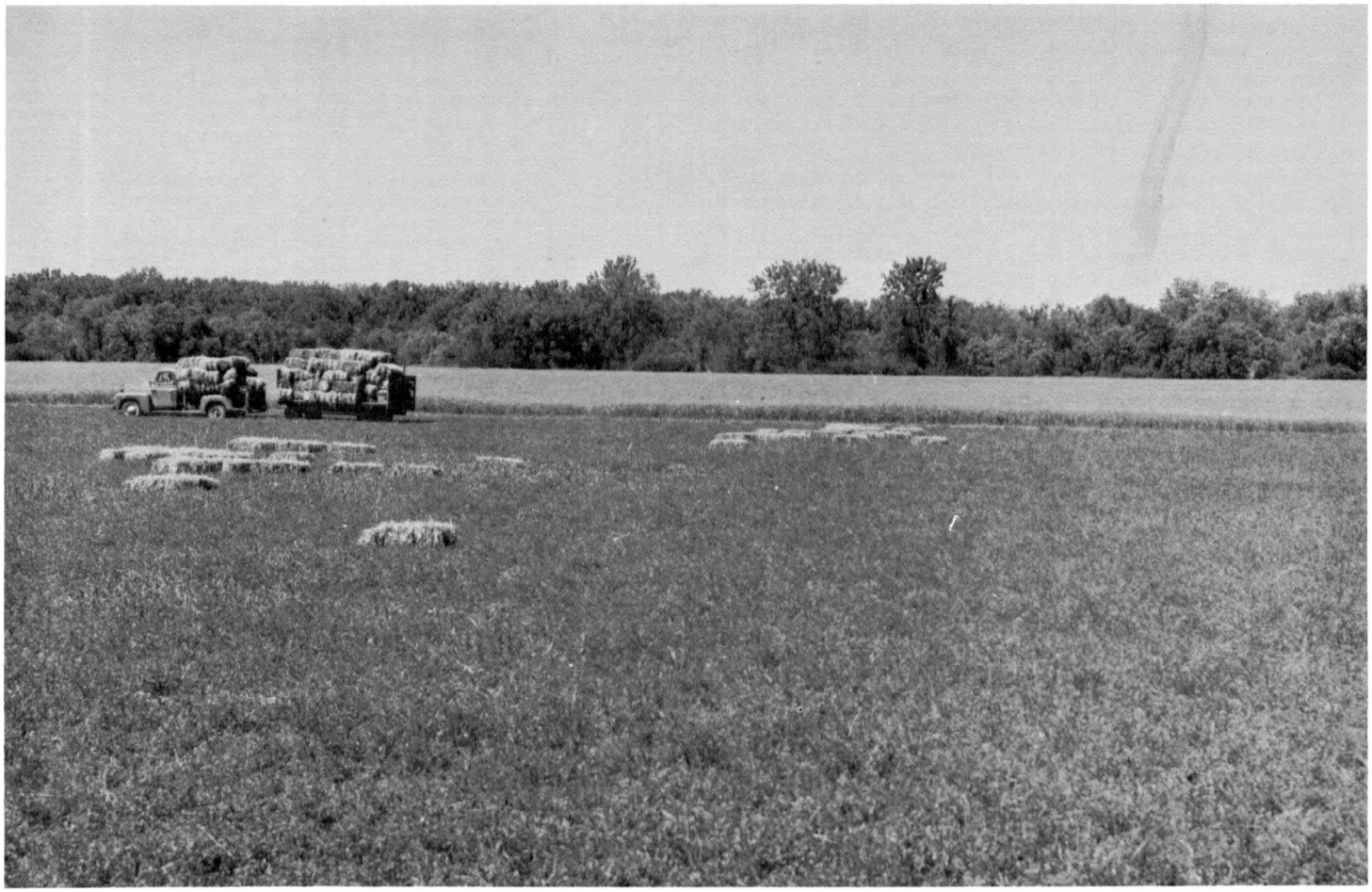

Figure 5.—**Alfalfa on Havrelon silty clay loam. Wooded Havrelon soils are in the background.**

VC4—40 to 46 inches, olive-gray (5Y 5/2) silt loam and silty clay loam, olive gray (5Y 4/2) when moist; common, medium, distinct, reddish-yellow (5YR 7/8) mottles; massive breaking to weak, thin, platy structure; friable when moist; calcareous, mildly alkaline.

VIC5—46 to 60 inches, pale-yellow (5Y 7/3) very fine sandy loam, olive (5Y 4/3) when moist; massive; very friable when moist; calcareous, mildly alkaline.

The A horizon ranges from 3 to 18 inches in thickness. It is loam, fine sandy loam, or silty clay loam and is dark grayish brown to grayish brown when moist. Thin strata of contrasting textures and colors are common in the C horizon. The medium and moderately fine textures dominate.

Havrelon soils are associated with Banks, Lallie, and Lohler soils. They are finer textured than Banks soils. They are better drained than Lallie soils. They are coarser textured than Lohler soils.

Havrelon fine sandy loam (0 to 3 percent slopes) (Hm).—This soil is adjacent to coarser textured soils on levees near the Missouri River. Some areas are covered with brush and are slightly undulating. Each mapped area is about 80 percent Havrelon fine sandy loam. Included in mapping were areas of Banks soils, areas of Havrelon soils that have a finer textured surface layer, and small areas where the substratum is fine sandy loam.

This Havrelon soil is fine sandy loam to a depth of 6 to 20 inches, but otherwise has a profile similar to the one described as representative for the series.

Surface runoff is slow. Fertility is medium. The organic-matter content is low.

This soil is suited to all locally grown crops. About half the acreage is cultivated, and part of this is irrigated. The rest is covered with brush, trees, and grass and is used for grazing and for wildlife. Capability unit IIIe-3; Sandy range site; windbreak group 1.

Havrelon loam (0 to 3 percent slopes) (Hn).—This soil is on bottom land of the Missouri River. Included in mapping were areas where the surface layer is silt loam and very fine sandy loam and a few small areas of Banks and Lallie soils.

This Havrelon soil has the profile described as representative for the series.

Surface runoff is slow. Fertility is medium, and the organic-matter content is low. The seasonal high water table is within a depth of 3 feet.

Most of the acreage is cultivated, and a considerable acreage is irrigated. Small grain and feed crops are grown. Native grasses are grown for hay and pasture. Heavily wooded areas are used for wildlife habitat and recreation. Capability unit IIc-6; Silty range site; windbreak group 1.

Havrelon loam, clay subsoil variant (0 to 3 percent slopes) (Ho).—This soil is on bottom land along the Mis-

souri River. It is underlain by silty clay or clay at a depth of 18 to 40 inches. Included in mapping were a few small areas of Lohler soils and areas of Havrelon soils that do not have a clay subsoil.

Surface runoff is slow. Permeability is slow in the fine-textured layer. Fertility is medium, and the organic-matter content is low.

This soil is well suited to the crops commonly grown. Most of the acreage is cultivated. Native grasses are grown for hay or grazing. Wooded areas are used for wildlife habitat and recreation. Capability unit IIc–6; Silty range site; windbreak group 1.

Havrelon silty clay loam (0 to 3 percent slopes) (Hr).—This soil occupies low areas of the Missouri River bottom land. Each mapped area is about 85 percent Havrelon silty clay loam and 15 percent Lohler and another Havrelon soil, both of which have a coarser textured surface layer.

This Havrelon soil has a finer textured surface layer and has mottles within a depth of 10 inches, but otherwise has a profile similar to the one described as representative for the series.

Surface runoff is slow. Fertility is medium. The seasonal high water table is within a depth of 3 feet in some areas.

Most of the acreage is cultivated, and a considerable acreage is irrigated. The rest is in native grass. All locally grown crops are well suited. Some of the wooded areas are used for grazing, wildlife habitat, and recreation. Capability unit IIc–7; Clayey range site; windbreak group 1.

Heil Series

The Heil series consists of deep, nearly level, poorly drained soils that formed in fine-textured alluvium in flat-bottomed basins and sloughs. These soils have a claypan in the upper part of the subsoil.

In a representative profile, the surface layer is gray silt loam about 1 inch thick. The pan is dark-gray, very firm clay about 4 inches thick. It has a thin film of gray silty material in the upper part. The lower part of the subsoil is gray, very firm clay about 15 inches thick. The underlying material is light brownish-gray, very firm clay that is strongly limy. It grades to light yellowish-brown, very firm clay that is slightly limy.

Permeability is very slow. The available water capacity and organic-matter content are moderate. Fertility is medium.

These soils are suited only to native grass and hay and to plantings for wildlife habitat. Most areas are in native grass. Slough grasses, rushes, and cattails occur in the more poorly drained areas.

Representative profile of a Heil clay under native grass within an area of Heil soils, 135 feet north and 1,900 feet west of the southeast corner of sec. 30, T. 139 N., R. 77 W.:

A2—0 to 1 inch, gray (10YR 5/1) silt loam, dark gray (10YR 4/1) when moist; moderate, thin, platy structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; abrupt, smooth boundary.

B21t—1 to 5 inches, dark-gray (2.5Y 4/1) clay, black (2.5Y 2/2) when moist; weak, medium, columnar structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; columnar tops coated with gray silt particles; gradual, wavy boundary.

B22t—5 to 20 inches, gray (N 5/0) clay, very dark gray (5Y 3/1) when moist; weak, medium, angular blocky structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; gradual, irregular boundary; tongues extend to a depth of 24 inches.

C1ca—20 to 30 inches, light brownish-gray (2.5Y 6/2) clay, olive (5Y 4/3) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; strong effervescence, few masses of segregated lime; gradual boundary.

C2—30 to 60 inches, light yellowish-brown (2.5Y 6/3) clay, olive (5Y 5/3) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; slight effervescence.

The combined thickness of the A1 and A2 horizons ranges from 1 to 3 inches. The A1 horizon, if present, is usually very dark gray when moist and dark gray when dry and ranges from loam to silty clay loam. In places it is thin, dark colored, and platy. The A2 horizon ranges in thickness from a thin film on top of the B21t horizon to a layer 3 inches thick. It ranges from very dark gray to gray when moist and from dark gray to light gray when dry. It is silt loam, silty clay loam, or silty clay. The B21t horizon ranges from 2 to 7 inches in thickness. It is black to very dark grayish brown when moist. The B22t horizon is dominantly silty clay and clay that ranges from 5 to 28 inches in thickness. The underlying C horizon is silty clay and clay and ranges from dark gray to olive. The depth to lime ranges from 15 to more than 38 inches.

Heil soils are associated with Dimmick, Harriet, Parnell, and Rhoades soils. They differ from Dimmick and Parnell soils in having an alkaline claypan. They are finer textured than Harriet and Rhoades soils.

Heil soils (0 to 3 percent slope) (Hs).—These soils are mainly in a series of sloughs connected by narrow channels. The basins in which these soils formed range in size from 10 to several thousand acres. Each mapped area is about 80 percent Heil clay, 10 percent Dimmick clay, and 10 percent Regan soils, strongly saline. Heil soils are in areas that are flooded for short periods, and the Dimmick and Regan soils are in wet low areas.

These Heil soils have the profile described as representative for the Heil series.

These soils receive additional moisture from adjacent areas. Surface runoff is very slow. Fertility is medium. The hazard of flooding and the dense claypan are the major concerns in management.

The best drained areas are grazed or used for hay production. Wet areas are suitable for wildlife habitat. Some areas are mowed or grazed in all but wet years. Capability unit VIw–Ov; Overflow range site; windbreak group 10.

Lallie Series

The Lallie series consists of deep, nearly level, very poorly drained soils in swales, oxbows, and backwater areas of the Missouri River flood plain.

In a representative profile, the surface layer is dark-gray silty clay loam about 3 inches thick. The underlying material is stratified silt loam, silty clay loam, silty clay, and clay and is light brownish gray, dark gray, olive gray, gray, and light gray. It is slightly to moderately limy.

Permeability is slow. Available water capacity is moderate. The organic-matter content and fertility are low.

Most areas are too wet for tillage and are used for wildlife or pasture.

Representative profile of Lallie silty clay loam in an area of native grass, 640 feet north and 85 feet west of the southeast corner of sec. 15, T. 137 N., R. 79 W.:

A1—0 to 3 inches, dark-gray (5Y 4/1) silty clay loam, dark olive gray (5Y 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; abrupt boundary.

C1g—3 to 13 inches, about 25 percent light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist, and 75 percent dark-gray (5Y 4/1) silty clay loam, dark olive gray (5Y 3/2) when moist; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; abrupt boundary.

C2g—13 to 30 inches, olive-gray (5Y 4/2) silty clay, dark olive gray (5Y 3/2) when moist; moderate, very fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence; gradual boundary.

C3g—30 to 52 inches, gray (5Y 5/1) clay, olive gray (5Y 4/2 and 5/2) when moist; many, fine, faint mottles, light olive brown (2.5Y 5/6) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; moderate effervescence, common masses of segregated lime; gradual boundary.

C4g—52 to 60 inches, light-gray (5Y 7/2) silty clay loam, olive gray (5Y 5/2) when dry; many, fine, prominent mottles, light olive brown (2.5Y 5/6) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight to moderate effervescence; abrupt boundary.

The A horizon ranges from 1 to 7 inches in thickness. It is mainly silty clay loam but ranges from fine sandy loam to clay. The C horizon is dominantly silty clay loam, silty clay, or clay but contains thin strata of coarser textured material. It is dominantly dark grayish brown and olive gray when moist but ranges from very dark gray to brown.

Lallie soils are associated with Dimmick, Havrelon, and Heil soils. They differ from Dimmick soils in having a thinner A horizon. In contrast with Havrelon soils, they are poorly drained. They do not have an A2 horizon or a claypan, both of which are characteristic of Heil soils.

Lallie silty clay loam (0 to 3 percent slopes) (La).—This soil is in swales, oxbows, and backwater areas on the flood plain of the Missouri River. Most areas are long and narrow.

This Lallie soil has the profile described as representative for the series.

This soil has poor surface drainage and receives runoff from adjacent areas. Fertility is low. Flooding is the major concern in management. Maintaining tilth is difficult because the organic-matter content is low.

The driest areas are used for alfalfa and small grain. Wetness sometimes delays tillage. The wettest areas are used for wildlife and for grazing. Capability unit IIw-6; Overflow range site; windbreak group 2.

Lehr Series

The Lehr series consists of shallow, nearly level to sloping, somewhat excessively drained soils that are underlain by gravel or coarse sand. These soils formed in glacial outwash on stream terraces. The slope gradient is 1 to 9 percent.

In a representative profile, the surface layer is dark grayish-brown loam about 6 inches thick. The subsoil is friable loam about 11 inches thick (fig. 6). It is dark grayish brown in the upper part and grayish brown in the lower part. The upper part of the underlying material is light brownish-gray gravelly coarse sandy loam about 5 inches thick. It contains a large amount of lime. The lower part is pale-brown gravel.

Permeability is moderately rapid to very rapid. Available water capacity is low. The organic-matter content and fertility are low.

About half the acreage is used for small grain, grass, corn, and legumes, and the rest for native hay and pasture.

Representative profile of Lehr loam, nearly level, in an area of native grass, 60 feet south and 60 feet west of the northeast corner of sec. 4, T. 139 N., R. 77 W.:

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B21—6 to 10 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; weak, coarse and medium, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B22—10 to 17 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (10YR 4/2) when moist; moderate, medium and fine, prismatic structure parting to weak, medium, angular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

IIC1ca—17 to 22 inches, light brownish-gray (2.5Y 6/2) gravelly coarse sandy loam, dark grayish brown (10YR 4/2) when moist; tongues of grayish brown (2.5Y 5/2) and very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strong effervescence; gradual, wavy boundary.

IIIC2—22 to 60 inches, pale-brown (10YR 6/3) gravel, brown (10YR 5/3) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slight effervescence, moderate lime masses.

The solum ranges from 10 to 20 inches in thickness. The depth to gravelly sediments ranges from 13 to 20 inches, and the depth to lime from 10 to 18 inches. The A horizon is dark gray, dark grayish brown, very dark gray, or very dark grayish brown and ranges from 4 to 8 inches in thickness. It is predominantly loam but in places is fine sandy loam and silt loam. The B horizon is dominantly loam, but in places is fine sandy loam or gravelly loam. The IIC horizon is gravel or cross-bedded sand and gravel 30 inches or more thick.

Lehr soils are associated with Manning and Wabek soils. They differ from Manning soils in having a finer textured control section. In contrast with Wabek soils, they have a B horizon and are more than 10 inches deep over gravel.

Lehr loam, nearly level (0 to 3 percent slopes) (LeA).—This mapping unit is about 85 percent Lehr loam. The rest is Manning fine sand loam, Wabek soils, Arnegard silt loam, and Williams loam.

This Lehr loam has the profile described as representative for the series. It is easily worked but is somewhat droughty and slightly susceptible to blowing. Surface runoff is slow. Fertility is low.

Figure 6.—Profile of Lehr loam showing dark-colored surface layer and light-colored, limy subsurface layer. The depth to gravel is about 20 inches.

About 65 percent of the acreage is cultivated. The rest is in native or tame grass. Small grain, corn, and alfalfa are suitable crops. Capability unit IIIs–5; Shallow to Gravel range site; windbreak group 6.

Lehr loam, undulating (3 to 6 percent slopes) (LeB).—This soil is in glacial outwash areas. Each mapped area is about 80 percent Lehr loam and areas of Manning fine sandy loam, Wabek soils, and Arnegard silt loam. Wabek soils are on ridges and knolls, the Lehr soil is on the sides of the ridges and knolls, and the Arnegard soil is in swales.

This soil is shallower over gravel but otherwise has a profile similar to the one described as representative for the series.

This soil is easily worked and has good tilth. Because it is shallow over gravel, it is droughty and thus susceptible to blowing and water erosion. Surface runoff is medium. Fertility is low.

About half the acreage is cultivated. The rest is mainly in native grass. Small grain, corn, and alfalfa are suitable crops. Trees are fairly well suited. Conserving moisture, controlling erosion, and maintaining fertility are the major concerns in management. Capability unit IIIes–5; Shallow to Gravel range site; windbreak group 6.

Lehr loam, sloping (6 to 9 percent slopes) (LeC).—This soil is in glacial outwash areas. Each mapped area is about 75 percent Lehr loam. The rest is Williams loam and small areas of Wabek soils. The Wabek and Williams soils are on ridgetops and knolls, and the Lehr soil is on the sides of ridges. Slopes are short.

This soil is shallower over gravel but otherwise has a profile similar to the one described as representative for the series.

This soil is easily tilled. Excess tillage destroys the structure and thus increases the hazard of blowing and water erosion. Surface runoff is medium. Conserving moisture, controlling erosion, and maintaining fertility are the main concerns in management.

This soil is commonly used for native and tame grasses. It is fairly well suited to small grain and alfalfa. Frequent use of grasses and legumes in the crop rotation is needed. Capability unit IVes–5; Shallow to Gravel range site; windbreak group 6.

Lihen Series

The Lihen series consists of deep, nearly level to steep, well-drained soils that formed in wind-reworked sandy glacial deposits. These soils are in broad valleys and on benches on the uplands.

In a representative profile this soil is loamy fine sand to a depth of about 20 inches. The upper 7 inches is dark gray, the next 7 inches is very dark grayish brown, and the lower part is dark grayish brown. The upper 8 inches of the underlying material is grayish-brown fine sand. Below this is the surface layer of a buried soil. It is grayish-brown loamy fine sand about 6 inches thick. At a depth of about 34 inches is olive-gray fine sand.

Permeability is rapid. Available water capacity and the organic-matter content are moderate. Fertility is medium.

Most of the less sloping areas are cropped and are suited to small grain, grass, corn, and legumes. The steeper areas are mostly in native grass, to which they are well suited.

Representative profile of Lihen loamy fine sand, nearly level, in a cultivated field, 1,320 feet south and 1,270 feet east of the northwest corner of sec. 25, T. 138 N., R. 77 W.:

Ap—0 to 7 inches, dark-gray (10YR 4/1) loamy fine sand, very dark brown (10YR 2/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; abrupt boundary.

A12—7 to 14 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, very dark brown (10YR 2/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; gradual, wavy boundary.

A13—14 to 16 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; gradual, wavy boundary.

AC—16 to 20 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; gradual, wavy boundary.

C1—20 to 28 inches, grayish-brown (10YR 5/2) fine sand, dark grayish brown (2.5Y 4/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; abrupt, smooth boundary.

A1b—28 to 34 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; moderate effervescence, many fine masses of segregated lime; gradual, smooth boundary.

C2ca—34 to 60 inches, olive-gray (5Y 5/2) fine sand, dark olive gray (5Y 3/2) when moist; single grain; soft when dry, very friable to loose when moist, nonsticky and nonplastic when wet; moderate effervescence, few fine and many very fine masses of segregated lime.

These soils are darkened by organic matter to a depth of 20 to 40 inches. The depth to lime ranges from 20 to 60 inches. The A horizon is mostly very dark grayish brown or dark gray. It is dominantly loamy fine sand but in places is fine sandy loam. The C horizon ranges from dark grayish brown to olive gray. It is dominantly loamy fine sand or fine sand but in places is finer textured.

Lihen soils are associated with Flaxton, Parshall, and Telfer soils. They differ from Flaxton soils in not having a glacial till substratum. They have a coarser textured substratum than Parshall soils. In contrast with Telfer soils, the dark colors extend to a depth of more than 20 inches.

Lihen loamy fine sand, nearly level (0 to 3 percent slopes) (LfA).—This soil is in valleys or on terraces. In some places, it is slightly hummocky. Included in mapping were areas of Lihen fine sandy loam and small areas of Flaxton, Telfer, Parshall, and Arveson soils. The Arveson soil is in the low wet basins or seep areas. The other soils are intermingled with the Lihen soil.

This Lihen loamy fine sand has the profile described as representative for the Lihen series.

Surface runoff is slow. Fertility is medium. Some surface ponding occurs in the low areas on inclusions of Arveson soils. In cultivated areas the Lihen soil is highly susceptible to blowing. Small areas are moderately eroded. Conserving moisture and controlling erosion are the major concerns in management.

This soil is suitable for irrigation. More than half the acreage is cultivated. Small grain, corn, and alfalfa are the main crops. Capability unit IVe–2; Sands range site; windbreak group 5.

Dihen loamy fine sand, clay subsoil variant (0 to 3 percent slopes) (Lg).—This soil is 18 to 52 inches of wind-deposited sands over a substratum of lake-deposited clay. About 90 percent of the mapping unit is Lihen loamy fine sand, clay subsoil variant. Included in mapping were areas of Lihen fine sandy loams and loamy fine sands that do not have a clay subsoil and areas of Parshall fine sandy loam.

This Lihen soil is underlain by clay at a depth of 18 to 52 inches but otherwise has the profile described as representative for the series.

This soil is highly susceptible to blowing and in some cultivated areas is moderately eroded. Surface runoff is slow. Fertility is medium. Conserving moisture and controlling erosion are the major concerns in management.

This soil is fairly well suited to small grain, corn, and alfalfa. About half the acreage is cultivated. Capability unit IVe–2; Sands range site; windbreak group 5.

Lihen, Livona, and Parshall fine sandy loams, hilly (9 to 15 percent slopes) (LhD).—Some areas of this mapping unit are Lihen fine sandy loam, some are Livona fine sandy loam, and some are Parshall fine sandy loam. Other areas contain all three soils. In such areas Livona soils are on the upper slopes, and the Lihen and Parshall soils are on the lower slopes and in swales. Slopes are short, broken, and complex.

Each soil is fine sandy loam to a depth of 6 to 20 inches. Otherwise, its profile is similar to the one described as representative for the series. Livona soils are described under the heading "Livona Series," and Parshall soils under the heading "Parshall Series."

Surface runoff is medium on the lesser slopes and rapid on the steeper slopes. Fertility is medium. Soil blowing and water erosion are moderate to severe hazards in cultivated areas.

Nearly all the acreage is in native grass. Some of the less sloping areas are cultivated. Capability unit VIe–Sy; Sandy range site; windbreak group 5.

Lihen, Parshall, and Telfer fine sandy loams, rolling (6 to 9 percent slopes) (LkC).—This mapping unit is on uplands. Some areas are Lihen fine sandy loam, some are Parshall fine sandy loam, and some are Telfer fine sandy loam. Other areas contain all three soils. The Telfer soil is on the upper slopes or ridges, and the Lihen and Parshall soils are on the lower slopes and in swales.

The Lihen and Telfer soils have a fine sandy loam surface layer but otherwise have profiles similar to those described as representative for the respective series. Parshall and Telfer soils are described under the headings "Parshall Series" and "Telfer Series."

Surface runoff is medium. Fertility is medium in Lihen and Parshall soils and low in the Telfer soil. The Telfer soil is droughty. All are highly susceptible to blowing and water erosion. Controlling erosion and conserving moisture are the major concerns in management.

Most areas are in native grass. Some are used for small grain, corn, and alfalfa. Capability unit IVe–3; Sandy range site; Lihen and Parshall soils in windbreak group 5 and Telfer soil in windbreak group 7.

Lihen-Telfer loamy fine sands, undulating (3 to 6 percent slopes) (LlB).—Blowing has made this complex of soils hummocky. Most areas are about 65 percent Lihen loamy fine sand, 20 percent Telfer loamy fine sand, and 15 percent inclusions of Flaxton and Parshall soils. The Lihen soil is on the lower slopes, and the Telfer soil is on the higher convex slopes.

Surface runoff is slow. Fertility is medium in the Lihen soil and low in the Telfer soil. Both soils are highly susceptible to blowing and moderately eroded in some areas. Controlling blowing and conserving moisture are the major concerns in management.

Most of the acreage is in native grass. Cultivated areas are used for small grain, corn, and alfalfa. Some areas are suitable for irrigation. Capability unit IVe–2; Lihen soil in Sands range site and windbreak group 5; Telfer soil in Sands range site and windbreak group 7.

Lihen-Telfer loamy fine sands, rolling (6 to 9 percent slopes) (LmC).—This complex is about 55 percent Lihen loamy fine sand and 20 percent Telfer loamy fine sand. The rest is Lihen fine sandy loam and Flaxton soils. Slopes are short and complex.

Surface runoff is medium. Fertility is medium in the Lihen soil and low in the Telfer soil. Both soils are highly susceptible to blowing in cultivated areas. Controlling blowing and conserving moisture are the main concerns in management.

Most of the acreage is in native grass. Small acreages are cultivated, and most of these are moderately eroded. Capability unit VIe–Sa; Lihen soil in Sands range site and windbreak group 5; Telfer soil in Sands range site and windbreak group 7.

Linton Series

The Linton series consists of deep, nearly level to steep, well-drained soils that formed in thick loess deposits. These soils are on benches and uplands near the Missouri River. Slopes are plane and convex and have a gradient of 1 to 15 percent.

In a representative profile, the surface layer is grayish-brown silt loam about 7 inches thick. The subsoil, about 21 inches thick, is very friable silt loam (fig. 7). It is grayish brown in the upper part and light brownish gray in the lower part. It contains a small amount of lime. The underlying material is light brownish-gray, very friable silt loam. It contains a moderate amount of lime.

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

These soils are well suited to small grain, grass, legumes, and trees. Most areas are cropland.

Representative profile of a Linton silt loam under native grass within an area of Mandan-Linton silt loams, undulating, 420 feet north and 635 feet west of the southeast corner of sec. 30, T. 139 N., R. 80 W.:

A1—0 to 7 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B2—7 to 15 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic

Figure 7.—**Profile of Linton silt loam showing prismatic structure. The dark-colored layer at a depth of 5 feet is the surface layer of a buried soil.**

when wet; slight effervescence; gradual, wavy boundary.

B3—15 to 28 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; gradual, wavy boundary.

C2—28 to 60 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence.

Silt loam is the predominant texture throughout the profile, but in a few areas the surface layer is very fine sandy loam. Sandy or gravelly material occurs below a depth of 40 inches in some areas. The loess mantle is 40 inches or more thick in most areas. The A horizon is very dark brown and very dark grayish brown when moist and ranges from dark grayish brown to grayish brown when dry. The B horizon ranges from 8 to 24 inches in thickness. It is dark grayish brown and grayish brown when moist.

Linton soils are associated with Grassna, Mandan, and Temvik soils. They are coarser textured and lighter colored within a depth of 20 inches than Grassna soils. They differ from Temvik soils in having a more weakly developed B horizon and in not having a glacial till substratum. They are lighter colored than Mandan soils in the top 20 inches and the depth to lime is greater.

Linton-Mandan silt loams, hilly (9 to 12 percent slopes (LnD).—This complex is adjacent to the Missouri River. It is about 55 percent Linton silt loam, 35 percent Mandan silt loam, and 10 percent inclusions of Werner, Grassna, Morton, and Temvik soils. The Linton soil is on the ridges and upper slopes, and the Mandan soil is on the lower slopes.

This Linton soil is lighter colored and is lower in organic-matter content but otherwise has a profile similar to the one described as representative for the series. The Mandan soils are described under the heading "Mandan Series."

Surface runoff is rapid. Available water capacity is high. Fertility is medium in the Linton soil and high in the Mandan soil. Controlling erosion and conserving moisture are the major concerns in management. Water erosion is a serious hazard, especially in areas that are row cropped.

Most of the acreage is in native grass. Moderate erosion is common in cultivated areas. Capability unit IVe-5; Silty range site; windbreak group 3.

Linton-Mandan silt loams, steep (LnE).—This complex is adjacent to the Missouri River. It is about 55 percent Linton silt loam, 35 percent Mandan silt loam, and 10 percent inclusions of Werner, Grassna, and Morton soils. The slope gradient is dominantly 12 to 15 percent but ranges to as much as 35 percent in some areas.

The Linton and Mandan soils are lighter colored and are lower in organic-matter content but otherwise have profiles similar to those described as representative for their respective series.

Runoff is rapid. Fertility is medium on the Linton soil and high on the Mandan soil. The erosion hazard is serious in areas where these soils do not have an adequate cover of vegetation. Controlling erosion and conserving moisture are the major concerns in management.

Most areas are in native grass. Capability unit VIe-Si; Silty range site; windbreak group 10.

Livona Series

The Livona series consists of deep, nearly level to steep, well-drained soils that formed in wind-deposited, moderately sandy material and the underlying glacial till. These soils are on upland till plains. Slopes are plane and convex, and the gradient is 1 to 15 percent.

In a representative profile, the surface layer is dark grayish-brown fine sandy loam about 8 inches thick. The upper part of the subsoil is grayish-brown, very friable fine sandy loam about 7 inches thick, the middle part is light brownish-gray, friable sandy clay loam about 4 inches thick, and the lower part is light brownish-gray, firm clay loam about 5 inches thick. The upper part of the underlying material is light-gray clay loam about 16 inches thick, the middle part is light yellowish-brown loam about 12 inches thick, and the lower part is pale-yellow loam.

Permeability is moderately rapid to a depth of about 14 inches and moderately slow below that depth. Available water capacity is moderate. The organic-matter content is high, and fertility is medium.

About half the acreage is cropland, and half is in native grass. These soils are suited to small grain, corn, legumes, native pasture, and hay.

Representative profile of a Livona fine sandy loam under native grass within an area of Flaxton-Livona fine sandy loams, 50 feet south and 1,570 feet west of the northeast corner of sec. 29, T. 137 N., R. 76 W.:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) when moist; weak, medium, subangular blocky structure parting to weak, fine, crumb; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many roots; many fine pores; neutral; gradual, wavy boundary.

B1—8 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common roots; common fine pores; neutral; clear, wavy boundary.

IIB21t—15 to 19 inches, light brownish-gray (10YR 6/2) sandy clay loam, dark grayish brown (10YR 4/2) when moist; strong, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; common pores; thin clay films, prism faces very dark grayish brown 10YR 3/2) when moist; neutral; clear, wavy boundary.

IIB22t—19 to 24 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; strong, coarse, prismatic structure parting to moderate, medium, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; common fine roots; common fine pores; thin patchy clay films on ped faces; neutral; clear, wavy boundary.

IIC1ca—24 to 40 inches, light-gray (2.5Y 7/2) clay loam, light yellowish brown (2.5Y 6/3) when moist; weak, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; common fine pores; strong effervescence, many, medium, soft lime concretions; moderately alkaline; gradual, wavy boundary.

IIC2ca—40 to 52 inches, light yellowish-brown (2.5Y 6/3) loam, olive brown (2.5Y 4/4) when moist; weak, coarse and fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; few pores;

common white lime spots in threads and concretions; a few, medium, yellowish-brown (10YR 5/6) mottles; few small stones; moderate effervescence, moderately alkaline; clear, wavy boundary.

IIC3—52 to 60 inches, pale-yellow (2.5Y 7/4) loam, light olive brown (2.5Y 5/4) when moist; massive parting to coarse and medium subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; a few lime spots and threads; a few, very fine, yellowish-brown (10YR 5/6) spots; a few small stones; slight effervescence, moderately alkaline.

The solum ranges from 18 to 36 inches in thickness. The depth to lime ranges from 18 to 36 inches. The fine sandy loam material ranges from 10 to 20 inches in thickness. The A horizon ranges from fine sandy loam to loamy fine sand. It is very dark grayish brown or dark grayish brown. The B1 horizon is fine sandy loam or sandy loam. It ranges from very dark grayish brown to dark brown when moist and from dark grayish brown to grayish brown when dry. The IIB2t horizon ranges from sandy clay loam to clay loam. It is dark grayish brown to brown when moist and dark grayish brown to light yellowish brown when dry. The Cca and C horizons are clay loam or loam.

Livona soils are associated with Flaxton, Lihen, and Williams soils. They differ from the Flaxton soils in being lighter colored within a depth of 20 inches and in having glacial till within a depth of 20 inches. They differ from Lihen soils in having glacial till within a depth of 40 inches. In contrast with Williams soils, their fine sandy loam surface layer in places extends to a depth of 10 to 20 inches.

Livona-Flaxton loamy fine sands, rolling (6 to 9 percent slopes) (LoC).—In most areas this complex is about 50 percent Livona loamy fine sand, 45 percent Flaxton loamy fine sand, and 5 percent inclusions of Lihen loamy fine sand and Williams fine sandy loam. There are boulders on the surface.

These Livona and Flaxton soils have a surface layer of loamy fine sand, but otherwise have profiles similar to those described as representative for their respective series. Flaxton soils are described under the heading "Flaxton Series."

These soils are highly susceptible to blowing. Surface runoff is medium. Fertility is medium. Controlling erosion and conserving moisture are the major concerns in management.

About 33 percent of the acreage is cultivated. The rest is in native grass. More than half of the cultivated acreage is moderately eroded. These soils are well suited to grass. Capability unit VIe–Sa; Sands range site; windbreak group 5.

Livona-Flaxton fine sandy loams, rolling (6 to 9 percent slopes) (LrC).—In most areas this complex is about 50 percent Livona fine sandy loam, 40 percent Flaxton fine sandy loam, and 10 percent inclusions of Parshall, Lihen, and Williams soils. The Livona soil is on the upper slopes and ridges, and the Flaxton soil is on the lower slopes.

Each soil has a profile similar to the one described as representative for the respective series.

These soils are highly susceptible to blowing and water erosion. Surface runoff is medium. Fertility is medium. Controlling blowing and conserving moisture are the major concerns in management.

About 30 percent of the acreage is cultivated, and about half of this is moderately eroded. The rest is in native grass. Small grain and alfalfa are suitable crops. Capability unit IVe–3; Sandy range site; windbreak group 5.

Livona and Lihen loamy fine sands, hilly (9 to 15 percent slopes) (LsD).—Some areas of this mapping unit are Livona loamy fine sand, some are Lihen loamy fine sand, and others contain both soils. Included in mapping were areas of Werner, Zahl, and Flasher soils. The Livona soil is on the upper convex slopes, and the Lihen soil is on the lower slopes. Surface stones and boulders are abundant on most of the ridgetops.

The Livona soil has a surface layer of loamy fine sand but otherwise has a profile similar to the one described as representative for the series. Lihen soils are described under the heading "Lihen Series."

When dry, these soils are highly susceptible to blowing. Surface runoff is medium. Fertility is medium. Soil blowing is the major hazard.

These soils are well suited to native grass. In the few areas cultivated, they are moderately and severely eroded. Capability unit VIe–Sa; Sands range site; windbreak group 5.

Livona, Lihen, and Flasher fine sandy loams, steep (more than 15 percent slopes) (LtF).—Some areas of this mapping unit are Livona fine sandy loam, some are Lihen fine sandy loam, and some are Flasher fine sandy loam. Other areas contain all three soils. The Flasher soil is typically on the ridgetops, the Livona soil is on the smooth upper slopes, and the Lihen soil is on the lower slopes and in swales.

The profile of this Livona soil differs from the one described as representative for the Livona series. This soil does not have prismatic and blocky structure below the sandy loam mantle, and it is limy above the glacial till. The Lihen soil differs in texture of the surface layer but otherwise has a profile similar to the one described as representative for the Lihen series. Flasher soils are described under the heading "Flasher Series."

Surface runoff is medium. Fertility is medium in the Livona and Lihen soils and low in the Flasher soil. Controlling erosion is the major concern in management.

These soils are used for native grass. Capability unit VIe–Sy; Livona and Lihen soils in Sandy range site and windbreak group 10; Flasher soil in Thin Sandy range site and windbreak group 10.

Livona-Williams fine sandy loams, hilly (9 to 15 percent slopes) (LuD).—This complex is on sand-mantled glacial till plains where the mantle is thin. It is about 50 percent Livona fine sandy loam and 25 percent Williams fine sandy loam. Included in mapping were small areas of Lihen, Parshall, Flasher, and Zahl soils. The Williams soil is on the upper slopes, and the Livona soil is on the lower slopes.

This Livona soil does not have prismatic and blocky structure in the subsoil, and it is limy above the glacial till. Otherwise, it has a profile similar to the one described as representative for the series. The Williams soil has a coarser textured surface layer but otherwise has a profile similar to the one described as representative for the series.

Surface runoff is medium. Fertility is medium in the Livona soil and high in the Williams soil. Controlling erosion is the major concern in management. In cultivated areas, these soils are highly susceptible to erosion.

These soils are moderately and severely eroded in cultivated areas. Most of the acreage is in native range.

Capability unit VIe–Sy; Sandy range site; Livona soil in windbreak group 5 and Williams soil in windbreak group 3.

Lohler Series

The Lohler series consists of deep, nearly level, moderately well drained soils that formed in alluvial material on bottom land along the Missouri River. The slope gradient is 0 to 3 percent.

In a representative profile, the surface layer is about 8 inches of light brownish-gray silty clay. The underlying stratified material, to a depth of 60 inches or more, is light brownish-gray and light-gray silty clay that is slightly limy. Thin strata of silt occur below a depth of 40 inches.

Permeability is slow. Available water capacity is high. The organic-matter content is low, and fertility is medium.

Most of the acreage is cropland. The soils are suited to small grain, grasses, and legumes. Some areas are used for native pasture and hay. Others are densely wooded and are used for grazing and for wildlife recreation.

Representative profile of Lohler silty clay in a cultivated field, 53 feet south and 53 feet east of the northwest corner of sec. 35, T. 140 N., R. 81 W.:

Ap—0 to 8 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; weak, coarse and medium, subangular blocky structure parting to moderate, fine, granular; hard when dry, firm when moist, sticky and plastic when wet; abundant roots; common fine pores; slight effervescence, mildly alkaline; abrupt, smooth boundary.

C—8 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; thin, medium and thick, platy structure in some layers and strong, very fine, angular blocky structure in others; thin layers of massive light-gray (2.5Y 7/2) silt below a depth of 40 inches; hard when dry, firm when moist, sticky and plastic when wet; common roots at a depth of 8 to 30 inches, few roots at a depth of 30 to 60 inches; common fine pores; slight effervescence, mildly alkaline.

The Ap horizon is silty clay, silty clay loam, or silt loam. It ranges from dark grayish brown to light brownish gray. The C horizon is dominantly clay and silty clay. It is commonly light brownish gray but ranges from light gray or pale yellow to grayish brown or olive gray. Variations in color and texture relate to stratification.

Lohler soils are associated with Banks, Havrelon, Lallie, and Magnus soils. They are finer textured than Banks and Havrelon soils. They are better drained than Lallie soils. They have a thinner surface layer than Magnus soils.

Lohler silt loam (0 to 3 percent slopes) (Lv).—This soil is on bottom land along the Missouri River. Included in mapping were a few small areas of Havrelon and Lallie soils.

The surface layer of this Lohler soil is silt loam 6 to 20 inches thick. Otherwise, the profile is similar to the one described as representative for the series.

Fertility is medium. Surface runoff is slow. In places, the soil receives runoff from surrounding areas. It has a seasonal high water table. In some years wetness delays cultivation.

Most areas are cultivated, and some are irrigated. Small grain, corn, and alfalfa are the chief crops. Small areas are in native grass or are wooded. Wooded areas are used for grazing, wildlife, and recreation. Capability unit IIc–6; Silty range site; windbreak group 1.

Lohler silty clay loam (0 to 3 percent slopes) (Lw).—This soil occupies the slightly lower areas on the bottom land of the Missouri River. Included in mapping were a few small areas of Havrelon and Lallie soils.

The surface layer of this Lohler soil is silty clay loam 6 to 20 inches thick. Otherwise, the profile is similar to the one described as representative for the series.

Fertility is medium. Surface drainage is slow. In places, water from adjacent areas ponds on this soil. A seasonal water table is within a depth of 5 feet. Wetness and fertility are the major concerns of management. In some years wetness delays cultivation.

Most areas are cultivated, and some are irrigated. Small grain and alfalfa are the main crops. Some areas are in native grass and are wooded. Wooded areas are suited to grazing, wildlife, and recreation. Capability unit IIc–7; Clayey range site; windbreak group 1.

Lohler silty clay (0 to 3 percent slopes) (Ly).—This soil is in backwater areas on the bottom land of the Missouri River. Included in mapping were a few small areas of Havrelon and Lallie soils.

This soil has the profile described as representative for the Lohler series.

Surface runoff is slow. Water from adjacent areas ponds on this soil for short periods. Wetness and fertility are the major concerns in management. Soil tilth is a minor concern. The soil is susceptible to blowing because the surface layer tends to slake.

This soil is suited to small grain, alfalfa, and tame grasses. About half the acreage is cultivated. The rest is in native grass or is wooded and brushy. Some wooded areas are used for grazing, and others are used for recreation and wildlife. Capability unit IIs–4; Clayey range site; windbreak group 1.

Magnus Series

The Magnus series consists of deep, nearly level, moderately well drained soils that formed in moderately fine textured and fine textured alluvium. These soils are on flood plains of creeks. The slope gradient is 0 to 3 percent.

In a representative profile, the surface layer is grayish-brown silty clay loam. Below this is about 9 inches of dark grayish-brown silty clay. At a depth of 16 inches is a buried soil. Its surface layer is dark-gray, firm silty clay about 10 inches thick, and its subsoil is grayish-brown, firm silty clay about 24 inches thick. It is slightly limy in the lower part. The underlying material, at a depth of about 50 inches, is stratified. It is light brownish-gray and light yellowish-brown, firm silt loam, silty clay loam, and silty clay and is moderately limy.

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

About half the acreage is used for crops, mainly small grain, legumes, and corn. The rest is used for native pasture and hay.

Representative profile of a Magnus silty clay loam in a cultivated field within an area of Magnus silty clay loam, 2,100 feet north and 2,480 feet east of the southwest corner of sec. 26, T. 138 N., R. 80 W.:

Ap—0 to 7 inches, grayish-brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist;

strong, fine, granular structure; hard when dry, friable when moist, sticky and plastic when wet; few large and common fine roots; many fine pores; slight effervescence, moderately alkaline; abrupt, smooth boundary.

A12—7 to 16 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; thin layers, black (2.5Y 2/2) when moist; weak, coarse, prismatic structure parting to moderate and strong, medium and very fine, blocky; very hard when dry, firm when moist, sticky and plastic when wet; common roots; many fine pores; slight effervescence, moderately alkaline; clear, smooth boundary.

A1b—16 to 26 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when crushed, coatings of black (10YR 2/1) when moist; moderate, coarse, prismatic structure parting to strong, medium and fine, angular blocky; very hard when dry, firm when moist, sticky and plastic when wet; common fine pores; shiny pressure faces on ped surfaces; few small lime masses; slight effervescence, moderately alkaline; gradual, wavy boundary.

B2b—26 to 34 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; weak, coarse, prismatic structure parting to strong, medium, angular blocky; very hard when dry, firm when moist, sticky and plastic when wet; shiny pressure faces on vertical ped surfaces; common fine limy masses; slight effervescence, moderately alkaline; gradual, wavy boundary.

B3b—34 to 50 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium and fine, angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common fine lime masses; slight effervescence, moderately alkaline; a few vertical cracks with pressure faces; gradual boundary.

C—50 to 60 inches, light brownish-gray and light yellowish-brown (2.5Y 6/2 and 6/4) stratified silty clay, silt loam, and silty clay loam, olive brown (2.5Y 4/4) and dark grayish brown (2.5Y 4/2) when moist; massive; very hard when dry, firm when moist, sticky and plastic when wet; few medium lime nodules; moderate effervescence, moderately alkaline.

The A horizon is mostly silty clay loam or silty clay. It is very dark brown or very dark grayish brown when moist and dark brown and grayish brown when dry. The color value and chroma in moist soil are less than 3.5. The B horizon ranges from 12 to 30 inches in thickness. It is very dark grayish brown to grayish brown. The C horizon is silt loam, silty clay loam, or silty clay. Buried horizons are common. In most places these soils contain a small amount of lime. In some places the surface soil is lime free. Layers darkened by organic matter are common in the substratum.

Magnus soils are associated with Harriet, Havrelon, Lohler, and Straw soils. They differ from Harriet soils in not having a claypan. They are darker colored than Havrelon and Lohler soils. They are finer textured than Straw soils.

Magnus silty clay loam (0 to 3 percent slopes) (Ma).—This soil is on the bottom land of small streams. Included in mapping were a few small areas of Straw and Harriet soils and areas of steep slopes, creek channels, and oxbows.

This soil has medium surface runoff. It is flooded for short periods during heavy rains or rapid snowmelt. In many areas it is dissected by stream channels, and farming is difficult. Fertility is high.

This soil is well suited to alfalfa, small grain, and corn. About half the acreage is cultivated. The rest is in native grass and is used for hay or pasture. Capability unit IIc-7; Clayey range site; windbreak group 1.

Makoti Series

This series consists of deep, nearly level, moderately well drained soils that formed in glaciolacustrine deposits. These soils are on lake plains in the glacial till plains.

In a representative profile, the surface layer is dark-gray silty clay loam about 5 inches thick. The subsoil is dark-gray, firm silty clay loam about 11 inches thick. The upper part of the underlying material is light-gray and white silty clay loam. It is strongly limy. The lower part is pale-yellow silty clay.

Permeability is moderately slow. Available water capacity is high. The organic-matter content is moderate, and fertility is medium.

These soils are well suited to small grain, grasses, and legumes. Most areas are cropped. Some are used for native pasture and hay.

Representative profile of a Makoti silty clay loam in a cultivated field within an area of Makoti-Williams silty clay loams, gently sloping, 2,565 feet south and 100 feet east of the northwest corner of sec. 1, T. 141 N., R. 75 W.:

Ap—0 to 5 inches, dark-gray (10YR 4/1) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

B21—5 to 11 inches, dark-gray (10YR 4/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; coatings of black (2.5Y 2/2) when moist; moderate, coarse, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; clear, wavy boundary.

B22—11 to 16 inches, dark-gray and grayish-brown (10YR 4/1 and 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; strong, medium and fine, prismatic structure parting to moderate, medium, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; clear, wavy boundary.

C1ca—16 to 42 inches, light-gray and white (2.5Y 7/2 and 8/2) silty clay loam, olive gray (5Y 5/2) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; strong effervescence, few to common lime masses; clear, wavy boundary.

C2—42 to 60 inches, pale-yellow (5Y 7/3) silty clay, olive gray (5Y 5/2) when moist; very hard when dry, firm when moist, sticky and plastic when wet; strong effervescence.

The A horizon ranges from 4 to 8 inches in thickness. It is silt loam or silty clay loam and very dark brown, very dark gray, dark gray, very dark grayish brown, or dark grayish brown when moist. The B horizon ranges from 8 to 20 inches in thickness. It is very dark grayish brown or dark grayish brown when moist. The Cca and C horizons are grayish brown, light olive brown, and olive gray when moist.

Makoti soils are associated with Roseglen, Savage, and Williams soils. They are more silty throughout the profile than Williams and Roseglen soils. They have a coarser textured substratum than Savage soils.

Makoti silty clay loam, level (0 to 3 percent slopes) (MkA).—This soil is in former glacial lakebeds. Slopes are long. Included in mapping were areas of Grail, Noonan, and Roseglen soils and areas in which stones are common on the surface.

This soil has a profile similar to the one described as representative for the series.

Surface runoff is medium. Fertility is medium. When dry, this soil is moderately susceptible to soil blowing.

This soil is well suited to small grain, corn, and alfalfa. More than half the acreage is cultivated. The rest is mostly in native grass. Capability unit IIc–7; Clayey range site; windbreak group 3.

Makoti-Williams silty clay loams, gently sloping (3 to 6 percent slopes) (MlB).—This complex is about 65 percent Makoti silty clay loam and 35 percent Williams silty clay loam. It occurs on lacustrine plains and glacial till plains. Glacial boulders are common on the Williams soil, but there are few on the Makoti soil.

The Makoti soil has the profile described as representative for the Makoti series. The Williams soil has a silty clay loam surface layer but otherwise has a profile similar to that described as representative for the series (see Williams Series).

Surface runoff is medium. Fertility is medium on the Makoti soil and high on the Williams soil. Controlling erosion is the major concern in management. The hazards of soil blowing and water erosion are moderate.

These soils are well suited to small grain, corn, and alfalfa. About half the acreage is cultivated. The rest is in native grass. Capability unit IIe–7; Clayey range site; windbreak group 3.

Mandan Series

The Mandan series consists of deep, nearly level to sloping, well-drained soils. These soils formed in thick recent loess deposits on benches and uplands adjacent to the Missouri River bottoms.

In a representative profile, the surface layer is dark grayish-brown and grayish-brown silt loam about 20 inches thick. The subsoil is grayish-brown, very friable silt loam about 9 inches thick. It is moderately limy. The underlying material is light brownish-gray, very friable silt loam about 18 inches thick. It is strongly limy and contains common small lime nodules. The material below is light brownish-gray, very friable loam grading to fine sandy loam.

Permeability is moderate. Available water capacity and fertility are high. The organic-matter content is moderate.

These soils are well suited to small grain, corn, and alfalfa. Most of the acreage is cultivated. Part is irrigated.

Representative profile of Mandan silt loam, level, in an area of tame grass, 400 feet south and 90 feet east of the northwest corner of the SW¼ of sec. 15, T. 138 N., R. 80 W.:

A11—0 to 13 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; very weak prismatic structure parting to weak, coarse and fine, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; many roots; many fine pores; mildly alkaline; gradual boundary.

A12—13 to 20 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; very weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; common roots; many fine pores; slight effervescence, mildly alkaline; gradual boundary.

B—20 to 29 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; very weak, coarse, prismatic and subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slighty plastic when wet; common fine roots; many fine pores; a few, very small, light-gray lime spots; moderate effervescence; gradual, wavy boundary.

C1—29 to 38 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic and subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common very fine pores; strong effervescence; common, faint, fine, light-gray lime spots, commonly around pores and root channels; gradual, smooth boundary.

C2—38 to 47 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) when moist; massive, vertical breakage typical of loess, breaking to irregular blocky fragments; slightly hard when dry, very friable when moist, slightly sticky and nonplastic when wet; strong effervescence, common, faint, very small lime spots and a few distinct spots of segregated lime; a very few small pebbles, lime crusts on underside, near base of horizon; a very few small roots; clear, smooth boundary.

IIC3—47 to 56 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; a few faint lime spots; a few small pebbles.

IIIC4—56 to 60 inches, fine sandy loam (auger sample), dark brown (10YR 3/3) when moist; strong effervescence.

The texture throughout the profile is dominantly silt loam, but in a few areas it is very fine sandy loam. Sandy to gravelly material occurs below a depth of 40 inches in some areas. The color value and chroma in moist soil are less than 3.5 to a depth of 20 to more than 35 inches. The depth to lime in most places ranges from 8 to 18 inches, but in a few places lime is at the surface. The A and B horizons range in color from very dark grayish brown to grayish brown. In contrast with other horizons, the C horizon contains more very fine sand. In some profiles, a dark-colored layer below a depth of 50 inches resembles the A horizon of a buried soil.

Mandan soils are associated with Grassna, Linton, and Temvik soils. They are less clayey throughout the profile than Grassna soils. In contrast with Linton soils, their dark colors extend to a depth of more than 20 inches. In contrast with Temvik soils, they do not have glacial till within a depth of 40 inches.

Mandan silt loam, level (0 to 3 percent slopes) (MnA).—This soil is on silt-mantled terraces and uplands adjacent to the Missouri River. Included in mapping were a few small areas of Linton silt loam.

This soil has the profile described as representative for the Mandan series.

Surface runoff is medium. Fertility is high. Controlling erosion is the major concern in management. Both soil blowing and water erosion are hazards.

This soil is well suited to small grain, corn, and alfalfa. Most of the acreage is cultivated. Part is irrigated. Capability unit IIe–5; Silty range site; windbreak group 3.

Mandan-Linton silt loams, undulating (3 to 6 percent slopes) (MoB).—This complex is on silt-mantled terraces and uplands adjacent to the Missouri River. It is about 55 percent Mandan silt loam and 45 percent Linton silt loam. The Linton soil is on the upper slopes and ridges, and the Mandan soil is on the lower slopes. Slopes are short in some areas and long in others.

The Mandan soil has a profile similar to the one described as representative for the Mandan series. Linton soils are described under the heading "Linton Series."

Surface runoff is medium. Fertility is medium on the Linton soil and high on the Mandan soil. Controlling soil blowing and water erosion are the major concerns in management. Unless a cover of vegetation is maintained, these soils are highly susceptible to erosion.

These soils are suited to irrigation. More than 75 percent of the acreage is cultivated. Crops commonly grown are small grain, corn, and alfalfa. Capability unit IIe-5; Silty range site; windbreak group 3.

Mandan-Linton silt loams, rolling (6 to 9 percent slopes) (MoC).—This complex is adjacent to the Missouri River. It is about 45 percent Mandan silt loam and 45 percent Linton silt loam. The Mandan soil is on the lower slopes, and the Linton soil is on the upper slopes. Included in mapping were a few small areas of Grassna and Temvik soils.

Each soil has a profile similar to the one described as representative for the respective series.

Surface runoff is medium. Fertility is high in the Mandan soil and medium in the Linton soil. Controlling erosion and conserving moisture are the major concerns in management. These soils are moderately susceptible to wind erosion and highly susceptible to water erosion, especially if row cropped.

These soils are suited to small grain and alfalfa. About half the acreage is cultivated, and the rest is in native grass. Capability unit IIIe-5; Silty range site; windbreak group 3.

Manning Series

The Manning series consists of moderately deep, nearly level to sloping, somewhat excessively drained soils. These soils formed on glacial outwash plains and stream terraces. They are underlain by gravel or coarse sand.

In a representative profile, the surface layer is dark grayish-brown fine sandy loam about 8 inches thick. The subsoil is dark-brown or brown fine sandy loam about 9 inches thick. The next layer is about 8 inches of light yellowish-brown, strongly limy fine sandy loam. The upper part of the underlying material is light brownish-gray, strongly limy gravel and coarse sand. The lower part is light olive-brown, slightly limy sand.

Permeability is moderately rapid to a depth of 25 inches and very rapid to a depth of more than 60 inches. Available water capacity is low. The organic-matter content is moderate, and fertility is medium.

These soils are used for small grain, corn, alfalfa, native pasture, and hay.

Representative profile of Manning fine sandy loam, undulating, in a cultivated field, 155 feet east and 120 feet north of southwest corner of sec. 3, T. 139 N., R. 77 W.:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) when moist; cloddy; soft when dry, very friable when moist, nonsticky and nonplastic when wet; abrupt boundary.

B21—8 to 17 inches, dark-brown or brown (10YR 4/3) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; clear, irregular boundary.

C1ca—17 to 25 inches, light yellowish-brown (2.5Y 6/3) fine sandy loam, olive brown (2.5Y 4/3) when moist; weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; strongly effervescent; clear, wavy boundary.

IIC2—25 to 33 inches, light brownish-gray (2.5Y 6/2) coarse sand and gravel, dark grayish brown (2.5Y 4/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; strongly effervescent; gradual boundary.

IIC3—33 to 60 inches, light olive-brown (2.5Y 5/3) coarse sand, olive brown (2.5Y 3/3) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slightly effervescent.

The A1 horizon ranges from 5 to 9 inches in thickness. It is dark grayish brown or very dark grayish brown. The B horizon ranges in thickness from about 6 to 15 inches. It is fine sandy loam and has weak to moderate prismatic structure. The depth to gravel ranges from about 20 to 30 inches. In most profiles, there is a zone of lime accumulation in the upper 12 inches of the substratum.

Manning soils are associated with Lehr, Parshall, and Wabek soils. They are coarser textured than Lehr soils. In contrast with Parshall soils, they have a thinner A horizon and are underlain by sand and gravel. They are deeper over gravel than Wabek soils.

Manning fine sandy loam, nearly level (0 to 3 percent slopes) (MrA).—This soil is on stream terraces and glacial outwash plains. Slopes are smooth. Included in mapping were a few small areas of Lehr and Wabek soils.

This soil has a profile similar to the one described as representative for the series.

This soil is droughty and is highly susceptible to blowing. Surface runoff is slow. Fertility is medium. Controlling blowing and maintaining fertility are the main concerns in management.

About 65 percent of the acreage is cultivated, and the rest is in grass. The main crops are small grain, corn, and alfalfa. The low available water capacity is the main limitation. Capability unit IIIes-3; Sandy range site; windbreak group 6.

Manning fine sandy loam, undulating (3 to 6 percent slopes) (MrB).—This soil is on stream terraces and glacial outwash plains. Slopes are short. Included in mapping were a few small areas of Lehr and Wabek soils.

This soil has the profile described as representative for the Manning series.

This soil is droughty and highly susceptible to blowing. Surface runoff is slow. Fertility is medium. Controlling blowing and maintaining fertility are the major concerns in management.

This soil is fairly well suited to small grain and alfalfa. About half the acreage is cultivated. The rest is in grass. The low available water capacity is the main limitation. Capability unit IIIes-3; Sandy range site; windbreak group 6.

Manning fine sandy loam, sloping (6 to 9 percent slopes) (MrC).—This soil is on stream terraces and glacial outwash plains. Slopes are short. Included in mapping were a few small areas of Lehr and Wabek soils.

This soil has a profile similar to the one described as representative for the series.

This soil is droughty and unless well managed is highly susceptible to soil blowing and water erosion. Surface runoff is medium. Fertility is medium. Control-

ling erosion and maintaining fertility are the major concerns in management.

This soil is suited to small grain and alfalfa. Less than half the acreage is cultivated. The rest is mostly in native grass. Droughtiness is the main limitation. The soil is fairly well suited to trees. Capability unit IVes–3; Sandy range site; windbreak group 6.

Max Series

The Max series consists of deep, undulating to steep, well-drained soils that formed on glacial till. These soils are commonly on the upper parts of ridges.

In a representative profile, the surface layer is very dark grayish-brown loam about 6 inches thick. The subsoil is dark grayish-brown and grayish-brown, friable loam about 4 inches thick. The underlying material, extending to a depth of 60 inches, is light olive-brown, dark grayish-brown, and light brownish-gray loam. It is strongly limy.

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

These soils are suited to small grain, corn, grass, and trees. The acreage is mostly used for crops, pasture, or hay.

Representative profile of a Max loam under native grass within an area of Max-Zahl loams, rolling, 475 feet east and 715 feet north of southwest corner sec. 17, T. 144 N., R. 79 W.:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) when moist; fine, weak, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B21—6 to 8 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

B3ca—8 to 10 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) when moist, stains of very dark grayish brown (2.5Y 3/2) when moist; medium, weak, prismatic structure parting to moderate, medium, angular blocky; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

C1ca—10 to 19 inches, light olive-brown (2.5Y 5/3) loam, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure parting to moderate, medium, angular blocky; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; strong effervescence; abrupt, wavy boundary.

C2ca—19 to 30 inches, dark grayish-brown (2.5Y 4/2) loam, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure parting to moderate, medium, angular blocky; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; very strong effervescence; abrupt, wavy boundary.

C3—30 to 60 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/3) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; strong effervescence.

The A horizon ranges from 4 to 7 inches in thickness. It is very dark brown to very dark grayish brown when moist. The B horizon is loam or clay loam and ranges from 4 to 14 inches in thickness. The Cca horizon has many to few, small or large threads of lime.

Max soils are associated with Parnell, Williams, and Zahl soils. They are better drained than Parnell soils. They have a thinner solum and a more weakly developed B horizon than Williams soils. They have a thicker solum than Zahl soils.

Max-Zahl loams, rolling (6 to 9 percent slopes) (MsC).—This complex is about 60 percent Max loam and 40 percent Zahl loam. The Max soil is on the lower slopes, and the Zahl soil is on the upper slopes and ridges.

The Max soil has the profile described as representative for the Max series. Zahl soils are described under the heading "Zahl Series."

Surface runoff is medium. Fertility is medium in the Max soil and low in the Zahl soil. Controlling water erosion and conserving moisture are the major concerns in management. Water erosion is a hazard.

About half the acreage is cultivated, and the rest is in native grass. Small grain and alfalfa are the chief crops. Capability unit IVe–4L; Max soil in Silty range site and windbreak group 3; Zahl soil in Thin Silty range site and windbreak group 8.

Mine Pits and Dumps

Mine pits and dumps (Mt) consists of areas seriously affected by coal mining operations: spoil banks from surface strip mining, severely pitted areas from subsurface mining, and land that is undermined but not yet pitted and now used for grazing. Much of the pitted area is used for grazing, but with occasional loss of livestock. Some of the spoil banks have a slope gradient that is nearly perpendicular. This mapping unit has limited use for wildlife. The largest area is just east of Wilton. Capability unit VIIIe–1; not assigned to a range site or windbreak group.

Miranda Series

The Miranda series consists of deep, nearly level to sloping, moderately well drained soils that have a claypan. These soils are on uplands. They formed in loamy glacial till. The slope gradient is less than 6 percent.

In a representative profile the surface layer is gray silt loam about 2 inches thick. The subsoil is a claypan about 4 inches thick. It is dark grayish-brown silty clay in the upper part and very dark grayish-brown clay in the lower part. The underlying material is yellowish-brown, light-gray, and grayish-brown, calcareous, loamy glacial till. It has threads and nodules of salts and lime in the upper part.

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

These soils should be used as rangeland. Most areas are in native grass.

Representative profile of a Miranda silt loam under native grass within an area of Miranda-Noonan complex, 2,330 feet south and 360 feet east of northwest corner of sec. 12, T. 143 N., R. 76 W.:

A2—0 to 2 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure and weak, medium, platy; soft when dry,

friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

B21t—2 to 4 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, columnar structure; thin continuous clay films on all faces of peds; hard when dry, very firm when moist, very sticky and plastic when wet; clear, wavy boundary.

B22t—4 to 6 inches, very dark grayish-brown (10YR 3/2) clay, very dark brown (10YR 2/2) when moist; moderate, medium, angular blocky structure; few, medium, distinct, gray salt mycelia; thin continuous clay films on all faces of peds; very hard when dry, very firm when moist, very sticky and plastic when wet; clear, wavy boundary.

C1casa—6 to 17 inches, yellowish-brown (10YR 5/4) clay loam, dark yellowish brown (10YR 4/4) when moist; massive; gray salt threads and masses; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence; gradual, wavy and irregular boundary.

C2—17 to 23 inches, light-gray (10YR 7/2) clay loam, brown (10YR 5/3) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; gradual, irregular boundary.

C3—23 to 48 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; few, fine, faint, dark-red (2.5Y 3/6) mottles; massive to weak, coarse, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence, few masses of segregated lime; abrupt, wavy boundary.

The solum ranges from 6 to 16 inches in thickness. Pebbles and cobblestones occur throughout the profile. The A2 horizon is loam or silt loam 1 to 4 inches thick. It is gray when dry and very dark gray when moist. The B horizon is clay or silty clay and ranges from 3 to 10 inches in thickness. It is moderately to strongly alkaline. The C horizon is clay loam or silty clay loam and is strongly alkaline. It is limy throughout and has soft masses of lime and threads and masses of gypsum and other salts in the upper part.

Miranda soils are associated with Noonan and Niobell soils. They have a thinner surface layer than Noonan and Niobell soils.

Miranda-Noonan complex (0 to 6 percent slopes) (Mu).—This complex is about 50 percent Miranda soil and 35 percent Noonan soil. Included in mapping were a few small areas of Niobell and Williams soils. These are nearly level and gently sloping soils on glacial till plains. They have microrelief of 1 to 6 inches. The Miranda soil is in the low spots, and the Noonan soil is in the high spots.

The Miranda and Noonan soils have the profiles described as representative for their respective series (fig. 8). Noonan soils are described under the heading "Noonan Series."

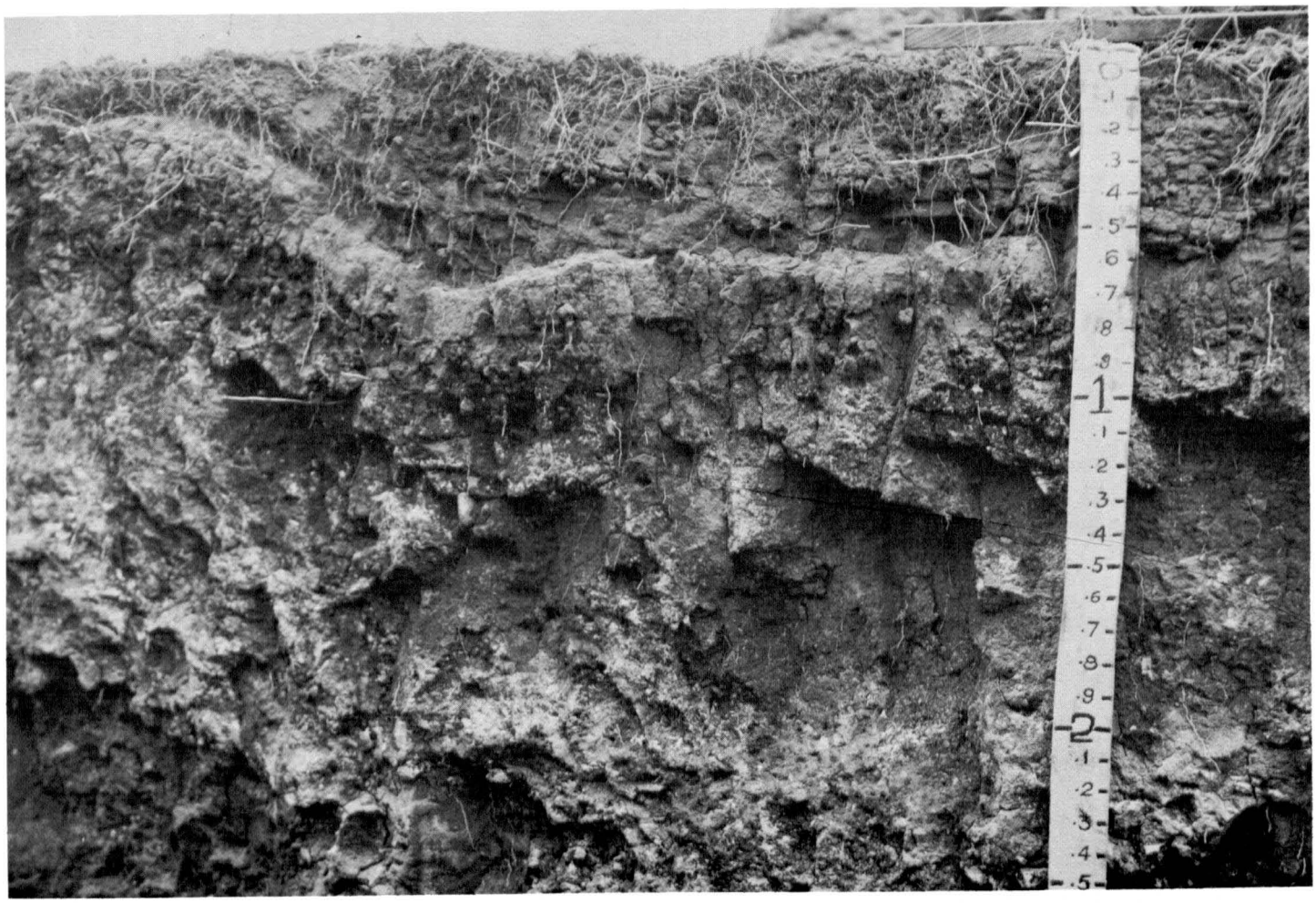

Figure 8.—**Profiles of Miranda silt loam and Noonan loam showing wavy claypan below surface layer. The depth to the pan is 6 inches in the Noonan soil and only 2 inches in the Miranda soil.**

Surface runoff is rapid on the strong slopes and medium on the gentle slopes. Fertility is medium in the Noonan soil and low in the Miranda soil. Conserving moisture in the grasslands and controlling erosion and maintaining tilth in cultivated areas are the main concerns in management.

This complex is used chiefly for native range. Cultivation is not satisfactory because of the dense claypan subsoil. Capability unit VIs–CP; Claypan range site; windbreak group 9.

Morton Series

This series consists of moderately deep, gently sloping or sloping, well-drained soils. These soils are on uplands. They formed in material weathered from soft siltstone and shale. Slopes are smooth. The gradient is 3 to 9 percent.

In a representative profile the surface layer is dark grayish-brown silt loam about 4 inches thick. The subsoil is about 24 inches thick. The upper part is dark grayish-brown, friable silt loam about 8 inches thick; the middle part is olive, friable silty clay loam about 4 inches thick; and the lower part is light olive-gray, calcareous, friable silty clay loam. The underlying material is about 10 inches of grayish-brown, calcareous loam. It overlies platy soft siltstone and shale at a depth of about 38 inches.

Permeability is moderate. Available water capacity is moderate. The organic-matter content is moderate, and fertility is medium.

These soils are suited to crops, grass, and trees. Most areas are used for small grain, corn, and pasture or hay.

Representative profile of Morton silt loam, gently sloping, under native grass, 150 feet north and 1,980 feet west of the southeast corner of sec. 32, T. 140 N., R. 80 W.:

A1—0 to 4 inches, dark grayish-brown (2.5Y 4/2) silt loam, black (2.5Y 2/2) when moist; moderate, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary.

B21t—4 to 12 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium and coarse, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; thin continuous clay films on vertical faces of peds; clear, wavy boundary.

B22t—12 to 16 inches, olive (5Y 5/3) silty clay loam, olive brown (2.5Y 3/3) when moist; moderate, medium, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; thin continuous clay films on vertical faces of peds; gradual, wavy boundary.

B3ca—16 to 28 inches, light olive-gray (5Y 6/2) silty clay loam, olive (5Y 4/3) when moist; weak, medium, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; violent effervescence; gradual, wavy boundary.

C1ca—28 to 38 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; gradual boundary.

C2—38 to 60 inches, platy soft siltstone and shale.

The solum ranges from 12 to 30 inches in thickness. The A horizon is silt loam 3 to 7 inches thick. It is very dark grayish brown, black, or very dark brown when moist. The B2t horizon ranges from 10 to 22 inches in thickness. The upper part is dark grayish-brown or brown silt loam or silty clay loam, and the lower part is grayish brown, light olive gray, or olive. Typically, the lower part is calcareous. The C horizon is grayish brown, olive gray, olive brown, or olive.

Morton soils are associated with Sen, Werner, and Vebar soils. They are more clayey in the subsoil than Sen soils. They have a thicker solum and are darker colored than Werner soils. They are finer textured than Vebar soils.

Morton silt loam, gently sloping (3 to 6 percent slopes) (MvB).—This soil is on the uplands. Slopes are smooth. Included in mapping were small areas of Sen, Williams, and Arnegard soils. The Sen and Williams soils are on the higher lying convex slopes, and the Arnegard soil is in narrow swales and on toe slopes.

This soil has the profile described as representative for the Morton series.

This soil is moderately susceptible to soil blowing and water erosion. Surface runoff is medium. Fertility is medium. Controlling water erosion is the major concern in management.

This soil is well suited to small grain, corn, alfalfa, and trees. About half the acreage is cultivated. The rest is in native grass. Capability unit IIe–6; Silty range site; windbreak group 3.

Morton silt loam, sloping (6 to 9 percent slopes) (MvC).—This soil is on the uplands. It has long, smooth slopes. Included in mapping were areas of Sen, Williams, and Arnegard soils. The Sen and Williams soils are on the higher lying convex slopes, and the Arnegard soil is in narrow swales and on toe slopes.

Surface runoff is medium. Fertility is medium. Controlling water erosion is the major concern in management. If row cropped, this soil is highly susceptible to water erosion. Soil blowing and water erosion are hazards in all cultivated areas.

This soil is well suited to small grain and alfalfa. About half the acreage is cultivated. The rest is in grass. Capability unit IIIe–6; Silty range site; windbreak group 3.

Niobell Series

The Niobell series consists of deep, nearly level to sloping, moderately well drained soils. These are rolling soils on uplands. They formed in loamy glacial till. Slopes are plane and convex.

In a representative profile, the surface layer is dark-grayish-brown or grayish-brown loam about 10 inches thick. The subsoil is grayish-brown, firm clay loam about 17 inches thick. The lower part of the subsoil is calcareous and contains masses and nodules of lime. The underlying glacial till is light brownish-gray, calcareous clay loam.

Permeability is moderately slow. Available water capacity is high. The organic-matter content is moderate, and fertility is medium.

These soils are suited to crops. They are used for small grain, corn, alfalfa, native pasture, and hay.

Representative profile of a Niobell loam in an area of native grass within an area of Niobell-Noonan loams, nearly level, 60 feet south and 2,620 feet east of the northwest corner of sec. 1, T. 139 N., R. 77 W.:

A1—0 to 3 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; soft when dry, very fria-

ble when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

A2—3 to 10 inches, grayish-brown (10YR 5/2) loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

B21t—10 to 14 inches, grayish-brown (2.5Y 5/2) clay loam, olive brown (2.5Y 4/3) when moist; coatings of dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) when moist and tongues of black (2.5Y 2/1); weak, medium and fine, prismatic structure parting to moderate, fine, angular blocky; continuous films of clay on all ped faces; hard when dry, firm when moist; sticky and plastic when wet; clear, wavy boundary.

B22t—14 to 20 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; coatings of dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) and a few tongues of black (10YR 2/1) when moist; weak, coarse, prismatic structure parting to moderate, medium, angular blocky; clay films on all ped faces; hard when dry, firm when moist, sticky and plastic when wet; clear, wavy boundary.

Bca—20 to 27 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; coatings of dark grayish brown (2.5Y 4/2); weak, coarse, prismatic structure parting to moderate, medium, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, moderate lime masses; gradual, irregular boundary.

C1ca—27 to 44 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; weak, coarse, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many lime masses; gradual, irregular boundary.

C2—44 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, common lime masses.

The depth to lime ranges from 16 to 30 inches. The upper part of the A horizon is dark-gray to dark grayish-brown loam 2 to 10 inches thick. The lower part is gray or grayish-brown loam 3 to 8 inches thick. The B horizon is dark grayish-brown, grayish-brown, or brown clay loam 5 to 18 inches thick. The lower part is calcareous. The C horizon is calcareous clay loam that has soft masses of lime in the upper part.

Niobell soils are associated with Noonan and Miranda soils. They have a thicker surface layer and a more permeable subsoil than Noonan and Miranda soils. They resemble Belfield soils, but have a thinner surface layer. Also, they formed in loamy glacial till, whereas Belfield soils formed in material derived from soft shale and siltstone.

Niobell-Noonan loams, nearly level (0 to 3 percent slopes) (NbA).—This complex is on glacial till plains, on the leeward side of large saline lakes. It is about 40 percent Niobell loam, 30 percent Noonan loam, and 30 percent Williams loam. Included in mapping were small areas of Parnell, Tonka, and Miranda soils and of strongly calcareous, slightly saline loams and clay loams. The Miranda soil is in low areas of the microrelief, and the Williams soil is on the higher lying convex slopes.

The Niobell and Noonan soils have the profiles described as representative for their respective series. Noonan soils are described under the heading "Noonan Series."

Surface runoff is slow. Fertility is medium. Maintaining tilth is the major concern in management. Soil blowing and water erosion are only slight hazards.

These soils are suited to small grain and alfalfa. More than half the acreage is cultivated. The rest is in grass. Capability unit IIIs–P6; Niobell soil in Silty range site and windbreak group 4; Noonan soil in Claypan range site and windbreak group 9.

Niobell-Noonan loams, undulating (3 to 6 percent slopes) (NbB).—This complex is about 40 percent Niobell loam and 25 percent Noonan loam. Included in mapping were small areas of Miranda and Williams soils and small areas where the slope gradient is 6 to 9 percent. The Miranda and Noonan soils are in the low areas of the microrelief, and the Niobell soil is in the higher areas. The Williams soil is on upper convex slopes.

Surface runoff is medium. Fertility is medium. Maintaining tilth and conserving moisture are the major concerns in management. These soils are moderately susceptible to soil blowing and water erosion.

More than half the acreage is cultivated. The rest is in grass. Crops commonly grown are small grain and alfalfa. Capability unit IIIe–P6; Niobell soil in Silty range site and windbreak group 4; Noonan soil in Claypan range site and windbreak group 9.

Noonan Series

The Noonan series consists of deep, nearly level to sloping, moderately well drained soils that have a claypan. These are rolling soils on the uplands. They formed in loamy glacial till. Slopes are plane and convex.

In a representative profile, the surface layer is dark-gray and gray loam about 6 inches thick. The subsoil is dark grayish-brown, very firm clay loam about 5 inches thick. It is moderately limy in the lower part. The upper part of the underlying material is pale-brown clay loam about 5 inches thick and has an accumulation of lime and soluble salts. The middle part is light brownish-gray clay loam about 22 inches thick. The lower part is light-gray clay loam.

Permeability is slow. Available water capacity is moderate. The organic-matter content is moderate, and fertility is medium.

These soils are suitable for crops. They are used for small grain, corn, alfalfa, pasture, and hay.

Representative profile of a Noonan loam under grass within an area of Miranda-Noonan complex, 2,870 feet north and 340 feet east of the southwest corner of sec. 12, T. 143 N., R. 76 W.:

A1—0 to 4½ inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

A2—4½ to 6 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) when moist; weak to moderate, medium, platy structure; common pores; soft and dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

B21t—6 to 8 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, columnar structure; very hard when dry, very firm when moist, sticky and plastic when wet; clear, wavy boundary.

B22t—8 to 11 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, prismatic structure parting to moderate, medium, angular blocky;

very hard when dry, very firm when moist, sticky and plastic when wet; slight effervescence, few masses of segregated lime; clear, wavy boundary.

C1casa—11 to 16 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak, medium, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence, many masses of segregated lime; few salt crystals; gradual, irregular boundary.

C2—16 to 38 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; weak, medium and coarse, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; moderate effervescence, many masses of segregated lime; clear, wavy to irregular boundary.

C3—38 to 52 inches, light-gray (5Y 6/1) clay loam, gray (5Y 5/1) when moist; common, coarse, prominent, red (2.5YR 5/8) when moist, mottles and few, coarse, prominent, black carbon masses; massive; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence, common masses of segregated lime; gradual, irregular boundary.

The solum ranges from 10 to 25 inches in thickness. The A horizon is loam or silt loam 5 to 8 inches thick. It is dark grayish brown, dark gray, or gray. The lower part of the A horizon has platy structure. The B horizon is dark-gray or dark grayish-brown clay loam 4 to 16 inches thick. It is calcareous in the lower part. The C horizon is calcareous clay loam. It contains soft masses of lime and a slight accumulation of soluble salts.

Noonan soils are associated with Niobell and Miranda soils. They have a thicker surface layer and a more permeable subsoil than Miranda soils. They have a thinner surface layer and a more slowly permeable subsoil than Niobell soils.

The Noonan soils in this county are mapped only with Miranda and Niobell soils.

Parnell Series

The Parnell series consists of deep, nearly level, very poorly drained soils. These soils are in closed depressions on the glacial till plains. They are frequently ponded with runoff from adjacent slopes. They formed in local alluvium washed from surrounding slopes.

In a representative profile, a thin, fibrous organic mat overlies the surface layer. The surface layer is dark-gray silty clay loam about 5 inches thick. The subsoil is dark-gray, friable silty clay about 12 inches thick. The underlying material is dark-gray clay.

Permeability is slow. Available water capacity is high. The organic-matter content and fertility are high.

The depth and frequency of ponding determine how these soils are to be used. Most areas are used for native pasture or hay. Some have been artificially drained and are cultivated.

Representative profile of Parnell silty clay loam, very poorly drained, 1,600 feet west and 1,100 feet south of the northeast corner of sec. 11, T. 142 N., R. 76 W.:

O—½ inch to 0, mat of very fibrous organic matter, black (10YR 2/1) when moist.

A1—0 to 5 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) when moist; weak, very fine, angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet.

B21t—5 to 11 inches, dark-gray (2.5Y 4/1) silty clay, black (10YR 2/1) when moist; weak, medium, prismatic structure parting to strong, medium, angular blocky; slightly hard when dry, firm when moist, sticky and plastic when wet.

B22t—11 to 17 inches, dark-gray (2.5Y 4/1) silty clay, black (10YR 2/1) when moist; strong, very fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet.

C—17 to 60 inches, dark-gray (10YR 4/1) clay, black (10YR 2/1) when moist; massive; hard when dry, firm when moist, very sticky and very plastic when wet.

The A horizon is 4 to 12 inches thick. It is dark-gray or very dark gray silt loam or silty clay loam. The B horizon is 8 to 24 inches thick. It is dark-gray or very dark gray clay or silty clay. The C horizon is clay or silty clay loam. It ranges from dark gray to light olive gray. Olive and yellowish-red mottles are common in the lower part. In most places the soil is free of lime to a depth of 3 feet or more. In some places there is a zone of lime accumulation below a depth of 3 feet. In a few places there are stones and boulders on the surface.

Parnell soils are associated with Tonka and Williams soils, and they are similar to Dimmick soils. They are more poorly drained than Tonka soils and lack the light-gray, lower A horizon that is typical of those soils. They are more poorly drained and are grayer than Williams soils. They do not have the reddish and brown mottlings in the subsoil that are characteristic of Dimmick soils.

Parnell silty clay loam, very poorly drained (0 to 3 percent slopes) (Pa).—This soil is in depressions. All areas mapped are larger than 2 acres. Smaller areas are indicated by a depression spot symbol on the soil map. Included in mapping were a few small areas of Dimmick, Colvin, Tonka, and Heil soils.

This soil has the profile described as representative for the Parnell series.

Runoff ponds unless artificial drainage is installed. Fertility is high. Wetness is the major limitation.

Most areas are in native grass and are used for hay or pasture. Cultivation is limited to the outer edges or to drained areas. Some of the smaller areas are cultivated during dry periods. The crops commonly grown are small grain and millet. Reed canarygrass is planted in some areas for hay or pasture. Capability unit IIIw-4; Wetland range site; windbreak group 10.

Parshall Series

The Parshall series consists of deep, nearly level to sloping, well-drained soils. These soils are on uplands. They formed in deep sandy loam of lacustrine or glacial outwash origin. Slopes are plane and concave.

In a representative profile, the surface layer is very dark grayish-brown fine sandy loam about 18 inches thick. The subsoil is dark grayish-brown, very friable fine sandy loam about 7 inches thick. The underlying material is mainly dark grayish-brown fine sandy loam and loamy fine sand. At a depth of 32 to 40 inches is very dark grayish-brown fine sandy loam, which is the surface layer of a buried soil.

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

These soils are suited to crops, grasses, and trees. More than half the acreage is used for small grain, corn, and alfalfa. The rest is used mostly for pasture or hay.

Representative profile of Parshall fine sandy loam, nearly level, under native grass, 1,610 feet south of the northwest corner of sec. 16, T. 137 N., R. 78 W.:

A11—0 to 5 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary.

A12—5 to 18 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure parting to weak, medium, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B2—18 to 25 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure parting to weak, coarse and medium, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

C1—25 to 32 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand, very dark grayish brown (2.5Y 3/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; abrupt, wavy boundary.

Ab1—32 to 40 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist; moderate, coarse, prismatic structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; clear boundary.

Ab2—40 to 46 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, coarse, prismatic structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; clear boundary.

IIC2—46 to 51 inches, dark grayish-brown (2.5Y 4/2) clay loam, very dark grayish brown (2.5Y 3/2) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence; clear boundary.

IIIC3—51 to 60 inches, loamy fine sand, dark grayish brown (2.5Y 4/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet.

The depth to lime ranges from 24 to 40 inches. The A horizon is 10 to 22 inches thick. It is very dark grayish-brown or dark grayish-brown fine sandy loam. These soils are grayish brown or darker to a depth of more than 20 inches. In swales the dark color extends to a depth of 48 inches or more. The underlying material is dark grayish brown to light brownish gray or pale brown. It is mainly fine sandy loam. Buried horizons of very dark grayish brown occur in many places. In most places the soil is calcareous below a depth of 40 inches.

Parshall soils are associated with Flaxton and Lihen soils. They are not so clayey in the subsoil as Flaxton soils. They are finer textured than Lihen soils.

Parshall fine sandy loam, nearly level (0 to 3 percent slopes) (PhA).—This soil is in swales and on foot slopes in the uplands. Included in mapping were areas of Arnegard, Lihen, Vebar, and Flaxton soils. The Parshall soil occupies a lower position on the landscape than the included soils.

This soil has the profile described as representative for the Parshall series.

Surface runoff is slow. Fertility is medium. Low areas receive runoff from adjacent higher lying areas. When dry, this soil is moderately susceptible to blowing.

This soil is well suited to small grain, corn, and alfalfa. More than half the acreage is cultivated. Areas in grass are used for hay or pasture. Capability unit IIIe–3; Sandy range site; windbreak group 5.

Parshall fine sandy loam, gently sloping (3 to 6 percent slopes) (PhB).—This soil is in swales and on foot slopes in the uplands. Included in mapping were a few areas of Arnegard, Lihen, Vebar, and Flaxton soils and a few areas where the slope gradient is 6 to 9 percent.

This soil has profile characteristics similar to those described for the series, but it has a thinner, dark-colored surface layer.

Surface runoff and fertility are medium. Runoff from adjacent areas causes slight gullying. Soil blowing and water erosion are moderate hazards.

This soil is suited to small grain, corn, alfalfa, and trees. Less than half the acreage is cultivated. Areas in grass are used for hay and pasture. Capability unit IIIe–3; Sandy range site; windbreak group 5.

Parshall fine sandy loam, clay subsoil variant (0 to 3 percent slopes) (Pk).—This soil is in swales and concave positions. It has a thin mantle of fine sandy loam over a layer of lake deposited clay, which is at a depth of less than 40 inches. Included in mapping were a few small areas of Flaxton, Lihen, and Rhoades soils.

This soil has profile characteristics similar to those described as representative for the series but is underlain by clay or silty clay within a depth of 40 inches.

Surface runoff is slow. Fertility is medium. Because of the clayey layer, permeability is slower than is typical in Parshall soils. When dry, this soil is moderately susceptible to blowing.

This soil is suited to small grain, corn, alfalfa, and trees. About half the acreage is cultivated. Areas in grass are used for hay and pasture. Capability unit IIIe–3M; Sandy range site; windbreak group 5.

Parshall and Lihen fine sandy loams, nearly level (0 to 3 percent slopes) (PlA).—This mapping unit consists of varying amounts of Parshall and Lihen fine sandy loams. Some areas are nearly all Parshall soils, some are nearly all Lihen soils, and others contain both soils. The Lihen soil is on upper slopes, and the Parshall soil is on lower slopes. Included in mapping were areas of Lihen loamy fine sand, a few small areas of Flaxton soils, and small, moderately eroded areas.

The Parshall and Lihen soils have profile characteristics similar to those described for their respective series. This Lihen soil, however, has a surface layer of fine sandy loam. It is described under the heading "Lihen Series."

Surface runoff is medium. Fertility is medium. Soil blowing is the main limitation. When dry, the Parshall soil is moderately susceptible to soil blowing, and the Lihen soil is highly susceptible.

These soils are suitable for irrigation. They are well suited to small grain, corn, alfalfa, and trees. More than half the acreage is cultivated. Capability unit IIIe–3; Sandy range site; windbreak group 5.

Parshall, Lihen, and Telfer fine sandy loams, undulating (3 to 6 percent slopes) (PtB).—This mapping unit consists of varying amounts of slightly and moderately eroded Parshall, Lihen, and Telfer fine sandy loams. Some areas consist entirely of Parshall soils, some of Lihen soils, and some of Telfer soils. Other areas contain all three soils. In these areas the Telfer soil is on upper slopes, the Parshall soil is on mid slopes, and the Lihen soil is on lower slopes and in swales.

The Parshall soil has a profile similar to the one described as representative for the Parshall series. Except for texture of the surface layer, the Lihen and Telfer soils have profile characteristics similar to those

described for the series. These soils are described under the headings "Lihen Series" and "Telfer Series."

Surface runoff is medium. Fertility is medium in the Parshall and Lihen soils and low in the Telfer soil. Controlling blowing and conserving moisture are the major concerns in management. The Parshall soil is moderately susceptible to soil blowing, and the Lihen and Telfer soils are highly susceptible.

These soils are suited to small grain, corn, alfalfa, and trees. About half the acreage is cultivated. Capability unit IIIe-3; Parshall and Lihen soils in Sandy range site and windbreak group 5; Telfer soil in Sandy range site and windbreak group 7.

Regan Series

The Regan series consists of deep, nearly level, very poorly drained soils in basins and sloughs and on stream bottoms. These soils formed in alluvium. They have a seasonal high water table.

In a representative profile, the surface layer is dark-gray and gray, calcareous silty clay loam about 9 inches thick. It is underlain by 19 inches of light-gray and gray, calcareous silty clay loam. Below this is gray, calcareous clay loam and sandy clay loam alluvium.

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

These soils are suited to pasture and hay. Most of the acreage is used for this purpose. A few areas have been artificially drained and are cultivated.

Representative profile of Regan silty clay loam under native grass, 1,000 feet east and 1,650 feet south of the northwest corner of sec. 34, T. 144 N., R. 78 W.:

A1—0 to 4 inches, dark-gray (2.5Y 4/1) silty clay loam, very dark gray (2.5Y 3/1) when moist; moderate, fine, crumb structure; slightly hard when dry, slightly sticky and nonplastic when wet, friable when moist; many roots; slight effervescence, moderately alkaline; clear, wavy boundary.

A12—4 to 9 inches, gray (2.5Y 5/1) silty clay loam, very dark gray (5Y 3/1) when moist; strong, fine and very fine, subangular blocky to granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; common fine pores; slight effervescence, moderately alkaline; gradual, wavy boundary.

C1ca—9 to 16 inches, light-gray (5Y 6/1) silty clay loam, dark gray (5Y 5/1) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; common fine pores; very strong effervescence; moderately alkaline; gradual, wavy boundary.

C2ca—16 to 28 inches, gray (5Y 5/1) silty clay loam, dark gray (5Y 4/1) when moist; massive separating to very weak, medium and fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few roots; very strong effervescence, moderately alkaline; gradual, wavy boundary.

IIC3g—28 to 54 inches, gray (5Y 5/1) clay loam, olive gray (5Y 4/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; few salt crystals; moderate effervescence, moderately alkaline.

IIIC4g—54 to 60 inches, gray (5Y 5/1) sandy clay loam, olive gray (5Y 4/2) when moist; few, fine, faint mottles of dark yellowish brown (10YR 4/4); soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, moderately alkaline.

These soils are calcareous at or near the surface and throughout the profile. In places they are slightly or moderately saline. The A horizon ranges from 7 to 16 inches in thickness. Gray colors are predominant because of the high lime content. The C horizon ranges from light gray to dark gray. The upper part contains accumulations of lime. The texture is mostly silty clay loam, but in a few places, it is loam, sandy clay loam, and silty clay. Gravel or gravelly loam is below a depth of 40 inches in many places.

Regan soils have a thinner surface layer and a more saline and sandy substratum than Colvin soils. They are finer textured than Arveson soils. They are more limy than Parnell soils.

Regan silty clay loam (0 to 3 percent slopes) (Rc).—This soil is in flat basins and seep areas on stream bottom land. It is flooded during part of the year and has a water table close to the surface. Included in mapping were a few small areas of Colvin, Parnell, and Dimmick soils.

This soil has the profile described as representative for the Regan series.

Surface runoff is slow. Fertility is medium. Seepage from adjacent areas has accumulated salts in the soil and on the surface. Plant roots are limited because of the high water table and the salinity. Wetness and salt accumulations are the major limitations (fig. 9).

This soil is in native grass. It is suited to hay and pasture and to wildlife. Drainage is generally not feasible. Quality of forage can be improved by planting reed canarygrass in areas where this soil is not too strongly saline. Capability unit Vw-WL; Wetland range site; windbreak group 10.

Regent Series

The Regent series consists of gently sloping and sloping, well-drained soils that are moderately deep over soft shale. These are rolling soils on uplands. They formed in material weathered from soft clayey shale. Slopes are smooth. The gradient is 6 to 9 percent.

In a representative profile, the surface layer is dark-gray silty clay loam about 5 inches thick. The subsoil is about 23 inches thick. It is dark grayish-brown, firm silty clay in the upper part, grayish-brown, firm silty clay in the middle part, and light brownish-gray silty clay loam in the lower part. The underlying material is light yellowish-brown, calcareous silty clay loam to a depth of about 38 inches. It contains soft segregations of lime and grades to soft platy shale below.

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

These soils are suited to crops, grass, and trees. Most areas are used for small grain, corn, alfalfa, and native range.

Representative profile of Regent silty clay loam, sloping, in cropland, 2,000 feet west and 2,000 feet south of the northeast corner of sec. 16, T. 140 N., R. 80 W.:

Ap—0 to 5 inches, dark-gray (2.5Y 4/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; tongues extend to a depth of 10 inches; abrupt, wavy boundary.

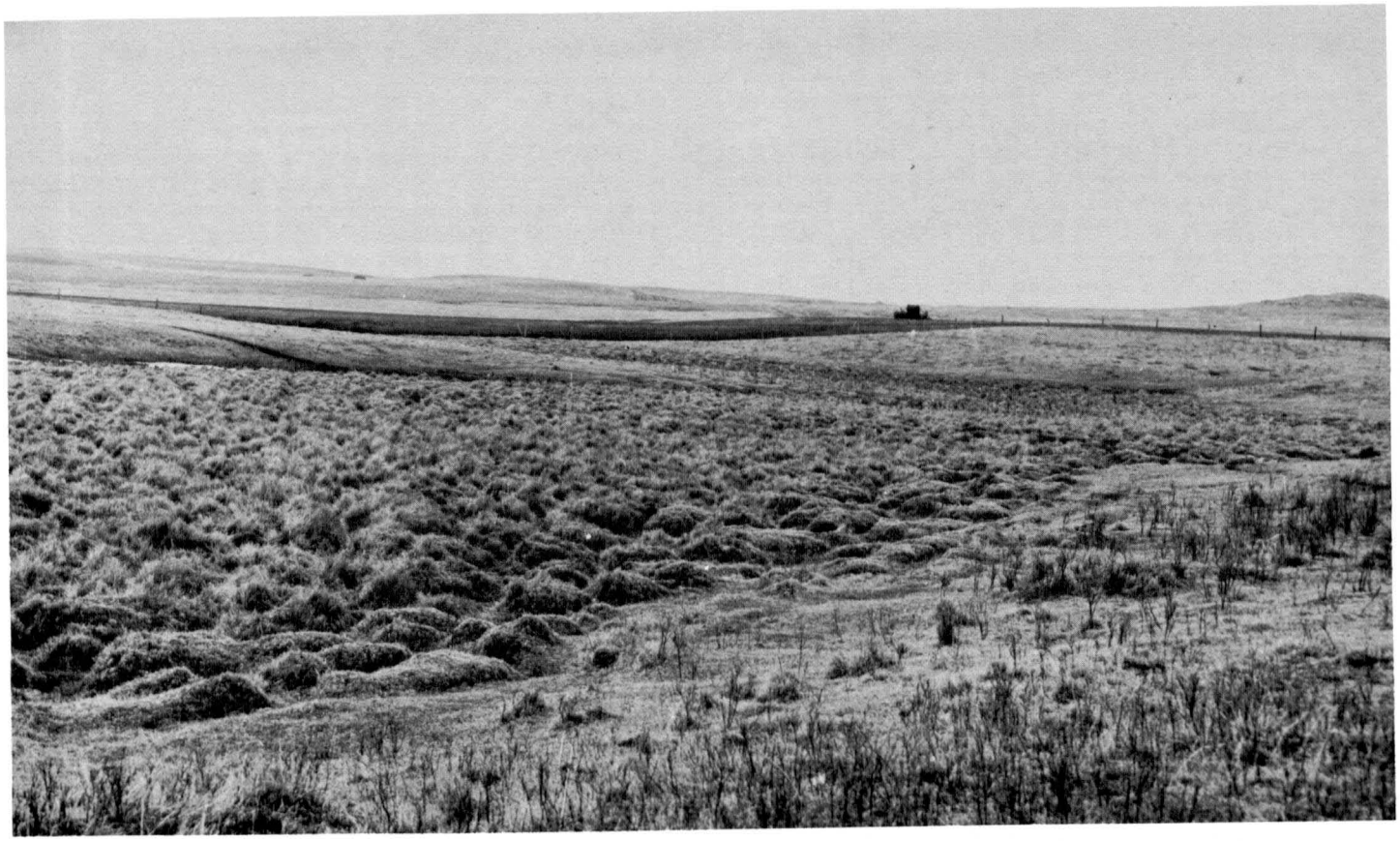

Figure 9.—**Microrelief on Regan soils. The uneven surface is the result of wetness.**

B21t—5 to 10 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; strong, fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; thin continuous clay films on all faces of peds; clear, wavy boundary.

B22t—10 to 17 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; thin continuous clay films, very dark grayish brown (2.5Y 3/2) when moist on all faces of peds; strong, fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; slight effervescence; gradual, wavy boundary.

B3ca—17 to 28 inches, light brownish-gray (2.5Y 6/2) silty clay clay loam, olive (2.5Y 4/3) when moist; few tongues of very dark grayish brown (2.5Y 3/2) when moist; weak, medium, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; gradual, wavy boundary.

C1—28 to 38 inches, light yellowish-brown (2.5Y 6/3) silty clay loam, olive brown (2.5Y 4/3) when moist; weak, coarse, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, few masses of segregated lime; gradual, wavy boundary.

C2—38 to 60 inches, soft platy shale that crushes to light brownish-gray (2.5Y 6/2) silty clay, olive brown (2.5Y 4/3) when moist; strong effervescence, many masses of segregated lime.

The depth to soft shale ranges from 30 to 40 inches. The A horizon ranges from 4 to 9 inches in thickness and from dark gray to dark brown. The B horizon ranges from 15 to 30 inches in thickness and from dark grayish brown to light brownish gray. In most places it is limy in the lower part. The C horizon has varying colors of grayish brown, light grayish brown, light brownish gray, light yellowish brown, olive brown, and light olive brown and textures of silty clay loam, clay loam, and silty clay. This horizon contains soft masses of accumulated lime in the upper part.

Regent soils are associated with Morton, Sen, and Grail soils. They are more clayey than Morton and Sen soils. They do not have the thicker, darker colored surface layer that is characteristic of Grail soils. They resemble Savage soils, but they formed in material derived from shale rather than in deep alluvium.

Regent silty clay loam, sloping (6 to 9 percent slopes) (RgC).—This soil is on the uplands. It has long smooth slopes. Included in mapping were a few areas of Grail and Morton soils.

This soil has the profile described as representative for the Regent series.

This soil is highly susceptible to wind and water erosion. Surface runoff and fertility are medium. Controlling erosion, conserving moisture, and maintaining tilth are the major concerns in management.

This soil is well suited to small grain, alfalfa, and tame grasses. Most of the acreage is cultivated. Trees do well, but they should be planted across the slope to lessen the hazard of erosion. Areas not cultivated are in native grass. Capability unit IIIe-7; Clayey range site; windbreak group 3.

Regent-Grail silty clay loams, gently sloping (3 to 6 percent slopes) (RhB).—This complex is in the uplands. It is about 70 percent Regent silty clay loam, 20 percent Grail silty clay loam, and 10 percent small inclusions of Morton and Daglum soils. The Regent soil is on the upper

slopes, and the Grail soil is in swales and concave positions.

Each soil has a profile similar to the one described as representative for the respective series. Grail soils are described under the heading "Grail Series."

These soils are moderately susceptible to erosion. Surface runoff is medium. Fertility is medium in the Regent soil and high in the Grail soil. Controlling erosion, conserving moisture, and maintaining tilth are the major concerns in management.

These soils are well suited to small grain and alfalfa. About 75 percent of the acreage is cultivated. Some corn is grown, but this crop increases the hazard of water erosion if it is planted up and down the slope. Capability unit IIe-7; Grail soil in Clayey range site and windbreak group 1; Regent soil in Clayey range site and windbreak group 3.

Rhoades Series

The Rhoades series consists of deep, nearly level to sloping, moderately well drained soils that have a claypan. These rolling soils are in uplands. They formed in material weathered from soft shale or in local alluvium derived from shale. Slopes are plane and concave.

In a representative profile, the surface layer is grayish-brown silt loam about 1 inch thick. The upper part of the subsoil is a claypan (fig. 10). It is dark grayish-brown, very firm silty clay loam about 5 inches thick. The lower part is olive, calcareous silty clay about 8 inches thick. It contains some segregations of salt. The underlying material is calcareous and strongly alkaline. It is olive silty clay loam to a depth of about 40 inches and pale-olive silty clay to a depth of about 60 inches.

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

These soils should be used for rangeland. Most areas are in native grass.

Representative profile of a Rhoades silty clay loam under native grass, within an area of Rhoades-Daglum complex, 530 feet west and 2,600 feet north of the southeast corner of sec. 6, T. 141 N., R. 80 W.:

A2—0 to 1 inch, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; soft when dry, friable when moist, slightly sticky and slightly plastic when wet: abrupt, wavy boundary.

Figure 10.—**Exposed claypan in Rhoades soil showing round tops of columns. The surface layer has been removed and turned upside down to show impressions of the column tops.**

B21t—1 to 6 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; strong medium, columnar structure; very hard when dry, very firm when moist, sticky and plastic when wet; slight effervescence; clear boundary.

B3casa—6 to 14 inches, olive (5Y 4/3) silty clay, dark olive gray (5Y 3/2) when moist; weak, coarse, prismatic structure parting to moderate, medium, angular blocky; very hard when dry, very firm when moist, sticky and plastic when wet; some salts spots; strong effervescence; gradual, wavy boundary.

C1ca—14 to 40 inches, olive (5Y 5/3) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, prismatic structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; strong effervescence; gradual, wavy boundary.

C2—40 to 60 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 5/3) when moist; few faint mottles, olive (5Y 5/6) when moist; massive; very hard when dry, very firm when moist, sticky and plastic when wet; strong effervescence.

The solum ranges from 10 to 20 inches in thickness. The A horizon is dark grayish-brown or grayish-brown silt loam, loam, or silty clay loam 1 to 4 inches thick. The B horizon ranges from 10 to 17 inches in thickness and from dark grayish brown to olive gray or olive. Its texture is silty clay, silty clay loam, clay loam, or clay. The C horizon is silty clay loam, clay loam, or silty clay and is strongly to moderately alkaline.

Rhoades soils have a thinner surface layer than the associated Belfield and Daglum soils. They resemble Miranda soils, but they formed over shale, whereas Miranda soils formed in glacial till.

Rhoades complex (0 to 3 percent slopes) (Rm).—This complex is about 60 percent Rhoades soil. Other major soils are Daglum and Belfield. Also included are small areas of Regan and Arveson soils. The Rhoades soil is in low areas, and the Belfield and Daglum soils are in the higher areas. Slopes are smooth, plane to concave, and uneven. There are slight high and low spots that have a difference of 1 to 6 inches in elevation. Where the claypan is near the surface, the soil is dispersed and the vegetation is sparse (fig. 11).

Figure 11.—Uneven, scabby surface on Rhoades complex.

Each soil has a profile similar to the one described as representative for the respective series.

Surface runoff is slow. Fertility is low. Conserving moisture and maintaining a vegetative cover are the major concerns in management. These soils are moderately susceptible to erosion.

Most areas are in native grass. Productivity is low because of the dense, shallow claypan. Capability unit VIs–Cp; claypan range site; windbreak group 9.

Rhoades-Daglum complex (3 to 9 percent slopes) (Rn).—This complex is in the uplands. It is about 55 percent Rhoades soils, 25 percent Daglum soils, and small inclusions of Belfield, Regent, and Werner soils. Also included were a few small areas of raw saline-alkaline shale and several small areas where the slope gradient is 9 to 12 percent. Slopes are plane to concave and uneven. There are slight high and low spots that have a difference of 1 to 5 inches in elevation. The Rhoades soil is in the low spots, and the Daglum soil is in the high spots.

The Rhoades soil has the profile described as representative for the Rhoades series. Daglum soils are described under the heading "Daglum Series."

These soils are highly susceptible to water erosion because permeability is slow in the shallow, dense claypan. Surface runoff is rapid. Fertility is low in the Rhoades soil and medium in the Daglum soil. Conserving moisture and controlling erosion are the major concerns in management. A good grass cover is needed.

Most of the acreage is in native grass and is used for pasture. Capability unit VIs–Cp; Claypan range site; windbreak group 9.

Riverwash

Riverwash (0 to 3 percent slopes) (Rv) consists of sandbars within and adjacent to the channel of the Missouri River. The texture is commonly very fine sandy loam but ranges from fine sand to silt loam. These areas are less than a foot to more than 3 feet above the normal riverflow. They have a seasonal high water table and are susceptible to flooding. They are subject to change in size and slope through erosion and deposition. Some of the lower lying areas are nearly barren. Others have a thick cover of annual weeds, willows, and other brushy plants. Unless these areas are stabilized by vegetation, dunes are formed by wind action.

Riverwash is used as wildlife habitat and to some extent for grazing. A few small areas are cultivated. Capability unit VIIIe–1; not assigned to a range site or windbreak group.

Roseglen Series

The Roseglen series consists of deep, nearly level, well-drained soils. These soils are on silty lacustrine plains and glacial outwash deposits.

In a representative profile, the surface layer is dark grayish-brown silt loam about 7 inches thick. The subsoil is silt loam about 17 inches thick. It is grayish brown in the upper 7 inches and brown below. The underlying material is pale-brown silt loam to a depth of about 53 inches and is very pale brown below. It is calcareous and contains segregations of lime.

Permeability is moderate. Available water capacity, the organic-matter content, and fertility are high.

These soils are suited to crops, grass, and trees. Most areas are used for small grain, corn, and alfalfa. A few are in native grass and are used for pasture and hay.

Representative profile of a Roseglen silt loam in cropland within an area of Roseglen-Tansem silt loams, nearly level, 1,990 feet north and 2,525 feet east of the southwest corner of sec. 29, T. 139 N., R. 78 W.:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; smooth, abrupt boundary.

B21—7 to 14 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, prismatic structure parting to weak, medium, subangular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; wavy, irregular boundary.

B22—14 to 21 inches, brown (10YR 5/3) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, coarse and medium, prismatic structure parting to weak, medium, angular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; wavy, clear boundary.

B23—21 to 24 inches, brown (10YR 4/3) silt loam, dark brown (10YR 3/3) when moist; moderate, coarse and medium, prismatic structure parting to weak, medium, angular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

C1ca—24 to 34 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure parting to weak, medium, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; gradual, irregular boundary.

C2—34 to 53 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; moderate effervescence; abrupt, irregular boundary.

C3—53 to 60 inches, very pale brown (10YR 8/4) silt loam, dark grayish brown (10YR 4/2) when moist; few, coarse, distinct, light-gray (10YR 7/1) and few, medium, prominent, reddish-yellow (7.5YR 6/8) mottles; strong, very thin, platy structure; many fine pores; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; moderate effervescence, few masses of segregated lime.

The depth to lime ranges from 15 to 30 inches. The A horizon is dark grayish-brown or grayish-brown silt loam 6 to 9 inches thick. The B horizon ranges from 11 to 24 inches in thickness. The C horizon is silt loam and has a zone of prominent lime accumulation in the upper part.

Roseglen soils are thicker and darker colored in the A horizon and the upper part of the B horizon than the associated Tansem soils. They are coarser textured than Savage soils. They are finer textured than Parshall soils.

Roseglen-Tansem silt loams, nearly level (0 to 3 percent slopes) (RwA).—This complex is on terraces. It is about 45 percent Roseglen silt loam, 40 percent Tansem silt loam, and small inclusions of Savage and Parshall soils. The Roseglen soil is on the lower concave parts of the landscape, and the Tansem soil is on the slightly higher convex parts.

These soils have the profiles described as representative for their respective series (for Tansem soils, see Tansem Series).

These are among the best soils in the county for farming. Production is good. Tilth and workability are good.

Surface runoff is slow. Fertility is high in the Roseglen soil and medium in the Tansem soil. The soils are free of stones and boulders and are only moderately susceptible to blowing.

These soils are suited to irrigation. They are well suited to small grain, corn, alfalfa, and trees. More than 45 percent of the acreage is cultivated. Capability unit IIc–6; Roseglen soil in Silty range site and windbreak group 1; Tansem soil in Silty range site and windbreak group 3.

Savage Series

The Savage series consists of deep, nearly level to sloping, well-drained soils on terraces and in large glacial valleys. These soils formed in deep clayey sediments.

In a representative profile, the surface layer is dark grayish-brown silt loam about 8 inches thick. The subsoil is firm silty clay and silty clay clay loam about 18 inches thick. It is dark grayish brown in the upper part and grades to olive gray in the lower part. The underlying material is light olive-gray and pale-olive silty clay. It is calcareous and contains masses of lime in the upper part.

Permeability is moderately slow. Available water capacity is high. The organic-matter content is moderate, and fertility is medium.

These soils are suited to crops, grass, and trees. Most areas are used for small grain, corn, and alfalfa. A few are in native grass and are used for pasture and hay.

Representative profile of Savage silt loam, level, in cropland, 2,175 feet east and 60 feet north of the southwest corner of sec. 2, T. 138 N., R. 77 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A12—6 to 8 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark grayish brown (2.5Y 3/2) when moist; weak, medium, prismatic structure parting to weak, medium, angular blocky; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; clear boundary.

B21t—8 to 15 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; patches of clay films on vertical faces of peds; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard when dry, firm when moist, sticky and plastic when wet; clear, boundary.

B22t—15 to 19 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; continuous clay films on all faces of peds; moderate, medium, prismatic structure parting to moderate, coarse and medium, angular blocky; very hard when dry, very firm when moist, very sticky and very plastic when wet; clear boundary.

Bca—19 to 26 inches, olive-gray (5Y 5.5/2) silty clay loam, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure parting to moderate, coarse and medium, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; clear, irregular boundary; tongues extend to a depth of 31 inches.

C1ca—26 to 36 inches, light olive gray (5Y 6/2) silty clay, olive gray (5Y 4/2) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; strong effervescence, many masses of segregated lime; clear boundary.

C2—36 to 60 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 4/3) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; strong effervescence.

The solum ranges from 12 to 30 inches in thickness. The A horizon is dark grayish-brown silt loam or silty clay loam 4 to 9 inches thick. The B2t horizon ranges from 8 to 18 inches in thickness. It is dark grayish-brown or grayish-brown, firm silty clay loam or silty clay. The C horizon is light olive-gray or pale-olive silty clay loam and silty clay.

Savage soils are finer textured than Tansem or Williams soils. They do not have the thicker, darker colored surface layer that is typical of Grail soils.

Savage silt loam, level (0 to 3 percent slopes) (SeA).—This soil is on stream and lake terraces. Relief is low, and local variation is less than 5 feet in most places. Included in mapping were areas of Tansem, Roseglen, and Grail soils.

This soil has the profile described as representative for the Savage series.

This soil is moderately susceptible to soil blowing. Surface runoff is slow. Fertility is medium. Runoff ponds on some of the lower areas for short periods.

This soil is well suited to small grain, corn, and alfalfa. About 75 percent of the acreage is cultivated. Capability unit IIc–6; Silty range site; windbreak group 3.

Savage silt loam, gently sloping (3 to 6 percent slopes) (SeB).—This soil is on terraces. Slopes are less than 300 feet long, and maximum relief is 12 feet. Included in mapping were a few areas of Tansem, Roseglen, and Grail soils.

This soil has a profile similar to the one described as representative for the series.

This soil is moderately susceptible to water erosion. Surface runoff is medium. Fertility is medium. Controlling water erosion is the major concern in management.

This soil is suited to small grain and alfalfa. About 75 percent of the acreage is cultivated. Areas in grass are used for hay and pasture. Capability unit IIe–6; Silty range site; windbreak group 3.

Savage silt loam, sloping (6 to 9 percent slopes) (SeC).—This soil is on stream and lake terraces. Included in mapping were a few small areas of Tansem, Roseglen, and Grail soils and one small area where the slope gradient is 9 to 11 percent.

This soil is slightly shallower, but otherwise has profile characteristics similar to those described as representative for the Savage series.

This soil is moderately susceptible to water erosion. Surface runoff is medium. Fertility is medium. Controlling water erosion is the major concern in management.

This soil is suited to small grain and alfalfa. About half the acreage is cultivated. Capability unit IIIe–6; Silty range site; windbreak group 3.

Savage silty clay loam, level (0 to 3 percent slopes) (SgA).—This soil is on smooth terraces. Included in mapping were small areas of Savage silt loam and a few small areas of Grail and Niobell soils.

This soil has profile characteristics similar to those described as representative for the Savage series, except for texture of the surface layer.

Surface runoff is slow. Fertility is medium. Some ponding occurs in low areas for short periods. Soil blowing is the major limitation. When dry, the surface soil is moderately susceptible to blowing.

This soil is well suited to small grain, corn, and alfalfa. About 75 percent of the acreage is cultivated. Capability unit IIc–7; Clayey range site; windbreak group 3.

Savage silty clay loam, gently sloping (3 to 6 percent slopes) (SgB).—This soil occupies short slopes that extend from one bench level to another. Included in mapping were small areas of Savage silt loam and a few small areas of Grail and Niobell soils.

This soil has profile characteristics similar to those described as representative for the Savage series, except for texture of the surface layer.

This soil is moderately susceptible to soil blowing and water erosion. Surface runoff is medium. Fertility is medium. Water erosion is the major limitation.

This soil is suited to small grain, alfalfa, and corn. More than half the acreage is cultivated. Capability unit IIe–7; Clayey range site; windbreak group 3.

Sen Series

This series consists of moderately deep, gently sloping to steep, well-drained soils on uplands. These soils formed in material weathered from calcareous siltstone and very fine sandstone.

In a representative profile, the surface layer is dark grayish-brown silt loam about 6 inches thick. The subsoil is silt loam about 11 inches thick. It is dark grayish brown in the upper part and brown in the lower part. The underlying material is pale-brown silt loam to a depth of about 40 inches. Below this is soft shale of silty clay loam texture.

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

These soils are suited to crops, grass, and trees. Most areas are used for small grain, corn, and alfalfa. Some are in native grass and are used for pasture and hay.

Representative profile of Sen silt loam, sloping, in cropland 50 feet south and 1,040 feet west of the northeast corner of sec. 25, T. 140 N., R. 81 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

B21—6 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; tongues extend to a depth of 17 inches; weak, medium, prismatic structure parting to weak, medium, subangular blocky; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B3ca—12 to 17 inches, brown (10YR 5/3) silt loam, dark grayish brown (10YR 4/2) when moist; tongues extend to a depth of 21 inches; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight to strong effervescence; gradual, wavy boundary.

C1—17 to 40 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; pockets of very pale brown to yellow (10YR 7/5) or yellowish brown (10YR 5/4) when moist; weak, medium and coarse, prismatic structure parting to weak, medium, angular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, few lime masses; gradual, wavy boundary.

C2—40 to 60 inches, gray (5Y 6/1) platy shale, silty clay loam when crushed, olive gray (5Y 4/2) when moist; plates have thin coats of olive (5Y 5/6) when moist; very hard when dry, very firm when moist, very sticky and very plastic when wet and crushed; slight effervescence.

The thickness of the solum ranges from 12 to 24 inches. Texture throughout the profile is commonly silt loam, but there are lenses of clay loam and very fine sandy loam. The A horizon is 4 to 8 inches thick and is dark grayish brown or grayish brown. The B horizon ranges from 8 to 16 inches in thickness and is dark grayish brown, grayish brown, or brown. The C horizon is grayish brown, light brownish gray, pale brown, or light yellowish brown. It is calcareous silt loam in the upper part and with increasing depth grades to soft shale.

Sen soils are associated with Morton and Werner soils. They are less clayey in the subsoil than Morton soils. They have a thicker, darker colored solum than Werner soils.

Sen silt loam, gently sloping (3 to 6 percent slopes) (SnB).—This soil is in the uplands. Included in mapping were areas of Arnegard, Morton, and Williams soils and a few small areas of a soil similar to the Sen soil, but shallower.

This soil is moderately susceptible to soil blowing and water erosion. Surface runoff is medium. Fertility is medium. Controlling erosion and conserving moisture are the major concerns in management.

This soil is suited to small grain, corn, and alfalfa. About half the acreage is cultivated. The trees commonly grown in the area do well on this soil. Capability unit IIe–6; Silty range site; windbreak group 3.

Sen silt loam, sloping (6 to 9 percent slopes) (SnC).—This soil is in the uplands. Slopes are long and smooth. Included in mapping were small areas of Arnegard, Morton, and Williams soils. In areas associated with glacial till, there are numerous stones and boulders on the surface. About 20 percent of the cultivated acreage is moderately eroded.

This soil has the profile described as representative for the Sen series, but in some areas it is moderately eroded and has a thinner surface layer.

This soil is highly susceptible to water erosion and moderately susceptible to soil blowing. Surface runoff is medium. Fertility is medium. Controlling erosion and conserving moisture are the major concerns in management.

More than half the acreage is in native grass. Most of the remaining acreage is cultivated. This soil is suited to small grain and alfalfa. It is suited to corn if it is farmed across the slope. Capability unit IIIe–6; Silty range site; windbreak group 3.

Sen silt loam, hilly (9 to 12 percent slopes) (SnD).—This soil is on irregular, moderately long slopes. Included in mapping were small areas of Morton, Werner, Williams, and Arnegard soils. The Sen soil is on midslopes, and the Werner soil is on the ridges.

This soil has a thinner solum, but otherwise has profile characteristics similar to those described as representative for the series.

This soil is highly susceptible to water erosion. Surface runoff is rapid. Fertility is medium. Controlling water erosion and conserving moisture are the main concerns in management.

Most of the acreage is in native grass. In cultivated areas, this soil is moderately eroded. Capability unit IVe–6; Silty range site; windbreak group 3.

Seroco Series

The Seroco series consists of deep, undulating to hilly, excessively drained, wind-deposited sands.

In a representative profile, the surface layer is dark grayish-brown loamy sand about 6 inches thick. This is underlain by light olive-brown, loose fine sand.

Permeability is rapid. Available water capacity is very low. The organic-matter content and fertility are low.

These soils should be in grass. Most areas are in native grass and are used for pasture.

Representative profile of a Seroco loamy sand under native grass within an area of Telfer-Seroco loamy sands, 2,330 feet south and 2,490 feet east of the northwest corner of sec. 32, T. 138 N., R. 79 W.:

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loamy sand, very dark grayish brown (10YR 3/2), when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; gradual boundary.

C—6 to 60 inches, light olive-brown (2.5Y 5/3) fine sand, dark grayish brown (2.5Y 4/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; noncalcareous to a depth of 56 inches, very slight effervescence below 56 inches.

The texture throughout the profile is loamy fine sand, loamy sand, or fine sand. The A horizon ranges from less than 1 inch to 7 inches in thickness. It is grayish brown or dark grayish brown. The C horizon is light olive brown, grayish brown, brown, or pale brown. It commonly contains one or more thin dark-colored layers. Some profiles are lime free. Others are calcareous in the lower part.

Seroco soils have a thinner surface layer than the associated Telfer and Lihen soils.

The Seroco soils in Burleigh County are mapped with Telfer soils.

Stirum Series

The Stirum series consists of deep, nearly level, poorly drained soils that are strongly alkaline. These soils are in slightly concave areas in the sandy outwash plains.

In a representative profile, the surface layer is dark-gray loam about 3 inches thick. Beneath this is gray fine sandy loam about 3 inches thick. The subsoil, about 7 inches thick, is dark-gray, friable fine sandy loam. Below this is about 8 inches of light-gray, loose fine sandy loam. The underlying material is light yellowish-brown or light olive-brown loamy fine sand and fine sand.

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

These soils should be in grass. Most areas are used for native pasture and hay.

Representative profile of Stirum loam in an area of native grass within an area of Arveson-Stirum loams, very poorly drained, 190 feet north and 365 feet west of the southeast corner of sec. 3, T. 137 N., R. 79 W.:

A11—0 to 3 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) when moist; single grain; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; abrupt, smooth boundary.

A12—3 to 6 inches, gray (10YR 5/1) fine sandy loam, very dark gray (10YR 3/1) when moist; weak, coarse, prismatic structure and moderate, very fine, subangular blocky; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; gradual, wavy boundary.

B2t—6 to 13 inches, dark-gray (2.5Y 4/1) fine sandy loam, very dark gray (5Y 3/1) when moist; weak, coarse, prismatic structure parting to weak, coarse, angular blocky; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; gradual, wavy boundary.

B3g—13 to 21 inches, light-gray (N 7/0) when moist, fine sandy loam; very weak, coarse, prismatic structure parting to single grain; loose when dry, loose when moist, slightly sticky and slightly plastic when wet; slight effervescence; gradual, wavy boundary.

C1g—21 to 32 inches, light yellowish-brown (2.5Y 6/3) loamy fine sand, light olive brown (2.5Y 5/4) when moist; few, coarse, faint mottles of yellowish brown (10YR 5/6) when moist and brownish yellow (10YR 6/6); single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slight effervescence; gradual, wavy boundary.

C2g—32 to 60 inches, light yellowish-brown (2.5Y 6/3) fine sand, light olive brown (2.5Y 5/3) when moist; few, coarse, distinct mottles of olive brown (2.5Y 4/4) when moist and light olive brown (2.5Y 5/6); single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; slight effervescence.

The A horizon is dark-gray or grayish-brown fine sandy loam or loam and ranges from 2 to 8 inches in thickness. The B horizon ranges from 4 to 16 inches in thickness. It is light-gray, gray, dark-gray, or olive-gray, strongly alkaline fine sandy loam or sandy clay loam. The C horizon is light yellowish-brown or light olive-brown fine sandy loam, loamy fine sand, or fine sand. It is strongly alkaline and calcareous.

Stirum soils are associated with Arveson and Tiffany soils. They are more strongly alkaline than Arveson soils and do not have a calcic horizon. They are more limy throughout the profile and more saline than Tiffany soils.

Straw Series

The Straw series consists of deep, nearly level, well-drained soils on flood plains of small creeks. These soils formed in alluvium.

In a representative profile, the surface layer is dark grayish-brown silt loam about 5 inches thick. The subsoil, about 15 inches thick, is dark grayish-brown, very friable silt loam. Below this is about 7 inches of olive-gray, very friable silt loam. The underlying material is light brownish-gray, calcareous silt loam.

Permeability is moderate. Available water capacity is high. The organic-matter content and fertility are high.

These soils are suited to corn, small grain, and alfalfa. Less than half of the acreage is cultivated.

Representative profile of a Straw silt loam in an area of native grass, 1,760 feet north and 200 feet west of the southeast corner of sec. 21, T. 139 N., R. 78 W.:

A1—0 to 5 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, medium, subangular blocky structure parting to moderate, medium, granular; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B21—5 to 10 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B22—10 to 20 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, coarse and medium, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B3ca—20 to 27 inches, olive-gray (5Y 4/2) silt loam, black (2.5Y 2/2) when moist; weak, coarse and medium, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, common masses of segregated lime; gradual, wavy boundary.

C—27 to 60 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence, few masses of segregated lime.

The solum ranges from 20 to more than 36 inches in thickness. The A horizon ranges from 4 to 8 inches in thickness and is very dark grayish-brown or dark grayish-brown silt loam. The B2 horizon is very dark grayish-brown, dark grayish-brown, or grayish-brown silt loam or loam. The C horizon is grayish-brown or light brownish-gray silt loam or loam. The surface layer of a buried soil is common in the substratum. The depth to lime ranges from 16 to 36 inches.

Straw soils are associated with Havrelon and Magnus soils. Straw soils have a darker colored surface layer than Havrelon soils. They are not so clayey as Magnus soils. They are darkened by organic matter to a greater depth than Tansem soils.

Straw silt loam (0 to 3 percent slopes) (St).—This soil is on flood plains of small streams and creeks. Some areas are dissected by stream channels and gullies.

This soil has the profile described as representative for the Straw series.

Surface runoff is slow. Fertility is high. The meandering stream and the steep valley walls, which limit the size, shape, and accessibility of the fields, are the major limitations. Some flooding occurs in spring, as a result of runoff or heavy rains. This soil is suited to small grain and corn and is well suited to alfalfa. It is suited to irrigation. About half the acreage is cultivated. The rest is in grass or is wooded. Capability unit IIc-6; Silty range site; windbreak group 1.

Straw, Arnegard, and Colvin soils, channeled (0 to 3 percent slopes) (Sv).—This mapping unit is in stream channels and on bottom land along small streams. Some areas are Straw soils, some are Arnegard soils, and some are Colvin soils. Other areas contain all three soils. These soils are dissected by meandering streams and abandoned channels. Slope gradient is generally less than 3 percent, but there are short steep embankments in some areas.

The Straw soil has profile characteristics similar to those described as representative for the series, but the dark color extends to a greater depth. Arnegard soils are described under the heading "Arnegard Series" and Colvin soils under "Colvin Series."

Surface runoff is slow on the Straw and Arnegard soils and is ponded or very slow on the Colvin soil. Fertility is high in the Straw and Arnegard soils and medium in the Colvin soil. Small fields and occasional floods are the main limitations.

Most areas are in native grass. Some are used for hay. Capability unit VIe-Si; Arnegard and Straw soils in Silty range site and windbreak group 1; Colvin soil in Subirrigated range site and windbreak group 2.

Tansem Series

The Tansem series consists of deep, nearly level to sloping, well-drained, calcareous soils. These soils formed in lacustrine and glacial outwash deposits.

In a representative profile, the surface layer is dark grayish-brown silt loam about 6 inches thick. The subsoil, about 11 inches thick, is friable silt loam and is grayish brown in the upper part, light olive brown in the middle part, and light yellowish brown in the lower part. The lower part is calcareous. The underlying material is silt loam. It is light yellowish brown to a depth of about 28 inches and pale yellow below. It is calcareous throughout and contains many lime masses in the upper part. The underlying material is lake deposited. Stratification is evident below a depth of 28 inches (fig. 12).

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

Most areas are used for small grain, corn, and alfalfa. A few are in native pasture and hay.

Representative profile of a Tansem silt loam in an area used for hay within an area of Roseglen-Tansem silt loams, nearly level, 1,650 feet north and 500 feet west of the southeast corner of sec. 5, T. 142 N., R. 75 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; cloddy to weak, medium and fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt boundary.

B21—6 to 10 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish-brown (10YR 3/2) when moist; moderate, coarse and medium, prismatic structure parting to strong, medium, blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; thin (10YR 2/2) coats of organic staining on prism faces; gradual boundary.

B22—10 to 14 inches, light olive-brown (2.5Y 5/4) silt loam, olive brown (2.5Y 4/3) when moist; moderate, coarse and medium, prismatic structure parting to moderate, medium, blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B3ca—14 to 17 inches, light yellowish-brown (22.5Y 6/3) silt loam, light olive brown (2.5Y 5/3) when moist; weak, coarse, prismatic structure parting to moderate, medium, prismatic and weak, coarse, blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence, a few, large, white lime spots; clear, wavy boundary.

C1ca—17 to 23 inches, light yellowish-brown (2.5Y 6/4) silt loam, light olive brown (2.5Y 5/4) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; very strong effervescence, many, large, prominent white lime accumulations; gradual boundary.

C2ca—23 to 28 inches, light yellowish-brown (2.5Y 6/4) silt loam, olive brown (2.5Y 4/3) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strong effervescence, a few, large, white lime and common, very small, white lime accumulations; clear, wavy boundary.

C3—28 to 60 inches, pale-yellow (2.5Y 7/3) silt loam, light olive brown (2.5Y 5/3) when moist; varved or platy; many dark yellowish-brown (10YR 4/4) stains on surface of varved material; moderate effervescence.

These soils are generally silt loam throughout the profile. The A horizon ranges from 4 to 9 inches in thickness. The B horizon ranges from 6 to 16 inches in thickness. The C horizon is stratified light yellowish brown, light olive brown, and pale yellow. In places it contains thin gravelly layers.

Tansem soils are associated with Makoti and Roseglen soils. They are less clayey and more sandy than Makoti soils.

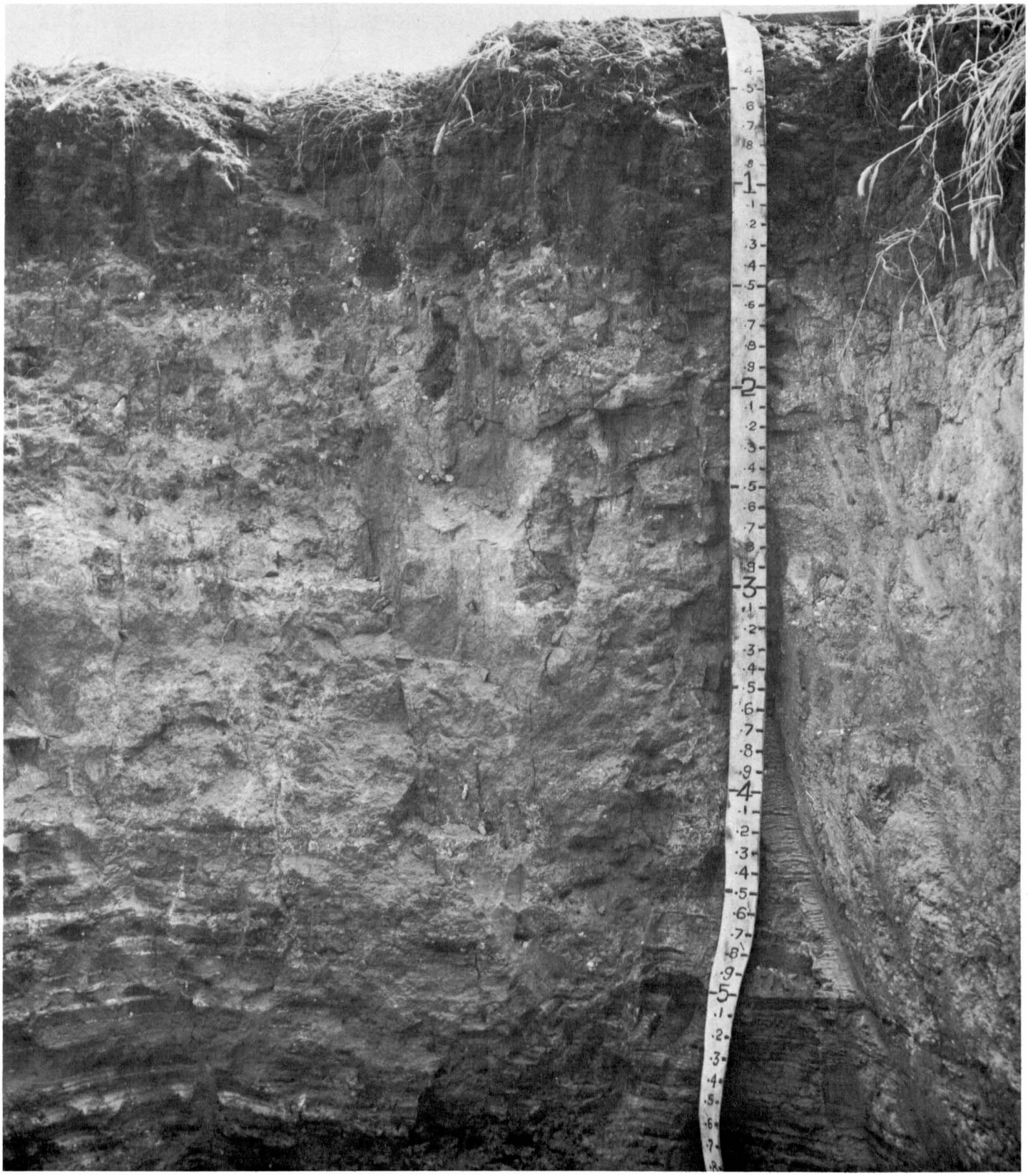

Figure 12.—**Profile of Tansem silt loam showing stratification in the lower part of the profile.**

They have a thinner, darker colored surface layer than Roseglen soils. They are more silty than Williams soils and do not have the random assortment of pebbles that is typical of those soils.

Tansem loam, sloping (6 to 9 percent slopes) (TaC).—This soil is underlain by silty lacustrine and glacial outwash materials. In most areas it is stone free. Slopes are less than 400 feet in length. Included in mapping were a few small areas of Roseglen silt loam and Tansem silt loam. The Tansem soil is on upper slopes, and the Roseglen soil is on lower slopes.

Except for texture of the surface layer, this soil has the profile characteristics similar to those described as representative for the series. It is easily worked and has good tilth. Unless well managed, it is highly susceptible to blowing and water erosion. Surface runoff is medium. Fertility is medium. Controlling erosion is the major concern in management.

This soil is well suited to small grain, alfalfa, and corn. Row crops, however, increase the erosion hazard unless planted across the slope. About half the acreage is cultivated. Capability unit IIIe–6; Silty range site; windbreak group 3.

Tansem-Lehr loams, nearly level (0 to 3 percent slopes) (TeA).—This complex is in glacial outwash areas and along stream terraces. It is about 35 percent Tansem loam and about 25 percent Lehr loam. Included in mapping were a few small areas of Roseglen soils and areas of soils that are similar to Tansem soils but contain thin layers of gravel.

Except for texture of the surface layer, the Tansem soil has profile characteristics similar to those described as representative for the series. Lehr soils are described under the heading "Lehr Series."

These soils are moderately susceptible to soil blowing. Surface runoff is slow. Fertility is medium. Controlling blowing and conserving moisture are the major concerns in management.

These soils are well suited to small grain, corn, and alfalfa and are fairly well suited to trees. About 60 percent of the acreage is cultivated. Capability unit IIe–5; Lehr soil in Shallow to Gravel range site and windbreak group 6; Tansem soil in Silty range site and windbreak group 3.

Tansem-Roseglen silt loams, gently sloping (3 to 6 percent slopes) (TgB).—This complex is about 60 percent Tansem silt loam and about 40 percent Roseglen silt loam. The Tansem soil is on the upper convex slopes, and the Roseglen soil is on the lower concave slopes.

Roseglen soils are described under the heading "Roseglen Series."

These soils are moderately susceptible to erosion. Surface runoff is medium. Fertility is medium in the Tansem soil and high in the Roseglen soil. Soil blowing and water erosion are the major concerns in management.

These soils are suited to small grain, corn, and alfalfa and are well suited to trees. They are suited to irrigation. About 75 percent of the acreage is cultivated. Capability unit IIe–6; Roseglen soil in Silty range site and windbreak group 1; Tansem soil in Silty range site and windbreak group 3.

Telfer Series

The Telfer series consists of deep, undulating to hilly, excessively drained soils that formed in wind-deposited sands. These soils are in hummocks and dunes. They are noncalcareous throughout.

In a representative profile, the surface layer is dark grayish-brown loamy sand that grades with increasing depth to sand. The underlying material is light olive-brown sand.

Permeability is rapid. Available water capacity is low. The organic-matter content is moderate, and fertility is low.

These soils should be kept in grass. Most of the acreage is in native grass and is used for pasture.

Representative profile of a Telfer loamy sand under native grass within an area of Telfer-Seroco loamy sands, 2,375 feet south and 2,490 feet east of the northwest corner of sec. 32, T. 138 N., R. 79 W.:

A1—0 to 6 inches, dark grayish-brown (10Y 4/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; many roots; clear boundary.

AC—6 to 14 inches, grayish-brown (2.5Y 5/2) sand, very dark grayish brown (2.5Y 3/2) when moist; loose when dry, loose when moist, nonsticky and nonplastic when wet; single grain; gradual boundary.

C—14 to 60 inches, light olive-brown (2.5Y 5/4) sand, dark grayish brown (2.5Y 4/2) when moist; loose when dry, loose when moist, nonsticky when wet; single grain.

The solum ranges from 10 to 20 inches in thickness. The A horizon is dark grayish brown, very dark grayish brown, or dark gray and ranges from fine sandy loam to loamy sand. The C horizon ranges from grayish brown to pale brown and from loamy fine sand to sand. It commonly contains one or more dark-colored surface layers of buried soils. In some places the lower part of the C horizon is calcareous.

Telfer soils are associated with Lihen and Seroco soils. They have a thinner surface layer and a more sandy substratum than Lihen soils. They are darkened by organic matter to a greater depth than Seroco soils.

Telfer-Lihen loamy sands, nearly level (0 to 3 percent slopes) (ThA).—This complex is about half Telfer loamy sand and half Lihen loamy sand. The Telfer soil is on the upper slopes, and the Lihen soil is on the lower slopes. The landscape is hummocky. Differences in elevation range from 3 to 10 feet.

Except for texture of the surface layer, the Lihen soil has profile characteristics similar to those described as representative for the Lihen series (see Lihen Series).

These soils are highly susceptible to soil blowing. In some areas they are moderately and severely eroded. Surface runoff is slow. Fertility is low in the Telfer soil and medium in the Lihen soil. The Telfer soil is droughty. Controlling blowing and maintaining a good cover of vegetation are the major concerns in management.

Most of the acreage is in native grass and is used for pasture or hay. Capability unit VIe–Sa; Lihen soil in Sands range site and windbreak group 5; Telfer soil in Sands range site and windbreak group 7.

Telfer-Lihen loamy fine sands, hilly (9 to 15 percent slopes) (TlD).—This complex is about 50 percent Telfer loamy fine sand and 25 percent Lihen loamy fine sand.

The rest is small areas of Flaxton soils. The Telfer soil is on the upper slopes, and the Lihen soil is on the lower slopes. Slopes are complex.

These soils have a thinner surface layer but otherwise have profile characteristics similar to those described as representative for their respective series.

These soils are highly susceptible to blowing. The erosion hazard is the major limitation.

Most of the acreage is in native grass and is used for pasture. Capability unit VIe–Sa; Lihen soil in Sands range site and windbreak group 5; Telfer soil in Sands range site and windbreak group 7.

Telfer-Seroco loamy sands (3 to 25 percent slopes) (Tm).—This complex is about 40 percent Telfer loamy fine sand, 30 percent Telfer loamy sand, and 30 percent Seroco loamy sand. The landscape is one of dunes and hummocks. Slopes are complex and very irregular. Summits of the hummocks or dunes range from 4 to 40 feet higher than the adjacent troughs.

These Telfer and Seroco soils have the profiles described as representative for their respective series.

These soils are highly susceptible to blowing. Surface runoff is slow. Fertility is low. Controlling soil blowing is the major concern in management. Blowouts (fig. 13) are common in areas where the grass cover is sparse or where it has been disturbed by tillage.

Most of the acreage is in native grass. Hay is cut in some of the more productive areas. Capability unit VIIe–CS; Seroco soil in Choppy Sands range site and windbreak group 10; Telfer soil in Sands range site and windbreak group 7.

Temvik Series

The Temvik series consists of deep, nearly level to sloping, well-drained soils that formed in loess over glacial till. These soils are in uplands.

In a representative profile, the surface layer is dark grayish-brown silt loam about 6 inches thick. The subsoil, about 16 inches thick, is friable silt loam that is dark grayish brown to a depth of about 17 inches and brown below. It is calcareous in the lower part. The underlying material is calcareous glacial till (fig. 14). It is light-gray loam to a depth of about 30 inches, light-gray clay loam to a depth of about 43 inches, and light-brownish-gray clay loam below this.

These soils formed in deposits of loess underlain by glacial till. The stone line and the lime zone, at a depth of about 22 inches, mark the boundary between the loess and the glacial till.

Representative profile of a Temvik silt loam in cropland within an area of Temvik silt loam, undulating, 65

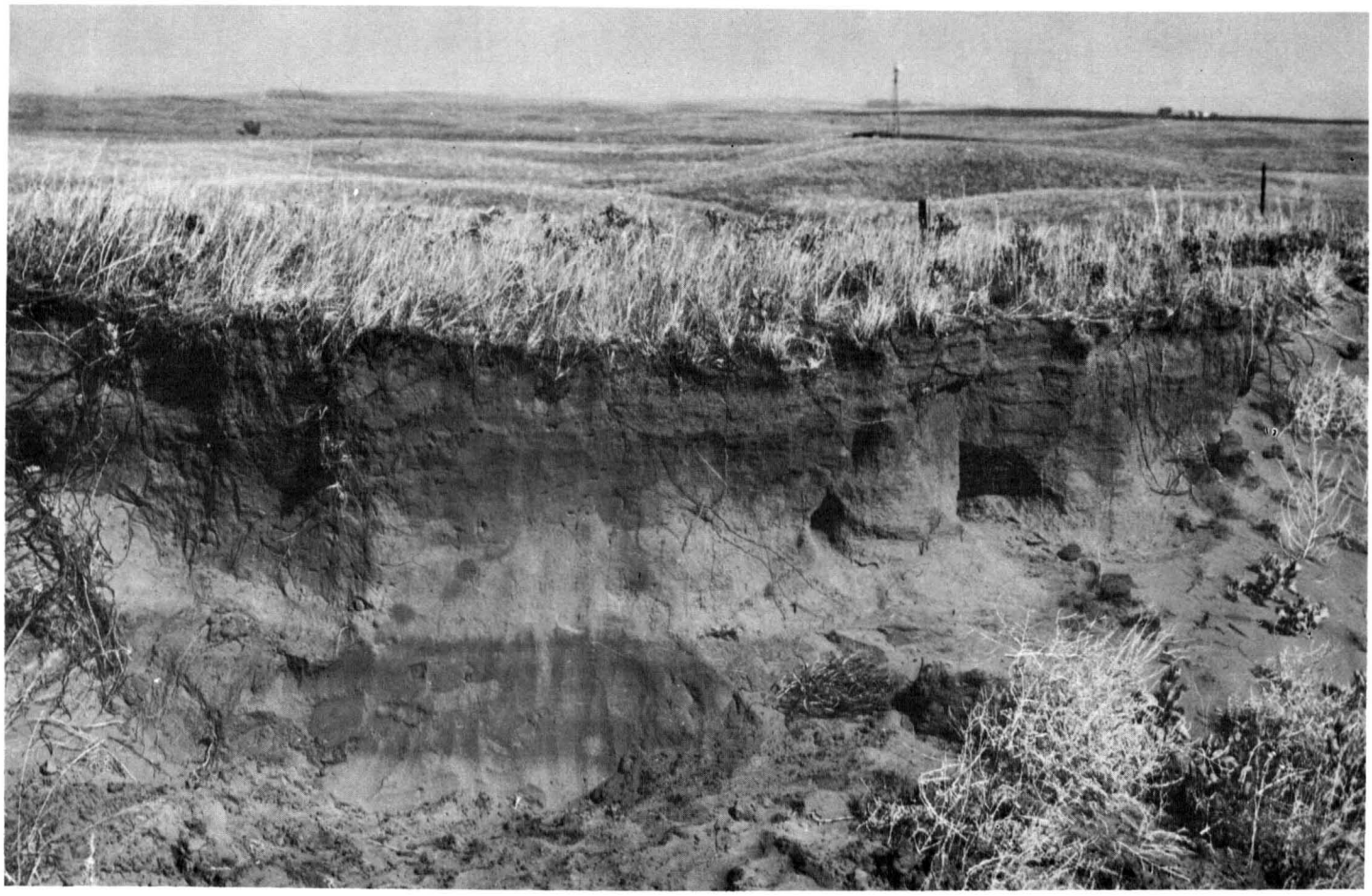

Figure 13.—**Blowout on Telfer loamy sands. The dark-colored layer in lower part of profile is the surface layer of a buried soil.**

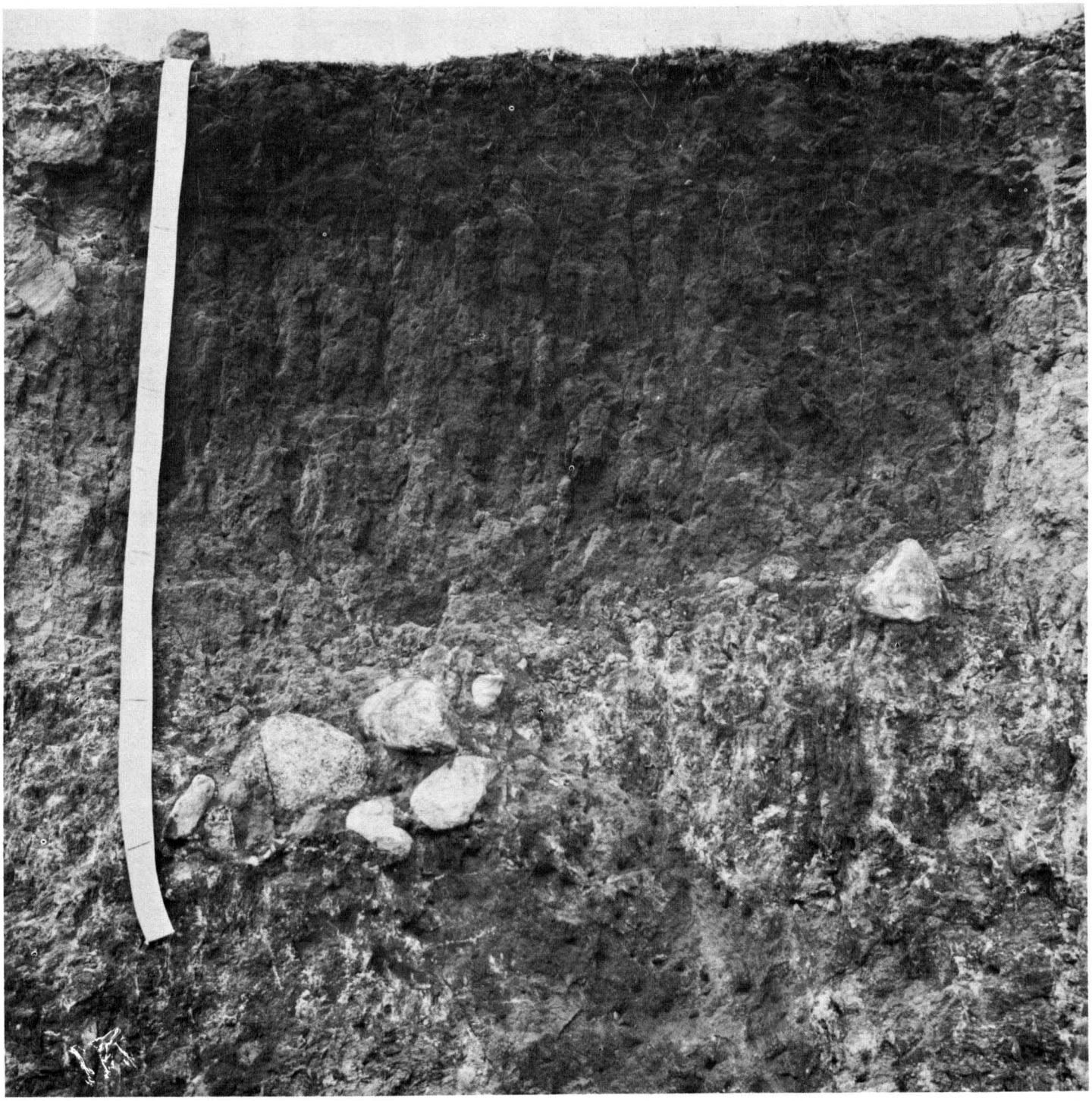

Figure 14.—**Profile of a Temvik silt loam showing stones and a lime zone at a depth of about 22 inches.**

feet south and 575 feet east of the northwest corner of sec. 2, T. 141 N., R. 80 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, fine, subangular blocky structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

B2—6 to 17 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B3ca—17 to 22 inches, brown (10YR 5/3) silt loam, brown or dark brown (10YR 4/3) when moist; moderate, coarse, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence at top to strong effervescence at bottom, common lime masses; gradual, wavy boundary.

IIC1ca—22 to 30 inches, light-gray (2.5Y 7/2) loam, light olive brown (2.5Y 5/3) when moist; massive; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; strong effervescence, many finely disseminated lime particles; gradual, wavy boundary.

IIC2ca—30 to 43 inches, light-gray (2.5Y 7/2) clay loam, light olive brown (2.5Y 5/3) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strong effervescence, many fine lime masses; gradual, wavy boundary.

IIC3—43 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/3) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strong effervescence, common lime masses.

The depth of loess over the glacial till ranges from 20 to 40 inches. A stone line commonly occurs at the contact of the loess and glacial till. The A horizon is dark grayish-brown or grayish-brown silt loam 6 to 12 inches thick. The B horizon, 8 to 20 inches thick, is dark grayish-brown and brown silt loam. It is commonly calcareous in the lower part. The C horizon is multicolored, calcareous loam or clay loam glacial till. In places the glacial till is a thin layer that is underlain by soft shale and siltstone. Depth to the prominent lime zone ranges from 14 to 30 inches.

Temvik soils are associated with Linton, Mandan, and Williams soils. They are shallower over glacial till than Linton and Mandan soils. In contrast with Williams soils, which formed in glacial till, they formed in a silty loess mantle over glacial till.

Temvik silt loam, nearly level (0 to 3 percent slopes) (TnA).—Included with this soil in mapping were a few small areas of Grassna, Mandan, Sen, and Williams soils. The Mandan and Grassna soils occur where the loess mantle is thick, and the Williams and Sen soils where the mantle is thinner. Scattered stones occur in a few areas where the mantle is thin.

This soil is moderately susceptible to blowing. Surface runoff is slow. Fertility is medium. Controlling soil blowing is the major concern in management.

This soil is well suited to small grain, corn, and alfalfa. All varieties of trees can be grown. More than 75 percent of the acreage is cultivated. The acreage in grass is used for pasture and hay. Capability unit IIc–6; Silty range site; windbreak group 3.

Temvik silt loam, undulating (3 to 6 percent slopes) (TnB).—This soil is in glacial uplands that have been mantled with windblown material. There are glacial stones and boulders on many of the upper slopes. Included in mapping were a few small areas of Williams, Grassna, and Mandan soils. The Temvik soil is on the upper slopes, and the Grassna and Mandan soils are in the lower positions.

This Temvik soil has the profile described as representative for the series. It is moderately susceptible to blowing and water erosion. Surface runoff is medium. Fertility is medium. Controlling erosion and conserving moisture are the major concerns in management.

This soil is well suited to small grain, corn, and alfalfa and to most varieties of trees. About 75 percent of the acreage is cultivated. Capability unit IIe–6; Silty range site; windbreak group 3.

Temvik silt loam, rolling (6 to 9 percent slopes) (TnC).—This soil is in glacial uplands that have been mantled with windblown silty material. Included in mapping were a few small areas of Williams, Sen, and Grassna soils. The Williams and Sen soils are in areas where the silty mantle is thin. There are glacial boulders and stones on ridges and the upper slopes in some areas.

This soil has profile characteristics similar to those described for the series, but the loess mantle is a little thinner. This soil is highly susceptible to water erosion and moderately susceptible to soil blowing. Surface runoff is medium. Fertility is medium. Controlling erosion and conserving moisture are the major concerns in management.

This soil is suited to small grain and alfalfa. About half the acreage is cultivated. Capability unit IIIe–6; Silty range site; windbreak group 3.

Tiffany Series

The Tiffany series consists of deep, nearly level, poorly drained soils in small basins and sloughs in glaciolacustrine deposits or on outwash plains.

In a representative profile, the surface layer is very dark gray and about 9 inches thick. It is loam in the upper part and fine sandy loam in the lower part. Beneath this is dark-gray, friable fine sandy loam about 8 inches thick. The underlying material is olive-gray fine sandy loam to a depth of about 38 inches. Below this, to a depth of 60 inches, is light olive-brown loamy fine sand.

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

These soils are suitable for grass, trees, and wildlife. Most of the acreage is native grass and is used for pasture.

Representative profile of Tiffany loam in an area of native grass, 75 feet south and 1,320 feet east of the northwest corner of sec. 19, T. 137 N., R. 76 W.:

A11—0 to 4 inches, very dark gray (2.5Y 3/1) loam, black (2.5Y 2/1) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet.

A12—4 to 9 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet.

A13—9 to 17 inches, dark-gray (5Y 4/1) fine sandy loam, black (2.5Y 2/2) when moist; common, medium, distinct, reddish-brown (5Y 4/4) mottles; massive to weak, medium, prismatic structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet.

C1—17 to 38 inches, olive-gray (5Y 4/2) fine sandy loam, olive gray (5Y 4/2) when moist; many, medium, faint, yellowish-red (5YR 5/6) mottles; single grain; soft when dry, friable when moist, slightly sticky and slightly plastic when wet.

C2—38 to 60 inches, light olive-brown (2.5Y 5/3) loamy fine sand, olive brown (2.5Y 4/3) when moist; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet.

The A horizon ranges from 12 to 36 inches in thickness and is black, dark gray, or very dark gray fine sandy loam or loam. The C horizon ranges from very dark gray to pale olive and from loamy fine sand to loam. It has few to many mottles. The depth to lime ranges from 18 to more than 60 inches.

Tiffany soils are not so limy as Arveson soils. They are coarser textured than Parnell and Dimmick soils.

Tiffany loam (0 to 3 percent slopes) (To).—This soil is in small basins and sloughs on the glacial outwash plains. The basins are about 2 to 4 feet lower than the

adjacent uplands. Included in mapping were areas of Arveson soils and a few small areas of soils similar to Tiffany soils but more poorly drained.

This soil has the profile described as representative for the Tiffany series.

Surface runoff is very slow. Fertility is medium. Wetness is the main limitation. If drained, this soil is suited to cultivation. Undrained areas are suitable for late seeded crops in some years.

This soil is well suited to wildlife. Most of the acreage is in native grass. A few small areas produce good hay crops. Capability unit IIIwe-3; Subirrigated range site; windbreak group 2.

Tonka Series

The Tonka series consists of deep, level, poorly drained soils in closed depressions in the glacial uplands. These soils formed in local alluvium.

In a representative profile, the surface layer is dark-gray silt loam about 7 inches thick. Beneath this is about 3 inches of gray silt loam. Next is about 3 inches of gray, firm silty clay loam. The subsoil is about 33 inches thick. The upper 5 inches is dark-gray, firm silty clay loam. The rest, to a depth of 46 inches, is gray, very firm silty clay. The underlying material, to a depth of 66 inches, is light-gray clay loam and gravelly clay loam. It is limy in the lower part.

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

About half the acreage is too wet for cultivation. It is in native grass and is suited only to native grass or hay. The drier soils are cultivated. They are suited to small grain, corn, legumes, grasses, and trees.

Representative profile of a Tonka silt loam in a cultivated field within an area of Tonka and Parnell soils, 2,500 feet north and 1,950 feet west of the southeast corner of sec. 2, T. 139 N., R. 76 W.:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A2—7 to 10 inches, gray (2.5 5/1) silt loam, very dark grayish brown (2.5Y 3/2) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

A&B—10 to 13 inches, gray (10YR 5/1) silty clay loam, very dark gray (2.5Y 3/1) when moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky or weak, medium, platy; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B21t—13 to 18 inches, dark-gray (5Y 4/1) silty clay loam, black (2.5Y 2/1) when moist; few, medium, faint, dark reddish-brown (5YR 3/4) mottles; strong, fine, angular blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B22t—18 to 34 inches, gray (10YR 5/1) silty clay, very dark gray (10YR 3/1) when moist; strong, fine, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; gradual boundary.

B3—34 to 46 inches, gray (2.5Y 5/1) silty clay, very dark gray (2.5Y 3/1) when moist; massive or weak, very fine, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet.

C1—46 to 56 inches, light-gray (5Y 7/1) clay loam, olive gray (5Y 5/2) when moist; common, medium, distinct, yellowish-brown (10YR 5/8) mottles and common very dark brown (10YR 2/2) granules; massive; very hard when dry, very firm when moist, sticky and plastic when wet.

IIC2ca—56 to 58 inches, light-gray (5Y 7/2) gravelly clay loam, olive gray (5Y 5/2) when moist; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; slight effervescence, common masses of segregated lime.

IIC3ca—58 to 66 inches, light-gray (5Y 7/2) clay loam, olive gray (5Y 4/2) when moist; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; slight effervescence, many masses of segregated lime.

The A1 horizon ranges from 6 to 16 inches in thickness. It is very dark gray or dark gray silt loam or silty clay loam. The A2 horizon ranges from 3 to 15 inches in thickness. It is gray, very dark gray, or dark gray and in places has mottles of yellowish or reddish brown. The B horizon is gray or dark-gray silty clay loam and silty clay. The C horizon is light-gray or gray clay loam, silty clay, or silt clay loam. Lime occurs at a depth of 20 to 60 inches.

Tonka soils are associated with Dimmick, Parnell, and Williams soils. The are coarser textured than Dimmick soils. They are better drained than Parnell soils. They are more poorly drained than Williams soils.

Tonka and Parnell soils (0 to 3 percent slopes) (Tp).—This mapping unit is in shallow depressions in the glacial till plain. The small depressions, dominantly Tonka soils, are generally better drained than the larger ones, which are dominantly Parnell soils. Included in mapping were a few small areas of Dimmick, Colvin, and Heil soils.

This Tonka soil has the profile described as representative for the Tonka series. The Parnell soil is described under the heading "Parnell Series."

Surface runoff is slow. Fertility is medium in the Tonka soil and high in the Parnell soil. Wetness is the main limitation.

Most of the small depressions are cultivated along with adjacent areas and are planted to small grain. The large depressions are in native grass and are used for hay and pasture. They also provide useful habitat for ducks. Capability unit IIw-6; Parnell soil in Wetland range site and windbreak group 2; Tonka soil in Overflow range site and windbreak group 2.

Vebar Series

This series consists of moderately deep, gently sloping and sloping well-drained soils that formed in material weathered from soft sandstone. The slope gradient is 3 to 9 percent.

In a representative profile, the surface layer is dark grayish-brown fine sandy loam about 10 inches thick. The subsoil is about 26 inches thick. The upper 4 inches is light brownish-gray, very friable fine sandy loam. The lower 22 inches is light yellowish-brown, very friable fine sandy loam. The underlying material is pale-yellow, massive, bedded sandstone. The substratum is moderately limy.

Permeability is moderately rapid. The available water capacity and organic-matter content are moderate. Fertility is medium.

These soils are suited to small grain, corn, and legumes. They are also suited to native grasses for pasture and hay. Most of the acreage is cultivated.

Representative profile of Vebar fine sandy loam, sloping, in an area of native grass, 700 feet south and 2,500 feet west of the northeast corner of sec. 5, T. 140 N., R. 80 W.:

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B2—10 to 14 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, olive brown (2.5Y 4/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; slight effervescence; gradual, wavy boundary.

B3—14 to 36 inches, light yellowish-brown (2.5Y 6/4) fine sandy loam, light olive brown (2.5Y 5/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence; gradual, wavy boundary.

C1—36 to 60 inches, pale-yellow (5Y 7/3), massive, soft, bedded sandstone that crushes easily to loamy fine sand, olive (5Y 5/4) when moist; soft and loose when moist, brittle when dry.

The solum ranges from 10 to 40 inches in thickness. These soils are darkened by organic matter to a depth of 10 to 24 inches. The A horizon is dark grayish brown or grayish brown to depth of 10 to 24 inches. It is fine sandy loam or coarse loam. The B horizon ranges from dark grayish brown to light yellowish brown and from coarse loam to sandy loam. The upper part of the C horizon ranges from fine sandy loam to loamy sand. The lower part is soft sandstone. In most places the depth to lime ranges from 9 to 25 inches.

Vebar soils are associated with Flasher, Lihen, Manning, and Sen soils. They are deeper and less sloping than Flasher soils. They differ from Lihen soils in having less sand in the control section and in having a darker colored surface layer less than 20 inches thick. In contrast with Manning soils, they do not have a Cca horizon and they overlie soft sandstone instead of sand and gravel. They are sandier than Sen soils.

Vebar fine sandy loam, gently sloping (3 to 6 percent slopes) (VbB).—This soil is on the sandy uplands. Slopes are short to long. The local relief ranges from 5 to 50 feet. Included in mapping were areas of Williams soils and a few small areas of Flasher, Parshall, Sen, and Arnegard soils. In a few areas, Williams soils make up as much as 35 percent of the unit.

The Vebar soil has a profile similar to the one described as representative for the series.

This soil is highly susceptible to blowing and water erosion. In cultivated areas it is moderately eroded. Surface runoff is medium. Fertility is medium. Controlling erosion is the major concern in management.

This soil is suited to small grain, corn, and alfalfa and to most of the trees and shrubs commonly grown. About 65 percent of the acreage is cultivated. Areas not cultivated are in native grass and are used for pasture and hay. Capability unit IIIe-3; Sandy range site; windbreak group 5.

Vebar fine sandy loam, sloping (6 to 9 percent slopes) (VbC).—This soil is in the sandy uplands. Slopes are short to moderately long. Included in mapping were a few small areas of Flasher, Parshall, Sen, and Arnegard soils. In a considerable acreage under cultivation, this soil is moderately eroded.

This Vebar soil has the profile described as representative for the series.

This soil is highly susceptible to both blowing and water erosion in cultivated areas. Surface runoff is medium. Fertility is medium. Controlling soil blowing and water erosion are the major concerns in management.

This soil is suited to small grain and alfalfa. About half the acreage is cultivated. Capability unit IVe-3; Sandy range site; windbreak group 5.

Wabek Series

The Wabek series consists of very shallow, nearly level to very steep, excessively drained soils that formed in gravel. These soils are on stream terraces and glacial outwash areas.

In a representative profile, the surface layer is dark grayish-brown loam about 5 inches thick. The upper part of the underlying material, about 4 inches thick, is light brownish-gray gravelly coarse sandy loam and is moderately limy. The lower part, to a depth of 60 inches, is pale-brown, loose coarse sand and gravel. It is only slightly limy.

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

These soils are suited to native pasture and hay. Most of the acreage is in native grass.

Representative profile of Wabek loam in an area of native grass within an area of Wabek soils, hilly, 2,600 feet north and 50 feet west of the southeast corner of sec. 1, T. 140 N., R. 77 W.:

A1—0 to 5 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; many roots; neutral; few to common pebbles; gradual, wavy boundary.

IIC1ca—5 to 9 inches, light brownish-gray (10YR 6/2) gravelly coarse sandy loam, brown (10YR 4/3) when moist; single grain; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence, lime crust on underside of pebbles and stones; mildly alkaline; diffuse, wavy boundary.

IIIC2—9 to 60 inches, pale-brown (10YR 6/3) coarse sand and gravel, grayish brown (10YR 5/2) when moist; stratified sand, gravel, and cobblestones or a mixture of these materials; loose when dry, loose when moist, nonsticky and nonplastic when wet; a few roots in upper 10 inches; moderate effervescence decreasing to slight in the lower part, mildly alkaline.

The A horizon ranges from loam to gravelly sandy loam and from grayish brown to dark grayish brown. In places these soils have a prominent zone of lime accumulation below the A horizon. The C horizon is mostly gravel, but in some areas it is cobblestones or a mixture of stones, boulders, and gravel or coarse sand.

Wabek soils are associated with Flasher, Lehr, and Manning soils. They are shallower over gravel than Lehr and Manning soils. They differ from Flasher soils in having a sandy and gravelly substratum.

Wabek soils, undulating (0 to 6 percent slopes) (WaB).—These soils are on glacial outwash plains. They

occupy the ridges and knolls and are intermingled with deeper soils on the smooth parts of the landscape. Slopes are short, and the total relief is less than 20 feet in most places. Included in mapping were areas of Lehr soils.

Wabek soils have a profile similar to the one described as representative for the series.

The soils are droughty and are moderately susceptible to erosion. Surface runoff is slow. Fertility is low. The low available water capacity is the major hazard.

Most of the acreage is in native grass. Small areas are cultivated along with adjacent deeper soils. Capability unit VIs–SwG; Shallow to Gravel range site; windbreak group 10.

Wabek soils, hilly (6 to 30 percent slopes) (WaD).—These soils are on the glacial outwash plain and in gravelly or stony pockets within areas of glacial till. Slope gradient is dominantly less than 15 percent but ranges to as much as 30 percent. Included in mapping were a few small areas of Lehr soils.

This Wabek soil has the profile described as representative for the series.

The soils are droughty and highly susceptible to erosion. Surface runoff is slow. Fertility is low. The low available water capacity and steep slopes are the main limitations.

Most of the acreage is in native grass. Capability unit VIs–SwG; Shallow to Gravel range site; windbreak group 10.

Werner Series

The Werner series consists of strongly sloping and moderately steep, well-drained soils that are shallow over soft sandstone, shale, and siltstone. These soils formed on the ridge crests and upper slopes of the residual uplands.

In a representative profile, the surface layer is dark grayish-brown loam about 6 inches thick. The subsurface layer, about 7 inches thick, is grayish-brown, friable loam and is slightly limy. The upper 4 inches of the underlying material is light yellowish-brown loam. It is strongly limy and contains common lime segregations. The middle 13 inches is pale-yellow bedded sandstone. The lower part is light-gray bedded sandstone and shale. The middle and lower parts of the underlying material contain only a small amount of lime.

Permeability is moderate. Available water capacity and fertility are low. The organic-matter content is moderate.

Most of the acreage is in native grass. The strongly sloping soils are suited to native pasture, and the soils that have milder slopes are suited to small grain, corn, legumes, and grasses.

Representative profile of Werner loam in an area of native grass within an area of Werner complex, steep, 3 miles north and 150 feet west of the southeast corner of sec. 31, T. 140 N., R. 80 W.:

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure separating to moderate, very fine, subangular blocky; friable; many roots, many fine pores; a few small stones; neutral; clear, wavy boundary.

AC—6 to 13 inches, grayish-brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) when moist; weak, medium, prismatic structure separating to weak, medium and fine, subangular blocky; friable; many roots, common fine pores; a few small stones; a few small, light-gray spots of lime, slight effervescence, mildly alkaline; clear, wavy boundary.

C1ca—13 to 17 inches, light yellowish-brown (2.5Y 6/3) loam, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure separating to weak, fine, subangular blocky; friable; common roots, few fine pores; a few small stones; common white lime spots, strong effervescence, moderately alkaline; clear, wavy boundary.

C2—17 to 30 inches, pale-yellow (2.5Y 7/3), soft, argillaceous sandstone; massive but breaks into plates; few roots in cracks; large white lime spots in cracks, slight effervescence, moderately alkaline; gradual boundary.

C3—30 to 60 inches, light-gray (5Y 7/2), thick, platy and blocky sandstone and shale strata, olive gray (5Y 5/2) when moist; light yellowish brown and yellow (10YR 6/4 and 2.5Y 7/6) on faces of plates and blocks; slight effervescence, moderately alkaline.

The solum ranges from 7 to 20 inches in thickness. The A horizon ranges from 4 to 9 inches in thickness. It is loam, silt loam, or clay loam and is dark grayish brown or very dark brown. The C horizon is soft sandstone, shale, and siltstone.

Werner soils are associated with Morton, Sen, and Zahl soils. They are shallower than Morton and Sen soils. In contrast with Zahl soils, they formed over soft shale and sandstone instead of glacial till.

Werner complex, steep (15 to 30 percent slopes) (WcF).—This mapping unit is mainly on breaks bordering the Missouri River bottoms. Slopes are 100 feet to more than one-fourth mile long. About 50 percent of this unit is Werner soils. Included in mapping were areas of Sen and Morton soils and small areas of Arnegard and Flasher soils.

Werner soils have the profile described as representative for the series.

The soils are droughty and highly susceptible to water erosion. Surface runoff is rapid. Fertility is low. Conserving moisture and controlling water erosion are the major concerns in management.

Most of the acreage is in native grass. Capability unit VIe–TSi; Thin Silty range site; windbreak group 10.

Werner-Morton-Sen complex, hilly (9 to 15 percent slopes) (WeE).—This mapping unit consists of shallow, hilly to steep soils and intervening areas of deeper soils in the residual uplands. It is about 40 percent Werner soils, 35 percent Sen soils, 5 percent Morton soils, and 20 percent small inclusions of Arnegard, Flasher, and Vebar soils. Slopes are 100 feet to one-fourth mile long. Glacial boulders are common.

The Werner soil has a profile similar to the one described as representative for the series.

The Morton and Sen soils in this complex are described under the headings for their respective series.

These soils are highly susceptible to water erosion. Surface runoff is rapid. Fertility is low in the Werner soil and medium in the Sen and Morton soils. The Werner soil is droughty. The low available water capacity in the Werner soil and the hazard of water erosion on all the soils are the major concerns in management.

Most areas are in native grass. Capability unit VIe-TSi; Werner soil in Thin Silty range site and windbreak group 10; Morton and Sen soils in Silty range site and windbreak group 3.

Werner-Sen loams, sloping (6 to 9 percent slopes) (WlC).—This complex is in the residual uplands. It is about 50 percent Werner loam and about 50 percent Sen loam. The Werner soil is on the ridgetops and upper slopes, and the Sen soil is on the lower slopes.

Each soil has a profile similar to the one described as representative for the respective series.

Surface runoff is rapid on the Werner soil and medium on the Sen soil. Fertility is low in the Werner soil and medium in the Sen soil. The low available water capacity in the Werner and the erosion hazard on both soils are the major concerns in management. The Werner soil is highly susceptible to erosion, and the Sen soil is moderately susceptible.

Most of the acreage is in native grass. A few acres are cultivated. Capability unit IVe–4L; Sen soil in Silty range site and windbreak group 3; Werner soil in Thin Silty range site and windbreak group 10.

Werner-Shale outcrop complex (15 to 50 percent slopes) (Wn).—This complex is on breaks adjacent to the Missouri River. It is about 80 percent Werner soils and 20 percent outcrops of shale and sandstone. The outcrops occur as ledges or as eroded areas. Slope gradients range from 15 to more than 50 percent. Included in mapping were a few small areas of Flasher soils.

This Werner soil has a profile similar to the one described as representative for the series.

Unless a good grass cover is maintained, the hazard of water erosion is severe. Surface runoff is rapid. Fertility is low. Conserving moisture and controlling water erosion are the major concerns in management.

All the acreage is in native grass. Capability unit VIIe–Si; Werner soil in Thin Silty range site and windbreak group 10.

Williams Series

The Williams series consists of deep, nearly level to steep, well-drained soils that formed in the glacial till uplands. The slope gradient is 0 to 15 percent.

In a representative profile, the surface layer is very dark grayish-brown loam about 4 inches thick. The subsoil is about 20 inches thick. The upper part is dark grayish-brown, friable loam. The middle part is brown to dark-brown, friable light clay loam, and the lower part is dark grayish-brown to olive-brown, strongly limy, firm clay loam. The underlying material is light clay loam and is strongly limy. It is olive gray to a depth of about 38 inches and light olive brown below this to a depth of 60 inches.

Permeability is moderate in the subsoil and moderately slow below. Available water capacity and fertility are high. The organic-matter content is moderate.

These soils are well suited to small grain, grasses, legumes, and trees. Most of the acreage is in crops.

Representative profile of Williams loam, undulating, in an area of native grass, 50 feet south and 2,600 feet east of the northwest corner of sec. 14, T. 141 N., R. 76 W.:

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary.

B21t—4 to 10 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; very dark grayish-brown (10YR 3/2) thin clay film on faces of peds; strong, medium and fine, prismatic structure parting to moderate, medium, angular blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B22t—10 to 16 inches, brown to dark-brown (10YR 4/3) light clay loam, dark brown (10YR 3/3) when moist; continuous clay films on all faces of peds; strong, medium and fine, prismatic structure parting to moderate, medium, angular blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, wavy boundary.

B3ca—16 to 24 inches, dark grayish-brown to olive-brown (2.5Y 4/3) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium and coarse, prismatic structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; strong effervescence, many lime masses; gradual, wavy boundary.

C1ca—24 to 38 inches, olive-gray (5Y 5/2) light clay loam, olive gray (5Y 4/2) when moist; weak, medium and coarse, prismatic structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; strong effervescence, many lime masses; gradual, wavy boundary.

C2—38 to 60 inches, light olive-brown (2.5Y 5/4) light clay loam, dark grayish brown to olive brown (2.5Y 4/3) when moist; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; strong effervescence, many lime masses.

The depth to lime ranges from 15 to 24 inches. The A horizon ranges from 3 to 8 inches in thickness and is loam or silt loam. The B horizon ranges from 9 to 22 inches in thickness. It is loam or clay loam and, when moist, ranges from very dark grayish brown to dark yellowish brown. The C horizon is loam or clay loam. A prominent lime zone occurs in the lower B and upper C horizons.

Williams soils are associated with Max, Parnell, Temvik, Tonka, and Zahl soils. They have a thicker solum than Zahl soils. They are more clayey in the B2 horizon than Max soils. In comparison with Temvik soils, they do not have a loess mantle. They have better drainage than Parnell and Tonka soils.

Williams stony loam, rolling (3 to 9 percent slopes) (WoC).—This soil has many boulders and stones on the surface and throughout the profile. Slopes are short, irregular, and complex. Included in mapping were a few small areas of Zahl and Arnegard soils.

This Williams soil is stony but otherwise has characteristics similar to those described as representative for the series.

This soil is moderately susceptible to erosion. Surface runoff is medium. Fertility is medium. The numerous stones on the surface and the hazard of water erosion on the steeper slopes are the major limitations.

This soil is used for native range. Small areas within cultivated fields are frequently cleared of stones and cultivated along with the adjacent soils. Capability unit VIIs–Si; Silty range site; windbreak group 10.

Williams loam, nearly level (0 to 3 percent slopes) (WsA).—This soil is on the glacial till plains. It is characterized by gentle convex slopes, swales, and shallow depressions. Total relief ranges from 4 to 15 feet. Included in mapping were a few small areas of Arnegard, Tonka, and Parnell soils. The Tonka and Parnell soils are in the depressions and the Arnegard soil is in the swales. Much of the surface drainage is into the depressions.

Except for a thicker surface layer in many places, this soil has characteristics similar to those described as representative for the series.

Surface runoff is slow. Fertility is high. The lack of an adequate drainage system and the ponding of water in the depressions are the major concerns in management. Wetness often delays tillage.

This soil is well suited to small grain, corn, alfalfa, and flax. Most of the commonly grown trees do well. About 75 percent of the acreage is cultivated. Areas not cultivated are in native grass. Capability unit IIc-6; Silty range site; windbreak group 3.

Williams loam, undulating (3 to 6 percent slopes) (WsB).—This soil is on a glacial till plain. It is characterized by low ridges and knolls and intervening concave areas. Slopes are commonly less than 300 feet long. In areas where no drainage pattern has developed, total relief ranges from 10 to 25 feet. In areas where there is a dissected drainage pattern, slopes are as much as one-fourth mile long, and relief is as much as 75 feet. Included in mapping were areas of Max, Arnegard, Tonka, and Parnell soils and some small areas of Sen, Vebar, and Temvik soils. Areas of Tonka and Parnell soils that are less than 2 acres in size are indicated by depression spot symbols on the soil map.

This Williams soil has the profile described as representative for the series.

This soil is moderately susceptible to blowing and water erosion. Surface runoff is medium. Fertility is high. Controlling erosion is the major concern in management.

This soil is well suited to small grain, corn, alfalfa (fig. 15), and flax. Most of the commonly grown trees and shrubs do well. More than half the acreage is cultivated. Capability unit IIe-6; Silty range site; windbreak group 3.

Williams loam, rolling (6 to 9 percent slopes) (WsC).—This soil is on the glacial till plains. It has complex and irregular slopes and small shallow depressions in many of the lower concave areas. It occurs either as a single ridge or as a series of ridges and intervening concave areas. On the single ridges the soil is shallower than is typical. Slopes are generally less than 500 feet long, and total relief ranges from 10 to 50 feet. Most of the drainage is into the local depressions. Included in mapping were small areas of Max or Zahl soils on the ridges, Arnegard soils in the swales, and Parnell and Tonka soils in the depressions. Also included in some areas were small areas of Sen, Vebar, and Temvik soils. Areas of Tonka and Parnell soils that are less than 2 acres in size are indicated by depression spot symbols on the soil map.

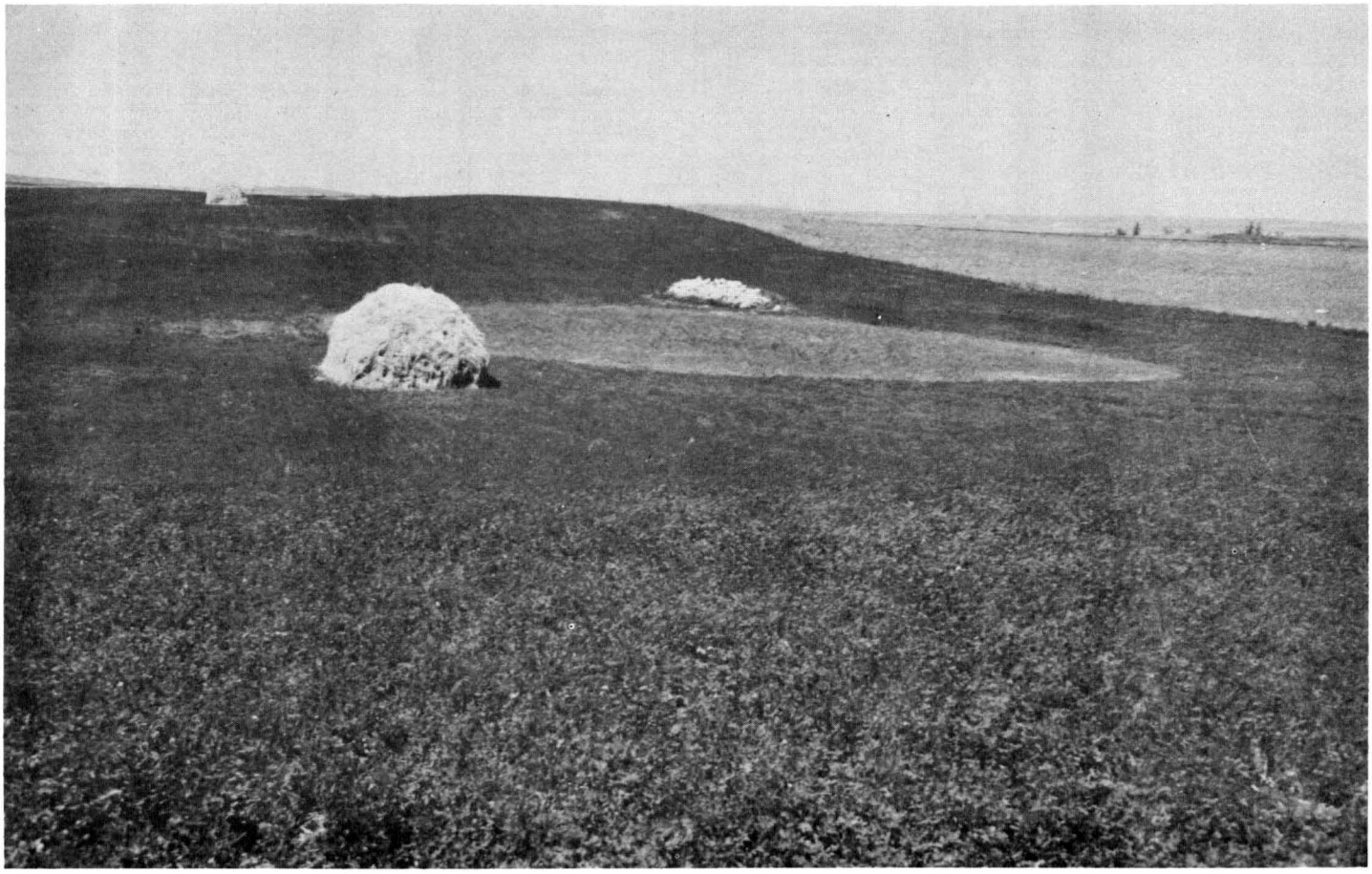

Figure 15.—**Alfalfa on Williams loam, undulating. The small basin between the haystack and the stone pile is Tonka soils.**

This Williams soil is slightly thinner on the upper slopes and thicker on the lower slopes but otherwise has characteristics similar to those described as representative for the series.

This soil is moderately susceptible to erosion. Surface runoff is medium. Fertility is high. Controlling water erosion is the major concern in management.

More than half the acreage is in native grass and is used for pasture. The rest is cultivated. The soil is suited to small grain and alfalfa. Some corn is grown, but water erosion is a hazard if this soil is row cropped. Capability unit IIIe–6; Silty range site; windbreak group 3.

Williams loam, hilly (9 to 12 percent slopes) (WsD).—This soil is on glacial till plains. It occurs as a single ridge or as a series of ridges, knolls, and intervening swales. On the single ridges, the soil tends to be shallower than is typical. Slopes are less than 400 feet long, and total relief ranges from 20 to 60 feet. Included in mapping were small areas of Max and Zahl soils on the ridges, Arnegard soils in the swales, and Tonka and Parnell soils in the depressions.

Except for a thinner solum, this Williams soil has characteristics similar to those described as representative for the series.

This soil is highly susceptible to water erosion. Surface runoff is rapid. Fertility is high. Controlling water erosion and conserving moisture are the major concerns in management.

About 20 percent of the acreage is cultivated. The rest is in native range. Capability unit IVe–6; Silty range site; windbreak group 3.

Williams-Zahl loams, hilly (9 to 12 percent slopes) (WzE).—This complex is on glacial till plains. It is about 40 percent Williams loam and 30 percent Zahl loam. Slopes are complex and typically less than 800 feet long. Local relief ranges from 15 to 200 feet. Included in mapping were areas of Arnegard, Max, Tonka, and Parnell soils and some small areas of Werner, Flasher, and Sen soils. The Zahl soil is on the ridgetops, and the Williams soil is on the middle and lower slopes.

This Williams soil has characteristics similar to those described for the series, but it has a thinner profile. The Zahl soil has the profile described as representative for the Zahl series (see Zahl Series).

These soils are susceptible to water erosion. Surface runoff is rapid. Fertility is high on the Williams soil and low on the Zahl soil. Controlling water erosion and conserving moisture are the major concerns in management.

Most of the acreage is in native grass. Capability unit VIe–Si; Williams soil in Silty range site and windbreak group 3; Zahl soil in Thin Silty range site and windbreak group 8.

Williams-Zahl loams, steep (WzF).—This complex is in the morainic hills. It is about 35 percent Williams loam, 25 percent Max loam, and 25 percent Zahl soils. Where an area consists of a single ridge, the percentage of Zahl soils is higher. The Williams soil is on the middle and lower slopes, and the Zahl soil is on the upper slopes and ridges. Slopes are irregular, and the gradient is more than 15 percent. Total relief ranges from 25 to 250 feet. Included in mapping were areas of Arnegard, Wabek, and Parnell soils.

The steep Williams soil in this complex is slightly shallower but otherwise has a profile similar to the one described as representative for the series.

The soils of this complex are highly susceptible to water erosion. Surface runoff is rapid. Fertility is high on the Williams soil and low on the Zahl soil. Controlling and conserving moisture are the major concerns in management.

These soils are used for native range. Capability unit VIe–Si; Williams soil in Silty range site and windbreak group 10; Zahl soil in Thin Silty range site and windbreak group 10.

Zahl Series

The Zahl series consists of deep, strongly sloping to steep, well-drained soils that formed in glacial till. These soils are on the steep sides and the tops of glacial moraines. Slope gradient ranges from 9 to more than 15 percent.

In a representative profile, the surface layer is very dark grayish-brown and grayish-brown loam about 7 inches thick. Beneath the surface layer to a depth of about 36 inches is strongly limy (fig. 16), firm clay loam that is olive gray in the upper part and light brownish gray in the lower part. The underlying material is pale-brown gravelly sandy loam and gravel to a depth of about 44 inches and light olive-brown clay loam below. It is moderately limy.

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

These soils are suited to native pasture and hay. Most of the acreage is in native grass.

Representative profile of Zahl loam in an area of native grass within an area of Williams-Zahl loams, hilly, 385 feet north and 1,750 feet west of southeast corner of sec. 7, T. 143 N., R. 75 W.:

A1—0 to 4½ inches, very dark grayish-brown (2.5Y 3/2) loam, black (2.5Y 2/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

C1ca—4½ to 7 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak to moderate, medium, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; moderate effervescence, many masses of segregated lime; gradual, wavy boundary.

C2ca—7 to 16 inches, olive-gray (5Y 5/2) clay loam, olive (5Y 4/3) when moist; weak, medium, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; clear, wavy boundary.

C3ca—16 to 36 inches, light brownish-gray (2.5Y 6/2) clay loam, olive brown (2.5Y 4/3) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; strong effervescence, many masses of segregated lime; gradual, wavy boundary.

IIC4—36 to 44 inches, pale-brown (10YR 6/3) gravelly sandy loam and gravel, dark grayish brown (10YR 4/2) when moist; few, fine to medium, distinct, light ol-

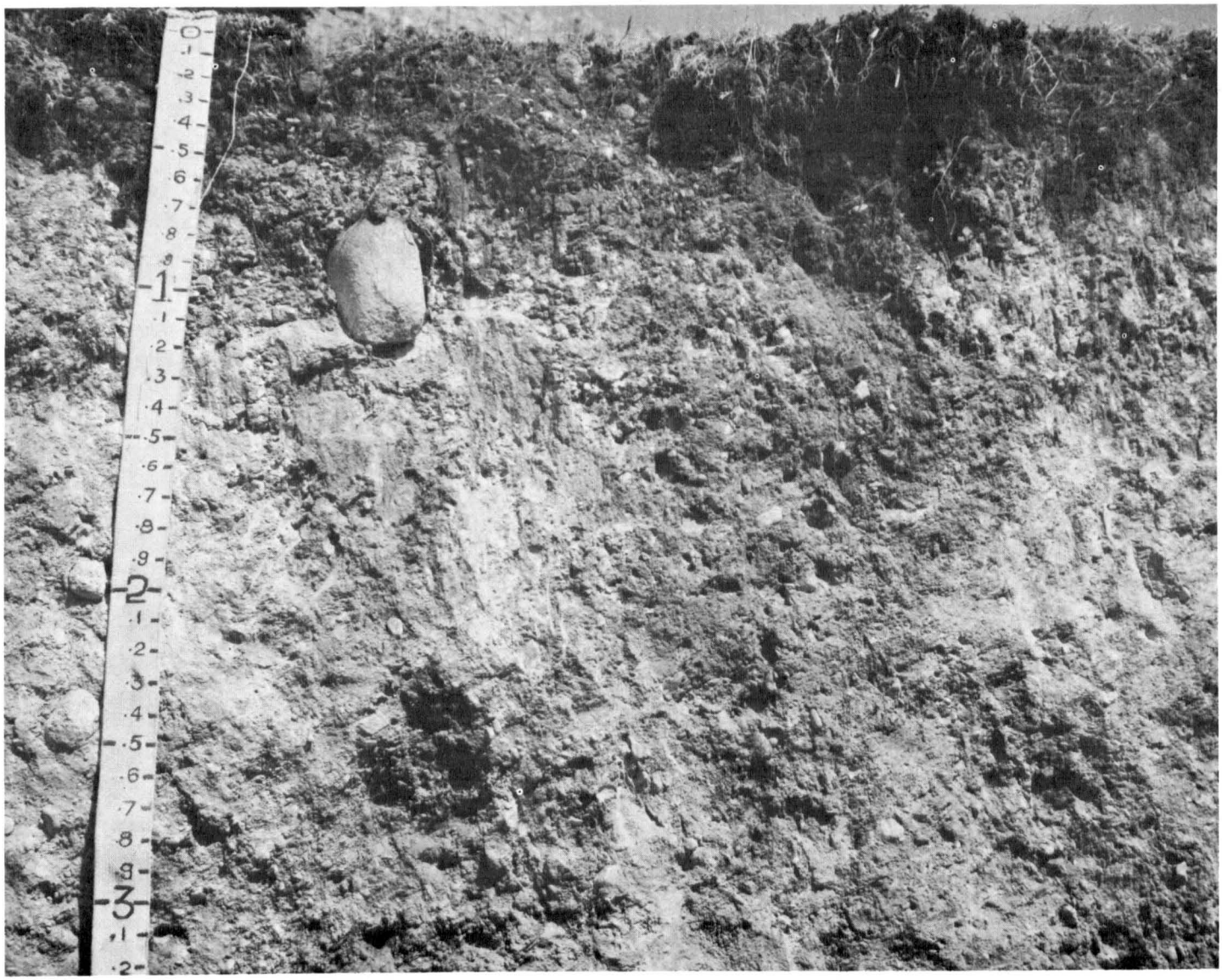

Figure 16.—**Profile of Zahl loam showing thin surface layer and lime near surface.**

ive-brown (2.5Y 5/6) mottles; single grain; loose when dry, loose when moist, nonsticky and nonplastic when wet; moderate effervescence; clear, discontinuous boundary.

IIIC5—44 to 60 inches, light olive-brown (2.5Y 5/3) clay loam, olive brown (2.5Y 4/3) when moist; few, coarse, distinct, gray (N 5/0) mottles; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; moderate effervescence.

The texture throughout the profile is mainly loam or clay loam. Lenses and pockets of gravel or sandy material are common. The A horizon is very dark brown, very dark grayish brown, or black when moist. The depth to lime ranges from 0 to 7 inches. A zone of prominent lime accumulation occurs in the upper part of the horizon.

Zahl soils are associated with Werner and Williams soils. They are shallower than Williams soils. In contrast with Werner soils, they formed in glacial till instead of soft shale and sandstone.

The Zahl soils in Burleigh County are mapped with Max and Williams soils.

Use of the Soils for Crops and Pasture [2]

About 45 percent of Burleigh County is cultivated. Spring wheat is the main crop. Other crops are oats, barley, flax, rye, corn, alfalfa, sweet clover, potatoes, beans, sugar beets, and grasses. Conserving moisture, controlling soil blowing, and maintaining fertility are the main considerations in management.

This section explains how the soils can be managed for crops and pasture. It defines the capability classification used by the Soil Conservation Service, in which the soils are grouped according to their suitability for crops, and describes use and management of the soils by capability

[2] By EDWARD R. WEIMER, agronomist, Soil Conservation Service.

units. It also shows predicted yields per acre of principal crops, under two levels of management.

General Management

Conserving moisture in dryfarmed areas generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Among the effective means are stubble mulching, contour farming, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, use of crop residue, and application of fertilizer. Fallow helps to control weeds and to build up the moisture content.

Among the measures that help to control erosion are cover crops, stripcrops, buffer strips, windbreaks, contour farming, diversions, waterways, minimum tillage, timely tillage, emergency tillage, and the use of crop residue. Generally, a combination of several measures is used.

Among the measures that help to maintain fertility are the application of chemical fertilizer, green manure, and barnyard manure; the use of summer fallow; and the inclusion in the cropping system of cover crops and grasses and legumes. Control of erosion also helps preserve fertility.

In some areas drainage and the removal of stones are needed to offset the effects of unfavorable soil characteristics.

Capability Grouping

Capability grouping (*4*) shows, in a general way, the suitability of soils for most kinds of field crops. 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, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (No class I soils in Burleigh County.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or 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 or 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 or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

Capability subclasses are soil groups within one class; they are designated by adding a small letter *e*, *w*, *s*, or *c* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or 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 management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-6 or IIIes-3. 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 paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass. An Arabic numeral is also used to indicate the susceptibility of the soil to wind erosion. The numbers range from 2, which is very high, 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. The letter M indicates a sandy soil that has a loam, clay loam or clay substratum. Following the subclass designation in capability units in classes V, VI, and VII is an abbreviation of the name of the range site into which the soils of the unit have been placed.

Management by Capability Units

In the following pages each of the capability units in Burleigh County 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 county. The names of the soil series represented are mentioned in the description of each unit, but this does not mean that all the soils of a given series are in the unit. The capability designation for each soil in the county can be found in the "Guide to Mapping Units."

Capability unit IIc-6

This unit consists of deep, well drained or moderately well drained, nearly level soils of the Arnegard, Grail, Grassna, Havrelon, Lohler, Roseglen, Savage, Straw, Tansem, Temvik, and Williams series. These soils have a surface layer of loam or silt loam that is more than 18 percent clay. The subsoil ranges from silt loam to clay. Available water capacity is high. Permeability is moderate, moderately slow, or slow. Fertility is medium or high. The organic-matter content is low in Havrelon and Lohler soils but is high or moderate in the rest.

These soils are easily tilled. They have a deep root zone and are readily permeable to roots, air, and moisture. Tilth is generally good. Water erosion and soil blowing are slight hazards. The lack of rainfall and available moisture is the main limitation.

About 75 percent of the acreage is cultivated. All locally grown crops are suited. Small grain and alfalfa are the main crops. Crop residue, manure, and grasses and legumes in the crop rotation supply organic matter. Summer fallowing, minimum tillage, and weed control conserve moisture. Rough tillage, standing stubble, and single-row tree belts to trap snow provide additional moisture for crops. Many areas of the Havrelon and Lohler soils are irrigated. The soils of this unit are also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIc-7

This unit consists of deep, well drained and moderately well drained, nearly level soils of the Grail, Havrelon, Lohler, Magnus, Makoti, and Savage series. These soils have a surface layer of silty clay loam that is less than 35 percent clay. The subsoil ranges from loam to clay. Available water capacity is high, and permeability is moderate, moderately slow, or slow. Fertility is medium or high. The organic-matter content is low in Havrelon and Lohler soils, but is high or moderate in the rest.

These soils are easily tilled. They have a deep root zone and are readily permeable to roots, moisture, and air. Tilth is generally good. If tilled when moist, these soils form stable granules and blocks that resist soil blowing. Water erosion and soil blowing are only slight hazards. Lack of rainfall and available moisture is the main limitation.

These soils are suited to all crops locally grown. Small grain and alfalfa are the chief crops. About 80 percent of the acreage is cultivated. Crop residue, manure, and grasses and legumes in the crop rotation supply organic matter. Summer fallowing, minimum tillage, and weed control conserve moisture. The use of stubble mulch tillage and single-row tree belts to trap snow provides additional moisture for crops. Many areas of the Havrelon and Lohler soils are irrigated. The soils of this unit are also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIe-5

This unit consists of nearly level to undulating soils of the Lehr, Linton, Mandan, and Tansem series. The texture of the surface layer and subsoil is silt loam or loam. Lehr soils have a shallow root zone and are somewhat excessively drained and droughty. Available water capacity is low, and permeability is moderate. The organic-matter content is low. The rest of the soils in this unit have a deep root zone, are well drained, and are readily permeable to roots, air, and moisture. Available water capacity is moderate to high, and permeability is moderate. Fertility is medium to high. The organic-matter content is moderate or high.

All of these soils are easily tilled and are generally in good tilth. They are moderately susceptible to soil blowing and slightly or moderately susceptible to water erosion.

These soils are suited to all locally grown crops. Small grain, corn, and alfalfa are the main crops. Most of the acreage is cultivated. Crop residue and grasses and legumes in the crop rotation supply organic matter and reduce the hazard of soil blowing. Stripcropping and stubble mulch tillage help control erosion. Single-row tree belts trap snow, provide additional moisture for crops, and help protect the soil against soil blowing. Summer fallowing stores moisture for the succeeding crop, but it increases the hazard of soil blowing and therefore should be used only for weed control. A small acreage is irrigated. The soils of this unit are also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIe-6

This unit consists of deep and moderately deep, well-drained, gently sloping or undulating soils of the Arnegard, Grail, Grassna, Morton, Roseglen, Savage, Sen, Tansem, Temvik, and Williams series. These soils have a surface layer of silt loam or loam that is more than 18 percent clay. The subsoil ranges from silt loam to silty clay. Available water capacity is moderate to high. Permeability is moderate, moderately slow, or slow. Fertility is medium to high, and the organic-matter content is high or moderate.

These soils have a deep or moderately deep root zone and are readily permeable to roots, air, and moisture. They are easily tilled and are generally in good tilth. They are slightly susceptible to soil blowing and moderately susceptible to water erosion.

These soils are suited to all locally grown crops. Small grain, corn, and alfalfa are the main crops. Most of the acreage is cultivated. Crop residue and grasses and legumes in the crop rotation supply organic matter, improve fertility, and help in controlling soil blowing. Single-row tree belts trap snow, provide additional moisture for crops, and reduce the hazard of soil blowing.

Summer fallowing stores moisture, but it increases the hazard of soil blowing and therefore should be used only for weed control. The soils of this unit are also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIe-7

This unit consists of deep and moderately deep, well drained and moderately well drained, gently sloping soils of the Grail, Makoti, Regent, Savage, and Williams series. These soils have a surface layer of silty clay loam that is less than 35 percent clay. The subsoil is silty clay loam, clay loam, or clay. Available water capacity is high, and permeability is moderate or moderately slow. Fertility is high or medium. The organic-matter content is high or moderate.

These soils are easily tilled and are generally in good tilth. They have a deep or moderately deep root zone and are readily permeable to roots, air, and moisture. If tilled when moist, they form stable granules and blocks that resist soil blowing. They are moderately susceptible to water erosion and are very slightly susceptible to soil blowing.

About 75 percent of the acreage is cultivated. All crops commonly grown are well suited. Small grain, corn, and alfalfa are the main crops. Crop residue and grasses and legumes in the crop rotation supply organic matter, improve fertility, and decrease the hazard of soil blowing. Field windbreaks and stubble mulch tillage help to conserve moisture and control erosion. The soils of this unit are suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIs-4

Lohler silty clay, the only soil in this unit, is deep, nearly level, and moderately well drained. It has a surface layer of silty clay. The subsoil is silty clay loam or silty clay. Available water capacity is high, and permeability is slow. Fertility is medium. The organic-matter content is low.

This soil is somewhat difficult to till. It is sticky when wet. It can be pulverized and formed into a good seedbed within only a narrow range of moisture content. It has a deep root zone that is readily permeable to roots. It warms up more slowly in spring than the friable loamy soils. The surface soil tends to slake; thus, the soil is susceptible to soil blowing, particularly if summer fallowed or fall plowed.

This soil is suited to irrigation and to the crops locally grown. About half the acreage is cultivated. A small acreage is irrigated. Crop residue and grasses and legumes in the crop rotation supply organic matter and reduce the hazard of soil blowing. Summer fallowing increases the hazard of soil blowing and therefore should be used only for weed control. This soil is also well suited to hay, pasture, and trees, or to other less intensive uses.

Capability unit IIw-4L

Colvin silty clay loam, the one soil in this unit, is deep, nearly level, and poorly drained. Its surface layer and subsoil are silty clay loam. This soil is calcareous throughout the profile. It has a seasonal high water table and is occasionally flooded. Available water capacity is high, and permeability is moderate. Fertility is medium. The organic-matter content is high.

Tilth and workability are favorable if moisture is not excessive. The root zone is deep. It is readily permeable to roots but is moderately slowly permeable to air and moisture. Because of the lime content, this soil is susceptible to blowing. In some areas, it is slightly to moderately saline. A seasonal high water table is the major concern in management.

Most of the acreage is in native grass. If drained, this soil is well suited to small grain and flax. In undrained areas it is suited to hay and pasture and late-planted barley and flax. Drainage ditches are beneficial in draining off floodwater and in lowering the water table. Summer fallowing tends to intensify the wetness and should be used only for control of weeds. This soil responds well to fertilizer, particularly phosphate.

Capability unit IIw-6

This unit consists of deep, nearly level soils of the Lallie, Tonka, and Parnell series. These soils are in shallow, closed depressions of the uplands, in swales, and in backwater areas of river bottoms. They are intermittently ponded by runoff from higher lying areas. The surface layer is silt loam or silty clay loam. The subsoil is silty clay loam, silty clay, or clay. Available water capacity is moderate or high, and permeability is slow. The organic-matter content is low in Lallie soil and high in the rest. Lallie and Parnell soils are very poorly drained. Tonka soils are poorly drained.

These soils are easily tilled when dry, but they remain wet for long periods. The root zone is deep. It is readily permeable to roots, but is moderately slowly or slowly permeable to air and moisture. Ponding is the main limitation. There is no erosion hazard.

The soils of this unit are usually farmed with the surrounding soils. Because they dry out slowly, planting is delayed several weeks. About half the acreage is cultivated. Surface drains can be used to remove excess water wherever there are satisfactory outlets. Even in drained areas, wetness is a limitation. Water is removed slowly because drainage ditches have only a slight gradient. Undrained areas are sometimes used for late-seeded small grain and flax. The soils of this unit are well suited to pasture and hay. Forage yields are high because moisture is abundant.

Capability unit IIIe-3

This unit consists of deep and moderately deep, well-drained, nearly level to gently sloping or undulating fine sandy loams of the Havrelon, Lihen, Parshall, Telfer, and Vebar series. Havrelon soils are on bottom land. The rest are on uplands. The slope gradient is less than 6 percent. Below the surface layer, Havrelon soils are mostly silt loam and very fine sandy loam, Telfer soils are fine sand, and the rest are fine sandy loam to loamy fine sand. All but Telfer soils have moderate or high available water capacity, moderate to rapid permeability, medium fertility, and moderate or low organic-matter content. Telfer soils have low available water capacity, moderate to rapid permeability, low fertility, and moderate or low organic-matter content.

These soils have a deep root zone and are readily permeable to roots, air, and moisture. They are easily tilled and are generally in good tilth. They are highly susceptible to soil blowing in cultivated areas. They are moderately susceptible to water erosion in gently sloping or undulating areas. They warm up rapidly in spring and are among the first to be ready for planting.

More than half the acreage is cultivated. All the crops commonly grown are well suited. Small grain, corn, and alfalfa are the chief crops. Flax produces only a small amount of residue and is easily damaged by windblown sand. A grass-legume mixture in the crop rotation, manure, and crop residue supply organic matter. A combination of practices is needed to control erosion. Crop residue and stubble mulching, along with stripcropping or patterned windbreak planting, are needed to reduce the hazard of soil blowing. Cover crops, buffer strips, and grass in the cropping system are also beneficial. Occasionally, emergency tillage is required. Tillage should be kept to the minimum needed for weed control and seedbed preparation. Summer fallow should be used only to control weeds, because the amount of moisture that can be stored is limited and soil blowing is a hazard. The soils of this unit are also well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IIIe-3M

This unit consists of deep, well-drained, nearly level or undulating soils of the Flaxton, Livona, and Parshall series. The surface layer is fine sandy loam about 20 inches thick. The subsoil and underlying material are clay loam or clay. Available water capacity is moderate. Permeability is moderately rapid in the upper part and moderately slow in the clay loam and clay. Fertility is medium, and the organic-matter content is moderate or high.

These soils are easily tilled. They have a deep root zone and are readily permeable to roots, air, and moisture. They are highly susceptible to soil blowing in cultivated areas. They are moderately susceptible to water erosion. These soils warm up rapidly in spring and are among the first to be ready for planting.

About 65 percent of the acreage is cultivated. All crops commonly grown are well suited. Small grain, corn, and alfalfa are the chief crops. Flax produces only a small amount of residue and is easily damaged by windblown sand. A grass-legume mixture in the crop rotation, manure, and crop residue help to replenish the supply of organic matter. A combination of practices is needed to control erosion. Crop residue and stubble mulching, along with stripcropping or patterned windbreak planting, are needed to reduce the hazard of soil blowing. Including cover crops, buffer strips, and grass in the cropping system is also beneficial. Occasionally, emergency tillage is required. Tillage should be kept to the minimum needed for weed control and seedbed preparation. Summer fallow should be used only to control weeds, because it increases the hazard of erosion. The soils of this unit are also well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IIIes-3

This unit consists of moderately deep, somewhat excessively drained, nearly level or gently sloping soils of the Manning series. The surface layer and subsoil of these soils are fine sandy loam. Coarse sand and gravel are at a depth of 20 to 40 inches. Available water capacity is low. Permeability is moderately rapid in the upper part and very rapid in the underlying sand and gravel. Fertility is medium, and the organic-matter content is moderate.

These soils are easily tilled. The effective root zone is moderately deep and is readily permeable to roots, air, and moisture. If cultivated, these soils are highly susceptible to soil blowing. In gently sloping areas, they are moderately susceptible to water erosion. They warm up rapidly in spring and are among the first to be ready for planting. Controlling erosion, conserving moisture, and maintaining fertility and the supply of organic matter are the major concerns in management.

About 75 percent of the acreage is cultivated. All crops locally grown are well suited. Small grain is the chief crop. Flax produces only a small amount of residue and is easily damaged by windblown sand. Because these soils are somewhat droughty, yields are generally lower than on deeper soils. A grass-legume mixture in the crop rotation, the application of manure, and the management of crop residue help to replenish the supply of organic matter. A combination of practices is needed to control erosion. Narrow stripcrops and the use of crop residue or stubble mulch tillage are essential. Tree windbreaks are beneficial, but species suitable for planting are limited. Also, the height of trees at maturity is limited. Summer fallow should be used only to control weeds because it increases the danger of erosion. The soils of this unit are also well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IIIe-5

Only Mandan-Linton silt loams, rolling, is in this unit. These are deep, well-drained soils on uplands. The surface layer and subsoil are silt loam. Available water capacity is high, and permeability is moderate. Fertility is medium to high. The organic-matter content is moderate.

These soils are easily tilled and are generally in good tilth. They have a deep root zone and are readily permeable to roots, air, and moisture. They are moderately susceptible to soil blowing. They are highly susceptible to water erosion, especially if row cropped.

About half the acreage is cultivated. Most crops locally grown are suited. Small grain and alfalfa are the main crops. Corn is seldom grown because erosion is a risk wherever rows are cultivated up and down the slope. Summer fallow and stubble mulch tillage store moisture for the succeeding crop. Good use of crop residue is necessary for control of erosion. The amount of crop residue, however, is generally not adequate for the acreage fallowed. Stripcrops or windbreaks and cover crops or buffer strips are essential. All tillage and stripcropping should be on the contour. Grass waterways are needed wherever water concentrates. The soils of this unit are also well suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIIes-5

Lehr loam, undulating, the only soil in this unit, is on glacial outwash plains and stream terraces. It is shallow and somewhat excessively drained. The surface layer and

subsoil are loam. Sand and gravel are at a depth of 13 to 20 inches. Available water capacity is low. Permeability is moderately rapid or very rapid. Fertility and the organic-matter content are low.

This soil is easily worked and has good tilth. It has a shallow root zone that is readily permeable to roots, air, and moisture. It is moderately susceptible to soil blowing and water erosion. Droughtiness is the major concern in management.

About half the acreage is cultivated. All crops commonly grown in the area are suited. Small grain, corn, and alfalfa are the main crops. Grasses and legumes in the crop rotation supply organic matter. Good use of crop residue is necessary for control of erosion. The amount of crop residue, however, is generally not adequate for the acreage fallowed. Stripcrops or windbreaks and cover crops are essential. Summer fallow should be used only for weed control, because the amount of moisture that can be stored is limited and soil blowing is a hazard. This soil is also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIIe-6

This unit consists of deep and moderately deep, well-drained, sloping and rolling soils of the Morton, Savage, Sen, Tansem, Temvik, and Williams series. These soils have a surface layer of silt loam or loam that is more than 18 percent clay. The subsoil ranges from silt loam to clay. The slope gradient is 6 to 9 percent. Available water capacity is moderate to high. Permeability is moderate or moderately slow. Fertility is medium to high, and the organic-matter content is moderate or high.

These soils have a deep or moderately deep root zone and are readily permeable to roots, air, and moisture. They are easily tilled. Tilth is generally good. Soil blowing is only a slight hazard, but the hazard of water erosion is severe in cultivated areas. Soil is washed from ridges and upper slopes during periods of intense rainfall or rapid snowmelt.

About half the acreage is cultivated. Most locally grown crops are suited. Small grain, flax, and alfalfa are the chief crops. Corn is seldom grown because the risk of erosion is high wherever rows are cultivated up and down the slope. Stubble mulch tillage, stripcropping, and crop residue management are the main practices used to control erosion. Grass waterways are needed wherever water concentrates. Contour stripcrops help in controlling erosion, but strips are generally short because slopes are irregular. Summer fallowing stores moisture, but it increases the erosion hazard. Thus, it should be used only for weed control. The soils in this unit are also well suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIIe-P6

This unit consists of well drained and moderately well drained, gently sloping and undulating soils of the Belfield, Daglum, Niobell, Noonan, and Rhoades series. These soils are on uplands. The surface layer is silty clay loam or loam. The subsoil is clay loam, silty clay loam, or silty clay.

Belfield, Daglum, and Niobell soils have a deep claypan, high available water capacity, medium fertility, and moderate organic-matter content. Permeability is moderately slow for Belfield and Niobell soils and slow for the Daglum soil. Noonan and Rhoades soils are shallow over a claypan and have moderate organic-matter content. Noonan soils have moderate available water capacity, slow permeability, and medium fertility. Rhoades soils have low available water capacity, very slow permeability, and low fertility.

The effective root zone ranges from deep to shallow. Soils that have a deep claypan are easily tilled, and the others are difficult to till. The shallow claypan soils are strongly alkaline and contain a large amount of soluble salts in the lower part of the subsoil. The soils of this unit are moderately susceptible to water erosion and slightly susceptible to soil blowing.

About half the acreage is cultivated. Small grain, alfalfa, and tame grasses are best suited. Alfalfa, sweet clover, and tame grasses in the crop rotation supply organic matter and improve soil structure, permeability, and tilth. Stubble mulch tillage, crop residue management, and stripcropping conserve moisture and help control erosion. Deep tillage and summer fallow are beneficial. They increase the intake of water and the leaching out of salts. The soils of this unit are well suited to native grasses and poorly suited to trees.

Capability unit IIIe-7

Only Regent silty clay loam, sloping, is in this unit. This is a moderately deep, well-drained soil on the uplands. The slope gradient is 6 to 9 percent. The surface layer is silty clay loam that is less than 35 percent clay. The subsoil is silty clay. Available water capacity is high, and permeability is slow. Fertility is medium. The organic-matter content is moderate.

This soil is easily tilled and is generally in good tilth. If tilled when moist, it forms stable granules and blocks that resist soil blowing. It has a moderately deep root zone that is readily permeable to roots, air, and moisture. It is slightly susceptible to blowing and highly susceptible to water erosion.

This soil is well suited to most locally grown crops. Small grain and alfalfa are the main crops. Corn is seldom grown because the risk of erosion is high wherever rows are cultivated up and down the slope. Stubble mulch tillage, stripcropping, and crop residue management are the main practices used to control erosion. Contour stripcropping is also useful. Grass waterways are needed wherever water concentrates. Summer fallowing stores moisture, but it increases the erosion hazard. Thus, it should be used only for weed control. This soil is also well suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIIs-5

This unit consists of shallow to deep, somewhat excessively drained, nearly level soils of the Banks and Lehr series. These soils have a loam surface layer. Loamy sand or sand and gravel is at a depth of about 13 to 30 inches. Available water capacity is low. Permeability is moderately rapid to very rapid. Fertility is low, and the organic matter content is low.

These soils have a shallow to deep root zone. They are easily tilled and readily permeable to roots, air, and moisture. They are moderately susceptible to soil blow-

ing and slightly susceptible to water erosion. Droughtiness is the major concern in management.

About 75 percent of the acreage is cultivated. All crops commonly grown are suited. Small grain, flax, corn, and alfalfa are the main crops. Grasses and legumes in the crop rotation supply organic matter. Good use of crop residue is necessary for control of erosion. The amount of crop residue, however, is generally not adequate for the acreage fallowed. Stripcrops or windbreaks and cover crops are essential. Summer fallow should be used only for weed control, because the amount of moisture that can be stored is limited and soil blowing is a hazard. The soils of this unit are also suited to pasture, hay, and trees, and to other less intensive uses.

Capability unit IIIs-P6

This unit consists of deep, nearly level soils of the Belfield, Daglum, Grail, Niobell, Noonan, and Rhoades series. All of these soils have a claypan.

Belfield, Daglum, and Niobell soils are deep over a claypan and have high available water capacity and moderately slow permeability. They have a silty clay loam or loam surface layer and a clay loam, silty clay, or silty clay loam subsoil. Noonan and Rhoades soils are shallow over a claypan and have moderate available water capacity and slow permeability. For all of these soils, fertility is medium or low and the organic-matter content is moderate. They are well drained or moderately well drained.

The root zone ranges from deep to shallow. Soils that are deep over a claypan are easily tilled, and the others are difficult to till. The soils that are shallow over a claypan are strongly alkaline and contain a large amount of soluble salts in the lower part of the subsoil. The soils of this unit are only slightly susceptible to erosion.

About half the acreage is cultivated. Small grain, alfalfa, and tame grasses are best suited. Alfalfa, sweetclover, and tame grasses in the crop rotation supply organic matter and improve soil structure, permeability, and tilth. Stubble mulch tillage, stripcropping, and crop residue management help conserve moisture and control erosion. Deep tillage and summer fallow are beneficial. They increase the intake of water and the leaching out of salts. The soils of this unit are well suited to native grasses and are poorly suited to trees.

Capability unit IIIwe-3

This unit consists of deep, nearly level, poorly drained and very poorly drained soils of the Arveson, Stirum, and Tiffany series. These soils are in depressions in sandy uplands. The water table is within a depth of 3 feet during much of the growing season. The surface layer is loam. The subsoil is fine sandy loam. Available water capacity is low or moderate. Fertility is low or medium, and the organic-matter content is moderate or high. Permeability is moderately slow in the Stirum soils and moderately rapid in the Arveson and Tiffany soils.

These soils are easily tilled when dry and are readily permeable to roots, air, and moisture. None of the Tiffany soils are cultivated, because in most places they are covered with willow and a perimeter of cottonwood trees. They can be drained if sufficient outlets are available. They are highly susceptible to soil blowing. Stirum soils are strongly alkaline and somewhat saline.

More than 75 percent of the acreage is in native grasses or brush. If drained, these soils are suited to the crops commonly grown, and to trees and tame grasses. Small grain, corn, and flax are the main crops. Most undrained areas are in grasses and are used for pasture, and hay, or as wildlife habitat. Some are covered with trees and shrubs. Stubble mulch tillage, cover crops, stripcropping, and field windbreaks reduce the hazard of soil blowing. Grasses and legumes in the crop rotation improve tilth and supply organic matter.

Capability unit IIIw-4

This unit consists of deep, nearly level, very poorly drained soils of the Dimmick and Parnell series. These soils are in depressions and are usually ponded for part of the growing season. They have a surface layer of silty clay loam or clay. The subsoil is silty clay. Available water capacity is high or moderate, and permeability is slow. Fertility is medium or high. The organic-matter content is moderate or high.

These soils are somewhat difficult to till. They are sticky when wet. They can be pulverized and formed into a good seedbed within only a narrow range of moisture content. The root zone is deep and is readily permeable to roots and slowly permeable to air and moisture. The surface soil tends to slake, and thus is susceptible to soil blowing, particularly if fall plowed. Ponding is the major concern of management. In places where outlets are available, these soils are usually drained.

Less than 10 percent of the acreage is cultivated. If drained, these soils are suited to the crops commonly grown and to trees and tame grasses. Small grain and alfalfa are the main crops. Undrained areas are mostly in grasses and are used for pasture and hay or as wildlife habitat. In drier years, some of the undrained areas are used for late-seeded barley or flax. Grass and legumes in the crop rotation improve tilth and replenish the supply of organic matter.

Capability unit IVe-2

This unit consists of deep, well-drained to excessively drained, nearly level to undulating soils of the Flaxton, Lihen, Livona, and Telfer series. These soils have a surface layer of loamy fine sand. The underlying material ranges from fine sand to clay. Permeability in the subsoil and underlying material is moderately slow for the Flaxton and Livona soils. It is moderately rapid or rapid throughout the profile for the Lihen and Telfer soils. For all soils available water capacity is low to moderate, fertility is medium or low, and the organic-matter content is moderate or high.

These soils have a deep root zone that is readily penetrated by roots, air, and moisture. They are subject to severe soil blowing in cultivated areas. They are slightly susceptible to water erosion.

About 35 percent of the acreage is cultivated. All locally grown crops are suited. Small grain and alfalfa are the main crops. Flax produces only a small amount of residue and is easily damaged by windblown sand. A grass-legume mixture in the crop rotation, the application of manure, and the management of crop residue help to replenish the supply of organic matter. A combi-

nation of practices is required to reduce the hazard of soil blowing. Narrow stripcrops or tree windbreaks along with crop residue or stubble mulching are needed. Fall plowing or summer fallow increases the hazard of soil blowing. Tillage should be kept to the minimum needed for weed control and seedbed preparation. Occasionally, emergency tillage is required. The soils in this unit are well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IVe-3

This unit consists of deep and moderately deep, well-drained to excessively drained, nearly level and rolling or sloping soils of the Banks, Flaxton, Lihen, Livona, Parshall, Telfer, and Vebar series. These soils have a surface layer of fine sandy loam. The subsoil is fine sandy loam or loamy fine sand. The Livona and Flaxton soils are clay loam at a depth of less than 40 inches. The nearly level Banks soil is fine sand or loamy sand at a depth of 6 to 20 inches. Available water capacity ranges from low to moderate. Permeability is moderately slow in the subsoil and underlying material for Flaxton and Livona soils and moderately rapid to rapid throughout the profile for the rest.

These soils have a deep root zone and are readily permeable to roots, air, and moisture. They are easily tilled and are generally in good tilth. They are highly susceptible to soil blowing in cultivated areas. All except Banks soils are highly susceptible to water erosion. Banks soils are only slightly susceptible.

About 35 percent of the acreage is cultivated. The crops commonly grown are well suited. Small grain and alfalfa are the chief crops. Flax produces only a small amount of residue and is easily damaged by windblown sand. A grass-legume mixture in the crop rotation, the application of manure, and the management of crop residue help to replenish the supply of organic matter. A combination of practices is needed to control erosion. Crop residue and stubble mulching along with stripcropping or patterned windbreak planting are needed to reduce the hazard of soil blowing. Grassed waterways are needed wherever water concentrates. Tillage should be kept to the minimum needed for weed control and seedbed preparation. Occasionally, emergency tillage is required. Summer fallow should be used only for weed control, because it increases the danger of erosion and because the amount of moisture that can be stored is limited. The soils of this unit are also well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IVe-4L

This unit consists of deep, moderately deep, and shallow soils of the Max, Sen, Werner, and Zahl series. These are well-drained, rolling or sloping soils on uplands. The surface layer is thin and of loam or silt loam texture. The subsoil is silt loam, loam, or clay loam. Available water capacity ranges from low to high. Permeability is moderate and moderately slow. Fertility is low or medium, and the organic-matter content is moderate.

These soils have a shallow to deep root zone that is readily permeable to roots, air, and moisture. The surface layer is calcareous. The lime content makes the soil moderately susceptible to blowing. These soils are highly susceptible to water erosion.

These soils are easily tilled. They are suited to cultivated crops if measures are taken to control erosion. About 35 percent of the acreage is cultivated. Small grain is the crop most commonly grown. Row crops are poorly suited because water erosion is a hazard wherever rows are cultivated up and down the slope. Stubble mulch tillage, stripcropping, contour stripcropping, and crop residue management are used for erosion control. Grass waterways are needed wherever water concentrates. Summer fallowing stores moisture, but it increases the erosion hazard. Thus, it should be used only for weed control. The soils of this unit are well suited to pasture and hay and to wildlife habitat. They are not well suited to trees.

Capability unit IVe-5

Only Linton-Mandan silt loams, hilly, is in this unit. These are deep, well-drained soils on the uplands. They have a surface layer and subsoil of silt loam. Available water capacity is high, and permeability is moderate. Fertility is medium to high. The organic-matter content is moderate or high.

These soils are easily tilled and are generally in good tilth. They have a deep root zone and are readily permeable to roots, air, and moisture. They are moderately susceptible to soil blowing and highly susceptible to water erosion.

About 25 percent of the acreage is cultivated. Small grain, alfalfa, and tame grasses are suitable crops. Row crops are not suitable. Stubble mulch tillage, crop residue management, grasses and legumes in the crop rotation, and winter cover crops along with stripcrops or tree windbreaks help control erosion and conserve moisture. Grassed waterways are needed wherever water concentrates. Summer fallow stores moisture, but it increases the erosion hazard and, therefore, should be used only for weed control. The soils of this unit are well suited to pasture and hay and to wildlife habitat. They are moderately well suited to trees.

Capability unit IVe-6

This unit consists of deep and moderately deep, well-drained, hilly soils of the Sen and Williams series. These soils have a surface layer of loam or silt loam that is more than 18 percent clay. The subsoil is loam or clay loam. Available water capacity is moderate to high, and permeability is moderate and moderately slow. Fertility is medium to high. The organic-matter content is moderate.

These soils have a moderately deep or deep root zone and are readily penetrated by roots, air, and moisture. They are easily tilled and are generally in good tilth. They are slightly susceptible to soil blowing and highly susceptible to water erosion. Soil is washed from ridges and upper slopes during periods of intense rainfall or rapid snowmelt.

About 25 percent of the acreage is cultivated. Small grain, alfalfa, and tame grasses are suitable crops. Row crops are not suitable because the hazard of water erosion is severe. Stubble mulch tillage, stripcropping, and crop residue management are the main practices used to

control erosion. Grass waterways are needed wherever water concentrates. Contour stripcrops help in controlling erosion, but strips are generally short because slopes are irregular. Summer fallow stores moisture, but it increases the erosion hazard. Thus, it should be used only for weed control. The soils of this unit are well suited to pasture and hay and to wildlife habitat. They are moderately well suited to trees.

Capability unit IVes-3

Manning fine sandy loam, sloping, the only soil in this unit, is on glacial outwash plains and stream terraces. It is moderately deep and somewhat excessively drained. The surface layer and subsoil are fine sandy loam. Coarse sand and gravel are at a depth of 20 to 40 inches. Available water capacity is low. Permeability is moderately rapid in the upper part and very rapid in the underlying sand and gravel. Fertility is medium, and the organic-matter content is moderate.

This soil is easily tilled. It has a moderately deep effective root zone that is readily permeable to roots, air, and moisture. It is highly susceptible to blowing in cultivated areas and to water erosion in all areas. Controlling erosion, conserving moisture, and maintaining fertility and the supply of organic matter are major concerns in management.

Less than half the acreage is cultivated. Small grain and alfalfa are well suited. Row crops are not suited, because the hazard of water erosion is severe. A grass-legume mixture in the crop rotation, the application of manure, and the management of crop residue help to replenish the supply of organic matter A combination of practices is required for erosion control. Narrow stripcropping and crop residue or stubble mulch are essential. Tree windbreaks are beneficial, but species suitable for planting are limited. Also, the height of trees at maturity is limited. Summer fallow should be used only to control weeds, because it increases the danger of erosion. The soil of this unit is also well suited to hay, pasture, and trees, and to other less intensive uses.

Capability unit IVes-5

Lehr loam, sloping, the only soil in this unit, is on glacial outwash plains and stream terraces. It is shallow and somewhat excessively drained. The surface layer and subsoil are loam. Sand and gravel are at depth of 13 to 20 inches. Available water capacity is low, and permeability is moderately rapid and very rapid. Fertility is medium. The organic-matter content is moderate.

This soil is easily worked and is in good tilth. It has a shallow root zone that is readily penetrated by roots, air, and moisture. It is moderately susceptible to blowing and highly susceptible to water erosion. Droughtiness and erosion are major considerations in management.

This soil is well suited to small grain and alfalfa. It is not suited to row crops, because the hazard of water erosion is severe. A grass-legume mixture in the crop rotation replenishes the organic-matter content. Good use of crop residue is necessary for control of erosion. The amount of crop residue is generally not adequate for the acreage fallowed. Stripcrops or windbreaks and cover crops are essential. Summer fallow should be used only for weed control, because the amount of moisture that can be stored is limited and soil blowing is a hazard. This soil is also suited to pasture and hay and to wildlife habitat. It is also fairly well suited to trees.

Capability unit Vw-WL

Regan silty clay loam, the only soil in this unit, is in basins and seep areas. It is deep, nearly level, and very poorly drained. It has water on or near the surface during much of the growing season. The surface layer is silty clay loam. The subsoil is silty clay loam and silty clay. Available water capacity and permeability are moderate. Fertility is low. The organic-matter content is high. Roots penetrate easily, but water restricts the movement of air. In places, the depth to which roots penetrate is limited by salinity and high lime content. This soil cannot feasibly be drained.

This soil is too wet for cultivation, but it is well suited to hay and pasture and to wildlife habitat. It supports a dense stand of native vegetation. There is no erosion hazard. To prevent trampling and puddling, grazing should be restricted when the soil is wet. Forage yields can be improved by seeding reed canarygrass in areas where vegetation is sparse.

Capability unit VIe-Sa

This unit consists of deep, well-drained to excessively drained, nearly level or rolling and hilly soils of the Banks, Flaxton, Lihen, Livona, and Telfer series. These soils have a surface layer of loamy fine sand or loamy sand. The subsoil ranges from fine sand to clay loam. Available water capacity is low in Banks and Telfer soils and moderate in the rest. Permeability is moderately rapid in the upper part and moderately slow in the underlying material for the Livona and Flaxton soils, and rapid throughout the profile for the rest. Fertility is low or medium in all the soils.

These soils are not suited to cultivation because of the slopes, droughtiness, and soil blowing. They are well suited to native range or hayland.

Careful management of grazing is needed, because rapid deterioration results from even a short period of overuse. Grass should be established in blownout areas. Manure or a straw mulch protects the soil until newly seeded grasses are established. The soils of this unit are poorly suited to trees. Only a few areas are favorable for wildlife.

Capability unit VIe-Si

This unit consists of deep, hilly and steep soils of the Linton, Mandan, Williams, and Zahl series and the Straw, Arnegard, and Colvin soils, on narrow bottom land, that are subject to periodic flooding. Available water capacity is high, but much of the rainfall runs off the steeper areas. Fertility is medium or high. All but the Colvin soils are well drained and have a surface layer of silt loam or loam and a subsoil of silt loam, loam, or clay loam. Colvin soils are poorly drained. They have a surface layer and a subsoil of silty clay loam.

These soils are not suitable for cultivation. They are steep, are intersected by uncrossable stream channels, and are highly susceptible to water erosion. They are well suited to native range and hay. Cultivated areas should be seeded to grass. A good protective cover helps to control runoff and erosion and maintain productivity. Proper range use is essential. Deferred grazing is benefi-

cial. Brush control is needed in a few places. The soils of this unit are poorly suited to trees. Some areas are favorable for wildlife.

Capability unit VIe-Sy

This unit consists of deep, well-drained to excessively drained, hilly and steep soils of the Flasher, Lihen, Livona, Parshall, and Williams series. These soils have a surface layer of fine sandy loam and a subsoil of loamy fine sand to clay loam. Fertility is low to medium. Permeability is moderately rapid and rapid in the upper layers. Runoff is excessive. Available water capacity is very low in the Flasher soils and moderate to high in the rest.

These soils are not suited to cultivation; they are droughty, steep, and highly susceptible to soil blowing. They are well suited to native range or hay. Careful grazing management is needed because rapid deterioration results from overgrazing. A good protective cover helps to control runoff and erosion and to maintain productivity. The soils of this unit are poorly suited to trees. Some are favorable for wildlife.

Capability unit VIe-TSi

This unit consists of hilly and steep soils of the Morton, Sen, and Werner series. The slope gradient is 9 to 25 percent. These soils are underlain by soft shale. They have a thin surface layer of loam or silt loam and a subsoil of loam or silt loam. They are readily permeable to roots, air, and moisture. Runoff is rapid. Available water capacity is low to high. Fertility is medium to low.

These soils are not suited to cultivation; they are steep and highly susceptible to water erosion. They are well suited to native range. A good protective cover helps to control runoff and maintain productivity. Proper range use is needed. Deferred grazing is beneficial. Fences for distribution of livestock are also helpful. Range recovers slowly from overuse. Cultivated areas should be reseeded to native grasses or adapted tame grasses. The soils of this unit are poorly suited to trees. Some areas are favorable for wildlife.

Capability unit VIe-TSy

This unit consists of shallow and moderately deep, sloping, hilly and steep soils of the Flasher and Vebar series. These soils are underlain by sandstone. They have a thin surface layer of fine sandy loam and a subsoil of fine sandy loam or loamy fine sand. They are readily permeable to roots, air, and moisture. Fertility is low to medium. Runoff is rapid. Available water capacity is very low in the Flasher soils and moderate in the Vebar soils. Rock outcrop occurs in places.

These soils are not suited to cultivation. They are steep and highly susceptible to erosion. They are well suited to native range. A good protective cover helps to control runoff and maintain productivity. Proper range use is needed. Deferred grazing is beneficial. Fences for distribution of livestock are also helpful. Range recovers slowly from overuse. The soils of this unit are poorly suited to trees. Some areas are favorable for wildlife.

Capability unit VIs-Cp

This unit consists of deep, nearly level to hilly soils of the Daglum, Miranda, Noonan, and Rhoades series. These soils have a dense, strongly alkaline claypan that limits penetration of roots, air, and moisture. In many areas, the pan is within a depth of 4 inches. Microrelief exposes the pan in some of the lower spots. In most areas the surface layer is loam or silt loam. Available water capacity is low or moderate. Fertility is low to medium.

These soils are not suited to cultivation, because tilth is extremely poor. They are suited to native grasses for pasture or hay. A few small areas are cultivated. Such areas should be reseeded to native grasses or adapted tame grasses. A good protective cover reduces the hazard of erosion and maintains productivity. Proper range use is necessary. Range recovers slowly from overuse. The soils are not suited to trees.

Capability unit VIs-SS

This unit consists of deep, slightly saline to strongly saline soils of the Arveson, Harriet, Regan, and Stirum series. These are nearly level, poorly drained and very poorly drained soils on bottom land and in shallow depressions. They have a thin to moderately thick surface layer of loam or silty clay loam. They have a seasonal high water table that rises as high as the lower part of the subsoil. In some places, they are ponded for several weeks of the growing season.

Because these soils are saline and poorly drained, they are not suited to cultivation. They are suitable for production of native grasses for range or hay. The few places that are too wet for pasture or hay make suitable wildlife habitat. These soils are not suited to trees.

Capability unit VIs-SwG

This unit consists of very shallow, excessively drained, undulating to hilly soils of the Wabek series. These soils have a surface layer of loam or gravelly sandy loam. The depth to loose sand and gravel ranges from 4 to 13 inches. Available water capacity is very low. Fertility is low.

These soils are not suitable for cultivation, because they are droughty and have a shallow root zone. They are best suited to native pasture and hay. They are poorly suited to trees. In some places strips of these soils have been cultivated with surrounding soils. These areas should be reseeded to adapted tame or native grasses. Proper range use is necessary. Range recovers slowly from overuse.

Capability unit VIw-Ov

Only Heil soils are in this unit. These are poorly drained, nearly level soils in large basins and sloughs. They have a silt loam or silty clay loam surface layer that is less than 4 inches thick over a dense claypan. They are alkaline and, in places, moderately saline. Ponding is common from a few days to several weeks in spring. The claypan limits penetration of roots, air, and moisture.

The thin surface layer, the dense claypan, and poor drainage make these soils unsuitable for cultivated crops and for trees. The soils are best suited to native pasture and hay. Restricted grazing when the soil is wet prevents trampling and puddling. The wettest areas are useful for wildlife habitat.

Capability unit VIIe-CS

This unit consists of deep, hummocky or hilly loamy sands and sands of the Telfer and Seroco series and severely eroded Blown-out land. All are loose and extremely erodible by wind. Available water capacity is low or very low. Fertility is low, and the organic-matter content is low or moderate.

These soils are not suited to cultivated crops or trees. They are suited to native grasses for forage and hay. Extreme care is necessary in grazing management. The soils are highly susceptible to blowing if overgrazed. Establishing vegetation is difficult on blownout spots.

Capability unit VIIe-Si

Only Werner-Shale outcrop complex is in this unit. It consists of shallow, steep soils in association with shale or sandstone outcrops. It is on uplands. Barren ledges, slips, outcrops, and eroded spots make up from 10 to 30 percent of the acreage. In most areas the soils are medium textured. In a few, they are moderately sandy. They are readily penetrated by roots, air, and moisture. Available water capacity is low. Runoff is rapid.

The steep, broken slopes, shallowness, and the severe erosion hazard make these soils unsuited to cultivated crops or trees. The soils are suited to native range. Careful grazing management is necessary.

Capability unit VIIs-Si

Williams stony loam, rolling, the only soil in this unit, is a deep, well-drained, undulating and rolling soil that is covered with glacial stones and boulders. The surface layer is loam, and the subsoil is clay loam. Available water capacity is high. Permeability is moderate to moderately slow. Fertility is high, and the organic-matter content is moderate.

This soil is too stony and rocky to be suited to cultivated crops and hay. It is well suited to native range and to trees. Proper range use is needed. Trees have to be hand planted because mechanical planting is not feasible.

Capability unit VIIIe-1

This unit consists of Mine pits and dumps and Riverwash. Mine pits and dumps consists of caved-in areas and piles of waste from strip mining operations, and Riverwash is made up of sandbars and mudbars adjacent to the channel of the Missouri River.

All of these areas are nearly barren. They are not suited to cropland or range, but they are suited to wildlife habitat and to watershed development.

Predicted Yields

Predicted yields of the principal crops grown in Burleigh County, under two levels of management, are shown in table 2. These predictions are based on information obtained from farmers and those who work with farmers. The figures represent averages that can be expected over a period long enough to include years of both favorable and unfavorable temperatures and moisture conditions. The predictions represent the acreage planted rather than the acreage harvested.

Woodland and Windbreaks [3]

Approximately 1.1 percent, or 12,000 acres, of Burleigh County is native woodland. Most wooded areas are on the Havrelon, Lohler, Arnegard, Grassna, and Mandan soils on bottom land along the Missouri River and on the adjacent draws and breaks, and on the Straw soils along Apple, Burnt, and Painted Woods Creeks.

The principal species of trees and shrubs are cottonwood, green ash, American elm, boxelder, chokecherry, wild plum, juneberry, redosier dogwood, Woods rose, and shrub willow.

The early settlers used trees for lumber, fenceposts, and fuel. Now, trees and shrubs are used chiefly for livestock protection, wildlife habitat, recreation, esthetic purposes, erosion control, and watershed protection.

Windbreak Management

Windbreaks have been planted in Burleigh County since the days of the early settlers mainly for the protection of farmsteads and livestock. Such plantings are still needed on thousands of acres in the county, in cultivated areas where the hazard of soil blowing is serious.

Windbreaks distribute and hold snow and thereby keep it from drifting around the farmstead. They protect the buildings and livestock from cold, wintery winds and thus reduce fuel and feed costs. They protect field crops, gardens, and orchards from strong damaging wind and thus reduce the hazards of erosion and evaporation. They provide a habitat for birds and other wildlife, and they enhance the beauty of the rural home 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, suitable preparation, and adequate maintenance. Grass and weeds have 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.

Windbreak Groups

Ten windbreak suitability groups are designated in North Dakota. All of these groupings occur in Burleigh County. 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 dominant and most critical factors. The slope and the texture are also important, because they largely determine the degree of water erosion and soil blowing.

The hazard of soil blowing is very severe if the soil is coarse textured, severe if moderately coarse textured, moderate to slight if medium textured, slight if moderately fine textured, and severe if fine textured. There is

[3] By ELMER L. WORTHINGTON, woodland conservationist, Soil Conservation Service.

TABLE 2.—*Predicted average yields per acre of principal crops*

[Figures in columns A indicate yields under prevailing management; those in columns B indicate yields under improved management. Absence of figure indicates the crop is not suited to the soil]

Soil	Wheat		Oats		Corn silage		Flax		Barley		Grass-legume hay		Range forage (annual growth)
	A	B	A	B	A	B	A	B	A	B	A	B	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Lbs./ac.*
Arnegard and Grassna silt loams, level	24	31	43	57	5.5	7.5	14	18	31	40	1.75	2.5	2,900
Arnegard and Grassna silt loams, gently sloping	22	27	40	53	5.0	7.0	13	17	28	37	1.5	2.4	2,500
Arveson-Stirum loams	12	16	21	29	2.7	4.0	8	9	16	20	1.4	2.3	3,850
Arveson-Stirum loams, very poorly drained	10	14	18	24	2.0	3.5	8	9	13	17	1.0	1.2	4,000
Banks loamy fine sand	----	----	----	----	----	----	----	----	----	----	1.0	1.7	2,500
Banks fine sandy loam	10	13	15	21	2.5	3.5	5	6	13	17	1.0	1.7	2,700
Banks loam	10	13	18	24	2.0	3.0	6	7	13	17	1.0	1.3	2,800
Belfield-Rhoades silty clay loams, nearly level	13	17	23	31	2.5	3.5	10	12	19	22	1.0	1.4	1,850
Belfield-Rhoades silty clay loams, gently sloping	11	14	20	24	2.0	3.0	10	12	19	19	1.0	1.3	1,700
Belfield-Rhoades-Grail silty clay loams	14	18	25	33	3.0	4.0	10	12	18	24	1.2	1.6	2,000
Blown-out land	----	----	----	----	----	----	----	----	----	----	----	----	1,300
Colvin silty clay loam	10	13	18	24	----	----	8	9	13	18	1.0	1.5	4,000
Daglum-Belfield-Harriet complex	12	15	21	29	2.5	3.5	4	6	16	20	1.0	1.5	1,850
Daglum-Rhoades silty clay loams	11	14	20	26	2.0	3.0	4	6	14	19	1.0	1.5	1,700
Dimmick silty clay	14	18	25	33	----	----	8	9	18	24	1.4	2.5	4,800
Flasher soils, sloping	----	----	----	----	----	----	----	----	----	----	----	----	1,950
Flasher-Vebar complex, hilly	----	----	----	----	----	----	----	----	----	----	----	----	2,100
Flasher-Vebar-Rock outcrop complex, steep	----	----	----	----	----	----	----	----	----	----	----	----	1,750
Flaxton fine sandy loam	16	21	29	38	4.0	5.5	9	10	21	27	1.1	1.8	2,500
Flaxton-Livona loamy fine sands, undulating	13	16	20	28	3.0	5.0	6	7	17	22	1.0	1.6	2,550
Flaxton-Livona fine sandy loams, undulating	15	20	27	36	3.5	5.0	9	10	19	25	1.0	1.7	2,500
Grail silt loam, level	24	31	43	57	5.0	6.5	14	18	31	40	1.7	2.5	2,800
Grail silt loam, gently sloping	22	27	40	53	4.5	6.0	13	16	28	37	1.4	2.3	2,500
Grail silty clay loam, level	24	32	43	57	5.0	6.7	12	15	31	41	1.7	2.5	2,400
Grail silty clay loam, gently sloping	22	29	40	53	4.5	6.5	11	13	28	37	1.5	2.4	2,250
Harriet complex	----	----	----	----	----	----	----	----	----	----	----	----	2,500
Harriet and Regan soils, strongly saline	----	----	----	----	----	----	----	----	----	----	----	----	2,000
Havrelon fine sandy loam	14	18	28	36	4.0	5.5	9	10	18	24	1.2	2.0	2,700
Havrelon loam	19	24	34	46	4.5	6.0	9	11	25	32	1.5	2.1	2,800
Havrelon loam, clay subsoil variant	20	26	36	48	4.5	6.0	9	11	26	34	1.5	2.1	2,850
Havrelon silty clay loam	20	26	36	48	4.5	6.0	9	11	26	34	1.4	2.1	2,800
Heil soils	----	----	----	----	----	----	8	9	----	----	----	----	2,700
Lallie silty clay loam	17	22	31	41	3.5	4.0	9	10	22	28	1.5	2.0	3,000
Lehr loam, nearly level	11	14	18	24	3.0	4.0	9	11	14	19	1.0	1.4	1,800
Lehr loam, undulating	11	14	18	24	2.5	3.5	8	10	14	19	.8	1.2	1,700
Lehr loam, sloping	8	10	14	18	2.0	3.0	5	7	11	14	.7	1.0	1,500
Lihen loamy fine sand, nearly level	11	14	18	24	2.5	3.5	5	6	14	19	1.0	1.7	3,000
Lihen loamy fine sand, clay subsoil variant	11	14	20	24	2.5	3.5	6	7	14	19	1.0	1.7	3,300
Lihen, Livona, and Parshall fine sandy loams, hilly	----	----	----	----	----	----	----	----	----	----	.8	1.2	2,600
Lihen, Parshall, and Telfer fine sandy loams, rolling	11	14	20	26	2.5	4.0	8	9	14	19	.9	1.4	2,750
Lihen-Telfer loamy fine sands, undulating	10	13	16	22	2.0	3.0	5	6	14	19	1.0	1.5	2,850
Lihen-Telfer loamy fine sands, rolling	----	----	----	----	----	----	----	----	----	----	.75	1.2	2,700
Linton-Mandan silt loams, hilly	11	14	20	28	----	----	7	10	14	19	1.0	1.4	2,225
Linton-Mandan silt loams, steep	----	----	----	----	----	----	----	----	----	----	----	----	2,150
Livona-Flaxton loamy fine sands, rolling	----	----	----	----	----	----	----	----	----	----	.75	1.2	2,450
Livona-Flaxton fine sandy loams, rolling	11	14	20	26	3.0	4.0	8	9	14	19	.8	1.5	2,425
Livona and Lihen loamy fine sands, hilly	----	----	----	----	----	----	----	----	----	----	.75	----	2,450
Livona, Lihen, and Flasher fine sandy loams, steep	----	----	----	----	----	----	----	----	----	----	----	----	1,800
Livona-Williams fine sandy loams, hilly	----	----	----	----	----	----	----	----	----	----	.6	1.1	2,350
Lohler silt loam	21	28	38	50	4.0	5.5	10	12	26	36	1.3	1.9	2,700
Lohler silty clay loam	18	23	32	43	4.0	5.5	11	12	23	30	1.2	2.0	2,650
Lohler silty clay	16	21	29	38	4.0	5.5	9	10	21	30	1.1	1.9	2,550
Magnus silty clay loam	20	26	36	48	5.0	6.0	10	12	26	34	1.6	2.5	3,000
Makoti silty clay loam, level	19	26	34	46	4.5	6.0	11	13	25	32	1.5	2.4	2,300
Makoti-Williams silty clay loams, gently sloping	17	24	31	41	4.0	5.4	10	12	22	33	1.3	2.2	2,200
Mandan silt loam, level	20	26	40	52	5.0	6.0	10	13	26	34	1.4	2.0	2,500
Mandan-Linton silt loams, undulating	18	23	32	43	4.2	5.5	10	12	23	30	1.4	1.8	2,350
Mandan-Linton silt loams, rolling	17	23	31	41	3.5	4.5	9	11	22	29	1.2	1.7	2,250
Manning fine sandy loam, nearly level	10	13	17	23	2.8	3.5	6	8	13	17	1.0	1.4	2,000
Manning fine sandy loam, undulating	10	13	17	23	2.5	3.2	6	8	13	17	.8	1.2	1,800
Manning fine sandy loam, sloping	7	9	12	16	2.0	2.7	5	7	10	12	.6	1.0	1,600
Max-Zahl loams, rolling	11	15	20	26	----	----	7	9	14	19	.8	1.4	2,050
Mine pits and dumps	----	----	----	----	----	----	----	----	----	----	----	----	----
Miranda-Noonan complex	----	----	----	----	----	----	----	----	----	----	----	----	1,200

TABLE 2.—*Predicted average yields per acre of principal crops*—Continued

Soil	Wheat		Oats		Corn silage		Flax		Barley		Grass-legume hay		Range forage (annual growth)
	A	B	A	B	A	B	A	B	A	B	A	B	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Lbs./ac.*
Morton silt loam, gently sloping	19	25	34	46	4.0	5.5	10	12	25	32	1.4	2.0	2,300
Morton silt loam, sloping	14	18	25	33	3.0	4.5	8	11	18	24	1.2	1.7	2,200
Niobell-Noonan loams, nearly level	15	19	27	36	3.0	4.5	10	13	19	25	1.0	1.6	1,800
Niobell-Noonan loams, undulating	14	18	25	33	2.8	4.2	10	13	18	24	.9	1.5	1,700
Parnell silty clay loam, very poorly drained	16	20	29	38	-----	-----	9	10	21	27	1.6	2.5	5,200
Parshall fine sandy loam, nearly level	17	22	31	41	4.0	6.0	9	11	22	29	1.3	2.0	2,775
Parshall fine sandy loam, gently sloping	15	20	27	36	3.5	5.5	9	10	19	25	1.2	1.8	2,650
Parshall fine sandy loam, clay subsoil variant	17	22	34	44	4.0	6.0	10	12	22	29	1.3	2.0	2,850
Parshall and Lihen fine sandy loams, nearly level	16	21	29	38	4.0	5.8	8	9	21	27	1.2	1.8	2,675
Parshall, Lihen, and Telfer fine sandy loams, undulating	14	19	25	33	3.5	4.8	8	9	18	24	1.0	1.6	2,550
Regan silty clay loam	9	11	17	21	-----	-----	8	9	11	15	1.0	1.5	4,200
Regent silty clay loam, sloping	16	20	29	38	3.5	4.0	9	11	21	27	1.0	1.5	2,100
Regent-Grail silty clay loams, gently sloping	18	23	32	43	4.0	4.7	10	12	23	30	1.4	1.9	2,200
Rhoades complex	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1,100
Rhoades-Daglum complex	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	850
Riverwash	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Roseglen-Tansem silt loams, nearly level	23	29	42	55	5.0	6.5	12	15	28	37	1.6	2.4	2,600
Savage silt loam, level	20	26	36	48	4.5	6.0	12	16	26	34	1.5	2.1	2,400
Savage silt loam, gently sloping	18	23	32	43	4.0	5.5	11	13	23	30	1.2	1.8	2,300
Savage silt loam, sloping	17	22	31	41	3.0	4.5	10	12	22	29	1.0	1.5	2,150
Savage silty clay loam, level	20	26	36	48	5.0	6.0	11	13	26	34	1.5	2.1	2,350
Savage silty clay loam, gently sloping	18	23	32	43	4.0	5.0	10	12	23	30	1.3	1.9	2,250
Sen silt loam, gently sloping	19	25	34	46	4.0	5.5	10	12	25	32	1.4	1.9	2,350
Sen silt loam, sloping	14	18	25	33	2.7	4.0	8	11	18	24	1.2	1.6	2,275
Sen silt loam, hilly	11	14	20	26	-----	-----	6	9	14	19	1.0	1.3	2,000
Straw silt loam	22	28	40	53	5.2	6.5	12	16	28	37	1.6	2.0	2,450
Straw, Arnegard, and Colvin soils, channeled	19	29	34	46	3.5	4.5	13	15	25	32	1.5	2.2	2,500
Tansem loam, sloping	16	21	29	38	3.5	4.8	9	12	21	27	1.2	1.8	2,300
Tansem-Lehr loams, nearly level	15	18	27	34	4.5	6.0	10	13	19	25	1.2	2.0	2,200
Tansem-Roseglen silt loams, gently sloping	19	25	34	46	4.5	5.8	11	14	25	32	1.4	2.1	2,450
Telfer-Lihen loamy sands, nearly level	10	13	18	24	2.0	3.0	4	4	13	17	.75	1.5	2,750
Telfer-Lihen loamy fine sands, hilly	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,600
Telfer-Seroco loamy sands	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,000
Temvik silt loam, nearly level	20	26	36	48	4.5	6.0	10	13	26	34	1.4	2.0	2,500
Temvik silt loam, undulating	19	25	34	46	4.0	5.5	10	12	25	32	1.4	1.9	2,400
Temvik silt loam, rolling	14	18	25	33	3.5	4.5	8	11	18	24	1.2	1.7	2,300
Tiffany loam	12	15	21	29	4.0	5.5	8	9	16	20	1.4	2.3	3,900
Tonka and Parnell soils	16	20	29	38	4.0	5.5	9	10	21	27	1.5	2.5	4,000
Vebar fine sandy loam, gently sloping	15	19	27	36	3.5	4.5	9	10	19	25	1.0	1.5	2,400
Vebar fine sandy loam, sloping	11	14	20	26	2.8	3.7	9	10	14	19	.8	1.2	2,250
Wabek soils, undulating	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	950
Wabek soils, hilly	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	800
Werner complex, steep	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1,850
Werner-Morton-Sen complex, hilly	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,000
Werner-Sen loams, sloping	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,000
Werner-Shale outcrop complex	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1,000
Williams stony loam, rolling	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,150
Williams loam, nearly level	20	26	36	48	4.5	6.0	12	15	26	34	1.4	2.1	2,350
Williams loam, undulating	19	25	34	46	4.0	5.5	11	14	25	32	1.3	2.0	2,250
Williams loam, rolling	14	18	25	33	3.5	5.0	9	12	18	24	1.1	1.7	2,100
Williams loam, hilly	12	16	21	29	-----	-----	8	11	16	20	.9	1.4	2,000
Williams-Zahl loams, hilly	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,000
Williams-Zahl loams, steep	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1,900

no hazard, or only a slight hazard, of water erosion if the slope is 0 to 3 percent. The hazard is moderate if the slope is 3 to 6 percent, severe if 6 to 9 percent, severe to very severe if 9 to 12 percent, and very severe if 12 percent or more.

Conserving water is most important on soils that have slopes of more than 6 percent. Special site preparation, planting, and cultivation are needed to successfully establish and maintain plantings if 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 critical for growing trees and shrubs.

Windbreak groups are not designated for Mine pits and dumps and Riverwash. These areas are so variable that grouping is not feasible. In selected locations, they are suited to spot plantings for wildlife, recreation, and beautification.

Table 3 lists the species of trees and shrubs commonly used in windbreak plantings in the county and 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 column headed "Vigor" 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, and also evidence of 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; extensive disease, insect, or climatic damage, severe stagnation, suppression, or decadence is evident; and 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.

Windbreak group 1

In this group are nearly level to sloping soils of the Arnegard, Grail, Grassna, Havelon, Lohler, Magnus, Roseglen, and Straw series. These soils are deep, loamy and clayey, and well drained or moderately well drained. Soil moisture is favorable for the growth and survival of trees and shrubs. The water table is within the reach of tree roots on Havrelon, Lohler, and Straw soils. Arnegard, Grail, and Grassna soils receive extra soil moisture in runoff from surrounding areas.

These soils are well suited to all types of windbreak and other plantings. Soil blowing is a serious hazard on some soils. Otherwise, there are no serious hazards or limitations.

Windbreak group 2

In this group are nearly level, poorly drained and very poorly drained soils of the Arveson, Colvin, Dimmick, Lallie, Parnell, Tiffany, and Tonka series. These soils are deep, loamy and clayey, and slightly to moderately saline in the subsoil and underlying material. They are ponded and have a high water table.

Unless drained, these soils are poorly suited or unsuited to trees and shrubs. If adequately drained, they are well suited to all types of windbreak and other plantings. Suitable species for planting, however, are more limited on Colvin soils than on other soils in this group because they are high in lime.

The hazard of soil blowing is serious on Colvin soils and the clayey soils of this group. Wetness is the only critical limitation.

Windbreak group 3

In this group are level to hilly soils of the Linton, Makoti, Mandan, Max, Morton, Regent, Savage, Sen, Tansem, Temvik, and Williams series. These are well-drained, loamy soils. Morton, Regent, and Sen soils are moderately deep over soft bedrock. The rest are deep.

If moisture is conserved, these soils are well suited to all types of windbreak and other plantings.

Soil blowing and water erosion are the only hazards. Soil blowing is only a slight hazard on most soils.

Windbreak group 4

In this group are nearly level to gently sloping soils of the Belfield and Niobell series. These soils are deep, loamy and clayey, and well drained or moderately well drained. The subsoil is clayey.

These soils are suited to windbreak and other plantings, but selection of species is limited.

Soil blowing and water erosion are slight to severe hazards on some soils in this group. The clayey texture of the subsoil, which limits the choice of species, is the only critical limitation.

Windbreak group 5

In this group are nearly level to hilly soils of the Flaxton, Lihen, Livona, Parshall, and Vebar series. These are well-drained, loamy and sandy soils. Vebar soils are moderately deep over soft bedrock. The rest are deep. Most of the precipitation is absorbed. Available water capacity is moderate.

These soils are suited to windbreak and other plantings, but selection of species is limited. Only suitable species should be planted.

The erosion hazard is serious. The moderate available water capacity is the main limitation.

TABLE 3.—*Height and vigor, by windbreak*

[Height measurements and vigor ratings for trees are at

Windbreak group	Eastern redcedar and Rocky Mountain juniper		Ponderosa pine		Black Hills spruce and Colorado blue spruce		Caragana		Chokecherry		Honeysuckle	
	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
		Ft.		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*
1	Good	10–12	Good	18–20	Good	18–20	Good	8–10	Good	11–12	Good	8–10
2	Good	12–14	Good	18–20	Good	16–18	Fair	7–8	Fair	8–10	Good	7–8
3	Good	10–12	Good	18–20	Good	17–19	Good	8–10	Good	8–10	Good	8–9
4	Good	9–11	Good	16–18	Poor	--------	Good	6–8	Fair	7–9	Good	6–7
5	Good	8–10	Good	18–20	Poor	--------	Good	7–9	Fair	6–8	Good	6–7
6	Fair	7–9	Fair	12–14	Poor	--------	Fair	6–8	Poor	--------	Poor	--------
7	Fair	7–9	Fair	12–14	Poor	--------	Poor	--------	Poor	--------	Poor	--------
8	Fair	6–8	Fair	12–14	Poor	--------	Fair	4–5	Poor	--------	Poor	--------

Windbreak group 6

In this group are nearly level to sloping soils of the Lehr and Manning series. These are loamy, somewhat excessively drained soils that are shallow and moderately deep over sand and gravel. They absorb most of the precipitation, but moisture moves very rapidly through the sand and gravel underlying material. Available water capacity is low.

Manning soils are poorly suited to all types of windbreak and other plantings. Lehr soils are unsuited to windbreak plantings and are poorly suited to wildlife, recreational, and beautification plantings. Plantings can be established if suitable species are selected, but optimum survival, growth, and vigor should not be expected.

The erosion hazard is severe. Low available water capacity and a restricted root zone are critical limitations.

Windbreak group 7

In this group are nearly level to hilly soils of the Banks and Telfer series. These soils are deep, sandy, and somewhat excessively drained or excessively drained. They have low available water capacity. They absorb most of the precipitation but retain little.

These soils are suited to plantings for wildlife, recreation, and beautification, but optimum survival, growth, and vigor of the plants should not be expected. The soils are poorly suited to field windbreaks. Selection of species is limited.

Soil blowing is a serious hazard. Water erosion is a slight to moderate hazard. Low available water capacity is the critical limitation.

Windbreak group 8

This group consists of hilly soils of the Zahl series. These are deep, well-drained, loamy soils that have convex slopes. Available water capacity is high, but runoff is excessive and restricts water intake and the amount of water available to trees and shrubs.

These soils are not suited to field windbreaks. They are suited to plantings for wildlife, recreation, and beautification, but optimum survival, growth, and vigor should not be expected.

Water erosion is a very serious hazard. The steep slope and the resulting excessive runoff and low water intake are the main limitations.

Windbreak group 9

In this group are nearly level to sloping soils of the Daglum, Miranda, Noonan, Rhoades, and Stirum series. These soils are deep, loamy and clayey, and moderately well drained and poorly drained. The subsoil is a dense claypan. The root zone is generally less than 20 inches thick. It is nonsodic and nonsaline. Available water capacity is low in Miranda and Rhoades soils and moderate in the rest.

These soils are not suited to any type of windbreak or other planting, but they are mapped with soils that are suitable for hand planted trees and shrubs for wildlife, recreation, and beautification.

Soil blowing is a slight hazard, and water erosion a slight to severe hazard. A restricted root zone, moderate to low available water capacity, and salt toxicity are the main limitations.

Windbreak group 10

In this group are undrained soils of the Arveson, Parnell, and Stirum series, soils of the Harriet, Heil, Regan, and Seroco series, stony soils of the Williams series, sloping to very steep soils of the Flasher, Wabek, and Werner series, steep soils of the Lihen, Linton, Livona, Mandan, Williams, and Zahl series, and areas of Blowout land.

All of these soils have a wide range of depth, texture, drainage, and slope, but all have one or more characteristics that are highly critical for tree and shrub planting, survival, vigor, and growth. They are too waterlogged, low in available water, stony, rocky, shallow, sodic, saline, steep, infertile, restrictive to rooting, or erosive to be suited to trees and shrubs.

These soils are not suitable for windbreak plantings. Some are suited to hand plantings for wildlife, recrea-

group, of specified trees and shrubs

20 years of age. Dashes indicate data not available]

Wild plum		American elm		Cottonwood		Green ash		Russian-olive		Siberian elm	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Ft.		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*
Good	6–8	Good	21–23	Fair or good.	42–46	Good	20–22	Fair	14–16	Good	28–30
Good	5–6	Good	20–22	Poor to good.	40–44	Good	20–22	Fair	12–14	Good	28–30
Good	6–8	Good	19–21	Poor		Good	19–21	Good	13–15	Good	24–27
Fair	6–7	Fair	14–16	Poor		Good	16–18	Good	16–18	Fair	18–20
Fair	4–6	Fair	14–16	Poor		Good	14–16	Good	16–18	Good	22–25
Poor		Poor		Poor		Fair	13–15	Fair	10–12	Fair	18–20
Poor		Poor		Poor		Poor		Poor		Poor	
Poor		Poor		Poor		Fair	8–10	Fair	8–9	Fair	10–12

tion, and beautification. Species and planting sites should be carefully selected.

Range[4]

About half the acreage of Burleigh County, approximately 527,000 acres, provides native forage for livestock. Rangeland occurs throughout the county, but is concentrated in steeper areas or on shallow soils. About 85 percent of soil association 10 (see General Soil Map) is range, about 75 percent of associations 3 and 8, and less than 25 percent of association 2. Most of the rangeland is fenced. Areas range in size from several thousand acres to 10 acres or less.

Rangeland is important to the economy of the county. The value of cattle sold is about one-third the value of all agricultural products sold, according to data from the United States Census of Agriculture. Cattle raising in the county is based chiefly on the use of range. Managing the time and intensity of grazing to restore or maintain a good to excellent range condition is the most important factor in good range management.

Range Sites and Condition Classes

A range site is a distinctive kind of rangeland that differs in its ability to produce different kinds or amounts of native vegetation. The establishment of a range site is based on factors that result in a significant difference in the potential plant community, not on differences in soil or in climate, and the difference must be great enough to require some change in management, a different rate of stocking, for example. Plants on a native range site are of three main kinds, each of which responds to grazing in a different way.

Decreasers are species in the potential plant community that tend to decrease in relative amount under close grazing. They generally are the tallest and most productive perennial grasses and forbs and the most palatable to livestock.

Increasers are species in the potential plant community that increase in relative amount as the more desirable plants are reduced by close grazing. They are commonly shorter than decreasers, and some are less palatable to livestock.

Invaders are plants that cannot withstand the competition for moisture, nutrients, and light in the potential plant community. Hence, they invade and grow along with the increasers after the potential vegetation has been reduced by grazing. Many are annual weeds. Some are forbs that have limited grazing value, but others have little value for grazing.

Range condition is the present state of the vegetation compared with that of the potential plant community for the site. The purpose in classifying range condition is to provide an approximate measure of any deterioration that has taken place in the plant cover and thereby provide a basis for predicting the degree of improvement possible. Four condition classes are defined. Range is in *excellent* condition if 76 to 100 percent of the vegetation is characteristic of the climax vegetation on the same site; it is in *good* condition if the percentage is between 51 to 75; in *fair* condition if the percentage is between 26 to 50; and in *poor* condition if the percentage is less than 26.

Potential forage production depends on the range site. Current forage production depends upon the range condition and the amount of moisture available to plants during the growing season. To maintain a good to excellent condition, no more than about half of the annual growth should be removed. The leaves that remain produce new growth and manufacture food for storage in roots. The leaves and other plant material eventually become mulch. The mulch increases moisture intake and maintains a more even soil temperature.

[4] By CLAYTON L. QUINNILD, range conservationist, Soil Conservation Service.

Descriptions of Range Sites

Thirteen range sites are recognized in Burleigh County. They are described in the following paragraphs. Estimates of total herbage yield, air-dry weight per acre, from plots in excellent condition are given for the ten more extensive sites. These estimates indicate the total annual production, not the forage available for grazing. The plant material weighed consists of all annual growth of the pasture grasses above the root crown and all new growth on woody plants in the form of twigs, leaves, fruits, and all young shoots.

The names of the soil series represented are mentioned in the description of each site, but this does not mean that all the soils in a given series are in the site. The range site designation for each soil is listed in the "Guide to Mapping Units." No designation is given for Mine pits and dumps and Riverwash.

Wetland range site

This site consists of loamy and clayey, poorly drained soils of the Dimmick, Parnell, and Regan series, but it is dominantly Parnell and Regan soils. These soils either are ponded or have a high water table. Water covers the plant crowns for 2 to 10 weeks during the growing season.

Areas of this range site are widely distributed throughout the county. They are mostly in native grass, because they are too wet for crops. The vegetation is mainly rivergrass, slough sedge, American mannagrass, northern reedgrass, woolly sedge, prairie cordgrass, and smartweed. The most common increasers are Baltic rush, spike sedges, Mexican dock, and medium-tall wetland sedges. Yields range from about 4,500 to 5,500 pounds per acre.

Because of wetness, this site normally is most suitable for grazing in the latter part of the growing season. Many of the large, coarse grasses remain lush throughout summer. In areas of more than 25 acres, and where it is feasible to do so, this site can be managed more effectively if it is fenced separately from other rangeland.

Subirrigated range site

This site consists of soils in the Colvin, Arveson, and Tiffany series, but it is dominantly Colvin soils. These soils are in valleys and swales or at the base of slopes. The water table is within the root zone of plants during most of the growing season. Sometimes water covers the surface for brief periods in spring.

If the site is in excellent condition, the vegetation is predominantly big bluestem, switchgrass, prairie cordgrass, Maxmilian sunflower, and tall goldenrod. Little bluestem is usually predominant on the calcareous soils. Plants less abundant are bearded wheatgrass, Macoun wildrye, northern reedgrass, fescue sedge, Rydbergs sunflower, golden ragwort, and tall cinquefoil. Common increasers are mat muhly, Baltic rush, common spike sedge, and silverweed cinquefoil. Yields range from about 3,000 to 4,000 pounds per acre.

This site is most suitable for summer and fall grazing. The most important forage plants are warm-season types that produce more late in summer and provide palatable forage throughout the growing season. Heavy grazing early in the growing season results in trampling damage. If feasible, this site should be fenced and managed separately.

Sands range site

This site consists of deep, loose, nearly level to rolling loamy fine sands and loamy sands of the Banks, Flaxton, Lihen, Livona, and Telfer series. Lihen and Flaxton are predominant. The rapid intake and deep penetration of water have the greatest influence on the species that dominate in the climax vegetation.

Tall, deep rooted plants are dominant. Prairie sandreed, needle-and-thread, and sand bluestem are the most important grasses. There are small amounts of woody plants. Common increasers are sun sedge, sand dropseed, field sagewort, and fringed sage. Yields range from about 2,100 to 2,900 pounds per acre.

The soils are highly susceptible to blowing if overgrazed. Because much of the vegetation is coarse, patchy grazing often creates an erosion hazard. Patchy grazing is especially serious if the site is grazed by livestock, such as sheep and horses, that have selective grazing habits. Uniform grazing patterns are best achieved through grazing mature cattle. Grazing small plots at a heavy stocking intensity for a short period also results in a more uniform grazing pattern.

Sandy range site

This site consists of deep and moderately deep, well-drained fine sandy loams of the Banks, Flaxton, Havrelon, Lihen, Livona, Manning, Parshall, Telfer, Vebar, and Williams series. Lihen, Flaxton, Livona, and Vebar soils are dominant. These soils absorb surface moisture at a moderately rapid rate and have a moderate water-holding capacity.

The most important plants are tall and medium-tall grasses. Prairie sandreed and needle-and-thread are the most widespread. Canada wildrye and big bluestem grow in dips and swales where there is extra moisture. About 10 percent of the yield is made up of broadleaf plants. Threadleaf sedge and blue grama are the chief increasers. Other common increasers are sun sedge, western yarrow, heath aster, and silverleaf scurfpea. Big bluestem decreases rapidly under grazing, followed in turn, by needle-and-thread and other mid and tall grasses. Yields range from 2,000 to 2,600 pounds per acre.

If watering facilities are adequate and correctly placed, good distribution of grazing is easy to attain, particularly on the larger areas. Both cool-season and warm-season grasses provide good grazing throughout a large part of the growing season. A proper rate of stocking is most important.

Silty range site

This is the most extensive site in Burleigh County. It consists of well-drained, medium-textured, nearly level to steep soils in the Arnegard, Banks, Belfield, Grail, Grassna, Havrelon, Linton, Lohler, Mandan, Max, Morton, Niobell, Roseglen, Savage, Sen, Straw, Tansem, Temvik, and Williams series. The Williams soil is the most extensive. If the range is in excellent condition, water intake is moderately rapid and water-holding capacity is high. Most of the moisture is available to plants.

Mid grasses and other plants of medium height dominate the climax vegetation. Western wheatgrass is the most important species. Green needlegrass is frequently dominant in swales and pockets where there is additional water. Needle-and-thread and a variety of broadleaf plants contribute much of the forage. Other mid grasses are bearded wheatgrass, prairie junegrass, and prairie dropseed. Blue grama is the chief increaser. Other common increasers are needleleaf sedge, threadleaf sedge, and fringed sage. In some places, particularly the more hilly areas, western snowberry (buckbrush) is a common increaser. Green needlegrass, bearded wheatgrass, and big bluestem gradually decline under continual heavy grazing. Yields range from about 1,800 to 2,400 pounds per acre.

If watering facilities are adequate, there are few concerns in management. If the site is in excellent condition, the most important forage plants are cool-season species, which furnish the best grazing in spring and early summer. Grazing early in spring should be avoided. A system of deferred grazing is desirable.

Clayey range site

This site consists of deep and moderately deep, nearly level to hilly, well drained and moderately well drained silty clay and silty clay loam soils of the Grail, Havrelon, Lohler, Magnus, Makoti, Regent, Savage, and Williams series. Savage, Grail, and Makoti soils are dominant. These soils have a high water-holding capacity and slow or moderately slow permeability. The slow permeability on slopes results in considerable runoff during heavy rains and only shallow wetting during normal rains.

Western wheatgrass and green needlegrass are the most important forage plants. There are a few broadleaf plants. Blue grama, which is moderately extensive in the climax vegetation, increases rapidly under heavy grazing. Other common increasers are needleleaf sedge, prairie junegrass, and fringed sagewort. Yields range from about 1,800 to 2,400 pounds per acre.

The site deteriorates rapidly if overgrazed. Increaser plants on the overgrazed areas are less productive and less protective against erosion than plants in the climax vegetation. This site stays wet late in spring. It should not be grazed when wet.

Thin sandy range site

Flasher soils make up this site. They are shallow, sandy, hilly and steep soils that have lime close to the surface. They are droughty and have shallow moisture penetration.

The chief plants in the climax vegetation thrive well on these limy soils and tolerate extended drought. Little bluestem and plains muhly are dominant grasses in the shallowest areas. Prairie sandreed is generally dominant in areas where the sands are very soft and loose. Needle-and-thread and sun sedge are important throughout most of the site. Many herbaceous and woody broadleaf plants are common. Stiff sunflower, dotted gayfeather, blacksamson echinacea, several species of penstemon, and purple prairie clover are important forbs. Woods rose, sand cherry, leadplant amorpha, and western snowberry are the common woody plants. Threadleaf sedge, generally the most dominant increaser, is always present. Spreading pasqueflower and several other minor forbs are also increasers. Yields range from about 1,500 to 1,950 pounds per acre.

Uniform grazing is difficult because of the topography. Livestock watering sources must be spaced closer on this site than on a smoother site. Fencing in smaller divisions and grazing at a heavier stocking intensity for short periods help to achieve more uniform grazing.

Thin silty range site

This site consists of shallow and moderately deep, hilly to steep, medium-textured soils of the Werner and Zahl series. The soils are shallow on the crests and upper parts of the ridges and moderately deep on the lower slopes.

Little bluestem is dominant in shallow areas, along with side-oats grama and plains muhly. If the range is in excellent condition, broadleaf plants include stiff sunflower, dotted gayfeather, blacksamson echinacea, and prairie clovers. Porcupinegrass, prairie dropseed, western wheatgrass, and several tall broadleaf plants are dominant in areas where the soils are moderately deep. On north-facing slopes a variety of woody plants, including western snowberry, dwarfindigo amorpha, and Arkansas rose, are often present in minor proportions. Penn sedge, needleleaf sedge, and a number of minor broadleaf plants, such as spreading pasqueflower, are the most common increasers. Yields range from about 1,400 to 1,850 pounds per acre.

Uniform grazing is difficult throughout this site. Fencing and adequate watering sources are important in management.

Shallow to Gravel range site

This site is most commonly in broad outwash areas. It consists of soils in the Wabek and Lehr series. These soils are droughty. They are typically about 13 inches deep over clean sand or gravel.

Needle-and-thread is dominant if this site is in excellent condition. Other common grasses are plains muhly, prairie junegrass, and blue grama. Broadleaf plants generally make up only a small fraction of the cover. Some of the more common ones are dotted gayfeather, Hoods phlox, scarlet globemallow, broom snakeweed, rush skeletonplant, and fringed sage. Blue grama and fringed sage are the chief increasers. Red three-awn and several less extensive, unpalatable broadleaf plants are also common increasers. Yields range from about 1,250 to 1,650 pounds per acre.

Continual heavy grazing lowers the range condition within a relatively short time. A rest-rotation grazing system is a practical method of slowing down vegetative deterioration. A range in poor condition recovers slowly.

Claypan range site

This site consists of medium-textured soils of the Daglum, Harriet, Miranda, Noonan, and Rhoades series. Miranda and Rhoades soils are dominant. In most places, these soils have a hard layer of dispersed clay within a

depth of 4 inches. In many places they have microrelief, and the claypan is exposed in the lower spots. The claypan significantly reduces forage yields. In areas where the claypan is exposed, there is little if any plant growth in a typical year.

The plant cover on this site varies considerably, depending on thickness of the surface soil, the number of areas in which the claypan is exposed, and the extent of other soils interspersed within this site. Generally, western wheatgrass is dominant. Blue grama makes up a significant part of the cover. Prairie junegrass and canby bluegrass are minor grasses commonly present. Several minor broadleaf species are common, including wild parsley, scarlet globemallow, Hoods phlox, and fringed sage. Inland saltgrass occurs on the more salty areas. Blue grama and, to a lesser extent, needleleaf sedge and Sandberg bluegrass are the chief increasers. Yields range from about 1,150 to 1,550 pounds per acre.

Proper stocking is important in management. If the range condition has deteriorated, the yield of desirable forage is seriously reduced, and recovery is slow. Pitting or furrowing, followed by a rest period, allows desirable plants to recover and in some instances improves deteriorated areas.

Overflow range site

This site consists of medium-textured and fine-textured soils of the Heil, Lallie, and Tonka series. It is on bottom land or low terraces along streams, shallow depressions, or swales in the uplands and regularly receives excess water from inflow or stream overflow.

If the site is in excellent condition, the vegetation is predominantly big bluestem, green needlegrass, porcupinegrass, prairie dropseed, slender wheatgrass, and western wheatgrass. Secondary plants are blue grama, Penn sedge, needleleaf sedge, and fescue sedge. Common forbs are fringed sage, purple prairieclover, western yarrow, and tall goldenrod. Small amounts of western snowberry and prairie rose also occur on this site. Total annual herbage production ranges from 2,600 to 3,400 pounds per acre.

This site is a valuable part of the range resource because it receives additional moisture and supports important warm-season forage plants. The most suitable time for grazing is during summer and fall.

Saline Subirrigated range site

This site consists of saline or alkali-affected soils of the Arveson, Harriet, Regan, and Stirum series. Harriet and Regan soils are dominant. The site is in low-lying areas that receive extra water from seepage or both. Accumulations of salts or alkali are sufficient to affect the kind and amount of vegetation.

The most important plants are western wheatgrass, nuttall alkaligrass, alkali cordgrass, slender wheatgrass, and plains bluegrass. Secondary plants are inland saltgrass, alkali muhly, mat muhly, foxtail barley, and silverweed cinquefoil. Total annual production ranges from 2,450 to 3,300 pounds per acre.

Although productivity is limited by moisture available for plant growth, this site furnishes useful forage for summer and fall grazing. Because it is wet, heavy grazing and trampling early in the growing season damage vegetation.

Choppy Sands range site

This site consists of loose, windblown fine sands of the Seroco series. Available water capacity is very low. Natural fertility and the organic-matter content are low.

If this site is in excellent condition, primary plants are sand bluestem, prairie sandreed, needle-and-thread, Canada wildrye, and little bluestem. Secondary plants are sand dropseed, blue grama, blowoutgrass, Penn sedge, and threadleaf sedge. Forbs common on the site are field sagewort, lemon scurfpea, hairy goldaster, prairie spiderwort, and silky prairieclover. Total annual herbage production ranges from 1,350 to 1,850 pounds per acre.

The soils are highly susceptible to blowing if overgrazed. Because much of the vegetation is coarse, patchy grazing often creates an erosion hazard. Patchy grazing is especially serious if the site is grazed by livestock, such as sheep and horses, that have selective grazing habits. Uniform grazing patterns are best achieved through grazing by mature cattle. Grazing small plots at a heavy stocking intensity for a short period also results in a more uniform grazing pattern. Controlled grazing and stocking intensity are essential in preventing soil blowing and deterioration of the site.

Wildlife [5]

Ring-necked pheasant, sharp-tailed grouse, gray partridge, duck, and white-tailed deer are the most important game species in the county. The mourning dove, the most secure game bird, is not being utilized to its potential. The eastern turkey is also present but of little importance because of limited woodland. Goose hunting is limited to the lake and slough area in the northeastern part of the county and to spots along the Missouri River. Mammals commonly sought are the long-tailed weasel, mink, striped skunk, badger, raccoon, red fox, fox squirrel, muskrat, beaver, white-tailed jackrabbit, and cottontail rabbit. Species in limited numbers are the bobcat, coyote, and gray fox. About 300 species of birds reside, visit, or migrate through the county.

This section describes the parts of the county best suited to important wildlife game species.

In planning habitat improvement, an inventory and evaluation should be made to determine the habitat needs of the wildlife concerned. After needs are determined, the only management required is choosing the vegetation and practices best suited to the particular soil or land area. Suggestions on establishing grasses, legumes, shrubs, and trees can be found in other parts of the survey.

The suitability of soils, by soil associations (see General Soil Map), for five important wildlife species are described in the following paragraphs. The suitability is based on land use and on the ease of establishing and maintaining suitable habitat. This information indicates where the best populations can be attained with the least effort and the least amount of land specifically needed for wildlife use.

SHARP-TAILED GROUSE.—This native game bird thrives in areas of native rangeland or grassland. It prefers grassland interspersed with shrub thickets and fairly large

[5] By ERLING B. PODOLL, biologist, Soil Conservation Service.

wooded tracts. The largest populations of grouse can be attained on soil associations 5, 8, 10, and 11.

GRAY PARTRIDGE (HUNGARIAN).—This small game bird was introduced from Europe. Its range requirements are quite similar to those of the ring-necked pheasant. Gray partridge do not need as good escape, nesting, roosting, and loafing cover as the pheasant needs. It is much more dependent on a good distribution of many, small, woody shrub thickets. Soil associations 4, 7, and 11 have the highest potential for gray partridge.

RING-NECKED PHEASANT.—Only soil associations 2, 4, and 7 have good potential for pheasant. About 30 percent of the county is poor habitat. Winter habitat in this county must be of superior quality to support pheasants.

DUCKS.—Common native species, such as pintail, mallard, and blue-winged teal, have the greatest potential in the county and are of greatest economic importance. Preserving and improving wetlands and developing other water sources improve the potential duck harvest and production. The most favorable areas for highest duck production are in soil associations 8 and 9. Soil association 13 is one of the best areas in the county for hunting, though it produces fewer waterfowl than the other associations do. Important soils for waterfowl production are the Parnell, Tonka, Regan, Colvin, and Dimmick soils.

WHITE-TAILED DEER.—The best range for deer is in areas predominantly covered with woods and shrubs. Soil associations 1 and 12 have the highest potential. Sloughs and areas of tall herbaceous vegetation provide habitat for fair populations of deer.

FISH.—Public fishing in the county is limited to the Missouri River and the Sterling Reservoir. There is only one private pond. A good potential for the construction of fishing ponds is in soil associations 9, 10, and 12 and in part of 8.

For assistance in evaluating habitat and wildlife needs and in applying management, contact the Soil Conservation Service or the Game and Fish Department.

Soils and Engineering [6]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, irrigation and drainage systems, and sewage disposal systems. Among the properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell potential, texture, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, available water capacity, and topography.

Information concerning these and related soil properties is given in tables 4, 5, and 6. The estimates and interpretations in these tables can be used to—

1. Make studies that will aid in selecting and developing industrial, commercial, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils in planning drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soil conditions that will aid in selecting sites for highways, airports, pipelines, and cables, and in planning detailed investigations at selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement other publications, such as maps, reports, and aerial photographs, that are used in preparation of engineering reports for a specific area.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or excavations deeper than the depths reported (ordinarily about 5 feet). Even in these situations, however, the soil map is useful in planning more detailed field investigations and in indicating the kinds of problems that may be expected.

Some of the terms used by soil scientists have special meanings in soil science that may not be familiar to engineers. These terms are defined in the Glossary.

Engineering Classification

The two systems most commonly used in classifying soils for engineering are the systems approved by the American Association of State Highway Officials (AASHO) and the Unified system.

The AASHO system (*1*) is used to classify soils according to those properties that affect use in highway construction. It groups together soils that have about the same load-carrying capacity. In this system all soil material is classified in seven principal groups. The groups range from A–1, which consists of soils that have the highest bearing strength and are the best soils for subgrade, to A–7, which consists of soils that have the lowest strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. The numbers range from 0, for the best material, to 20, for the poorest. The group index of a soil can be established only by laboratory tests. The AASHO classifications in table 4 include the group index number for the soils tested.

The Unified soil classification system used by the U.S. Department of Defense (*7*) is based on texture, plasticity, and liquid limit and on performance as engineering construction material. In this system, soil materials are identified as coarse grained (eight classes), fine grained

[6] By Clinton R. Johnson, State conservation engineer and Dennis Meyer, area engineer, Soil Conservation Service.

TABLE 4.—*Engineering*

[Tests performed by North Dakota State University in cooperation with North Dakota State Highway Department and the Bureau

Soil name and location	Parent material	North Dakota report number	Depth from surface	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			In.	*Lb. per cu. ft.*	*Pct.*
Lehr loam: 130 feet north and 140 feet east of south quarter corner of sec. 5, T. 139 N., R. 78 W. Coarse D horizon.	Alluvium over gravel.	288	7–16	115	13
		79	16–28	122	10
		289	28–44	134	11
		290	44–60	130	9
Lihen fine sandy loam: 225 feet east and 700 feet south of northwest corner of sec. 25, T. 138 N., R. 77 W.	Glaciofluvial sandy deposits.	227	0–18	116	12
		75	32–60	114	13
Lihen loamy fine sand: 1,270 feet east and 1,320 feet south of northwest corner of sec. 25, T. 138 N., R. 77 W. Modal.	Glaciofluvial sands, wind modified.	76	0–16	116	12
		83	36–60	114	12
Parshall fine sandy loam: 790 feet west of northeast corner of sec. 29, T. 137 N., R. 78 W. Fine-textured substratum.	Glaciofluvial sandy deposits.	228	2–14	112	14
		229	14–25	113	13
		73	32–60	112	14
Roseglen silt loam: 115 feet west and 650 feet south of center of sec. 29, T. 139 N., R. 78 W. Modal.	Glaciofluvial deposits.	217	7–24	106	16
		218	24–34	104	19
		71	34–51	110	16
		219	53–60	103	14
Savage silty clay loam: 0.10 mile south and 60 feet west of northeast corner of sec. 5, T. 138 N., R. 77 W. Fine textured.	Glaciofluvial deposits.	86	9–28	96	24
		293	28–42	94	24
		294	42–52	92	22
Williams loam: 0.2 mile west and 300 feet south of north quarter corner of sec. 36, T. 139 N., R. 77 W. Modal.	Glacial till.	221	7–19	105	18
		222	19–36	102	18
		84	36–60	109	16
0.24 mile north and 0.13 mile east of west quarter corner of sec. 22, T. 139 N., R. 75 W. No. B23 horizon.		88	11–18	103	20
		78	18–26	100	23
		223	26–47	99	21

[1] Based on AASHO Designation: T 99–57, Method A (*1*).

[2] Mechanical analysis according to AASHO Designation: T 88–57 (*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material 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 naming textural classes for soils.

test data

of Public Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—						AASHO	Unified [3]
¾-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.070 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
									Pct.			
100	93	86	74	48	43	27	15	11	30	7	A-4(3)	SM-SC
[4] 88	75	66	54	29	25	20	11	8	[5] NP	[5] NP	A-2-4(O)	SM
[6] 87	57	31	14	4	4	4	3	2	NP	NP	A-1-a(O)	SW
[7] 88	66	50	20	7	6	5	4	3	NP	NP	A-1-a(O)	SP-SM
-------	---------	100	97	29	24	16	10	7	NP	NP	A-2-4(O)	SM
-------	---------	100	97	20	17	13	11	10	NP	NP	A-2-4(O)	SM
-------	---------	100	95	24	20	14	7	7	NP	NP	A-2-4(O)	SM
-------	---------	100	96	13	12	9	8	8	NP	NP	A-2-4(O)	SM
-------	---------	---------	100	45	36	19	11	8	NP	NP	A-4(2)	SM
-------	---------	---------	100	44	35	21	12	9	NP	NP	A-4(2)	SM
-------	---------	---------	100	38	29	17	13	11	NP	NP	A-4(1)	SM
-------	---------	---------	100	90	76	47	27	21	33	12	A-6(9)	CL
-------	---------	---------	---------	94	82	57	35	27	37	15	A-6(10)	CL
-------	---------	---------	---------	89	71	42	25	20	30	8	A-4(8)	ML-CL
-------	---------	---------	---------	99	90	60	25	19	34	8	A-4(8)	ML
-------	---------	---------	100	97	96	91	70	55	51	26	A-7-6(17)	CH
-------	---------	---------	---------	99	99	99	82	66	64	36	A-7-6(20)	CH
-------	---------	100	99	98	98	98	89	64	66	36	A-7-5(20)	CH
-------	99	98	92	64	59	48	34	28	39	20	A-6(10)	CL
-------	99	97	92	68	64	54	39	29	43	19	A-7-6(11)	CL
-------	98	95	89	63	56	44	32	27	35	13	A-6(7)	ML-CL
100	98	97	92	68	64	53	39	33	38	15	A-6(9)	ML-CL
100	96	93	88	69	65	57	47	37	40	19	A-6(10)	CL
100	97	94	88	72	67	61	50	35	46	24	A-7-6(14)	CL

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are SM-SC and ML-CL.

[4] 100 percent passed 2-inch sieve.

[5] Nonplastic.

[6] 100 percent passed 1½-inch sieve.

[7] 100 percent passed 1-inch sieve.

TABLE 5.—*Estimates of soil properties*

[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 for referring to other series that appear in the first column

Soil series and map symbols	Depth to—		Depth from surface (typical profile)	Classification		
	Bedrock	Seasonal high water table		Dominant USDA texture	Unified	AASHO
	Ft.	*Ft.*	*In.*			
*Arnegard: AgA, AgB. For Grassna part of AgA and AgB, see Grassna series.	>5	>5	0–38	Silt loam or loam	CL	A–6
			38–53	Clay loam	CL	A–6
*Arveson: Ar, As. For Stirum part of Ar and As, see Stirum series.	>5	0–3	0–41	Fine sandy loam	ML or SM	A–4 or A–2
			41–60	Loamy fine sand	SM	A–2
Banks: Ba, Bf, Bk	>5	>5	0–60	Loamy fine sand or fine sand.	SM	A–2
*Belfield: BrA, BrB, Bs. For Rhoades part of BrA, BrB, and Bs, see Rhoades series. For Grail part of Bs, see Grail series.	0–3	5	0–16	Silt loam or silty clay loam.	CL	A–6
			16–44	Silty clay loam or clay loam.	CL or CH	A–7
			44–60	Silty clay	CL or CH	A–7
Blown-out land: Bt. No valid estimates can be made.	>5	>5				
Colvin: Ch	>5	0–3	0–48	Silty clay loam	CL	A–6 or A–7
			48–60	Coarse sand	SP or SM	A–1 or A–2
*Daglum: Da, Dg. For Belfield and Harriet parts of Da, see Belfield and Harriet series. For Rhoades part of Dg, see Rhoades series.	0–3	>5	0–8	Silt loam or silty clay loam	CL	A–6
			8–60	Silty clay	CH	A–7
Dimmick: Dk	>5	>5	0–50	Silty clay or silty clay loam	CH	A–7
			50–60	Silty clay loam or sandy clay loam.	CH or CL	A–6 or A–7
*Flasher: FhC, FmE, FrF. For Vebar part of FmE and FrF, see Vebar series.	0–1.5	>5	0–19	Fine sandy loam or loamy fine sand.	SM	A–4 or A–2
			19–60	Bedded sandstone	----------	----------
*Flaxton: Fs, FtB, FvB. For Livona part of FtB and FvB, see Livona series.	>5	>5	0–22	Fine sandy loam or loamy fine sand.	SM or ML	A–2 or A–4
			22–60	Clay loam	CL	A–6
Grail: GlA, GlB, GrA, GrB	>5	>5	0–16	Silt loam or silty clay loam	CL	A–6 or A–7
			16–60	Silty clay	CL or CH	A–7
Grassna. Mapped only with Arnegard soils.	>5	>5	0–60	Silt loam	CL	A–6
*Harriet: Hh, Hk. For Regan part of Hk, see Regan series.	>5	0–3	0–18	Clay loam	CL or CH	A–7
			18–60	Loam, clay loam, and very fine sandy loam.	CL or ML–CL	A–4 or –6
Havrelon:						
Hm, Hn, Hr	>5	0–5	0–60	Loam, silty clay loam, and silt loam.	ML or CL	A–4, A–6, or A–7
Ho	>5	0–5	0–18	Loam	ML	A–4
			18–60	Silty clay or clay	CH	A–7
Heil: Hs	>5	>5	0–60	Clay	CH	A–7
Lallie: La	>5	0–3	0–13	Silty clay loam	CL	A–7
			13–60	Silty clay, clay, or silty clay loam.	CH	A–7

See footnote at end of table.

significant in engineering

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions of this table. The symbol < means less than, > means more than]

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity—Concrete and uncoated steel
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
				In./hr.	*In./in. of soil*	*pH*			
100	100	90–100	50–90	0. 63–2. 0	0. 15–0. 17	6. 6–7. 3	None	Moderate	Moderate.
100	95–100	90–100	50–100	0. 63–2. 0	0. 15–0. 17	7. 4–7. 8	None	Moderate	Moderate.
100	100	70–85	25–60	2. 0–6. 3	0. 10–0. 12	7. 9–8. 4	Slight or moderate.	Low	High.
100	100	70–85	15–35	6. 3–20. 0	0. 05–0. 07	7. 9–8. 4	Moderate	Low	High.
100	100	70–95	10–25	6. 3–20. 0	0. 05–0. 10	7. 4–7. 8	None	Low	Moderate.
100	100	95–100	65–85	0. 63–2. 0	0. 18–0. 20	6. 1–7. 3	None	Moderate	High.
100	100	95–100	95–100	0. 20–0. 63	0. 17–0. 19	7. 9–8. 4	None or moderate.	High	High.
100	100	95–100	75–95	0. 06–0. 63	0. 15–0. 17	7. 9–8. 4	Moderate or severe.	High	High.
100	100	95–100	85–100	0. 63–2. 0	0. 19–0. 21	7. 4–8. 4	Slight or moderate.	Moderate	High.
100	100	35–60	5–15	6. 3–20. 0	0. 03–0. 06	7. 9–8. 4	Slight or moderate.	Low	High.
100	100	90–100	85–100	0. 63–2. 0	0. 16–0. 20	7. 4–7. 8	None	Moderate	High.
100	100	90–100	85–100	0. 06–0. 20	0. 12–0. 14	7. 4–9. 0	Moderate or severe.	High	High.
100	100	100	75–95	0. 06–0. 20	0. 15–0. 18	6. 6–7. 8	None	High	High.
100	100	85–100	50–90	0. 06–0. 20	0. 14–0. 17	7. 4–8. 4	None	High	High.
100	95–100	50–85	25–45	6. 3–20. 0	0. 10–0. 14	6. 6–7. 8	None	Low	Moderate.
--------	--------	--------	--------	0. 63–6. 3	0. 05–0. 07	7. 9–8. 4	None	Low	Moderate
100	100	60–85	25–55	2. 0–6. 3	0. 10–0. 14	6. 6–7. 8	None	Low	Moderate.
95–100	95–100	85–95	60–80	0. 20–0. 63	0. 15–0. 17	7. 4–7. 8	None	Moderate	High.
100	100	95–100	50–90	0. 63–2. 0	0. 15–0. 17	6. 6–7. 3	None	Moderate	High.
100	100	95–100	85–95	0. 20–0. 63	0. 18–0. 20	7. 4–8. 4	None or slight	Moderate to high.	High.
100	100	95–100	75–90	0. 63–2. 0	0. 19–0. 21	6. 6–7. 8	None	Moderate	Moderate.
100	100	95–100	75–90	0. 06–0. 20	0. 10–0. 14	6. 5–9. 0	Severe	High	High.
100	100	85–95	60–90	0. 06–2. 0	0. 10–0. 14	7. 9–9. 0	Severe	Moderate to high.	High.
100	100	85–100	50–80	0. 63–2. 0	0. 15–0. 20	7. 4–7. 8	None	Moderate	High.
100	100	100	80–95	0. 63–2. 0	0. 14–0. 16	7. 4–7. 8	None	Moderate	High.
100	100	95–100	85–95	0. 06–0. 20	0. 16–0. 18	7. 4–7. 8	None	High	High.
100	100	100	80–95	<0. 06	0. 11–0. 14	7. 9–9. 0	Moderate	High	High.
100	100	95–100	85–100	0. 06–0. 20	0. 16–0. 18	7. 4–7. 8	None	High	High.
100	100	95–100	85–100	0. 06–0. 20	0. 11–0. 14	7. 4–7. 8	None	High	High.

TABLE 5.—*Estimates of soil properties*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface (typical profile)	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO
	Ft.	*Ft.*	*In.*			
Lehr: LeA, LeB, LeC	>5	>5	0–17	Loam	ML	A–4
			17–60	Gravel and gravelly sandy loam.	SM or GM	A–1 or A–2
*Lihen: LfA, LhD, LkC, LlB, LmC. For Livona and Parshall parts of LhD and LkC, see Livona and Parshall series. For Telfer part of LkC, LlB, and LmC, see Telfer series.	>5	>5	0–20	Loamy fine sand or fine sandy loam.	SM	A–2 or A–4
			20–60	Loamy fine sand	SM	A–2
Lg	>5	>5	0–18	Loamy fine sand	SM	A–2
			18–60	Clay	CL or CH	A–7
*Linton: LnD, LnE. For Mandan part of LnD and LnE, see Mandan series.	>5	>5	0–60	Silt loam	ML	A–4
*Livona: LoC, LrC, LsD, LtF, LuD. For Flaxton part of LoC and LrC, see Flaxton series. For Lihen part of LsD and LtF, see Lihen series. For Flasher part of LtF, see Flasher series. For Williams part of LuD, see Williams series.	>5	>5	0–15	Fine sandy loam or loamy fine sand.	SM	A–2 or A–4
			15–60	Clay loam and loam.	CL	A–6
Lohler: Lv, Lw, Ly	>5	0–5	0–8	Silt loam, silty clay loam, and silty clay.	CL or CH	A–6 or A–7
			8–60	Silty clay or clay	CH	A–7
Magnus: Ma	>5	>5	0–7	Silty clay loam or silty clay	CL or CH	A–7
			7–60	Silty clay	CH	A–7
*Makoti: MkA, MlB. For Williams part of MlB, see Williams series.	>5	>5	0–42	Silty clay loam	CL	A–7
			42–60	Silty clay loam or silty clay	CL or CH	A–7
*Mandan: MnA, MoB, MoC. For Linton part of MoB and MoC, see Linton series.	>5	>5	0–47	Silt loam	ML	A–4
			47–60	Loam or fine sandy loam	ML	A–4
Manning: MrA, MrB, MrC	>5	>5	0–25	Fine sandy loam	SM or ML	A–4
			25–60	Coarse sand and gravel	SM or GM	A–1 or A–2
*Max: MsC. For Zahl part of MsC, see Zahl series.	>5	>5	0–60	Loam or clay	ML or CL	A–4 or A–6
Mine pits and dumps: Mt. No valid estimates can be made.						
*Miranda: Mu. For Noonan part of Mu, see Noonan series.	>5	>5	0–6	Silty clay or clay	CL or CH	A–7
			6–60	Clay loam	CL or CH	A–6 or A–7
Morton: MvB, MvC	3	>5	0–12	Silt loam	ML or CL	A–4 or A–6
			12–38	Silty clay loam	CL	A–7
			38–60	Soft siltstone		

See footnote at end of table.

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity—Concrete and uncoated steel
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
				In./hr.	*In./in. of soil*	*pH*			
90–100	85–95	80–90	50–65	2. 0–6. 3	0. 12–0. 14	6. 6–7. 3	None	Low	Moderate.
60–80	40–65	20–40	5–25	>20. 0	0. 04–0. 06	7. 4–7. 8	None	Low	Low.
100	100	90–100	15–40	6. 3–20. 0	0. 13–0. 15	6. 6–7. 3	None	Low	Moderate for uncoated steel; low for concrete.
100	100	90–100	15–30	6. 3–20. 0	0. 10–0. 12	7. 4–7. 8	None	Low	Moderate for uncoated steel; low for concrete.
100	100	90–100	15–30	6. 3–20. 0	0. 13–0. 15	6. 6–7. 3	None	Low	Moderate.
100	100	90–100	75–100	0. 06–0. 20	0. 11–0. 14	7. 4–8. 4	None to slight	High	High.
100	100	90–100	70–90	0. 63–2. 0	0. 19–0. 21	7. 4–7. 8	None	Low	High.
100	100	60–85	25–45	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	None	Low	Moderate.
95–100	95–100	85–95	60–80	0. 20–0. 63	0. 15–0. 17	7. 4–8. 4	None	Moderate	High.
100	100	95–100	85–95	0. 20–0. 63	0. 19–0. 21	7. 4–7. 8	None	Moderate to high.	High.
100	100	95–100	85–95	0. 06–0. 20	0. 18–0. 20	7. 4–8. 4	None	High	High.
100	100	95–100	90–95	0. 20–0. 63	0. 16–0. 18	7. 4–7. 8	None	High	High.
100	100	95–100	90–95	0. 20–0. 63	0. 16–0. 18	7. 4–7. 8	None to slight	High	High.
100	100	90–100	90–95	0. 20–0. 63	0. 19–0. 21	6. 6–7. 8	None	Moderate	High.
100	100	90–100	90–95	0. 20–0. 63	0. 18–0. 20	7. 4–8. 4	None	High	High.
100	100	90–100	80–90	0. 63–2. 0	0. 18–0. 20	7. 4–8. 4	None	Low	Moderate.
100	100	80–95	50–70	0. 63–6. 3	0. 14–0. 18	7. 4 8. 4	None	Low	Moderate.
95–100	90–95	70–85	35–60	2. 0–6. 3	0. 14–0. 16	6. 6–7. 3	None	Low	Moderate.
60–80	40–65	25–60	10–20	>20. 0	0. 05–0. 07	7. 4–8. 4	None	Low	Moderate for uncoated steel; low for concrete.
95–100	90–95	85–95	60–80	0. 63–2. 0	0. 16–0. 18	6. 6–8. 4	None	Moderate	Moderate.
95–100	90–95	85–95	70–85	<0. 06	0. 06–0. 08	6. 6–8. 4	Slight to severe	High	High.
95–100	90–95	80–95	60–80	0. 06–0. 20	0. 08–0. 10	8. 5–9. 0	Moderate	High	High.
100	100	90–100	70–90	0. 63–2. 0	0. 18–0. 20	6. 6–7. 3	None	Moderate	Moderate.
100	100	90–100	70–90	0. 63–2. 0	0. 18–0. 20	7. 4–8. 4	None	Moderate	Moderate.
--------	--------	--------	--------	0. 06–0. 20	0. 04–0. 08	7. 8–8. 4	None	Low to moderate.	Moderate.

TABLE 5.—*Estimates of soil properties*

Soil series and map symbols	Depth to—		Depth from surface (typical profile)	Classification		
	Bedrock	Seasonal high water table		Dominant USDA texture	Unified	AASHO
	Ft.	*Ft.*	*In.*			
*Niobell: NbA, NbB. For Noonan part of NbA and NbB, see Noonan series.	>5	>5	0–10	Loam	CL	A–6
			10–60	Clay loam	CL	A–6 or A–7
Noonan. Mapped only with Miranda and Niobell soils.	>5	>5	0–6	Loam	CL	A–6
			6–60	Clay loam	CL or CH	A–6 or A–7
Parnell: Pa	>5	0–5	0–5	Silty clay loam	CL	A–7
			5–60	Silty clay and clay	CH	A–7
*Parshall: PhA, PhB, PlA, PtB. For Lihen part of PlA and PtB, see Lihen series. For Telfer part of PtB, see Telfer series.	>5	>5	0–46	Fine sandy loam	SM	A–4 or A–2
			46–60	Loamy fine sand, fine sandy loam, and clay loam.	SM or CL	A–2 or A–4
Pk	>5	>5	0–40	Fine sandy loam	SM	A–4 or A–2
			40–60	Clay or silty clay	CL or CH	A–7
Regan: Rc	>5	0–3	0–28	Silty clay loam	CL	A–7
			28–60	Clay loam and sandy clay loam.	CL	A–6
*Regent: RgC, RhB. For Grail part of RhB see Grail series.	3	>5	0–5	Silty clay loam	CL	A–7
			5–38	Silty clay and silty clay loam.	CL or CH	A–7
			38–60	Soft platy shale	----------	----------
*Rhoades: Rm, Rn. For Daglum part of Rn, see Daglum series.	>5	>5	0–60	Silty clay loam and silty clay.	CL or CH	A–7
Riverwash: Rv. No valid estimates can be made.						
*Roseglen: RwA. For Tansem part of RwA, see Tansem series.	>5	>5	0–60	Silt loam	ML or CL	A–4 or A–6
Savage: SeA, SeB, SeC, SgA, SgB	>5	>5	0–8	Silt loam or silty clay loam.	CL	A–6 or A–7
			8–60	Silty clay or silty clay loam.	CL or CH	A–7
Sen: SnB, SnC, SnD	0–3	>5	0–40	Silt loam	ML or CL	A–4 or A–6
			40–60	Platy shale	----------	----------
Seroco. Mapped only with Telfer soils.	>5	>5	0–60	Fine sand	SM or SP	A–2 or A–3
Stirum. Mapped only with Averson soils.	>5	0–4	0–21	Fine sandy loam	SM or ML	A–4
			21–60	Loamy fine sand and fine sand.	SM	A–2 or A–4
*Straw: St, Sv. For Arnegard and Colvin parts of Sv, see Arnegard and Colvin series.	>5	>5	0–60	Silt loam	CL or ML	A–4 or A–6
*Tansem: TaC, TeA, TgB. For Lehr part of TeA, see Lehr series. For Roseglen part of TgB, see Roseglen series.	>5	>5	0–60	Silt loam	ML or CL	A–4 or A–6

See footnote at end of table.

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity—Concrete and uncoated steel
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
				In./hr.	*In./in. of soil*	*pH*			
95–100	90–95	85–95	65–85	0. 20–0. 63	0. 16–0. 18	6. 6–7. 3	None	Moderate	High.
95–100	90–95	85–95	60–80	0. 20–0. 63	0. 16–0. 18	7. 4–8. 4	Slight to moderate.	Moderate	High.
95–100	90–95	85–95	60–85	0. 06–0. 20	0. 16–0. 18	6. 6–7. 3	None	Moderate	High.
95–100	90–95	85–95	60–80	0. 06–0. 20	0. 12–0. 14	8. 4–9. 0	Moderate to severe.	High	High.
100	100	100	90–100	0. 63–2. 0	0. 19–0. 21	6. 6–7. 3	None	Moderate	High.
100	100	90–100	90–100	0. 06–0. 20	0. 19–0. 21	6. 6–7. 8	None	High	High.
100	100	80–95	25–45	2. 0–6. 3	0. 13–0. 15	6. 6–7. 3	None	Low	Moderate.
100	95–100	85–100	20–60	0. 20–6. 3	0. 08–0. 09	7. 4–8. 4	None	Low to moderate	Moderate.
100	100	80–95	25–45	2. 0–6. 3	0. 13–0. 15	6. 6–7. 3	None	Low	Moderate.
100	100	95–100	90–95	0. 06–0. 20	0. 12–0. 14	7. 4–8. 4	Low	High	High.
100	100	90–100	85–95	0. 63–2. 0	0. 12–0. 16	7. 4–8. 4	Slight or moderate	Moderate	High.
100	100	80–90	50–90	0. 63–2. 0	0. 12–0. 16	7. 9–9. 0	Moderate	Moderate	High.
100	100	95–100	80–95	0. 20–0. 63	0. 19–0. 21	6. 6–7. 3	None	Moderate	High.
100	100	95–100	80–95	0. 06–0. 20	0. 17–0. 19	7. 4–8. 4	None	High	High.
--------	--------	--------	--------	<0. 20	0. 04–0. 08	7. 4–9. 0	None to slight	High	High.
100	95–100	95–100	80–95	<0. 06	0. 03–0. 05	7. 9–9. 0	Moderate or severe.	High	High.
100	100	85–100	70–95	0. 63–2. 0	0. 19–0. 21	6. 6–8. 4	None	Moderate	Moderate.
100	100	90–100	80–95	0. 63–2. 0	0. 18–0. 20	6. 6–7. 3	None	Moderate	High.
100	100	90–100	80–95	0. 20–0. 63	0. 17–0. 19	7. 9–8. 4	None	High	High.
100	100	95–100	70–90	0. 63–2. 0	0. 18–0. 20	6. 6–7. 8	None	Moderate	Moderate.
--------	--------	--------	--------	0. 06–0. 20	0. 08–0. 10	7. 4–9. 0	None	Low to moderate.	Moderate.
100	100	70–90	5–25	6. 3–20. 0	0. 03–0. 05	6. 6–7. 3	None	Low	Low.
100	100	70–85	40–60	0. 20–0. 63	0. 12–0. 14	7. 9–9. 0	Moderate	Low	High.
100	95–100	70–85	20–40	2. 0–6. 3	0. 05–0. 09	7. 9–9. 0	Moderate	Low	High.
100	100	85–100	65–80	0. 63–2. 0	0. 19–0. 21	7. 4–8. 4	None	Moderate	High.
100	100	85–100	70–95	0. 63–2. 0	0. 19–0. 21	6. 6–8. 4	None	Moderate	Moderate.

TABLE 5.—*Estimates of soil properties*

Soil series and map symbols	Depth to—		Depth from surface (typical profile)	Classification		
	Bedrock	Seasonal high water table		Dominant USDA texture	Unified	AASHO
	Ft.	*Ft.*	*In.*			
*Telfer: ThA, TlD, Tm. For Lihen part of ThA and TlD, see Lihen series. For Seroco part of Tm, see Seroco series.	>5	>5	0–60	Loamy fine sand, fine sand, or loamy sand.	SM	A–2
Temvik: TnA, TnB, TnC	>5	>5	0–22	Silt loam	ML	A–4
			22–60	Loam and clay loam	CL	A–6 or A–7
Tiffany: To	>5	0–5	0–38	Loam or fine sandy loam	SM or ML	A–4
			38–60	Loamy fine sand	SM	A–2 or A–4
*Tonka: Tp. For Parnell part of Tp, see Parnell series.	>5	0–5	0–13	Silt loam and silty clay loam.	ML or CL	A–6 or A–7
			13–46	Silty clay loam and silty clay.	CL or CH	A–7
			46–60	Clay loam	CL	A–6 or A–7
Vebar: VbB, VbC	3	>5	0–36	Fine sandy loam	SM or ML	A–4
			36–60	Bedded sandstone	----------	----------
Wabek: WaB, WaD	>5	>5	0–9	Loam or gravelly sandy loam	SM	A–2
			9–60	Sand and gravel	SM or GM	A–1
*Werner: WcF, WeE, WlC, Wn. For Morton part of WeE, see Morton series. For Sen part of WeE and WlC, see Sen series.	0–1.5	>5	0–17	Loam	ML or CL	A–4 or A–6
			17–60	Sandstone and shale	----------	----------
*Williams: WsA, WsB, WsC, WsD, WzE, WzF. For Zahl part of WzE and WzF, see Zahl series.	>5	>5	0–10	Loam	ML or CL	A–4 or A–6
			10–60	Loam or clay loam	CL	A–6
WoC	>5	>5	0–60	Loam, stony loam, and clay loam.	ML or CL	A–4 or A–6
Zahl. Mapped only with Max and Williams soils.	>5	>5	0–7	Loam	ML or CL	A–4 or A–6
			7–60	Loam or clay loam	CL	A–6

[1] 15 to 25 percent of material more than 3 inches in diameter.

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity—Concrete and uncoated steel
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
				In./hr.	*In./in. of soil*	*pH*			
100	100	70–90	5–35	6. 3–20. 0	0. 03–0. 07	6. 6–7. 8	None	Low	Moderate
100	100	90–100	80–95	0. 63–2. 0	0. 19–0. 21	6. 6–7. 8	None	Moderate	Moderate.
90–95	90–95	85–95	60–75	0. 20–0. 63	0. 15–0. 17	7. 4–8. 4	None	Moderate	High.
100	100	75–90	40–70	2. 0–6. 3	0. 13–0. 15	6. 6–7. 3	None	Low	High.
100	100	80–90	30–50	2. 0–6. 3	0. 05–0. 10	7. 4–7. 8	None	Low	High.
100	100	85–95	65–95	0. 63–2. 0	0. 19–0. 21	5. 6–7. 3	None	Moderate	High.
100	100	85–95	75–95	0. 06–0. 20	0. 15–0. 17	6. 1–7. 8	None	High	High.
95–100	90–95	85–95	65–90	0. 20–0. 63	0. 14–0. 17	7. 4–7. 8	None	High	High.
95–100	95–100	85–100	40–55	2. 0–6. 3	0. 12–0. 14	6. 6–7. 8	None	Low	Moderate.
--------	--------	--------	--------	0. 20–2. 0	0. 06–0. 08	7. 9–8. 4	None to slight	Low	Moderate.
85–95	70–80	50–75	15–30	6. 3–20. 0	0. 09–0. 10	6. 6–7. 3	None	Low	Moderate.
55–80	30–60	20–40	5–20	6. 3–20. 0	0. 03–0. 05	7. 4–8. 4	None	Low	Low.
95–100	95–100	75–90	65–85	0. 63–2. 0	0. 16–0. 18	6. 6–7. 8	None	Moderate	High.
--------	--------	--------	--------	0. 06–0. 63	0. 08–0. 10	7. 4–8. 4	None or slight	Moderate	High.
95–100	95–100	85–95	60–80	0. 63–2. 0	0. 16–0. 18	6. 6–7. 3	None	Low	Moderate.
95–100	95–100	85–95	60–80	0. 20–0. 63	0. 16–0. 18	7. 8–8. 4	None	Moderate	High.
[1] 75–85	75–85	70–85	50–80	0. 20–0. 63	0. 16–0. 18	6. 6–8. 4	None	Moderate	High.
95–100	95–100	85–95	50–80	0. 63–2. 0	0. 16–0. 18	7. 4–7. 8	None	Low	Moderate.
95–100	95–100	85–95	50–80	0. 20–0. 63	0. 16–0. 18	7. 9–8. 4	None	Moderate	High.

TABLE 6.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in referring to other series that

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
*Arnegard: AgA, AgB. For Grassna part of AgA and AgB, see Grassna series.	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.
*Arveson: Ar, As. For Stirum part of Ar and As, see Stirum series.	Severe: seasonal high water table.	Severe: seasonal high water table; moderately rapid permeability.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table; moderately rapid permeability.	Severe: poorly drained.
Banks: Ba, Bf, Bk	Severe: subject to flooding; seasonal high water table.	Severe: rapid permeability; subject to flooding.	Moderate: subject to flooding.	Moderate: subject to flooding.	Severe: subject to flooding; rapid permeability.	Moderate: subject to flooding.
*Belfield: BrA, BrB, Bs. For Rhoades part of BrA, BrB, and Bs, see Rhoades series. For Grail part of Bs, see Grail series.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Slight	Severe: high shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential.
Blown-out land: Bt. No interpretations can be made.						
Colvin: Ch	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.
*Daglum: Da, Dg. For Belfield and Harriet parts of Da, see Belfield and Harriet series. For Rhoades part of Dg, see Rhoades series.	Severe: slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Slight	Severe: high shrink-swell potential.	Moderate: texture.	Severe: texture; high shrink-swell potential.
Dimmick: Dk	Severe: slow permeability.	Slight	Moderate: poorly drained.	Severe: high shrink-swell potential.	Moderate: poorly drained.	Severe: high shrink-swell potential.
*Flasher: FhC, FmE, FrF For Vebar part of FmE and FrF, see Vebar series.	Severe: depth to bedrock.	Severe: slope; depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.

See footnote at end of table.

interpretations

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for appear in the first column of this table]

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Fair: moderate shrink-swell potential.	Unsuitable.	Good	All features favorable.	Compaction characteristics; piping hazard.	No drainage needed.	All features favorable.	All features favorable.	All features favorable.
Poor: poorly drained.	Unsuitable.	Poor: soluble salt; poorly drained.	All features favorable for excavated ponds.	Poor compaction; piping hazard.	Seasonal high water table.	Poorly drained and very poorly drained.	Not needed.	Not needed.
Fair: binder needed in places.	Fair: contains fines.	Poor: low organic-matter content.	Rapid permeability.	Poor compaction; piping hazard.	Seasonal high water table.	Available water capacity.	Not needed.	Not needed.
Fair: moderate shrink-swell potential.	Unsuitable.	Fair: texture.	All features favorable.	Moderate shrink-swell potential.	No drainage needed.	Slow intake rate.	Not needed.	All features favorable.
Fair: moderate shrink-swell potential; poorly drained.	Unsuitable.	Poor: poorly drained.	All features favorable for excavated ponds.	Moderate shrink-swell potential.	Seasonal high water table.	Poorly drained.	Not needed.	Not needed.
Poor: high shrink-swell potential.	Unsuitable.	Poor: texture; depth; alkalinity.	All features favorable.	High shrink-swell potential.	Slow permeability.	Slow intake rate.	Slow permeability.	Alkalinity.
Poor: high shrink-swell potential.	Unsuitable.	Poor: texture.	All features favorable for excavated ponds.	High shrink-swell potential.	Slow permeability.	Slow intake rate.	Not needed.	Not needed.
Fair: depth to bedrock.	Unsuitable.	Fair: depth; low organic-matter content.	Shallow over bedrock.	Poor compaction; piping hazard.	Steep slope.	Shallow over bedrock.	Steep slope.	Erosion; slope.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
*Flaxton: Fs, FtB, FvB. For Livona part of FtB and FvB, see Livona series.	Severe: moderately slow permeability.	Slight	Moderate: texture.	Moderate: moderate shrink-swell potential.	Moderate	Moderate: moderate shrink-swell potential.
Grail: GlA, GlB, GrA, GrB.	Severe: moderately slow permeability.	Moderate: moderately slow permeability.	Moderate: texture.	Severe: high to moderate shrink-swell potential.	Moderate: moderately slow permeability.	Severe: high to moderate shrink-swell potential.
Grassna. Mapped only with Arnegard soils.	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.
*Harriet: Hh, Hk. For Regan part of Hk, see Regan series.	Severe: slow permeability; subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high shrink-swell potential; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Moderate: subject to flooding; high shrink-swell potential.
Havrelon: Hm, Hn, Ho, Hr.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Moderate: subject to flooding.
Heil: Hs	Severe: very slow permeability.	Slight	Severe: poorly drained.	Severe: high shrink-swell potential; poorly drained.	Severe: poorly drained.	Severe: high shrink-swell potential.
Lallie: La	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high shrink-swell potential; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: high shrink-swell potential.
Lehr: LeA, LeB, LeC	Slight: rapid permeability; possible pollution hazard.	Severe: rapid permeability.	Slight	Slight	Severe: rapid permeability.	Slight
*Lihen: LfA, Lg, LhD, LkC, LlB, LmC. For Parshall and Livona parts of LhD and LkC, see Livona and Parshall series. For Telfer part of LkC, LlB, and LmC, see Telfer series.	Slight if slope is less than 9 percent, moderate if more than 9 percent; restrictive layer below a depth of 40 inches in places.	Severe: rapid permeability.	Slight	Slight if slope is less than 9 percent, moderate if more than 9 percent.	Severe: rapid permeability.	Slight if slope is less than 9 percent, moderate if more than 9 percent.

See footnote at end of table.

interpretations—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Fair: moderate shrink-swell potential.	Poor: fines.	Good	Piping hazard; requires cutoff to hold water.	Piping hazard.	Not needed	Moderately slow permeability.	Uniformity of slope.	All features favorable.
Severe: high to moderate shrink-swell potential.	Unsuitable.	Fair: texture.	All features favorable.	Severe: shrink-swell potential.	Not needed	Slow intake rate.	Uniformity of slope.	All features favorable.
Fair: moderate shrink-swell potential.	Unsuitable	Good	Moderate permeability.	Moderate: shrink-swell potential.	Moderate permeability.	All features favorable.	Uniformity of slope.	All features favoorable
Poor: texture; high shrink-swell potential.	Unsuitable	Poor: soluble salts.	All features favorable.	High shrink-swell potential; low shear strength.	Slow permeability; flood hazard.	Slow intake rate; flood hazard.	Not needed.	Soluble salts.
Good	Unsuitable	Fair: texture.	Stratified material.	Piping hazard.	Flood hazard.	Flood hazard.	Not needed.	Not needed.
Severe: high shrink-swell potential.	Unsuitable.	Poor: texture; soluble salts.	All features favorable for excavated ponds.	High shrink-swell potential; compaction characteristics.	Very slow permeability; inadequate outlets.	Soluble salts; poorly drained.	Not needed.	Not needed.
Poor: high shrink-swell potential; seasonal high water table.	Unsuitable.	Poor: texture.	Not needed.	High shrink-swell potential; compaction characteristics.	Not needed.	Not needed.	Not needed.	Not needed.
Good	Poor for sand. Fair for gravel; shale content.	Good	Rapid permeability.	Compaction characteristics; piping hazard.	Not needed.	Low available water capacity.	Not needed.	Not needed.
Good	Poor for sand: fines. Unsuitable for gravel.	Fair: texture.	Rapid permeability.	Piping hazard.	Not needed.	Low available water capacity; slope.	Uniformity of slope.	Erosion.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
*Linton: LnD, LnE. For Mandan part of LnD and LnE, see Mandan series.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderate permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderate permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderate permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent.
*Livona: LoC, LrC, LsD, LtF, LuD. For Flaxton part of LoC and LrC, see Flaxton series. For Lihen part of LsD and LtF, see Lihen series. For Flasher part of LtF, see Flasher series. For Williams part of LuD, see Williams series.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderately slow permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderately slow permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent; moderately slow permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent.
Lohler: Lv, Lw, Ly	Severe: slow permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding.	Severe: high shrink-swell potential; frost action.
Magnus: Ma	Severe: subject to flooding; moderately slow permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding.	Severe: high shrink-swell potential.
*Makoti: MkA, MlB. For Williams part of MlB, see Williams series.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Slight	Severe: high shrink-swell potential.	Slight	Severe: high shrink-swell potential.
Mandan: MnA, MoB, MoC. For Linton part of MoB and MoC, see Linton series.	Slight	Moderate: moderate permeability.	Slight: possibility of sand below a depth of 40 inches.	Moderate: moderate potential frost action.	Moderate: moderate permeability.	Moderate: moderate potential frost action.
Manning: MrA, MrB, MrC.	Slight: rapid permeability; pollution hazard.	Severe: rapid permeability.	Slight	Slight	Severe: rapid permeability.	Slight
*Max: MsC. For Zahl part of MsC, see Zahl series.	Moderate: moderate permeability.	Moderate: moderate permeability; slope.	Slight	Moderate: moderate shrink-swell potential.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.

See footnote at end of table.

interpretations—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Fair: slope	Unsuitable.	Good	Moderate permeability; slope.	Compaction characteristics; piping hazard; shear strength.	Not needed.	Slope; erosion.	Slope	Slope; erosion.
Fair: moderate shrink-swell potential.	Poor: thickness; fines. Unsuitable for gravel.	Fair: texture.	Piping hazard; requires cutoff to hold water.	Compaction characteristics; piping hazard.	Not needed.	Slope; erosion.	Slope	Slope; erosion.
Poor: high shrink-swell potential.	Unsuitable.	Fair: texture.	All features favorable for excavated ponds.	High shrink-swell potential.	Slow permeability.	Flood hazard; slow intake rate.	Not needed.	Not needed.
Poor: high shrink-swell potential.	Unsuitable.	Fair: texture; depth.	All features favorable.	High shrink-swell potential; poor compaction.	Moderately slow permeability; flood hazard.	Flood hazard; slow intake rate.	Not needed.	Not needed.
Poor: high shrink-swell potential.	Unsuitable.	Fair: texture.	All features favorable.	High shrink-swell potential.	Moderately slow permeability.	Slow intake rate.	Moderately slow permeability.	All features favorable.
Good	Unsuitable.	Good	Moderate permeability.	Piping hazard; compaction characteristics.	Not needed.	All features favorable.	Uniformity of slope.	All features favorable.
Good	Fair for sand: fines. Good for gravel; check site for shale content.	Good	Rapid permeability.	Compaction characteristics; piping hazard.	Not needed	Low available water capacity.	Not needed.	Erosion; slopes more than 6 percent.
Fair: moderate shrink-swell potential.	Unsuitable	Fair: texture.	Moderate permeability.	Moderate shrink-swell potential.	Not needed	Slope	Uniformity of slope.	Slope.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
Mine pits and dumps: Mt. No interpretations can be made.						
*Miranda: Mu. For Noonan part of Mu, see Noonan series.	Severe: very slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Severe: dense claypan.	Severe: high shrink-swell potential.	Moderate: dense claypan.	Severe: high shrink-swell potential.
Morton: MvB, MvC	Severe: depth to bedrock.	Moderate: slope; moderate permeability.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Moderate: moderate shrink-swell potential; depth to bedrock.
*Niobell: NbA, NbB. For Noonan part of NbA and NbB, see Noonan series.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Slight	Moderate: moderate shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential; stones.
Noonan. Mapped only with Miranda and Niobell soils.	Severe: slow permeability.	Slight	Moderate: dense claypan.	Severe: high shrink-swell potential.	Moderate: dense claypan.	Severe: high shrink-swell potential.
Parnell: Pa	Severe: slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: high shrink-swell potential; subject to flooding.	Severe: subject to flooding.	Severe: high shrink-swell potential; subject to flooding.
*Parshall: PhA, PhB, Pk, PlA, PtB. For Lihen part of PlA and PtB, see Lihen series. For Telfer part of PtB, see Telfer series.	Slight	Severe: moderately rapid permeability.	Slight	Slight	Severe: moderately rapid permeability.	Slight
Regan: Rc	Severe: seasonal high water table.	Severe: seasonal high water table.	Moderate: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: very poorly drained.
*Regent: RgC, RhB. For Grail part of RhB, see Grail series.	Severe: slow permeability.	Moderate: slope.	Moderate: depth to bedrock.	Severe: high shrink-swell potential; depth to bedrock.	Moderate: depth to bedrock.	Moderate: high shrink-swell potential; depth to bedrock.
*Rhoades: Rm, Rn. For Daglum part of Rn, see Daglum series.	Severe: very slow permeability.	Slight	Severe: dense claypan.	Severe: high shrink-swell potential.	Moderate: dense claypan.	Severe: high shrink-swell potential.
Riverwash: Rv. No interpretations can be made.						

See footnote at end of table.

interpretations—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Poor: high shrink-swell potential.	Unsuitable	Poor: texture.	All features favorable for excavated ponds.	High shrink-swell potential; compaction characteristics.	Very slow permeability.	Slow intake rate.	Dense claypan.	Dense claypan.
Fair: moderate shrink-swell potential; depth to bedrock.	Unsuitable	Fair: depth.	Depth to bedrock.	Moderate shrink-swell potential.	Not needed	Depth to bedrock.	Uniformity of slope.	All features favorable.
Fair: moderate shrink-swell potential; stones.	Unsuitable	Fair: texture.	All features favorable for excavated ponds.	Moderate shrink-swell potential.	Not needed	Slow intake rate.	Slope	All features favorable.
Poor: high shrink-swell potential.	Unsuitable	Fair: depth.	All features favorable for excavated ponds.	High shrink-swell potential.	Not needed	Slow intake rate; dense claypan.	Not needed	Dense claypan.
Poor: high shrink-swell potential.	Unsuitable	Poor: poorly drained.	All features favorable for excavated ponds.	High shrink-swell potential.	Inadequate outlets.	Slow intake rate; poor drainage.	Not needed	Not needed.
Good	Poor: fines.	Good	Moderately rapid permeability.	Piping hazard; compaction characteristics.	Not needed	All features favorable.	Uniformity of slope.	All features favorable.
Fair: moderate shrink-swell potential.	Unsuitable	Poor: texture; soluble salts.	All features favorable for excavated ponds.	Compaction characteristics.	Inadequate outlets.	Seasonal high water table.	Not needed	Not needed.
Fair: high shrink-swell potential; depth to bedrock.	Unsuitable	Poor: texture.	Shallow over bedrock.	High shrink-swell potential.	Not needed	Shallow over bedrock.	Uniformity of slope.	All features favorable.
Poor: high shrink-swell potential.	Unsuitable	Poor: soluble salts.	All features favorable.	High shrink-swell potential.	Not needed	Dense claypan.	Dense claypan.	Dense claypan.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
*Roseglen: RwA. For Tansem part of RwA, see Tansem series.	Slight	Moderate: moderate permeability.	Slight	Moderate: moderate potential frost action.	Moderate: moderate permeability.	Moderate: moderate potential frost action.
Savage: SeA, SeB, SeC, SgA, SgB.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if more than 3 percent.	Moderate: texture.	Severe: high shrink-swell potential.	Slight	Severe: high shrink-swell potential.
Sen: SnB, SnC, SnD	Severe: depth to bedrock.	Severe: depth to bedrock.	Moderate: depth to bedrock.	Moderate: moderate shrink-swell potential.	Severe: depth to bedrock.	Moderate: moderate shrink-swell potential; depth to bedrock.
Seroco. Mapped only with Telfer soils.	Slight: rapid permeability; possible pollution hazard.	Severe: rapid permeability.	Slight	Slight	Severe: rapid permeability.	Slight
Stirum. Mapped only with Arveson soils.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.
*Straw: St, Sv. For Arnegard and Colvin parts of Sv, see Arnegard and Colvin series.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Moderate: moderate shrink-swell potential.
*Tansem: TaC, TeA, TgB. For Lehr part of TeA, see Lehr series. For Roseglen part of TgB, see Roseglen series.	Slight	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.
*Telfer: ThA, TlD, Tm. For Lihen part of ThA and TlD, see Lihen series. For Seroco part of Tm, see Seroco series.	Slight: rapid permeability; possible pollution hazard.	Severe: rapid permeability.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent.	Severe: rapid permeability.	Slight
Temvik: TnA, TnB, TnC.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if 3 to 9 percent.	Slight	Moderate: moderate shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential.
Tiffany: To	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.

See footnote at end of table.

interpretations—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Good	Unsuitable	Good	Moderate permeability.	Compaction characteristics; piping hazard.	Not needed	All features favorable.	All features favorable.	All features favorable.
Fair: high shrink-swell potential.	Unsuitable	Fair: texture.	All features favorable.	High shrink-swell potential; compaction characteristics.	Not needed	Slow intake rate.	Texture	Texture.
Fair: moderate shrink-swell potential; depth to bedrock.	Unsuitable	Fair: depth.	Shallow over bedrock.	Moderate shrink-swell potential; compaction characteristics.	Not needed	Shallow over bedrock.	Shallow over bedrock.	All features favorable.
Fair: binder needed in places.	Fair for sand: fines. Poor for gravel.	Poor: low organic-matter content.	Rapid permeability.	Piping hazard; compacted permeability.	Not needed	Low available water capacity.	Not needed	Not needed.
Poor: poorly drained.	Unsuitable	Poor: soluble salts.	All features favorable for excavated ponds.	Seasonal high water table.	Not needed; seasonal high water table.	Soluble salts; seasonal high water table.	Dense claypan.	Not needed.
Good	Unsuitable	Good	Moderate permeability.	Compaction characteristics; piping hazard.	Flood hazard.	Flood hazard.	All features favorable.	All features favorable.
Good	Unsuitable	Good	Moderate permeability.	Compaction characteristics; piping hazard.	Not needed	All features favorable.	Uniformity of slope.	All features favorable.
Fair: binder needed in places.	Unsuitable	Poor: texture.	Rapid permeability.	Compaction characteristics; piping hazard.	Not needed	Low available water capacity.	Uniformity of slope.	Not needed.
Fair: moderate shrink-swell potential.	Unsuitable	Fair: depth.	All features favorable.	Moderate shrink-swell potential.	Not needed	Slow intake rate.	Uniformity of slope.	All features favorable.
Good	Unsuitable	Poor: poorly drained.	All features favorable for excavated ponds.	Compaction characteristics; piping hazard.	Inadequate outlets.	Flood hazard.	Not needed	Not needed.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill [1]—Trench	Local roads and streets
*Tonka: Tp. For Parnell part of Tp, see Parnell series.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Vebar: VbB, VbC	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Moderate: depth to bedrock.
Wabek: WaB, WaD	Slight if slope is less than 9 percent, moderate if more than 9 percent; possible pollution hazard.	Severe: rapid permeability.	Moderate if slope is less than 15 percent, severe if more than 15 percent; stoniness.	Moderate if slope is less than 15 percent, severe if more than 15 percent; stoniness.	Severe: rapid permeability.	Slight if slope is less than 9 percent, moderate if slope is more than 9 percent.
*Werner: WcF, WeE, WIC, Wn. For Morton part of WeE, see Morton series. For Sen part of WeE and WIC, see Sen series.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.
*Williams: WoC, WsA, WsB, WsC, WsD, WzE, WzF. For Zahl part of WzE and WzF, see Zahl series.	Severe: moderately slow permeability.	Slight if slope is less than 3 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent.
Zahl. Mapped only with Max and Williams soils.	Severe: moderately slow permeability.	Severe if slope is more than 9 percent.	Moderate if slope is 9 to 15 percent, severe if more than 15 percent.	Moderate if slope is 9 to 15 percent, severe if more than 15 percent.	Moderate if slope is 9 to 15 percent, severe if more than 15 percent.	Moderate if slope is 9 to 15 percent, severe if more than 15 percent.

[1] Onsite studies of the underlying strata, water table, and hazards of aquifer pollution and drainage into ground water need to be made for land fill deeper than 5 or 6 feet.

interpretations—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grass waterways
Poor: high shrink-swell potential.	Unsuitable.	Poor: texture.	All features favorable for excavated ponds.	High shrink-swell potential.	Inadequate outlets.	Flood hazard.	Not needed.	Not needed.
Good	Unsuitable.	Fair: depth.	Shallow over bedrock.	Compaction characteristics; piping hazard.	Not needed.	Shallow over bedrock.	Uniformity of slope.	All features favorable.
Good: binder needed in places.	Fair: fines; check site for shale and iron oxide content.	Poor: depth.	Rapid permeability.	Compacted permeability.	Not needed.	Low available water capacity.	Not needed.	Not needed.
Poor: depth	Unsuitable.	Poor: depth.	Shallow over bedrock.	Shallow over bedrock.	Not needed.	Shallow over bedrock; slope.	Shallow over bedrock.	Not needed.
Good if slope is less than 15 percent, fair if more than 15 percent.	Unsuitable.	Poor	Slopes of more than 12 percent.	Stoniness	Not needed.	Slow intake rate; slope; stoniness.	Uniformity of slope.	All features favorable on slopes less than 6 percent.
Fair: texture	Unsuitable.	Poor	Slopes of more than 12 percent.	Stoniness	Not needed.	Slow intake rate; slope; stoniness.	Not needed.	Not needed.

(six classes), or highly organic (one class). The coarse-grained soils (less than half the material, by weight, passes the No. 200 sieve) are identified by the following symbols: GC, GW, GP, GM, SW, SP, SM, and SC. The fine-grained soils (more than half the material, by weight, passes the No. 200 sieve) are identified by the following symbols: ML, CL, OL, MH, CH, and OH.

Soil scientists use the USDA textural classification (*6*). In this, the texture of the soil is determined according to the proportion of soil particles smaller than 2 millimeters in diameter, that is, the proportion of sand, silt, and clay. Textural modifiers, such as gravelly, stony, shaly, and cobbly, are used as needed.

Table 4 shows the AASHO and Unified classifications of specified soils in Burleigh County as determined by laboratory tests. Table 5 shows the estimated classification of all the soils in the county according to all three systems of classification.

Engineering Test Data

Soil samples, representing 6 soil series, taken from 8 profiles in the county, were tested in accordance with standard procedures to help evaluate the soils for engineering purposes. The results of those tests are shown in table 4.

Moisture-density data are obtained by compacting soil material at a 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, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is the *maximum dry density*, and the corresponding moisture content is the *optimum moisture*. Moisture-density data are important in earthwork because, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density at approximately optimum moisture content.

The tests for plastic limit and liquid limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The *plastic limit* is the moisture content at which the soil material passes from a semisolid to a plastic state. The *liquid limit* is the moisture content at which the material passes from a plastic to a liquid state. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Estimated Properties

Table 5 shows estimates of soil properties significant in engineering. Some of the column headings are explained in the following paragraphs.

Depth to bedrock is shown as the depth to soft, bedded sandstone, shale, or siltstone.

Depth to seasonal high water table is shown as the highest level that ground water reaches in the soil in most years.

Permeability indicates the rate at which water moves downward through undisturbed soil material. The estimates are based on structure and porosity and on the results of permeability and infiltration tests on undisturbed cores of similar soil material.

Available water capacity is 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.

Reaction (pH) is the degree of acidity or alkalinity of a soil expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary. Soils that have a pH of less than 8.5 are likely to have higher consolidation potential and better shear strength than soils that have a pH of more than 8.5. A high degree of alkalinity, particularly a pH of more than 8.5, promotes dispersion.

Salinity refers to the amount of soluble salts. Soils that have moderate to severe salinity, as shown in table 5, contain gypsum. The gypsum content is not harmful if the soil material is to be used as borrow material. It is critical if the material is to be used in foundations, because abnormal porosity may result when the gypsum crystals dissolve.

Shrink-swell potential indicates the volume change to be expected when the moisture content of the soil material changes. It is based on the liquid limit and plasticity index of the soil. Shrink-swell potential is low if the liquid limit is 30 or less and the plasticity index is 10 or less; it is moderate if the liquid limit is 31 to 40 and the plasticity index is 11 to 20; it is high if the liquid limit is 41 to 60 and the plasticity index is 21 to 40. Coarse sand and gravel have such a very low shrink-swell potential that they are designated as having none.

Corrosivity, as used in table 5, refers to the detrimental chemical reaction that can be expected on concrete or uncoated steel when it is buried in the soil. Concrete may be affected by acid-salt crystals, such as sodium and magnesium sulfates. These salts are soluble. The salt solution enters the pores of concrete. When the concrete dries, the salt crystals reform and cause deterioration by expanding and rupturing the concrete material. Rusting or corrosion of uncoated steel in contact with soil is a process of oxidation, requiring air and water. Soil acidity, drainage, and texture all affect the corrosion of uncoated steel.

Engineering Interpretations

Table 6 shows the degree and kind of limitation for septic tanks and sewage lagoons for each soil in the county. It indicates suitability for local roads and streets, road fill, sand or gravel, and topsoil. It also provides interpretations for farm ponds, drainage, and irrigation. The following are explanations of some of the columns in table 6.

Septic tank absorption fields are influenced by the ease at which effluent moves downward through the soil. Soils

that have slow permeability are rated *severe*. Other properties that affect septic tank absorption fields are flood hazard, seasonal high water table, salinity and alkalinity, and topography.

Sewage lagoons require use of the soil as a reservoir for the impounded area and as material for the dam. In selecting a site, it must be considered whether soil material suitable for construction is available, and whether the soil holds water, having only minimum seepage. Soils that are subject to flooding have severe limitations as sites for lagoons. Floodwaters interfere with the functioning of the lagoon and carry away sewage before bacterial decomposition has taken place. Pollution of streams is a serious hazard.

Shallow excavations are those that require digging or trenching to a depth of 6 feet or less as, for example, excavations for underground utility lines, cemeteries, and open ditches. Desirable soil qualities and characteristics are good workability, moderate resistance to sloughing, gentle slopes, and no flood hazard.

The degree and kind of limitation for foundations of dwellings with basements are shown in table 6. All ratings are based on undisturbed soil to a depth of 5 feet. Included in the ratings are single family dwellings and other structures for which foundation requirements are similar. Excluded are buildings of more than 3 stories and buildings that have foundation loads exceeding 3 stories. Also considered in rating the limitations of soils for dwellings are slope and flood hazard or other hydrologic conditions, such as seasonal wetness. The properties affecting bearing strength and settlement of the natural soil are density, wetness, flood hazard, plasticity, texture, and shrink-swell behavior. Onsite investigations are needed for specific placement of buildings and utility lines and for detailed design or foundations.

Sanitary landfill is a method for disposing of refuse. The trench type of landfill is considered in table 6. Ratings apply only to a depth of about 6 feet, and therefore, limitation ratings of *slight* or *moderate* may not be valid if excavations are much deeper than 6 feet. Every site should be investigated before it is selected.

The trench type of sanitary landfill is a dug trench in which refuse is buried. The refuse is covered with at least 6 inches of compacted soil material.

Properties affecting use of the soils for sanitary landfill are depth to seasonal high water table, drainage, flood hazard, depth to bedrock, permeability, and slope.

Evaluations of soils for construction and maintenance of local roads and streets refer to improved roads and streets that have all-weather surfacing, commonly asphalt or concrete, and that are expected to carry automobile traffic all year. Excluded are highways designed for fast-moving heavy trucks. Properties that affect design and construction affect the load-supporting capacity and stability of the subgrade and the workability and amount of cut and fill. Wetness and flooding affect stability. Slope, depth to hard rock, stoniness, and wetness affect the ease of excavation and the amount of cut and fill needed to reach an even grade.

Road fill is soil material used in making embankments for roads. The suitability rating predicts how well the soil will perform after it has been placed in a road embankment and evaluates soil characteristics, such as slope, that affect the ease or difficulty of excavating the soil material.

The suitability of a soil as a source of sand or gravel depends on thickness of the layer and the quality of the material for road construction or concrete aggregate. A layer rated as *good* or *fair* should be at least 3 feet thick. Soils that are shown as suitable should be explored extensively to find material that meets gradation requirements for specific uses.

A *good* topsoil has physical, chemical, and biological characteristics favorable for the establishment and growth of common plants. It is friable and easy to handle and spread. Usually, only the surface layer is rated. If all other characteristics are favorable, a surface layer less than 6 inches thick is *poor*, and one about 12 inches thick is *good*.

The suitability of the soil for water impoundment or for pond reservoir areas is determined on the features and qualities of undisturbed soils. Properties most important are permeability, depth to water table, and depth to bedrock.

Properties of undisturbed soil that affect suitability for constructing earthfill are considered for embankment material. These properties include compaction characteristics, permeability when compacted, piping hazard, and salinity and alkalinity.

The factors considered for drainage are features and qualities of the soil that affect the installation and performance of surface and subsurface drainage systems. The somewhat poorly drained or very poorly drained soils have a seasonal or permanent high water table. They have severe limitations for crop production because water saturation excludes air from plant roots and permits only water-tolerant plants to grow.

Irrigation is affected by such features as available water capacity, water intake rate, slope, and natural drainage. The type of irrigation, sprinkler or gravity, was not considered in the interpretations given in table 6. Soils that have low available water capacity require frequent applications of water to maintain rapid plant growth. Soils that have slow permeability are somewhat difficult to irrigate. In order to avoid runoff, irrigation water must be applied very slowly to allow it to infiltrate the soil.

Factors considered for diversions and terraces are the features and qualities of soils that affect stability or hinder layout and construction.

Factors considered for grass waterways are the features and qualities of soils that affect the establishment, growth, and maintenance of plants, and the features and qualities that hinder layout and construction.

Formation and Classification of the Soils

This section describes the major factors of soil formation and tells how these factors have affected the soils in Burleigh County. It also defines the system of soil classification currently used and shows how the soils of the county have been classified according to the current 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 (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and plant and animal life, chiefly plants, are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a soil 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 profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. Usually a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated 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

Burleigh County is at the western edge of the glaciated part of North Dakota. More than three-fourths of the soils in Burleigh County formed in material of glacial origin, including loamy and clayey glacial till, glacial melt-water deposits, windborne silt and sand, and postglacial alluvium.

At least four glaciers invaded the survey area. Each left a residue of glacial drift. The earliest glacier that can be identified covered the entire county and left a thin mantle of drift. The last glacier covered only about 25 square miles in the northeast corner of the county.

The mantle of drift ranges from thin and patchy to continuous and many feet thick. It is thickest in the northern and eastern parts of the county. Glacial drift consists of glacial till and glacial melt-water deposits. Glacial till covers more than 400,000 acres of Burleigh County. The soils that formed on glacial till are the Williams, Max, Zahl, Niobel, Noonan, Miranda, Tonka, and Parnell soils and most of the soils in soil associations 7, 8, 9, and 11 (see General Soil Map).

Glacial melt-water deposits extend from the front of former glaciers and cover former glacial lakes. The most extensive area of these deposits in Burleigh County is a huge basin or valley that covers much of the southwestern third of the county. This basin consists of glacial outwash areas and a former glacial lake system, of which Long Lake is a remnant. There are smaller outwash areas and former glacial lakes in the northern and eastern parts of the county. Among the soils that formed in outwash are the Lehr, Wabek, and Manning soils. The most extensive soils in former glacial lakes are the Parnell, Roseglen, Tansem, Savage, and Regan soils. Most of the soils in soil associations 2, 3, 4, and 13 formed in glacial melt-water deposits.

Some of the more sandy melt-water deposits have been restored and redistributed by wind. As a result these are areas of undulating to dunelike topography. The Telfer and Seroco soils and most of the Lihen and Flaxton soils formed in these areas. These areas occur mostly in soil association 5, and to a lesser extent in soil association 4.

On the western and central uplands, substantial acreages of soil formed in material derived from soft shale, siltstone, and soft sandstone. Loess deposits a few inches to several feet thick cover several thousand acres east of, and adjacent to, the Missouri River. Recent alluvium, ranging in texture from clay to sand, covers the bottom lands of the Missouri River and other streams.

Most of the preglacial bedrock formations in Burleigh County are covered with loess, glacial drift, or recent alluvium. These formations are exposed in the western and west-central parts of the county, and in a few places in the southern part. The topography in these areas is gently sloping to steep. There are several buttes and many slopes leading into major drainageways, especially in soil associations 10, 11, and 12, in the western and west-central parts of the county.

The oldest of these preglacial formations is the Fox Hills Formation of Upper Cretaceous age. It is exposed in a few places in the southeastern part of the county. The next younger formation is the Hell Creek, also of Upper Cretaceous age, which is exposed in some of the bluffs in the southwestern and south-central parts of the county. The two formations that have extensive surface exposure are the Cannonball and the Tongue River, both of the Paleocene Fort Union Group. The Cannonball has extensive surface exposure in the western and central parts of the county and directly underlies the glacial drift in much of the eastern and northern parts of the county where sandstone buttes and ridges are common. Most of the Flasher, Vebar, and Sen soils and some of the Werner soils formed in material derived from the Tongue River Formation. Morton soils, most of the Werner soils, and a few of the Sen soils formed in material derived from the Cannonball Formation. Most of the soils in associations 6 and 10, and some in associations 11 and 12, formed in material derived from preglacial formations.

Recent alluvium covers the flood plains of the Missouri River, shown as soil association 1 on the General Soil Map. The principal soils that formed in recent alluvium are the Havrelon, Lohler, and Banks soils. Recent alluvium also occurs on the flood plains of creeks, and on this alluvium the Straw, Magnus, and Harriet soils formed.

Texture is generally the most important physical property of the parent material, because it determines the texture of the soil. For example, many of the soils that formed in sandy, wind-reworked outwash are too sandy for cultivation. In contrast, soils that formed in loess are silty, easily tilled, and easily penetrated by water and plant roots. Properties of parent material other than texture also have an important effect on the soil. For example, some soils that have an alkali claypan have formed in parent material high in sodium.

Climate

Burleigh County has warm summers and cold winters. The average annual precipitation is slightly more than 15 inches, three-fourths of which falls during the growing season.

Rainfall and temperature directly affect the soils of Burleigh County through weathering of parent material; leaching and redistribution of carbonates and clay particles in the soil profile, as in the Williams and Morton soils; and through accumulation of organic matter, as in the Arnegard and Grail soils. Rainfall and temperature are also directly responsible for the type of plant and animal life that contributes to soil development.

Chemical processes of weathering proceed more slowly in Burleigh County than in the warmer, more humid parts of the country. Frozen ground prevents soil leaching in winter. In summer, rainfall peaks when evaporation and transpiration are approaching their maximum. Rapid evaporation and maximum growth of vegetation at this period tend to decrease soil leaching. The older upland soils are leached of carbonates to a depth of about 12 to 24 inches.

Plant and animal life

Native vegetation consists mostly of short, mid, and tall grasses. Composition varies according to the site. In swale sites that receive extra moisture, the dominant species are tall and mid grasses, including green needlegrass, western wheatgrass, needle-and-thread, prairie sandreed, and big bluestem. On excessively drained sites, such as ridgetops, species are mainly short grasses, including blue grama, plains muhly, little bluestem, and threadleaf sedge. Among the species commonly found in the poorly drained sites are prairie cordgrass, rivergrass, reed canarygrass, switchgrass, and cattails.

In Burleigh County, native vegetation produces a large amount of organic matter that decays and is incorporated into the soil. In addition, the roots penetrate the soil and bring up calcium, phosphorus, potassium, and other nutrients. These nutrients are left near the surface as the plants decay.

Bacteria and other minute organisms have an important role in soil formation. They break down dead plant and animal matter to help form humus. Some forms of bacteria remove nitrogen from the atmosphere and, in association with legumes, convert it into a form that can be used by plants. Earthworms, some insects, and small rodents also affect soil development.

Relief

Relief, or lay of the land, affects soil formation in several ways. Water stands in some basins part or all of the time because of the relief pattern. Soils in such areas are poorly drained. They have many properties that differ from the other soils, including arrangement of soil horizons and mottling in the subsoil. The Dimmick, Parnell, and Tonka soils, for example, are poorly drained.

Poorly drained soils that have a high water table, for example, Colvin and Regan soils, contain a large amount of lime in the upper part of the profile. In soils that have a low water table, for example, Tonka and Tiffany soils, water movement is downward and the lime in many places is leached to a depth of more than 3 feet.

Nearly level to strongly sloping soils are most common in the survey area. On the tops of sharp ridges and knolls, where drainage is excessive, the soils are shallow, the organic-matter content is low, and lime is close to the surface. Examples are the Flasher, Wabek, Werner, and Zahl soils.

Time

Williams soils are considered to be the oldest soils in the survey area. They formed in glacial till, which according to geologists, ranges in age from about 12,000 to somewhat more than 38,000 years (*2*). They are dark colored, are high in organic-matter content, and have prismatic structure in the subsoil. Leaching has caused a noticeable increase of fine-clay particles in the subsoil and a layer of lime accumulation at a depth of 12 to 24 inches.

At the other extreme are the young soils in calcareous alluvium on bottom lands of the Missouri River. Havrelon soils are an example. They are light colored, have a low organic-matter content, and show no evidence of leaching or horizonation. They are uniformly limy throughout the profile and, in contrast with the older Williams soils, they do not have a layer of lime accumulation.

Loess from sandbars in the Missouri River is continually deposited on benches adjacent to the river, at a rate slow enough to permit some of the soil-forming processes to keep up with the rate of deposition. The two chief soils in such deposits are Mandan and Linton soils. They are young, but not so young as the bottom land soils. The accumulation of organic matter is nearly as much as in the much older soils on glacial till. Horizonation, however, is weak. There is no evidence that clay particles have been moved downward in the profile by leaching. In places, lime has been leached to a depth of less than 12 inches, and in contrast with the older soils, there is no zone of visible lime accumulation.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

The current system of soil classification (*3*, *5*) was adopted by the National Cooperative Soil Survey in 1965. It is a comprehensive system designed to accommodate all soils. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together.

The current system of classification has six categories. Beginning with the most inclusive, these categories are

the order, the suborder, the great group, the subgroup, the family, and the series.

Table 7 shows the classification of each soil series of Burleigh County by family, subgroup, and order, according to the current system. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions are the Entisols and Histosols, which occur in many different climates. Two soil orders are represented in Burleigh County. They are Mollisols and Entisols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only weakly expressed beginnings of such horizons. They do not have traits that reflect a mixing of the soil caused by shrinking and swelling.

Mollisols formed under grass. They have a thick, dark-colored surface horizon containing colloids that are dominated by bivalent cations. The soil material has not been mixed by shrinking and swelling.

SUBORDER.—Each order is divided into suborders, primarily on the basis of soil characteristics that seem to produce classes that have the greatest genetic similarity.

TABLE 7.—*Soil series classified according to the current system of classification*

Series	Classification		
	Family	Subgroup	Order
Arnegard	Fine-loamy, mixed	Pachic Haploborolls	Mollisols.
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Banks	Sandy, mixed, frigid	Typic Ustifluvents	Entisols.
Belfield	Fine, montmorillonitic	Glossic Natriborolls	Mollisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Daglum	Fine, montmorillonitic	Typic Natriborolls	Mollisols.
Dimmick	Fine, montmorillonitic, frigid	Vertic Haplaquolls	Mollisols.
Flasher	Mixed, frigid, shallow	Typic Ustipsamments	Entisols.
Flaxton	Fine-loamy, mixed	Pachic Argiborolls	Mollisols.
Grail	Fine, montmorillonitic	Pachic Argiborolls	Mollisols.
Grassna	Fine-silty, mixed	Pachic Haploborolls	Mollisols.
Harriet	Fine, mixed, frigid	Typic Natraquolls	Mollisols.
Havrelon	Fine-loamy, mixed, calcareous, frigid	Typic Ustifluvents	Entisols.
Heil	Fine, montmorillonitic, frigid	Typic Natraquolls	Mollisols.
Lallie	Fine, montmorillonitic, calcareous, frigid	Typic Fluvaquepts	Entisols.
Lehr	Fine-loamy over sandy or sandy-skeletal, mixed	Typic Haploborolls	Mollisols.
Lihen	Sandy, mixed	Entic Haploborolls	Mollisols.
Linton	Coarse-silty, mixed	Typic Haploborolls	Mollisols.
Livona	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Lohler	Fine, montmorillonitic, calcareous, frigid	Typic Ustifluvents	Entisols.
Magnus	Fine, montmorillonitic	Cumulic Haploborolls	Mollisols.
Makoti	Fine-silty, mixed	Typic Haploborolls	Mollisols.
Mandan	Coarse-silty over sandy or sandy-skeletal, mixed	Pachic Haploborolls	Mollisols.
Manning	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Max	Fine-loamy, mixed	Typic Haploborolls	Mollisols.
Miranda	Fine, mixed	Leptic Natriborolls	Mollisols.
Morton	Fine-silty, mixed	Typic Argiborolls	Mollisols.
Niobell	Fine-loamy, mixed	Glossic Natriborolls	Mollisols.
Noonan	Fine-loamy, mixed	Typic Natriborolls	Mollisols.
Parnell	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Parshall	Coarse-loamy, mixed	Pachic Haploborolls	Mollisols.
Regan	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Regent	Fine, montmorillonitic	Typic Argiborolls	Mollisols.
Rhoades	Fine, montmorillonitic	Leptic Natriborolls	Mollisols.
Roseglen	Fine-loamy, mixed	Pachic Haploborolls	Mollisols.
Savage	Fine, montmorillonitic	Typic Argiborolls	Mollisols.
Sen	Fine-silty, mixed	Typic Haploborolls	Mollisols.
Seroco	Mixed, frigid	Typic Ustipsamments	Entisols.
Stirum	Coarse-loamy, mixed, frigid	Typic Natraquolls	Mollisols.
Straw	Fine-loamy, mixed	Cumulic Haploborolls	Mollisols.
Tansem	Fine-loamy, mixed	Typic Haploborolls	Mollisols.
Telfer	Sandy, mixed	Entic Haploborolls	Mollisols.
Temvik	Fine-silty, mixed	Typic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Vebar	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Wabek	Sandy-skeletal, mixed	Entic Haploborolls	Mollisols.
Werner	Loamy, mixed, shallow	Entic Haploborolls	Mollisols.
Williams	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Zahl	Fine-loamy, mixed	Entic Haploborolls	Mollisols.

The suborder has a narrower climatic range than an order has. The criteria for suborders reflect either the presence of absence of waterlogging or differences in climate or vegetation.

GREAT GROUP.—Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major horizons and features. The horizons considered are those in which clay, iron, or humus has accumulated or those that have a pan that interferes with the growth of roots or the movement of water. Among the features selected are the self-mulching properties of clay, the soil temperature, and the major differences in chemical composition, mainly calcium, magnesium, sodium, and potassium.

SUBGROUP.—Each great group is divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group.

FAMILY.—Families are established within each subgroup, primarily on the basis of properties important to plant growth. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

General Nature of the County

Burleigh County was organized in 1873. Many of the early settlers immigrated directly from Norway, Sweden, Ireland, Germany, and Russia. Others migrated from central and eastern farming areas of the United States.

Bismarck, the principal city, is the county seat and State capital. Smaller towns are Driscoll, Sterling, McKenzie, Menoken, Baldwin, Regan, Wing, Moffit, and Wilton. In 1970, the population of Burleigh County was 40,500, and that of Bismarck was 35,000.

The chief highway, Interstate 94, extends east and west through the south-central part of the county. U.S. Highway 83 and North Dakota Highway 14 are hard-surface roads that provide for north and south travel. There is also a well-developed system of oiled, gravelled, and graded farm to market roads. Most roads follow section lines.

Since the early 1930's, the number of farms in the county has decreased and the size has increased. In 1959, there were 1,022 farms and the average size was 1,015 acres. By 1964, this number had declined to 867, and the average size had increased to 1,180 acres. There were 331 farms operated by full owners, 425 by part time owners, 103 by tenants, and 8 by managers. Most farms have electricity, and more than 78 percent have telephones.

About 68 percent of the farmland is suitable for cultivated crops, and 7 percent is suitable for limited cropping. In 1964, there were 325 cash-grain farms, 347 livestock farms, 122 general farms, and 73 miscellaneous farms. About 3,745 acres was irrigated. Most of the irrigated acreage is on the Missouri River bottom land or on adjacent terraces. Some irrigation water is pumped from the river. The rest is supplied by wells.

Hard red spring wheat, durum wheat, oats, barley, flax, corn, and alfalfa are the common dryland crops. Irrigated crops are corn, alfalfa, sugar beets, potatoes, and small grain.

Livestock make up a large part of the economy. There are a few large beef operations and many small ones. Sales are mostly to local markets. The dairy industry markets most products to local processors for local use.

Several small manufacturing firms operate in Bismarck. There is a large oil refinery across the Missouri River at Mandan, in Morton County. A small amount of lignite coal is mined in the vicinity of Wilton.

The native vegetation in Burleigh County is mainly grasses, sedges, and forbs. The chief grasses on the upland sites are green needlegrass, western wheatgrass, bluestem, and needle-and-thread. Saltgrass grows on the saline soils. Prairie sandreed and sand dropseed are dominant on the sandy soils, and rivergrass, switchgrass, prairie cordgrass, rushes, and cattails on the wet soils.

Native shrubs and trees are common on much of the creek and river bottom land in some ravines. Tree species include willow, cottonwood, ash, and elm. Shrubs include plum, chokecherry, and juneberry. For more information on native vegetation see the sections headed "Range" and "Woodland and Windbreaks."

Climate [7]

Burleigh County has a continental climate. The summers are pleasantly warm. Winters are long and cold, but there are usually several mild periods when temperatures are well above freezing. About 80 percent of the precipitation falls during the warm season, a period from April through October.

Frontal passages are a frequent occurrence throughout the year, and several large and rapid fluctuations in temperature often occur for a period of a week or two. The normal daily range in temperature is about 18 degrees in midwinter and 29 degrees early in fall. In the 96-year period for which records are available for Bismarck, maximum temperatures have ranged as high as 114° F. and minimum temperatures have fallen as low as −45°, a range of 159°. Averages of temperature and precipitation data, based on records at Bismarck, are given in table 8. In an average year the maximum temperature will equal or exceed 90° on 20 days in the northwestern part of the county and 27 days in the extreme southern part. About three-fourths of the days that are 90° or above occur in July and August. The greatest likelihood of five or more consecutive days of temperatures above 90° is during the last 2 weeks of July, and the chances are that this will occur only in 15 years out of every 100 years. Minimum temperatures drop to freezing or below on about 190 days during the year and to zero or below on about 50 days.

The probability of freezing temperatures on specified dates is given in table 9. The average length of a freeze-free period ranges from about 130 days in the western half of the county to about 120 days along the eastern border. No time of the year can be considered absolutely frost or freeze free. According to the 96-year record at Bismarck, freezing temperatures have occurred in every month except June, July, and August and in those

[7] By RAY E. JENSEN and ALFRED A. SKREDE, climatologists for North Dakota, National Weather Service, U.S. Department of Commerce.

TABLE 8.—*Temperature and precipitation data*

[All data from Bismarck, Burleigh County, N. Dak.]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	2 years in 10 will have at least 4 days with—		Average total	1 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.	In.	In.	In.	No.	In.
January	20	−2	43	−26	0.44	0.05	0.96	24	4
February	23	2	47	−23	.43	.14	1.03	22	6
March	35	15	58	−9	.78	.26	1.52	15	5
April	55	31	76	18	1.22	.37	3.03	2	3
May	68	43	85	30	1.97	.70	4.25	(1)	2
June	77	52	90	42	3.40	1.24	5.68	----------	----------
July	86	59	96	48	2.19	.93	4.17	----------	----------
August	84	56	95	45	1.73	.48	3.44	----------	----------
September	73	45	89	31	1.19	.30	2.66	(1)	3
October	59	33	78	19	.85	.21	1.94	(1)	2
November	39	18	61	−4	.59	.11	1.36	7	3
December	27	7	46	−18	.36	.11	1.05	15	3
Year	54	30	[2] 100	[3] −33	15.15	11.98	20.32	88	----------

[1] Less than 1 day. [2] Average annual highest temperature. [3] Average annual lowest temperature.

months a minimum of 33 degrees has been recorded in June and August, and a minimum of 36 degrees in July.

Based on maps showing normal amounts of precipitation for the period 1931 through 1960, precipitation ranged from slightly more than 15 inches in the southwest corner of the county to nearly 17 inches in the northeast corner. The amount of annual rainfall varies widely. At Bismarck annual rainfall has ranged from 5.97 to 30.92 inches. Normally, 0.01 inch or more of precipitation is received on 96 days, and thunderstorms are heard on about 37 days. The percentage probabilities of receiving a specified amount of precipitation during various periods of the growing season are given in table 10. The data taken at Mandan, in Morton County, should represent Burleigh County as well.

In a 20-year period, hail can be expected on about 40 days in the northwestern part of the county and on about 50 days in the extreme southeastern part. Hailstorms can be expected in June and July; hail occurs on 10 to 15 days each month every 20 years.

The mean seasonal snowfall is about 36 inches. Since 1886, snowfall at Bismarck has ranged from 13.2 to 86.8 inches. The average monthly snowfall in the period November through March is 5 to 8 inches. Light snowfall can be expected in 1 out of 6 years in September and in 1 out of every 4 years in May. Blizzards occur

TABLE 9.—*Probability of freezing temperatures later than specified dates in spring and earlier than specified dates in fall*

Probability	Dates for given probability and temperature				
	32° F. or lower	28° F. or lower	24° F. or lower	20° F. or lower	16° F. or lower
Spring:					
10 percent	May 25	May 18	May 10	April 29	April 17
25 percent	May 18	May 11	May 2	April 22	April 9
50 percent	May 11	May 4	April 24	April 13	March 31
75 percent	May 4	April 27	April 16	April 5	March 22
90 percent	April 27	April 20	April 8	March 28	March 14
Fall:					
10 percent	September 9	September 16	September 28	October 3	October 16
25 percent	September 16	September 23	October 6	October 11	October 24
50 percent	September 22	September 30	October 14	October 20	November 2
75 percent	September 28	October 7	October 22	October 29	November 11
90 percent	October 4	October 13	October 30	November 6	November 19

TABLE 10.—*Percentage probability of specified amounts of precipitation*

[All data from Mandan, Morton County. Dashes indicate a probability of less than 10 percent]

Period	Probability of receiving rainfall of—						
	4 inches or less	More than—					
		4 inches	6 inches	8 inches	10 inches	12 inches	14 inches
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
77-day season:							
March 15 to May 30	55	45	15	----	----	----	----
March 22 to June 6	40	60	25	----	----	----	----
March 29 to June 13	35	65	30	10	----	----	----
April 5 to June 20	30	70	40	20	----	----	----
April 12 to June 27	20	80	50	25	10	----	----
April 19 to July 4	15	85	55	30	10	----	----
April 26 to July 11	15	85	60	30	15	----	----
May 3 to July 18	15	85	60	30	15	----	----
May 10 to July 25	15	85	60	30	15	----	----
May 17 to August 1	10	90	65	35	15	----	----
May 24 to August 8	10	90	65	35	15	----	----
May 31 to August 15	15	85	60	30	15	----	----
June 7 to August 22	15	85	55	25	10	----	----
June 14 to August 29	20	80	45	20	----	----	----
91-day season:							
March 15 to June 13	20	80	40	15	----	----	----
March 22 to June 20	20	80	50	20	----	----	----
March 29 to June 27	15	85	60	30	10	----	----
April 5 to July 4	10	90	65	35	15	----	----
April 12 to July 11	10	90	70	40	20	----	----
April 19 to July 18	5	95	70	45	20	----	----
April 26 to July 25	5	95	70	45	25	10	----
May 3 to August 1	5	95	70	45	25	10	----
May 10 to August 8	10	90	70	40	20	----	----
May 17 to August 15	5	95	75	45	25	----	----
May 24 to August 22	5	95	80	50	25	----	----
May 31 to August 29	10	90	70	40	20	----	----
June 7 to September 5	10	90	65	35	15	----	----
June 14 to September 12	10	90	60	25	----	----	----
119-day season:							
April 26 to August 22	1	99	90	70	40	25	10
May 3 to August 29	2	98	90	65	40	20	----
May 10 to September 5	2	98	85	65	35	20	----
May 17 to September 12	2	98	90	65	40	20	----
May 24 to September 19	2	98	90	65	40	20	----
May 31 to September 26	5	95	85	60	35	15	----

nearly every year, and ground blizzards, or blowing snow that restricts visibility, occur several times each winter.

The annual evaporation from Weather Bureau Class A pans averages about 47 inches, of which 84 percent occurs in the period May through October. The annual evaporation from lakes is 34 or 35 inches.

The annual average of possible sunshine is 60 percent. July is the sunniest month, and November and December are the cloudiest.

Prevailing winds are west-northwesterly except in May, July, and August, when the prevailing wind direction is easterly. Soil blowing is usually most severe in March and April, when velocities of more than 19 miles per hour occur 18 to 22 percent of the time. The windiest month is April, during which the mean hourly velocity averages 13 miles per hour.

Heavy rainfall in amounts that range from 1.1 to 2.7 inches in 30 minutes to 24 hours can be expected at least once every 5 years.

Physiography, Relief, and Drainage

Burleigh County lies within the mid-grass prairie. Short, irregular slopes characterize areas of glacial deposits in the northern, eastern, and central parts of the county. In the northern part the slope range is 6 to 20 percent. In the east-central part it is generally less than 6 percent, except for isolated knobs. Gentle slopes and slightly lower relief characterize the areas of glacial melt-water deposits. Short, irregular slopes and gradient up to 20 percent are common in the areas of sandy melt-water deposits, which have been resorted and distributed by wind.

In the western part of the county, the glacial deposits and preglacial formations adjacent to the Missouri River are mantled with loess. The shores and mudbars of the river are the chief source of the loess. The mantle is 8 feet thick in nearly level areas adjacent to the river and becomes thinner with increasing distance to the east.

Along the breaks of the Missouri River, the slope gradient is as much as 20 percent.

Much of the bedrock is buried under loess, glacial drift, or alluvium. Some formations are exposed in the western and west-central parts of the county and in a few places in the southern part. The highest elevations in the county, more than 2,000 feet above sea level, are on these formations.

Recent alluvium covers the flood plain of the Missouri River. Seasonal runoff flooded this bottom land before the completion of the Garrison Dam. The flood plain is nearly level, except for the short slopes between benches. The lowest elevation in the county is on the flood plain. It is slightly less than 1,600 feet above sea level.

The Missouri River and its tributaries provide surface drainage. The chief creeks are Apple, Burnt, and Painted Woods, all of which are in the western part of the county. In the rest of the county, the drainage is into local kettles or potholes.

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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.

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.

Base saturation. The degree to which material that has base-exchange properties is saturated with exchangeable cations other than hydrogen, expressed as a percentage of the cation-exchange capacity.

Buried soil. A developed soil, once exposed but now overlain by more recently formed 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.

Complex, soil. A mapping unit consisting of different kinds of soil that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

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.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Glacial drift (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by meltwater as it flowed from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, and covered by grass for protection against erosion; used to conduct surface water away from cropland.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

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.

Nutrient, plant. Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.

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.*

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.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.2 to 7.3		

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.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

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 it is ordinarily overlain by sediment of variable thickness.

Stripcropping. Growing crops in a systematic arrangement of strips, or bands, to serve as vegetable barriers to wind and water erosion.

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).

Stubble mulch. Stubble or other crop residues left on the soil, or partly worked into the soil, to provide protection from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order

of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

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.

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

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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