SOIL SURVEY OF

Renville County, North Dakota

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

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SOIL SURVEY OF RENVILLE COUNTY, NORTH DAKOTA

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

RENVILLE COUNTY is in the north-central part of North Dakota (fig. 1). It has a total area of 576,501 acres. Mohall, the principal town and the county seat, is on the east-central edge of the county.

Physiographically, the county consists of nearly level glacial till plains dissected by glacial outwash channels. The Des Lacs River cuts across the southwestern corner of the county, and the Souris River meanders from north to south through the entire length of the county. Both of these rivers have deeply entrenched valleys. Lake Darling, the only major artificial impoundment, has flooded the bottom lands along the Souris River in the southern half of the county.

The semi-arid, continental climate is characterized by cold, long, snowy winters and by summers that have warm, bright days and cool nights. The average annual precipitation at Mohall is 16.77 inches, of which about 80 percent falls during the growing season.

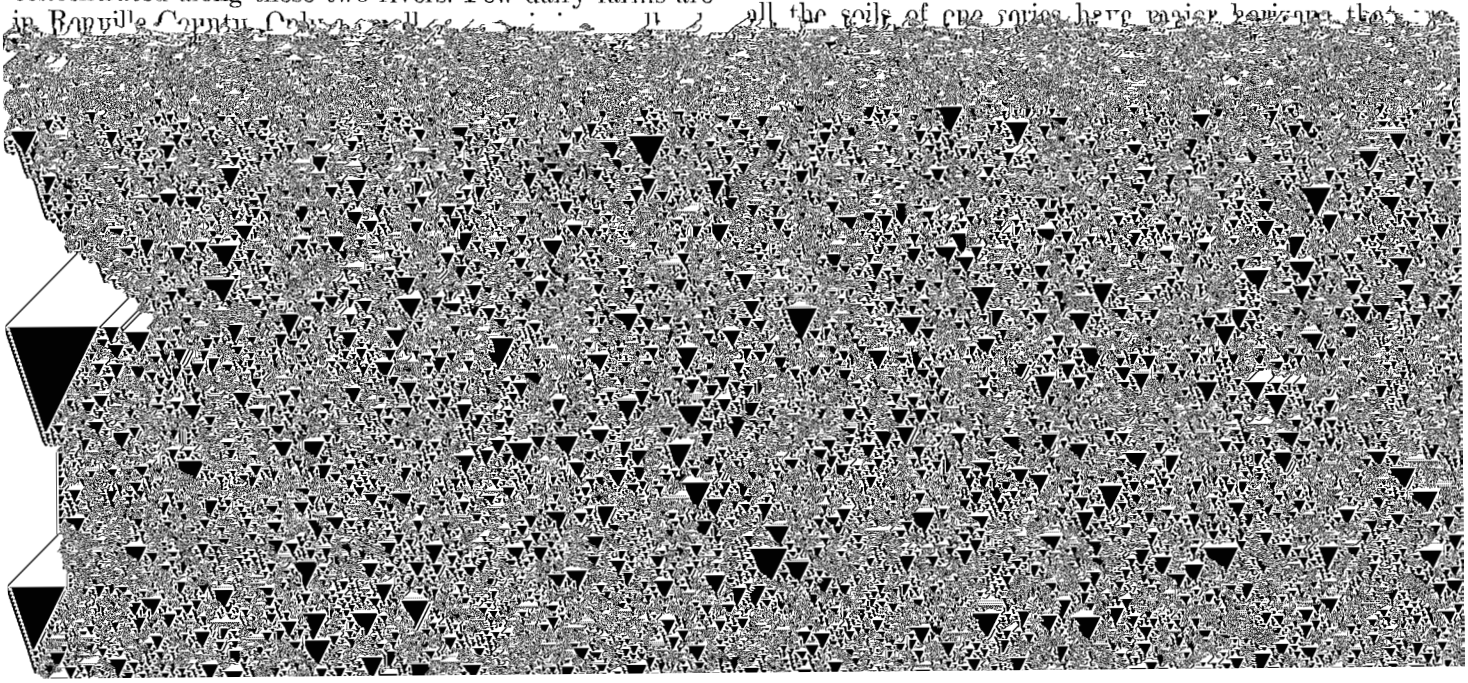
About 80 percent of Renville County is used for crops, mainly wheat, barley, and flax. Oats and rye are also commonly grown. The only large areas of native grass are along the breaks of the Des Lacs and Souris Rivers. Raising beef cattle is a relatively minor enterprise and is concentrated along these two rivers. Few dairy farms are in Renville County. Only a small [illegible]

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Renville 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 classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have easier horizons that are



trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from aerial photographs.

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

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

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Buse loams, 3 to 6 percent slopes, 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." Barnes and Buse very stony loams, 3 to 15 percent slopes, is an example.

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

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

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

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust 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 Renville County. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map that shows soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning of a watershed, a wooded tract, or a wildlife area or for broad planning of recreation facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road, building, or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The seven soil associations in Renville County are described in the pages that follow.

1. Barnes-Hamlet association

Nearly level, well drained and moderately well drained, medium textured soils on glacial till plains

This association consists of deep, nearly level soils that formed in glacial till. There are many small depressions.

This association covers about 75 percent of the county. Barnes soils make up about 62 percent of the association, Hamlet soils 13 percent, and minor soils 25 percent.

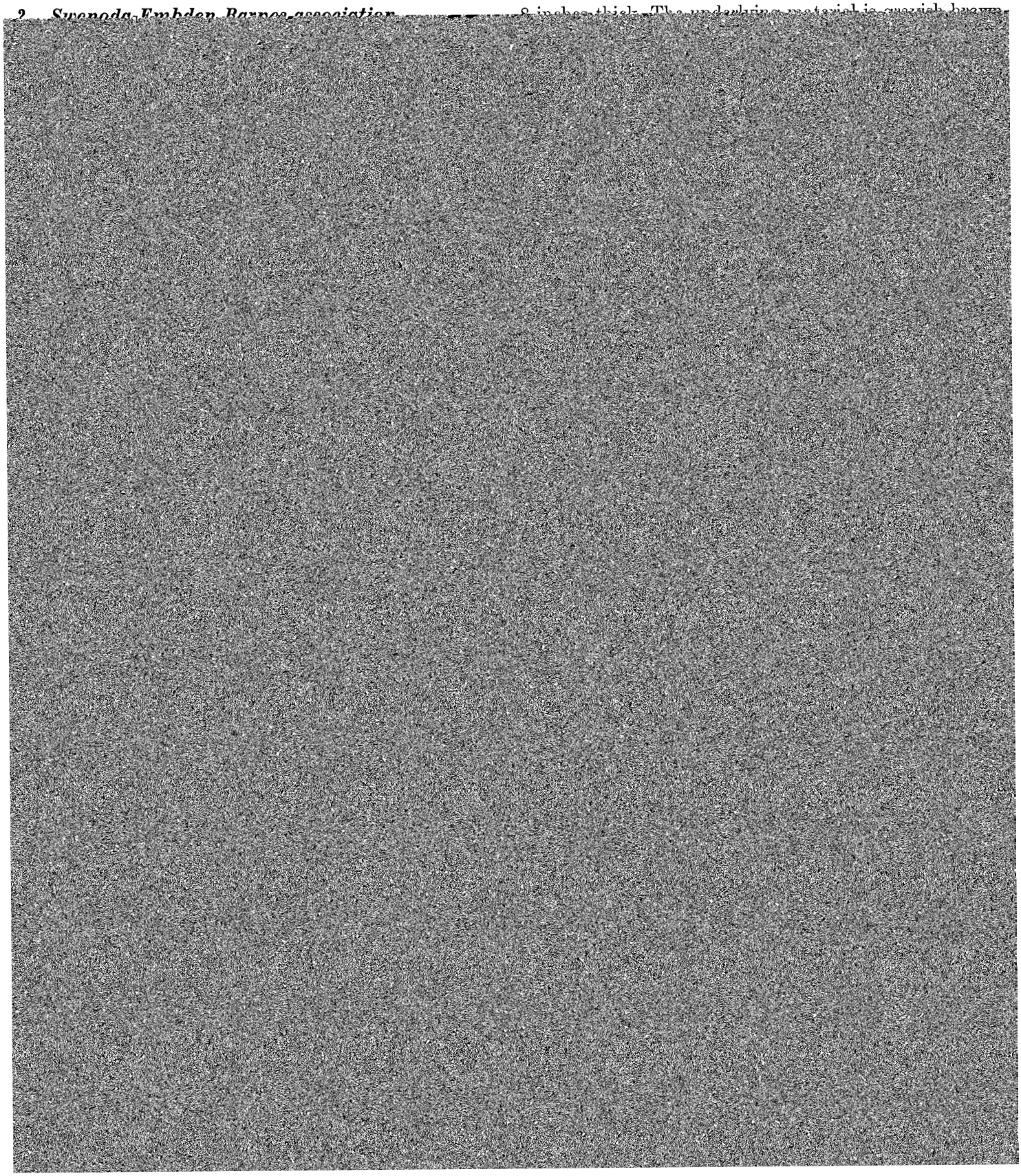
Barnes soils are on nearly level to slightly convex side slopes and are well drained. The surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown and dark-brown loam about 9 inches thick. The underlying material is calcareous loam glacial till.

Hamlet soils are on nearly level to slightly concave side slopes and are moderately well drained. The surface layer is black loam about 8 inches thick. The subsoil is very dark grayish-brown and dark grayish-brown loam about 11 inches thick. The underlying material is calcareous loam glacial till.

Some of the minor soils are Tonka and Parnell soils in depressions, Hamerly soils adjacent to depressions, Svea soils in swales, and Buse soils on hilltops and ridges.

Growing cash crops is the main enterprise. The soils of this association have high potential for all cultivated crops commonly grown in the county. Nearly all the acreage is cultivated. The soils are high in fertility, and the available water capacity is high. The main concerns of management are controlling soil blowing and improving

2. *Svenoda-Embden-Barnes association*

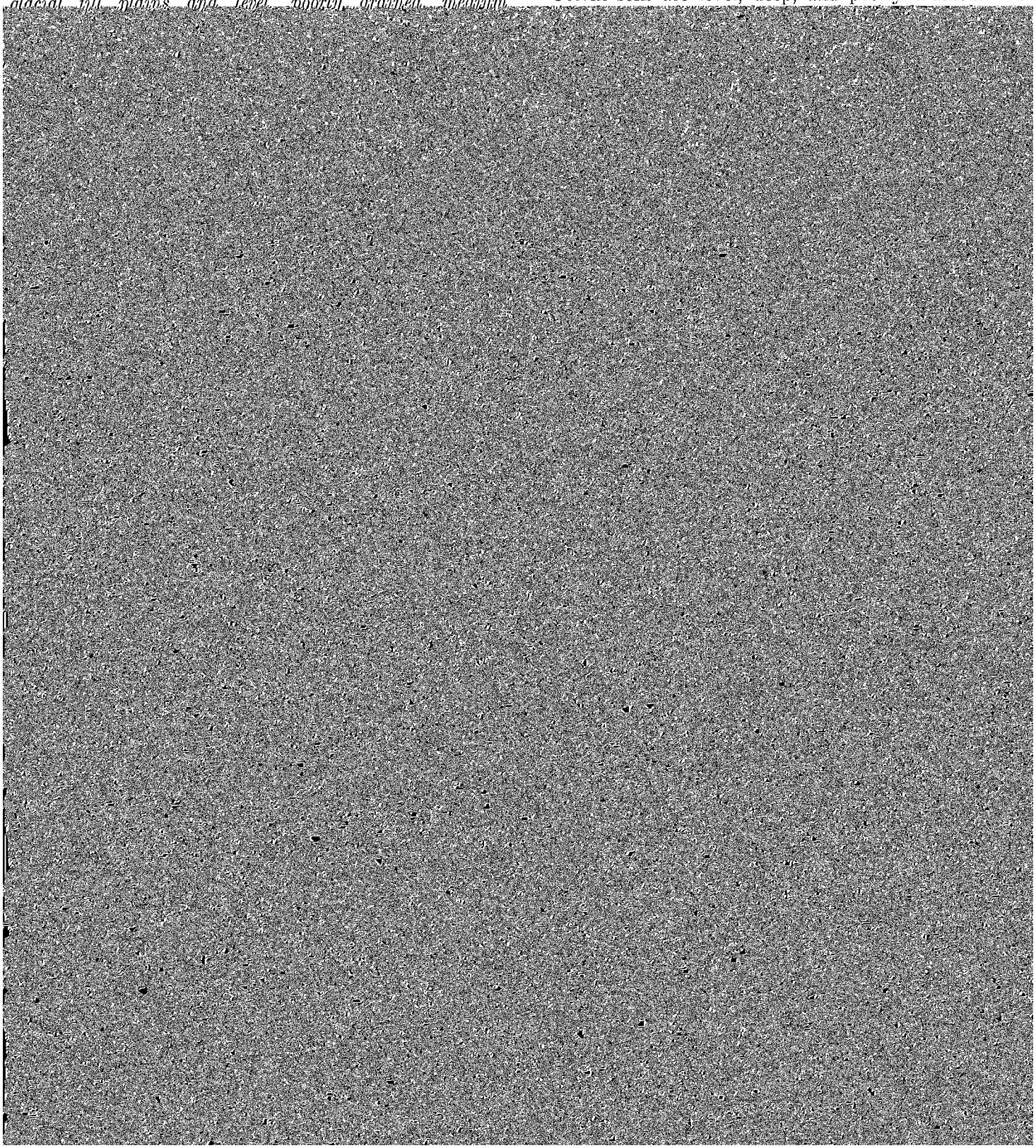


5. *Barnes-Colvin association*

Nearly level, well drained, medium textured soils on glacial till plains and level, poorly drained, medium

dark grayish-brown loam about 11 inches thick. The underlying material is coarse sand and gravel.

Colvin soils are level, deep, and poorly drained. The



An important part of the description of each soil series in which the mapping unit has been placed. The page for

AwA—Arvilla-Sioux sandy loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are in areas of gravelly outwash. About 80 percent of the complex is Arvilla sandy loam, and 20 percent is Sioux sandy loam. The Arvilla soil has concave and plane slopes, and the Sioux soil has convex areas. The Sioux soil is shallower to sand and gravel than the Arvilla soil. The Arvilla soil has the profile described as representative of the Arvilla series.

Both soils are droughty and are highly susceptible to soil blowing. Runoff is slow.

This complex is not well suited to cultivated crops. Many areas once used for annual crops are now in grass and used for tame pasture and hay. Droughtiness and soil blowing are the main concerns of management. Capability unit IIIes-3; Arvilla soil in windbreak suitability group 6; Sioux soil in windbreak suitability group 10.

AwB—Arvilla-Sioux sandy loams, 3 to 6 percent slopes. The soils making up this complex are gently sloping and are in areas of gravelly outwash. About 75 percent of the complex is Arvilla sandy loam, and 25 percent is Sioux sandy loam. The Arvilla soil has concave and plane slopes, and the Sioux soil has convex slopes. The Sioux soil is shallower to sand and gravel than the Arvilla soil.

Both soils are droughty and are highly susceptible to soil blowing. Runoff is slow.

This complex is not well suited to cultivated crops. Many areas once used for annual crops are now in grass and used for tame pasture and hay. Droughtiness and soil blowing are the main concerns of management. Capability unit IIIes-3; Arvilla soil in windbreak suitability group 6; Sioux soil in windbreak suitability group 10.

Barnes Series

The Barnes series consists of deep, well-drained, nearly level to rolling soils. These soils have plane and convex slopes and are on glacial till plains. They formed in calcareous, loamy glacial till.

In a representative profile (fig. 2) the surface layer is black loam about 7 inches thick. The subsoil is dark-brown, friable loam about 9 inches thick. The upper part of the underlying material is light olive-brown loam that contains a large amount of lime, and the lower part is mottled olive-brown loam.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. Runoff is slow to rapid. The content of organic matter is moderate, and fertility is high.

Barnes soils are well suited to farming. Most areas are used for crops, but some are used for hay and pasture.

Representative profile of Barnes loam, 1 to 3 percent slopes, 2,400 feet east and 75 feet south of the northwest corner of sec. 18, T. 158 N., R. 82 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; cloddy; soft, friable, sticky and plastic; neutral; clear, smooth boundary.

B21t—7 to 12 inches, dark-brown (10YR 4/3) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure; hard, friable, sticky and plastic; patches of distinct, very dark grayish-brown (10YR 3/2) clay films on faces of peds; neutral; gradual, wavy boundary.

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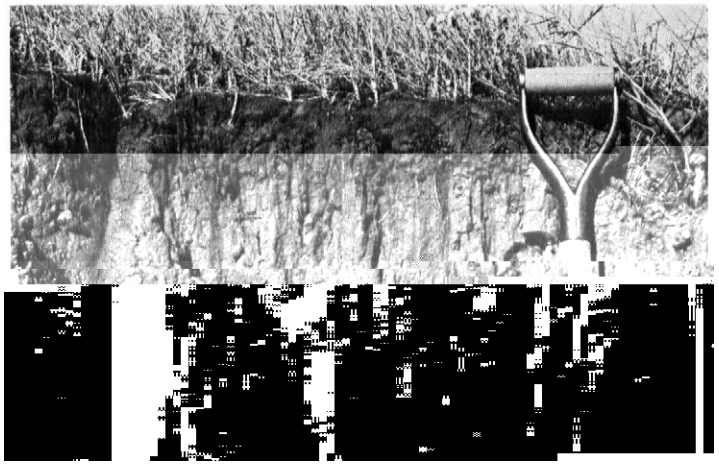


Figure 2.—**Profile of Barnes loam.**

B22—12 to 16 inches, dark-brown (10YR 4/3) loam, brown (10YR 5/3) when dry; weak, medium, prismatic structure; hard, friable, sticky and plastic; patches of clay films on faces of peds; slight effervescence; mildly alkaline; clear, wavy boundary.

C1ca—16 to 36 inches, light olive-brown (2.5Y 5/4) loam, pale yellow (5Y 7/3) when dry; weak, medium, prismatic structure parting to weak, fine, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual boundary.

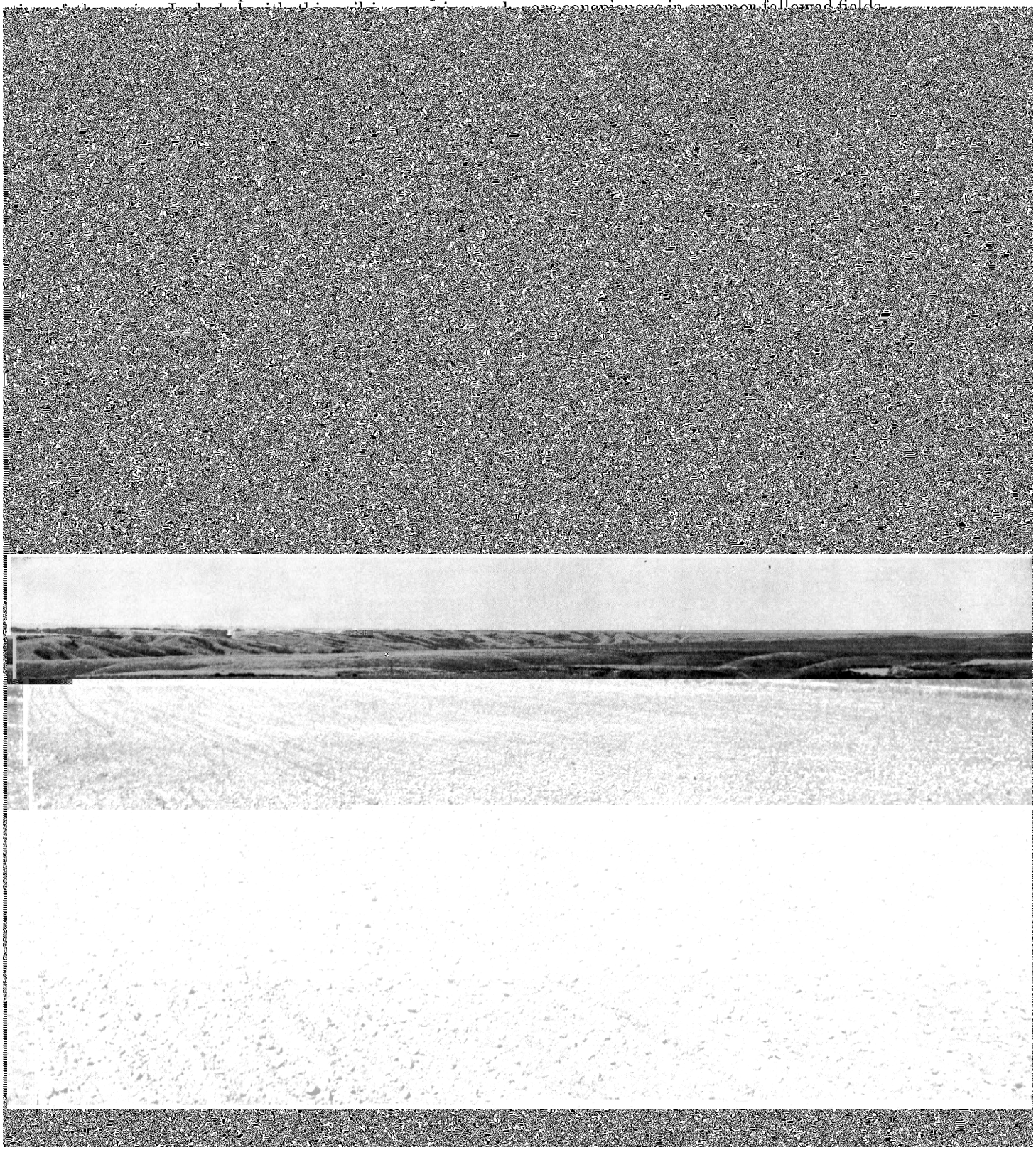
C2—36 to 60 inches, olive-brown (2.5Y 4/4) loam, pale yellow (5Y 7/3) when dry; common, fine, distinct, gray (2.5Y 6/1) mottles; massive; hard, firm, sticky and plastic; few small shale fragments; strong effervescence; moderately alkaline.

In many places the Ap horizon is very dark brown because it has been mixed with the upper part of the B2 horizon. It ranges from 4 to 8 inches in thickness. The B horizon is loam or light clay loam 5 to 14 inches thick. Pebbles and cobbles are common throughout the profile.

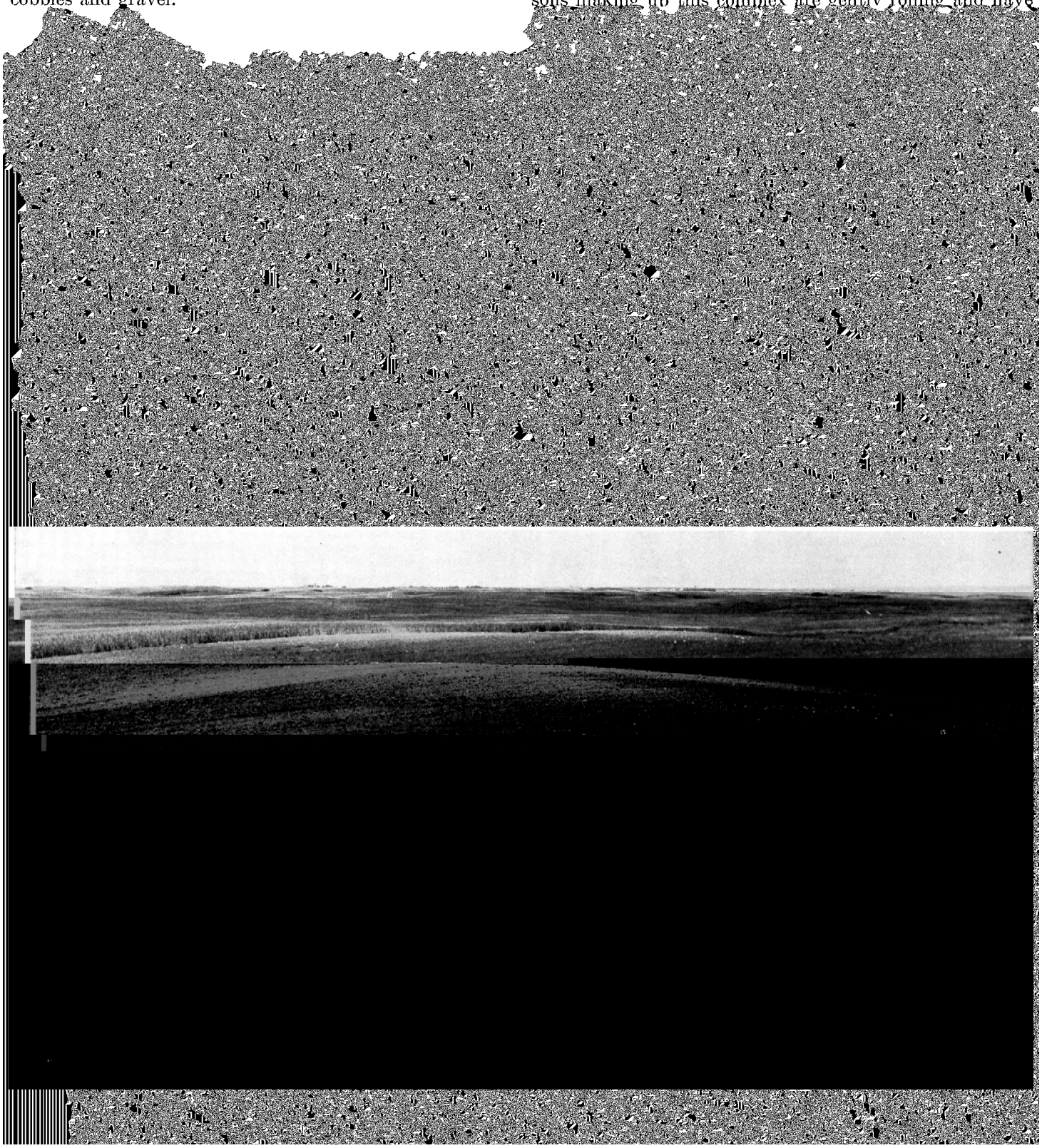
Barnes soils are associated with Svea, Hamlet, and Buse soils. They are better drained and have a thinner A horizon than Svea and Hamlet soils. They have a thicker solum than Buse soils, and they do not lack a B horizon.

BaA—Barnes loam, 1 to 3 percent slopes. This soil is nearly level and is on glacial till plains. The landscape is smooth. The soil has the profile described as representa-

surface layer, but in a few spots, the soil is eroded enough that the plow layer has been mixed with part of the limy underlying material. These spots are light olive brown, and



common for material in which other soils of the Barnes series formed. This soil has a profile similar to the one described as representative of the series, except for the cobbles and gravel.



soil in windbreak suitability group 3; Buse soil in windbreak suitability group 8.

BdC—Barnes-Buse loams, 6 to 9 percent slopes. The soils making up this complex are gently rolling and have

These soils are susceptible to soil blowing and water erosion. Runoff is medium.

This complex is suited to all crops commonly grown in the county, and most of the acreage is cultivated. The Cresbard soil is more droughty than the Barnes soil because it has a claypan and has soluble salts in the lower part of the subsoil and in the underlying material. Soil blowing and water erosion are easily controlled. Capability unit IIIs-6P; Barnes soil in windbreak suitability group 3; Cresbard soil in windbreak suitability group 4.

BgB—Barnes-Hamerly loams, 3 to 6 percent slopes. The soils making up this complex are undulating and are

loam, 15 percent is Tonka silt loam, and 5 percent is included areas of Hamerly loam and Parnell silty clay loam. The Barnes soil is in nearly level to slightly convex areas, the Hamlet soil is in slightly concave areas, and the Tonka soil is in depressions (fig. 5). The Hamlet soil has the profile described as representative of the Hamlet series.

These soils are susceptible to soil blowing and to water erosion. Runoff is slow.

This complex is well suited to all crops commonly grown in the county, and nearly all the acreage is cultivated. The Tonka soil is often wet in spring, and conse-

vated. The Tonka soil is often wet in spring, and consequently tilling and seeding either have to be delayed or cannot be done. Soil blowing and water erosion are easily controlled. Capability unit IIe–6; Barnes soil in windbreak suitability group 3; Hamlet soil in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

BnD—Barnes and Buse very stony loams, 3 to 15 percent slopes. The soils making up this undifferentiated unit are undulating to rolling and are in grassy areas of glacial till plains. Some areas consist of Barnes very stony loam, some consist of Buse very stony loam, and some contain both soils. The Barnes soil is generally on plane side slopes, and the Buse soil is generally on convex slopes. These soils are mapped together because they are managed in the same way and are limited in extent.

Runoff is medium to rapid.

These soils have so many stones that cultivation is not possible (fig. 6). They are better suited to grazing than to other uses. Most of the acreage is used for pasture. Both soils are in capability unit VIIs-6 and windbreak suitability group 10.

Buse Series

The Buse series consists of deep, well-drained, undulating to rolling soils. These soils are on till plains. They formed in loamy glacial till.

In a representative profile (fig. 7) the surface layer is very dark grayish-brown loam about 6 inches thick. The upper part of the underlying material is light olive-brown loam that contains an accumulation of lime. The lower part is olive and olive-brown loam.

Permeability is moderate, and the available water capacity is high. Runoff is medium to rapid. The content of organic matter is moderately low, and fertility is medium.

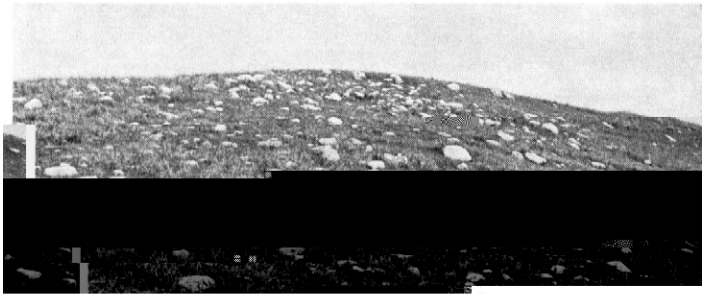


Figure 6.—**Area of Barnes and Buse very stony loams, 3 to 15 percent slopes.**

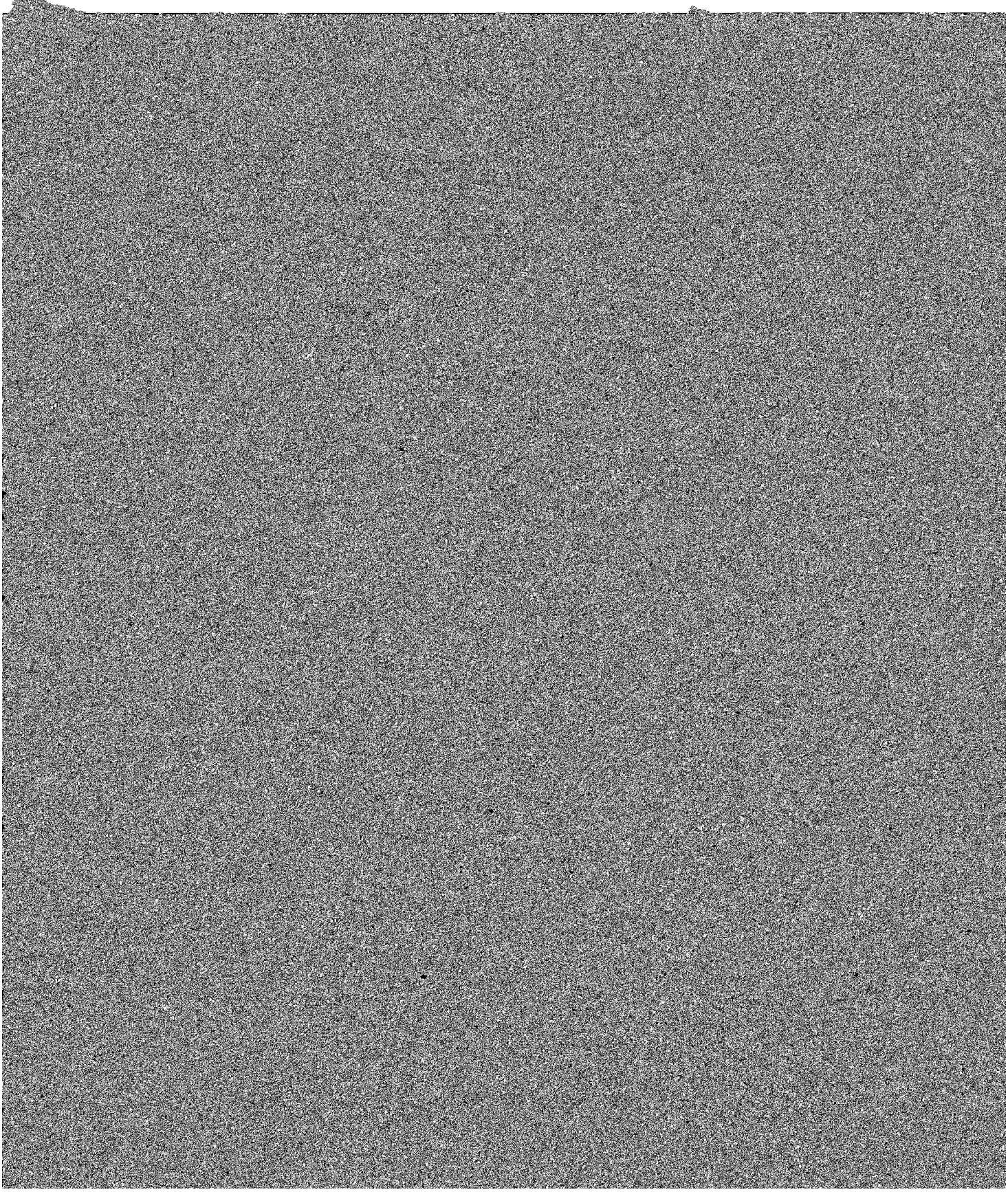
Figure 7.—**Profile of Buse loam.**

Most areas of these soils are used for crops, but the more sloping areas are better suited to pasture and hay.

Representative profile of Buse loam, in an area of Barnes-Buse loams, 3 to 6 percent slopes, 2,200 feet east and 1,500 feet north of the southwest corner of sec. 10, T. 161 N., R. 86 W., in a cultivated field.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; weak, medium, subangular blocky structure parting to moderate, medium, crumb; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; mildly alkaline; abrupt, smooth boundary.

Clca—6 to 16 inches, light olive-brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.



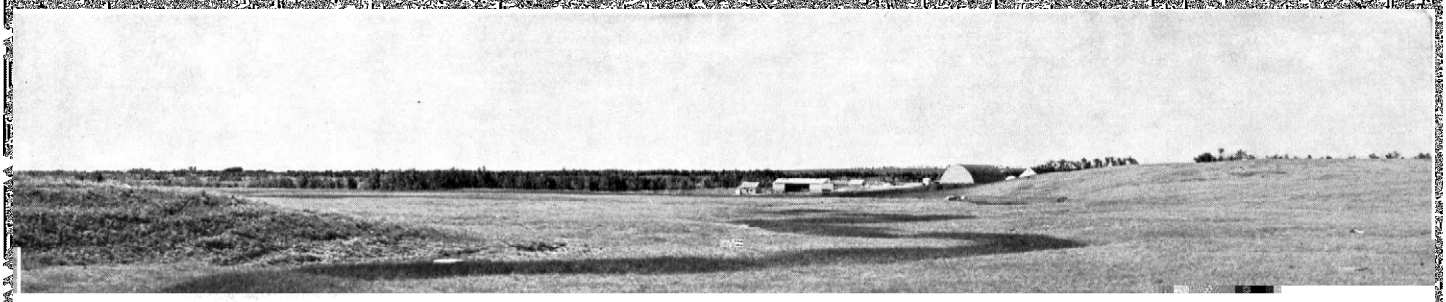
C2gca—14 to 30 inches, dark-gray (N 4/0) silty clay loam, gray and light gray (N 5/0 and 7/0) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C3gca—30 to 42 inches, dark-gray (N 4/0) silty clay loam, gray and light gray (N 5/0 and 7/0) when dry; massive; hard, friable, sticky and plastic; few pebbles at a depth of 42 inches; violent effervescence; moderately alkaline; gradual, wavy boundary.

C4gca—42 to 48 inches, light brownish-gray (2.5Y 6/2) silty clay loam, light-gray (2.5Y 7/2) when dry; few fine-

Runoff is very slow. The water table is near the surface in spring and during prolonged wet periods. This soil is ponded for a few days in some years, and tillage is delayed by wetness in most years. The hazard of soil blowing is severe in cultivated areas.

This soil is well suited to grass used for hay or pasture. It is suited to cultivated crops if excess water is removed, and most of the acreage is cultivated. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.



Runoff is very slow. These soils are ponded until midsummer or throughout the entire season in most years.

Nearly all the acreage is in native grass. These soils are used mainly for late-season hay. They are too wet for cultivated crops. Capability unit Vw–4; windbreak suitability group 10.

Cresbard Series

The Cresbard series consists of deep, moderately well drained, nearly level soils that have a claypan. These soils are in plane and concave areas on the till plain. They formed in loam glacial till.

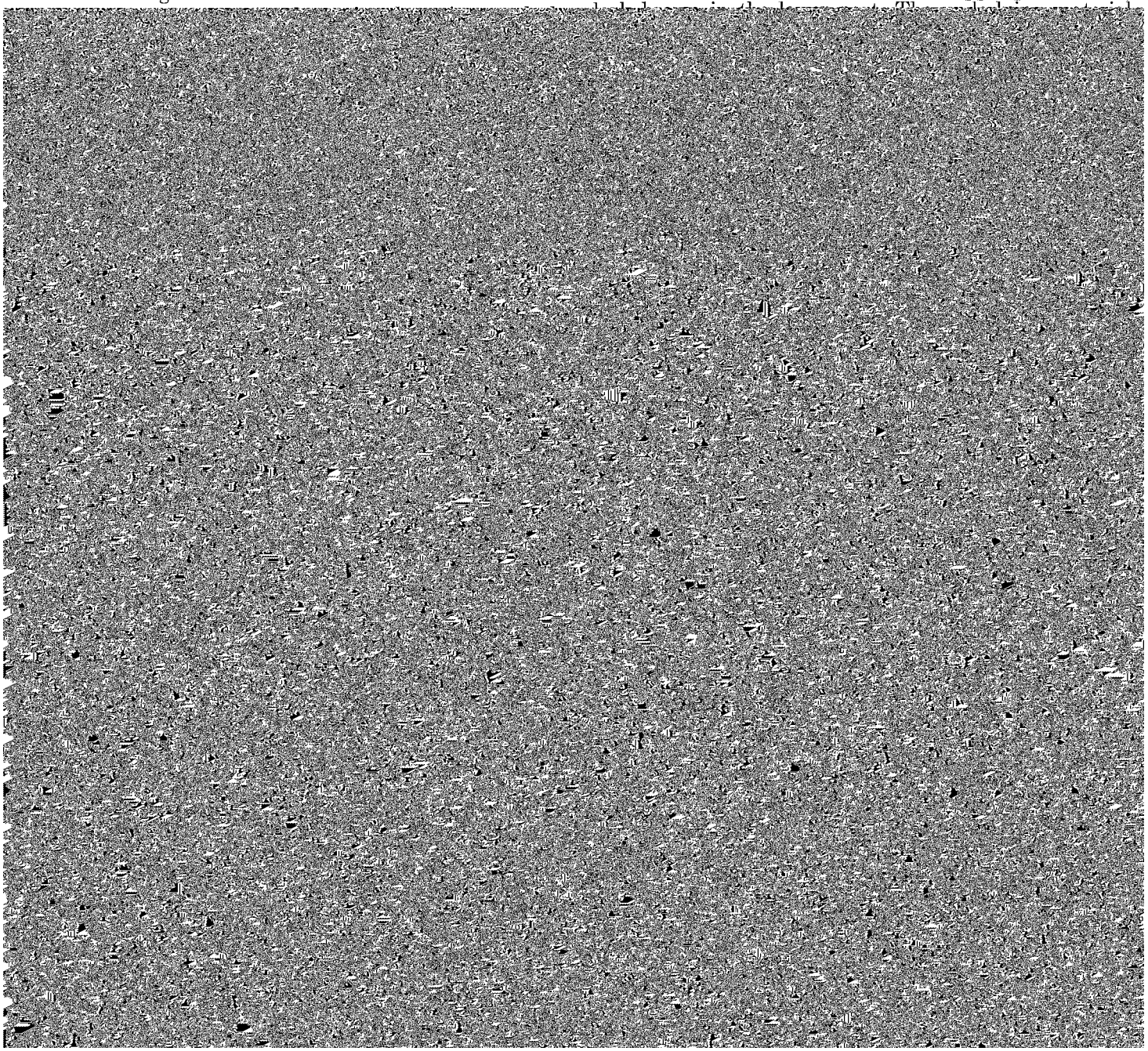
Cresbard soils have a less dense, more friable B horizon than Cavour soils.

Cresbard soils in Renville County are mapped only with Barnes and Cavour soils.

Divide Series

The Divide series consists of somewhat poorly drained, nearly level soils that have a zone of lime within 16 inches of the surface. These soils are in plane and slightly convex areas on glacial outwash plains. They formed in glacial outwash that is moderately deep to sand and gravel.

In a representative profile the surface layer is loam about 8 inches thick. It is black in the upper part and very



The A horizon is black or very dark brown and ranges from 5 to 10 inches in thickness. Depth to gravel and sand is 20 to 36 inches. The gravel and sand substratum contains 25 to 50 percent gravel. In this county loam glacial till is within 60 inches of the surface in most places.

Divide soils are in places that are similar to those areas where Marysland soils occur, but they are better drained. They formed in the same kind of material as that in which Renshaw soils formed, but they are more poorly drained.

DdA—Divide loam, loamy substratum, 1 to 3 percent slopes. This soil is nearly level and is in plane and slightly convex areas on glacial outwash plains.

Runoff is slow. This soil has a high water table in spring nearly every year, but only for a short period. The water table is as high during other extremely wet periods as it is in spring. The soil is susceptible to soil blowing in cultivated areas.

Most of the acreage is cultivated. Spring seeding is delayed. The soil is well suited to fall-seeded rye and grass that is used for pasture and hay. Wetness and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Embden Series

The Embden series consists of deep, moderately well drained, nearly level and undulating soils. These soils are in smooth and slightly concave areas on outwash plains. They formed in moderately coarse textured sediment.

In a representative profile the surface layer is fine sandy loam about 16 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is dark grayish-brown very friable fine sandy loam about 8 inches thick. The underlying material is yellowish-brown loamy fine sand in the upper part and mottled grayish-brown sandy loam in the lower part.

Permeability is moderately rapid, and the available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium.

Embden soils are well suited to farming. Most areas are used for cultivated crops. Some are used for pasture and hay.

Representative profile of Embden fine sandy loam, in an area of Embden-Tiffany fine sandy loams, 1 to 3 percent slopes, 1,750 feet north and 140 feet east of the southwest corner of sec. 10, T. 158 N., R. 84 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, fine, crumb structure; slightly hard and very friable; nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—7 to 16 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

B2—16 to 24 inches, dark grayish-brown (10YR 4/2) sandy loam, grayish brown (10YR 5/2) when dry; weak, coarse, subangular blocky structure parting to single grained; slightly hard, very friable, nonsticky and nonplastic; neutral; gradual boundary.

C1—24 to 48 inches, yellowish-brown (10YR 5/6) loamy fine sand, yellowish brown (10YR 5/6) when dry; single grained; loose, soft, nonsticky and nonplastic; neutral; gradual boundary.

C2—48 to 60 inches, grayish-brown (10YR 5/2) sandy loam, light gray (10YR 7/2) when dry; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; slightly hard, very friable, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The A horizon is black, very dark gray, or very dark grayish-brown fine sandy loam or sandy loam 10 to 20 inches thick. The B horizon is very dark grayish-brown or dark grayish-brown sandy loam or fine sandy loam 8 to 16 inches thick. In the upper part, the C horizon is fine sandy loam or loamy fine sand, and below a depth of about 40 inches, it is loamy fine sand, loamy sand, or sandy loam. In places there is a Cca horizon.

Embden soils formed in places that are similar to those where Swenoda soils formed, but they do not have the loam substratum that is typical of Swenoda soils. They formed in the same kind of material as Tiffany soils, but they are better drained.

EmB—Embden sandy loam, 1 to 6 percent slopes. This soil is nearly level to undulating and is on outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is sandy loam. Included with this soil in mapping were small areas of Swenoda fine sandy loam.

This Embden soil is highly susceptible to soil blowing, and it is somewhat droughty. Runoff is slow.

Most of the acreage is used for crops. The soil is well suited to fairly well suited to all crops commonly grown in the county. Soil blowing and the moderate available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

EoA—Embden-Tiffany fine sandy loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on outwash plains. About 80 percent of the complex is Embden fine sandy loam, and 20 percent is Tiffany fine sandy loam. The Embden soil is in smooth and slightly concave areas around slight depressions, and the Tiffany soil is in the depressions. The Embden soil has the profile described as representative of the Embden series.

The Embden soil is better drained than the Tiffany soil. Both soils are highly susceptible to soil blowing. Runoff is slow.

Most areas of this complex are used for crops. The soils are suited to all crops commonly grown in the county. Soil blowing and the moderate available water capacity are the main concerns of management. The Tiffany soil is occasionally ponded for short periods, and tillage is sometimes delayed by wetness. Capability unit IIIe–3; Embden soil in windbreak suitability group 1; Tiffany soil in windbreak suitability group 2.

Fargo Series

The Fargo series consists of deep, poorly drained, level soils. These soils are in glacial lake basins. They formed in calcareous, clayey lacustrine sediment.

In a representative profile the surface layer is black silty clay about 8 inches thick. The subsoil is very firm silty clay about 22 inches thick. It is very dark gray in the upper 7 inches and dark gray below. The underlying material is mottled gray and light-gray silty clay that has gypsum in the lower part.

Permeability is slow, and the available water capacity is high. Runoff is very slow. The content of organic matter and fertility are high.

Most areas are cultivated, but some are used for hay and pasture. These soils are suited to cultivated crops if excess water is removed.

Representative profile of Fargo silty clay, 2,615 feet west and 75 feet south of the northeast corner of sec. 32, T. 161 N., R. 86 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate, medium, angular blocky structure; very hard, very firm, very sticky and very plastic; neutral; abrupt, smooth boundary.

A12—5 to 8 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate, medium, angular blocky structure; very hard, very firm, very sticky and very plastic; neutral; clear, wavy boundary.

B2—8 to 15 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; moderate, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; mildly alkaline; gradual, irregular boundary.

B3g—15 to 30 inches, dark-gray (5Y 4/1) silty clay, gray (5Y 5/1) when dry; moderate, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; strong effervescence; moderately alkaline; gradual boundary.

C1g—30 to 48 inches, gray (5Y 5/1) silty clay, gray (5Y 6/1) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles; massive; very hard, very firm, very sticky and very plastic; strong effervescence; few masses of lime; moderately alkaline; gradual boundary.

C2gca—48 to 60 inches, light-gray and gray (5Y 6/1 and 5/1) silty clay, light gray (5Y 6/1) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles; massive; very hard, very firm, very sticky and very plastic; strong effervescence: common masses of lime; few nests of gypsum; moderately alkaline.

The solum is 16 to 36 inches thick. The A1 horizon is very dark gray or dark gray when dry and is 6 to 16 inches thick. It is calcareous in the lower part in places where it is thick. The B2 horizon is very dark gray or dark gray when dry and black or very dark gray when moist. It is silty clay or clay and is noncalcareous in places. It has moderate or strong, fine to medium, angular blocky structure. Tongues of A1 material fill cracks and extend through the B2 horizon in places. The Cg horizon ranges from slightly effervescent to strongly effervescent.

Fargo soils are in places similar to areas where Great Bend soils occur, but they are poorly drained and are finer textured than Great Bend soils.

Fa—Fargo silty clay. This soil is level and is in lake basins on glacial till plains. Most of the basins are large. The slope is 0 to 1 percent. The soil has the profile de-

This soil is used mainly for pasture and hay and it is best suited to grasses grown for hay or pasture. Suitable outlets for removing excess water are lacking. Capability unit Vw-4; windbreak suitability group 10.

Fulda Series

The Fulda series consists of deep, poorly drained, level soils. These soils are in slightly concave, shallow depressions on glacial till plains. They formed in clayey sediment.

In a representative profile the surface layer is black silty clay loam about 5 inches thick. The upper part of the firm subsoil, about 10 inches thick, is mottled very dark grayish-brown silty clay. The lower part, about 14 inches thick, is grayish-brown and light olive-brown silty clay. The underlying material is mottled grayish-brown and light olive-brown firm clay loam.

Permeability is slow, and the available water capacity is high. Runoff is very slow. The content of organic matter and fertility are high.

Fulda soils are well suited to cultivated crops if excess water is removed. Most areas are cultivated. Small grain is the main crop.

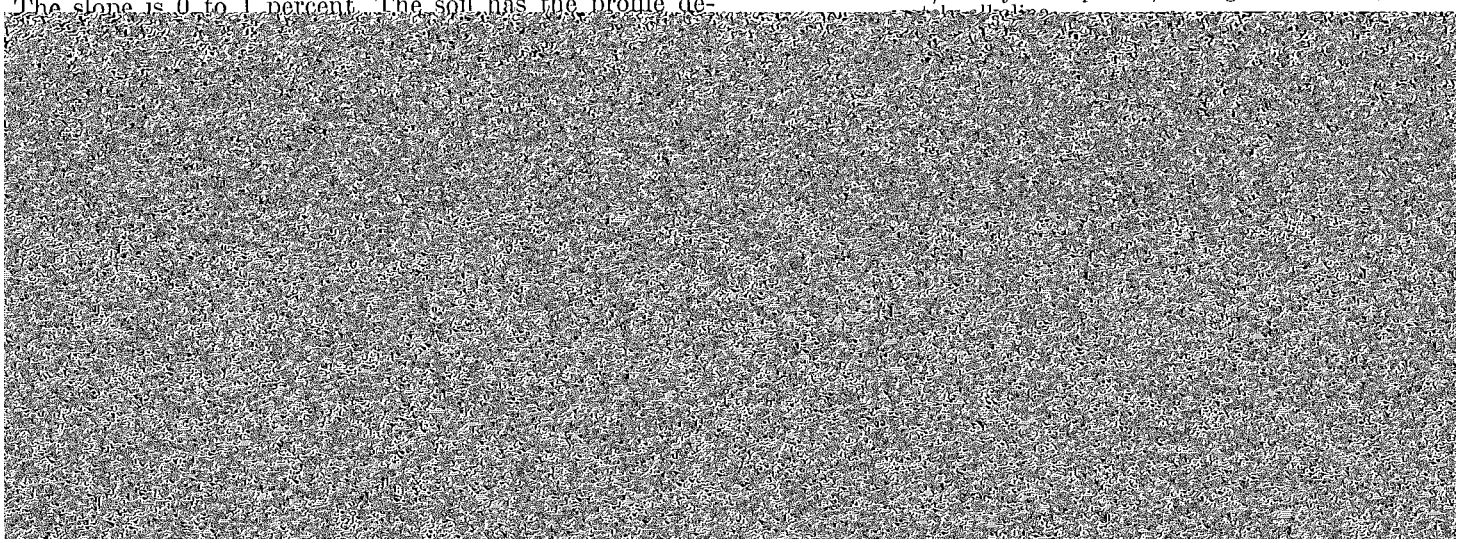
Representative profile of Fulda silty clay loam, 350 feet south and 130 feet east of the northwest corner of sec. 12, T. 161 N., R. 87 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; neutral; abrupt, smooth boundary.

B2—5 to 15 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark gray (10YR 4/1) when dry; few, medium, faint, light olive-brown (2.5Y 5/4) mottles; moderate, fine, subangular blocky structure; very hard, firm; very sticky and very plastic; neutral; clear, wavy boundary.

B3—15 to 29 inches, mixed grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/5) silty clay, grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/5) when dry; moderate, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; slight effervescence; mildly alkaline; gradual boundary.

C—29 to 60 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) when dry; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; hard, firm, sticky and plastic; strong effervesence; mod-



Gravel Pits

Gp—Gravel pits. This land type consists of irregularly shaped areas of excavated gravel pits and dumps more than 2 acres in size. The smaller areas are shown on the detailed soil map by a spot symbol.

Most areas of Gravel pits are barren. The pits are mainly in gravel and sand, and the dumps are mixed stones, cobbles, gravel, sand, and finer textured soil material. Some areas have a high water table.

Other than as a source of sand and gravel, gravel pits are well suited to and used mainly for wildlife habitat. Some have a high water table and are suited to special tree plantings for wildlife. If extensive leveling and reclamation are done, some areas are suited to grasses or crops. Capability unit VIIIs–1; windbreak suitability group 10.

Great Bend Series

The Great Bend series consists of deep, well-drained, nearly level soils. These soils are in glacial lake basins and on lake plains. They formed in calcareous, loamy, lacustrine sediment.

In a representative profile the surface layer is black silty clay loam about 7 inches thick. The subsoil is very dark grayish-brown firm silty clay loam about 8 inches thick. The underlying material, to a depth of about 60 inches, is grayish-brown silty clay loam about 9 inches thick over dark grayish-brown clay loam that is mottled in the lower part.

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

Nearly all areas are cultivated and used for small grain. These soils are suited to all crops commonly grown in the county.

Representative profile of Great Bend silty clay loam, 1 to 3 percent slopes, 200 feet east and 85 feet north of the southwest corner of sec. 21, T. 161 N., R. 85 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; strong, fine and very fine, crumb structure; slightly hard, friable, sticky and plastic; neutral; abrupt, smooth boundary.

B2—7 to 15 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; hard, firm, sticky and plastic; faces of peds coated with dark grayish brown (10Y 4/2) when dry; neutral; clear, wavy boundary.

C1ca—15 to 24 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, very sticky and very plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2ca—24 to 36 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; massive; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; many, medium, distinct, dark yellowish-brown (10YR 4/4) mottles in the lower 12 inches; massive; hard, firm, sticky and plastic; strong effervescence; few nests of gypsum; moderately alkaline.

Thickness of the solum and, in most places, depth to lime range from 13 to 18 inches. The B2 horizon has weak to moderate, prismatic structure parting to weak to strong, blocky. In places the lower part of the B horizon has few to common mottles of high chroma. In places the C horizon has loam glacial till below a depth of 40 inches.

Great Bend and Fargo soils are in similar topographic positions, but Great Bend soils have more silt and less clay than Fargo soils. Great Bend soils are near Barnes soils, but they have more silt and less sand.

GrA—Great Bend silty clay loam, 1 to 3 percent slopes. This soil is nearly level and is in lake basins and on flats on glacial till plains. Included with this soil in mapping were some small areas of moderately well drained soils and a few small areas of Barnes and Hamlet soils.

Runoff is slow. This soil is slightly susceptible to soil blowing.

Nearly all the acreage is used for small grain, but the soil is suited to all crops commonly grown in the county. Controlling soil blowing and maintaining fertility and the content of organic matter are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Hamerly Series

The Hamerly series consists of deep, moderately well drained, nearly level and undulating soils. These soils are in slightly convex areas around shallow basins and on slight rises of ground moraine on glacial till plains. They formed in loamy glacial till and are limy at or near the surface.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The underlying material, to a depth of about 19 inches, is light olive-brown loam that contains a large amount of lime. Below this, to a depth of about 60 inches, is olive-brown loam that contains a moderate amount of lime and that is mottled in the lower part.

Permeability is moderately slow, and the available water capacity is high. Runoff is medium to slow. The content of organic matter is moderate, and fertility is high. The water table is within 3 to 5 feet of the surface in spring in most years.

Most areas are cultivated and used for small grain. These soils are suited to all crops commonly grown in the county.

Representative profile of Hamerly loam, 1 to 3 percent slopes, 2,000 feet north and 150 feet east of the southwest corner of sec. 8, T. 158 N., R. 82 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; moderate, fine, crumb structure; slightly hard, friable, sticky and plastic; strong effervescence; moderately alkaline; clear, smooth boundary.

C1ca—6 to 19 inches, light olive-brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; massive; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual boundary.

C2—19 to 32 inches, olive-brown (2.5Y 4/4) loam, pale olive (5Y 6/3) when dry; massive; hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual boundary.

C3cs—32 to 60 inches, olive-brown (2.5Y 4/3) loam, pale olive (5Y 6/3) when dry; few, fine, prominent, gray (5Y 5/1) mottles, light gray (5Y 7/1) when dry; massive; hard, firm, sticky and plastic; few, large, prominent, light olive-gray (5Y 6/2) nests of gypsum; strong effervescence; moderately alkaline.

The A1 horizon is very dark gray or black and is 6 to 8 inches thick. It has slight effervescence, if any, in areas of native grass but strong or violent effervescence in cultivated areas. In places all or part of the C horizon is light clay loam. In a few places tongues of the A1 horizon extend into the upper part of the C horizon. Masses of gypsum in the C3 horizon are common in most places.

Hamerly soils are associated on the landscape with Vallers

Hamlet Series

The Hamlet series consists of deep, moderately well drained, nearly level to undulating soils. These soils are in plane and slightly concave areas on till plains. They formed in loamy glacial till.

In a representative profile the surface layer is black

Hamlet soils are associated with Barnes and Svea soils. They are not so well drained as Barnes soils and are not dark colored to so great a depth as Svea soils.

HhA—Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on the till plain on low flats and in broad drainageways, in which are shallow basins. About 55 percent of the complex is Hamlet loam, 25 percent is Hamerly loam, and 20 percent is Tonka silt loam. The Hamlet soil is in the higher, concave areas, the Hamerly soil is in the areas around and between depressions, and the Tonka soil is in the depressions. The Hamlet soil has a lower content of lime than the Hamerly soil, and both are less wet than the Tonka soil.

Runoff is generally slow, but the Tonka soil is subject to ponding.

Most areas of this complex are used for crops. Spring seeding is delayed on the Tonka soil in most years unless excess water has been removed. Soil blowing on the Hamerly soil is a special concern of management. This complex is suited to cultivated crops if excess water is removed. Capability unit IIc-6; Hamlet and Hamerly soils in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

HmA—Hamlet-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on the till plain in elongated swales and broad drainageways in which are shallow basins. About 65 percent of the complex is Hamlet loam, 25 percent is Tonka silt susceptible to soil blowing. Hecla soils are better suited to grass and legumes than to most other crops.

Representative profile of Hecla loamy sand, in an area of Hecla and Lohnes loamy sands, 1 to 3 percent slopes, 990 feet west of the northeast corner of sec. 8, T. 158 N., R. 84 W., in a cultivated area.

Ap—0 to 7 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—7 to 16 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

AC—16 to 24 inches, very dark grayish-brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) when dry; weak, medium, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; mildly alkaline; clear, wavy boundary.

Clca—24 to 40 inches, light olive-brown (2.5Y 5/4) loamy sand, pale yellow (2.5Y 7/4) when dry; single grained; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual boundary.

C2—40 to 60 inches, light olive-brown (2.5Y 5/4) medium and fine sand, light yellowish brown (2.5Y 6/4) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The solum is loamy fine sand, loamy sand, or fine sand 16 to 40 inches thick. Depth to lime ranges from 20 to more than 60 inches. The A1 horizon is very dark gray or black. In places

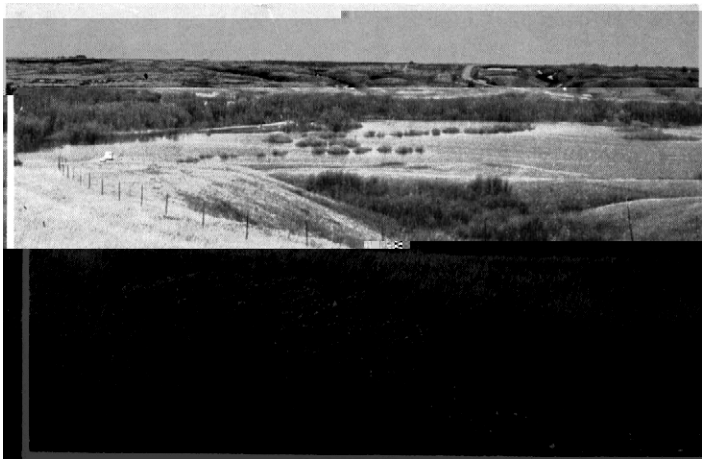


Figure 10.—**Flooded areas of bottom lands along the Souris River. The water covers areas of LaDelle, Ludden, and Velva soils.**

LaDelle soils are used mainly for cultivated crops. They are suited to all crops commonly grown in the county.

LaA—LaDelle silty clay loam, 1 to 3 percent slopes. This soil is nearly level and is on flood plains of the Des Lacs and Souris Rivers.

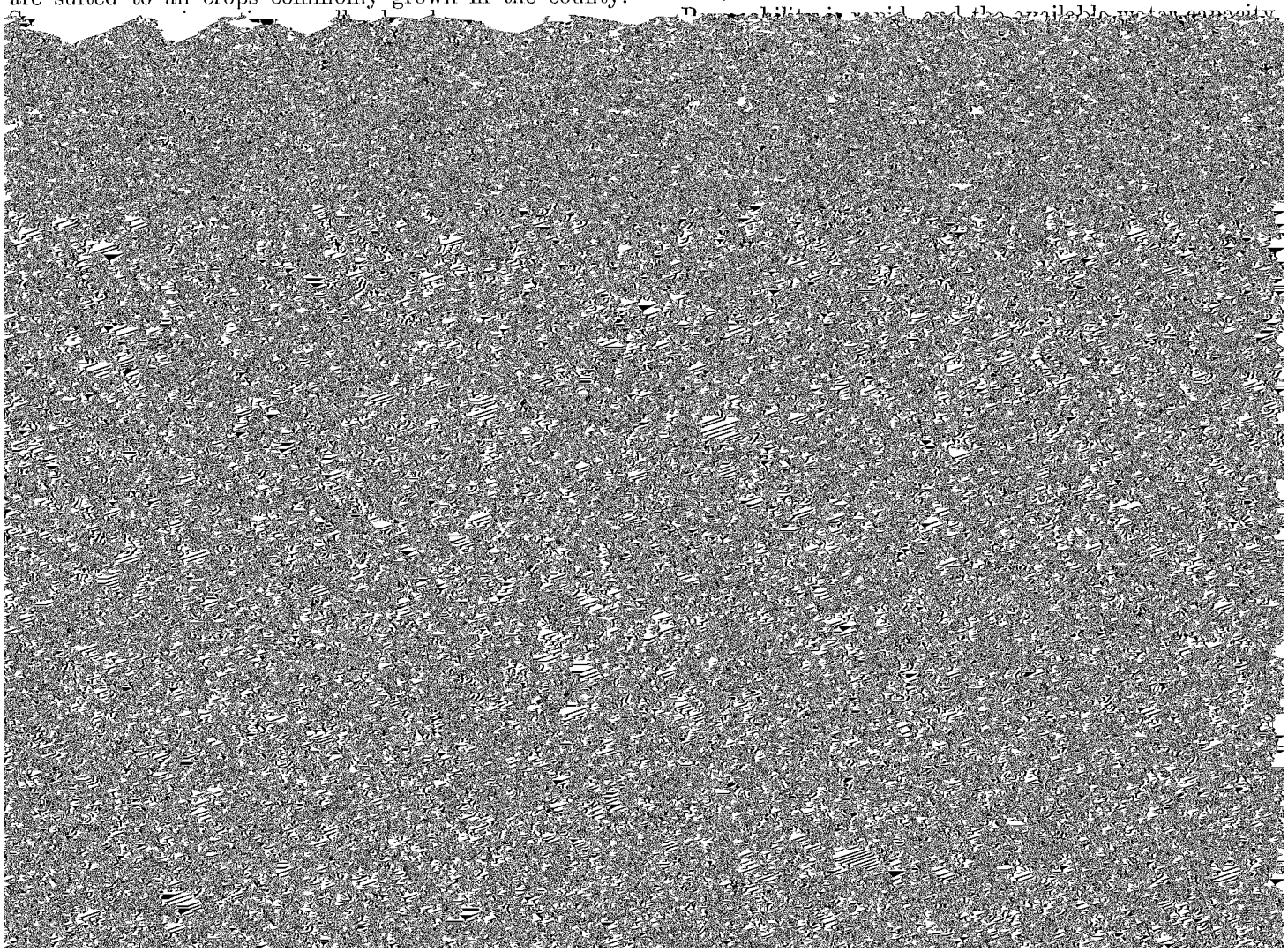
Runoff is slow. In some years the soil is flooded for a few days in spring.

This soil is suited to all crops commonly grown in the county, and most areas are used for cultivated crops. Some areas are in native woodland or grass. Flooding is a concern of management. Soil blowing and erosion are easily controlled. Capability unit IIc-6; windbreak suitability group 1.

Lohnes Series

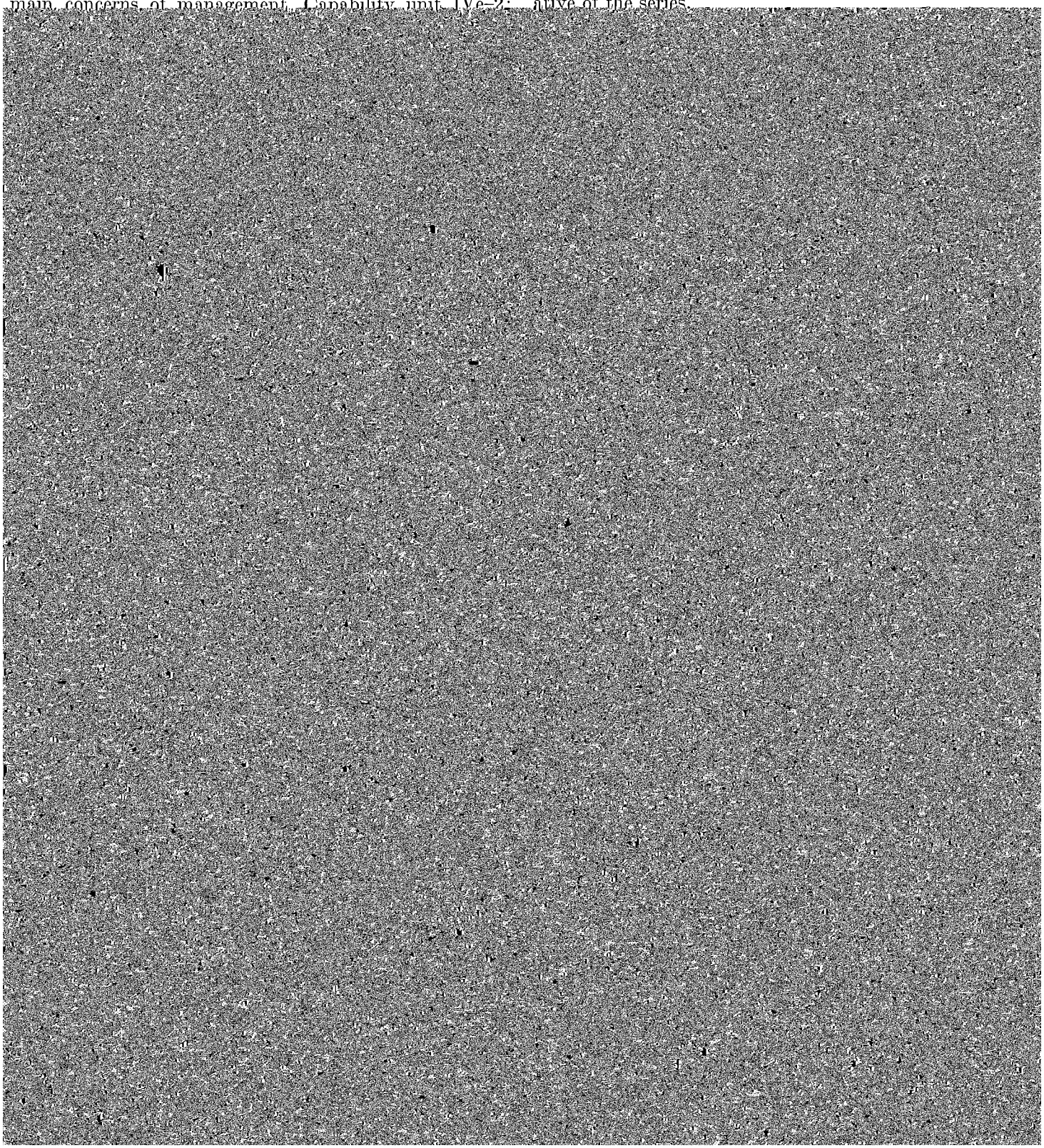
The Lohnes series consists of deep, moderately well drained, nearly level and undulating soils. These soils are mainly on outwash plains. They formed in sandy glacial outwash.

In a representative profile the surface layer is black loamy sand about 11 inches thick. The next layer is very friable very dark brown loamy sand about 4 inches thick. The underlying material, to a depth of about 60 inches, is loose brown sand.



This soil is suited to grass and legumes, but it is poorly suited to cultivated crops. Most areas are used for tame grass and alfalfa. Soil blowing and droughtiness are the main concerns of management. Capability unit IVe-2;

Lu—Ludden silty clay. This soil is on bottom lands of the Souris and Des Lacs Rivers. It has slopes of 0 to 1 percent. This soil has the profile described as representative of the series.



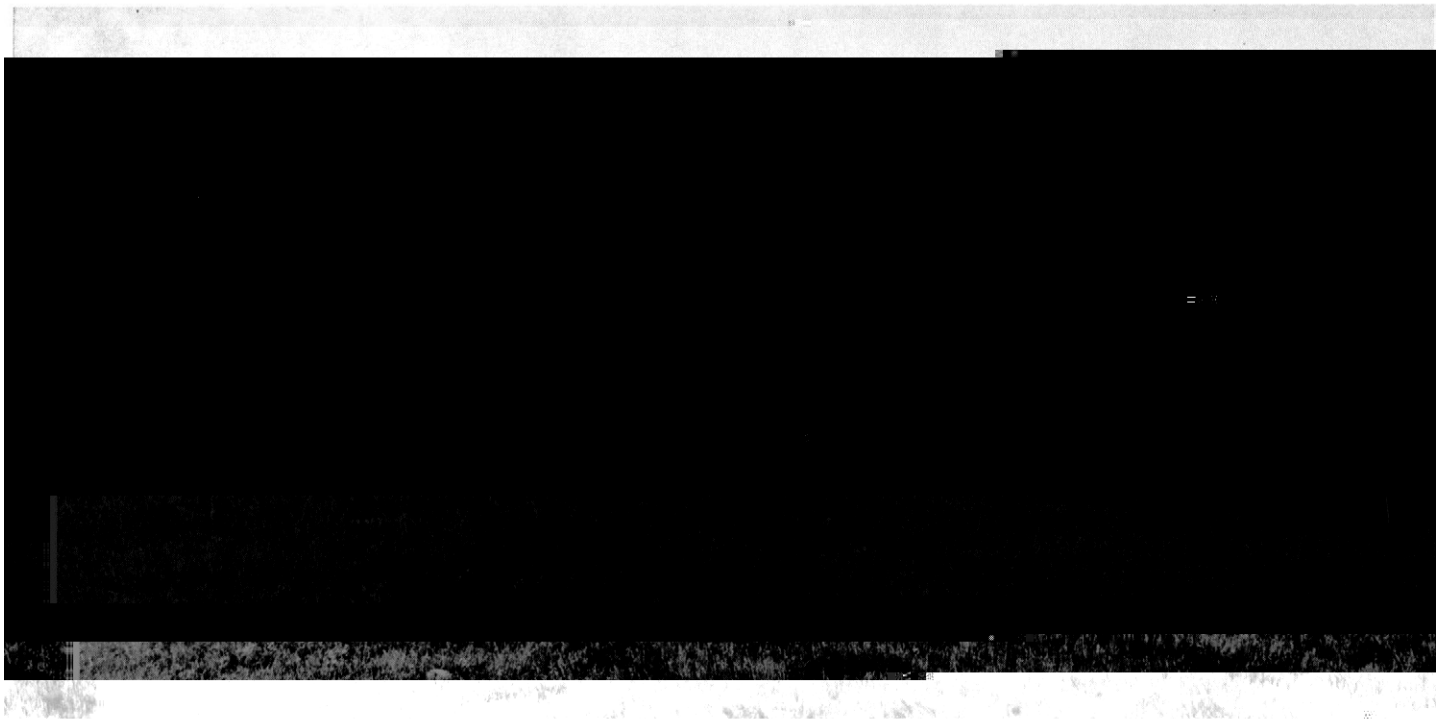


Figure 11.—**Marsh area at the north end of Lake Darling.**

Most areas are used for hay and pasture. Marysland soils are better suited to these uses than to others.

Representative profile of Marysland silt loam, 1,380 feet west and 90 feet north of the southeast corner of sec.

IIIC5—45 to 60 inches, olive-brown (2.5Y 4/4) gravelly coarse sand, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

Depth to sand and gravel ranges from 20 to 40 inches. The black

In a representative profile the surface layer is very dark brown loam about 4 inches thick. The subsoil is very dark grayish-brown, friable loam about 9 inches thick. The underlying material, to a depth of about 25 inches, is light olive-brown loam that has a large amount of lime. Below this, to a depth of about 60 inches, it is olive-brown loam.

Permeability is moderate in the subsoil and moderately slow in the underlying material. The available water capacity is high. Runoff is rapid. The content of organic matter is moderate, and fertility is high.

Nearly all the acreage is in native grass used for pasture. These soils are suited to pasture and wildlife habitat.

Representative profile of Max loam, in an area of Zahl-Max loams, 9 to 15 percent slopes, 1,055 feet east and 75 feet south of the northwest corner of sec. 25, T. 163 N., R. 87 W., in grass.

A1—0 to 4 inches, very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when dry; weak, medium and fine, crumb structure; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B2—4 to 13 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, angular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

Clca—13 to 25 inches, light olive-brown (2.5Y 5/4) loam, pale olive (5Y 6/3) when dry; many light-gray (2.5Y 7/2) masses of lime; moderate, medium and fine, subangular blocky structure; friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2—25 to 60 inches, olive-brown (2.5Y 4/4) loam, pale olive (5Y 6/3) when dry; massive; friable, sticky and plastic; strong effervescence; moderately alkaline.

The solum ranges from 12 to 20 inches in thickness. In a few cultivated areas, the Ap horizon is very dark grayish brown when moist and dark grayish brown when dry. The A1 horizon ranges from 3 to 7 inches thick. The B2 horizon has weak to moderate, medium or coarse, prismatic structure parting to fine to coarse, blocky. Lime occurs both in diffuse forms and in segregations of threads and masses.

are suited to and are used for cultivated crops if excess water is removed.

Representative profile of Parnell silty clay loam, 330 feet south and 960 feet west of the northeast corner of sec. 23, T. 158 N., R. 82 W., in native meadow.

A11—0 to 4 inches, black (10 YR 2/1) silty clay loam; moderate, fine, crumb structure; friable, sticky and plastic; neutral; clear boundary.

A12—4 to 9 inches, black (10 YR 2/1) silty clay loam; strong, fine, granular structure; friable, sticky and plastic; neutral; clear boundary.

B21t—9 to 22 inches, black (10 YR 2/1) silty clay; many, fine, distinct, light olive-brown mottles; strong, fine, angular blocky structure; firm, very sticky and very plastic; neutral; gradual boundary.

B22tg—22 to 34 inches, very dark gray (N 3/0) silty clay; few, prominent, dark-colored mottles; massive; firm, very sticky and very plastic; neutral; clear, irregular boundary.

C1g—34 to 44 inches, olive-gray (5Y 5/2) silty clay; massive; firm; very sticky and very plastic; strong effervescence; mildly alkaline; gradual boundary.

IICzg—44 to 60 inches, gray and olive-brown (5Y 5/1 and 2.5Y 4/4) clay loam; massive; friable, sticky and plastic; strong effervescence; mildly alkaline.

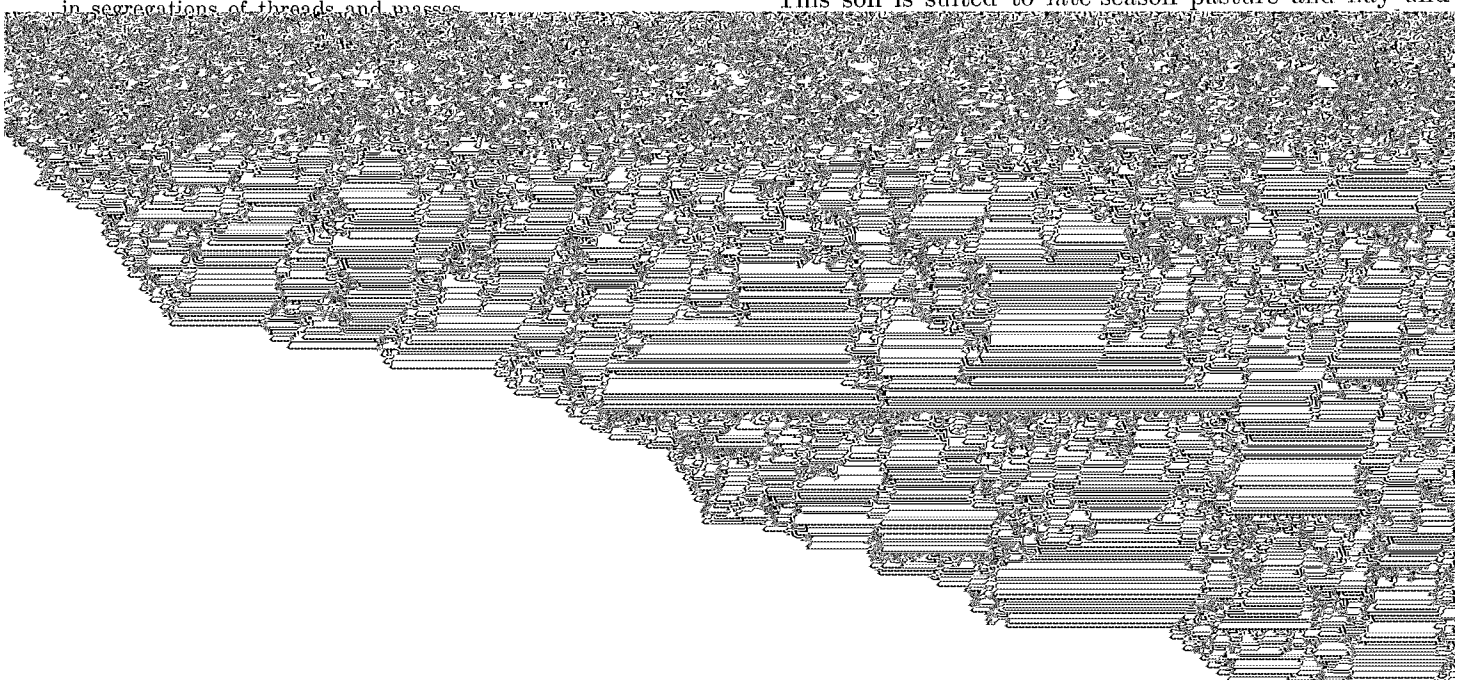
The solum ranges from 30 to 50 inches in thickness. It contains small snail shells in many places. The A1 horizon is silty clay loam or silt loam 6 to 12 inches thick. The B2t horizon is heavy silty clay loam to clay and, in some places, is not mottled. The Cg horizon, below a depth of 40 inches, is loamy glacial till in many places. In some places it has weak, blocky structure.

Parnell soils are in areas similar to those in which Fulda and Tonka soils occur. They have a thicker A1 horizon and solum than Fulda soils and lack a thick A2 horizon, which Tonka soils have.

Pa—Parnell silty clay loam. This soil is in closed depressions on glacial till plains (fig. 12). It has slopes of 0 to 1 percent.

This soil is ponded during most of the growing season in wet years unless excess water is removed. Many basins do not have adequate drainage outlets.

This soil is suited to late-season pasture and hay and



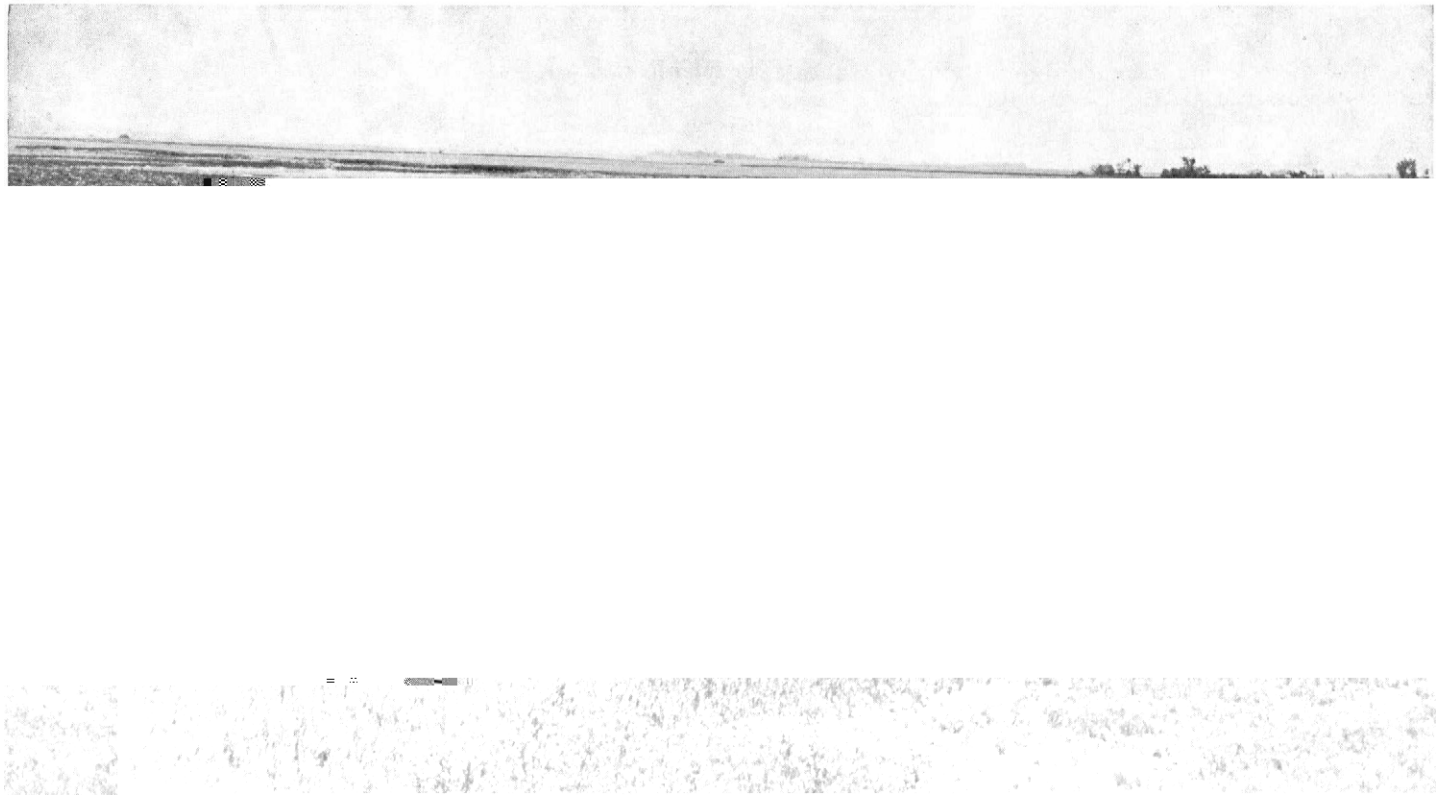


Figure 12.—**Parnell silty clay loam in a depression.**

inches of the underlying material, which is sand and gravel. These soils are droughty.

Most areas are cultivated. These soils are fairly well suited to cultivated crops, but they are better suited to pasture.

Representative profile of Renshaw loam, 1 to 3 percent slopes, 4,000 feet east and 420 feet south of the northwest corner of sec. 31, T. 164 N., R. 84 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and slightly plastic; neutral; abrupt, smooth boundary.

B2—5 to 11 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; neutral; abrupt, wavy boundary.

B3—11 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam and gravelly loam, dark grayish brown (10YR 4/2) when dry; weak, medium, subangular blocky structure; loose, nonsticky and nonplastic; neutral; clear, wavy boundary.

IIC1—16 to 40 inches, dark grayish-brown (10YR 4/2) gravel and sand, light brownish gray (10YR 6/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; mildly alkaline; gradual, wavy boundary.

IIC2—40 to 60 inches, brown (10YR 4/3) gravel and sand, pale brown (10YR 6/3) when dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline.

Thickness of the solum and depth to sand and gravel range from 10 to 20 inches. The A1 horizon is black or very dark gray and ranges from 4 to 7 inches in thickness. The B2 horizon is very dark grayish brown or very dark brown. It has weak to moderate, medium to coarse, prismatic structure that parts to weak to moderate, fine to medium, subangular blocky. A B3 horizon is lacking in places. The IIC1 horizon has a weakly expressed zone of lime accumulation, where the lime occurs in the form of crusts and coatings on pebbles.

Renshaw soils are near Arvilla and Sioux soils. They have less sand in the B horizon than Arvilla soils. They have a thicker solum over sand and gravel than Sioux soils.

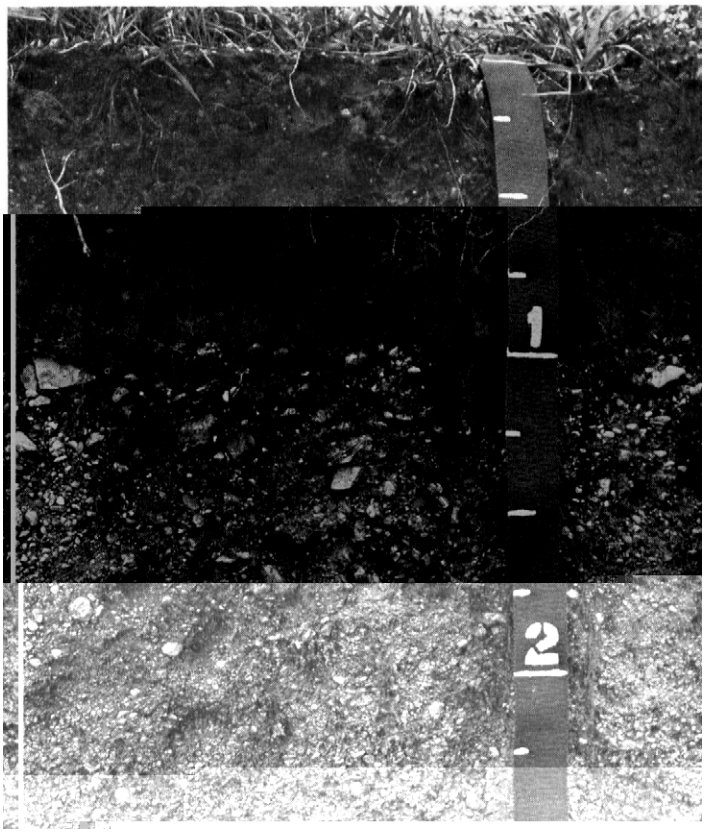
RnA—Renshaw loam, 1 to 3 percent slopes. This soil is nearly level and is on glacial outwash plains. Slopes are mainly plane. The soil has the profile described as representative of the series. Included with it in mapping were small areas of Arvilla and Sioux soils.

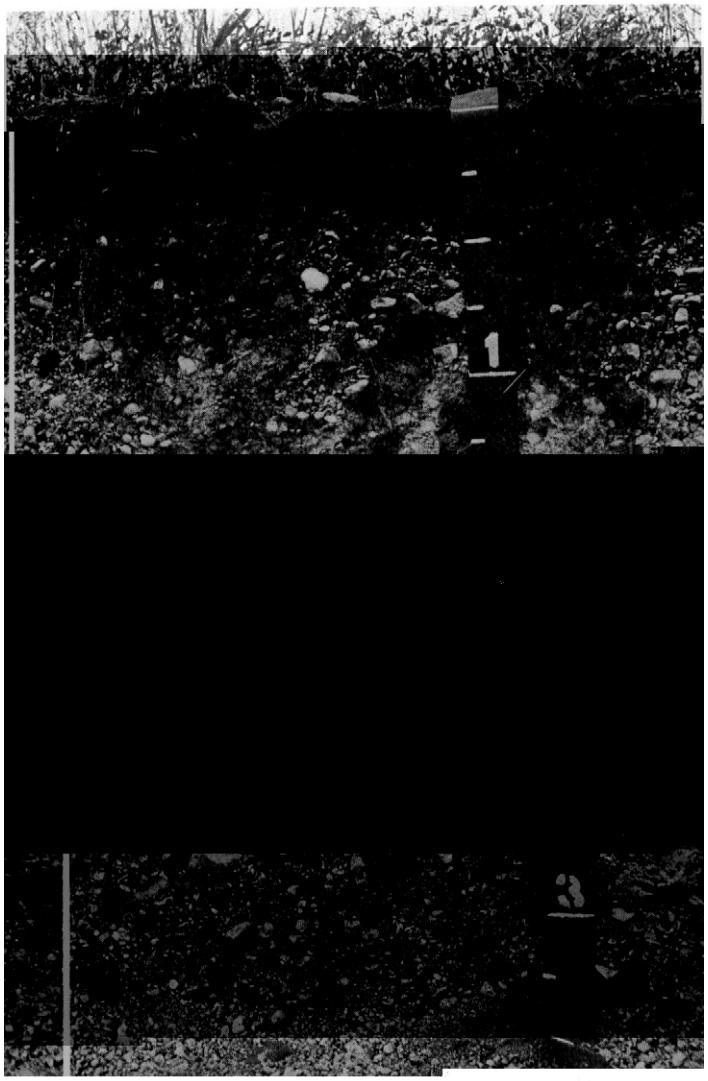
Runoff is slow. This soil has a restricted rooting zone and is droughty. Available water is not adequate during part of the growing season in most years. Soil blowing is a hazard, but it can easily be controlled.

This soil is suited to cultivated crops, but it is better suited to pasture. Most of the acreage is used for crops. Droughtiness is the main concern of management. Capability unit IIIs-6; windbreak suitability group 6.

RnB—Renshaw loam, 3 to 6 percent slopes. This soil is gently sloping and is on glacial outwash plains. Slopes are mainly plane and short and convex. Included with this soil in mapping were small areas of Arvilla and Sioux soils.

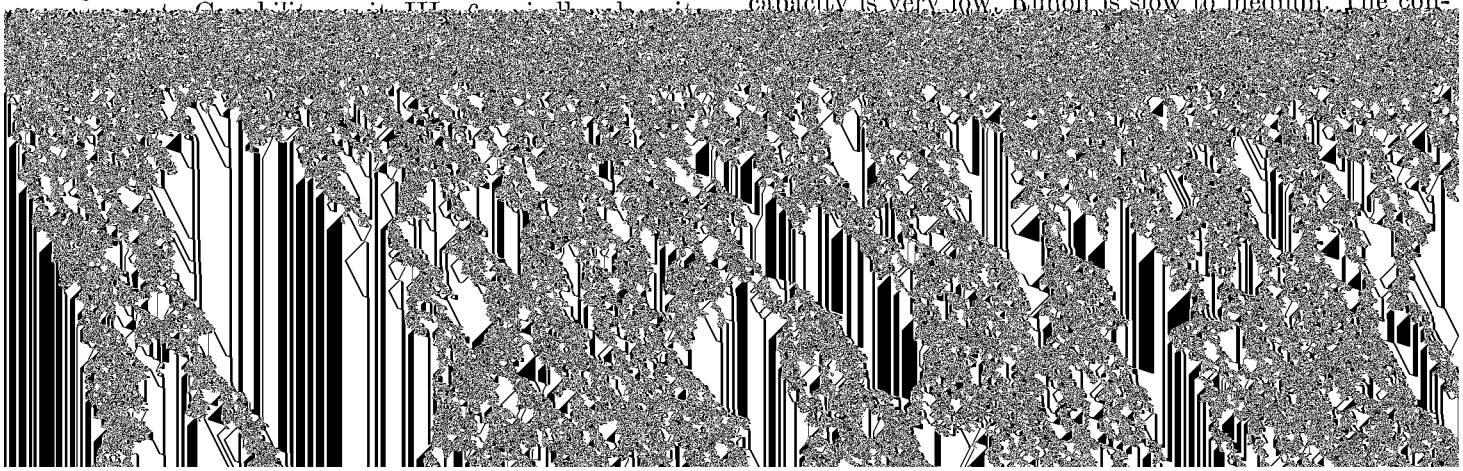
Runoff is medium. This soil has a restricted root zone and is droughty. Available water is not adequate during part of the growing season in most years. Soil blowing is a hazard, but it can be easily controlled. The hazard of water erosion is moderate.





This soil is suited to cultivated crops, but it is better suited to pasture. Most of the acreage is used for crops. Droughtiness and erosion are the main concerns of

Permeability is very rapid, and the available water capacity is very low. Runoff is slow to medium. The con-



IIC2ca—10 to 20 inches, grayish-brown (10YR 5/2) sand and gravel, white (10YR 8/2) when dry; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC3—20 to 60 inches, dark grayish-brown (10YR 4/2) sand and gravel, light gray (10YR 7/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The available water capacity is high. These soils receive some runoff from surrounding higher areas, and runoff is slow to medium. The content of organic matter and fertility are high.

Most areas are cultivated. Some narrow channeled areas are in native grass, trees, and shrubs used for pasture and

Figure 15.—**Dark-colored Svea loam in nearly level swales.**

concerns of management. Capability unit IIe-6; windbreak suitability group 1.

SwB—Svea loam, channeled, 1 to 6 percent slopes. This soil is nearly level to gently sloping and is along channeled intermittent drainageways in broad swales and valleys. Most of the acreage is on bottoms of coulees that adjoin the valleys of the Des Lacs and Souris Rivers. The channels are mainly 2 to 5 feet deep and have short, abrupt slopes. Except in the channels, the soils are mainly nearly level. Areas between the channels are small.

Runoff is slow to medium. This soil receives runoff from the surrounding higher areas. The hazard of water erosion is severe in the channels. This soil is susceptible to soil blowing if it is left bare.

Most areas are in native grass, and native trees and shrubs grow in the channels in many places. The soil is used mainly for pasture and hay. It is too cut up by

Most areas are cultivated. The soil is well suited to all crops commonly grown in the county. Controlling erosion in the channels and soil blowing and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIc-6; windbreak suitability group 1.

SyB—Svea loam, fans, 3 to 6 percent slopes. This soil is gently sloping and is on valley foot slopes. It has long, plane slopes and is at a higher elevation than flood plains along the river. It has a profile similar to the one described as representative of the series, but in many places it has thin sandy strata below the subsoil.

Runoff is medium. This soil receives runoff from surrounding higher areas. The hazard of soil blowing is slight. The hazard of water erosion is generally moderate, but it is severe in the channels carrying runoff from the adjacent uplands.

Most areas are cultivated. The soil is suited to all crops

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The subsoil is very friable and about 21 inches thick. It is very dark grayish-brown fine sandy loam in the upper part and dark-brown loam in the lower part. The underlying material is grayish-brown loam glacial till that is gravelly in the upper part.

Permeability is moderately rapid in the upper part of the soil and moderately slow in the lower part. The available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium. The hazard of soil blowing is severe.

Most areas are cultivated. These soils are suited to all crops commonly grown in the county.

SzB—Swenoda fine sandy loam, 3 to 6 percent slopes. This soil is undulating and is on glacial till plains that have a thin mantle of glacial outwash. Areas are mainly smooth or convex. The soil has a profile similar to the one described as representative of the series, but in places the surface layer is light loam. Included with this soil in mapping were small areas of Barnes loam and Tonka silt loam.

Runoff is slow. This soil is slightly susceptible to soil blowing and, in drainageways, is moderately susceptible to gullying.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Controlling soil blowing and water erosion and maintaining the content of organic matter and fertility are the main concerns

1 or 2. Mottles range from few to many, distinct to prominent from the lower part of the A1 horizon throughout the profile and are more numerous and more distinct with increasing depth. The soil between depths of 10 and 40 inches ranges from sandy loam to light loam and is stratified in places. Finer textured material is at a depth of more than 40 inches in many places.

Tiffany soils are near Embden soils. They are not so well drained as Embden soils and have lime at a greater depth than Wyndmere soils.

Tf—Tiffany fine sandy loam. This soil is level and is in swales and flats in areas of glacial outwash. It occurs as small areas and has plane or slightly concave slopes. Slope is 0 to 1 percent. Included with this soil in mapping

C1ca—36 to 50 inches, olive (5Y 5/4) loam, pale olive (5Y 6/4) when dry, few, medium, distinct, olive-gray (5Y 5/2) mottles; massive; hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, irregular boundary.

C2—50 to 60 inches, olive (5Y 5/4) loam, pale olive (5Y 6/3) when dry; few, medium, faint, olive-gray (5Y 5/2) mottles, light gray (5Y 7/2) when dry; massive; hard and friable; sticky and plastic; strong effervescence; moderately alkaline.

Depth to lime ranges from 20 to more than 60 inches. There is a wide range in the amount and distinctness of mottles in all horizons below the A1 horizon. The A horizon ranges from 8 to 24 inches in thickness. The A1 horizon is black or very dark

Representative profile of Vallers loam, 820 feet west and 140 feet south of the northeast corner of sec. 8, T. 162 N., R. 87 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

These soils are on bottom lands of the Souris and Des Lacs Rivers (fig. 16).

In a representative profile the surface layer is very dark brown loam about 8 inches thick. The subsoil is very dark grayish-brown, very friable silt loam about 11 inches thick. The underlying material, to a depth of 60 inches, is mottled dark grayish-brown very fine sandy loam. Permeability is moderate, and the available water-capac-

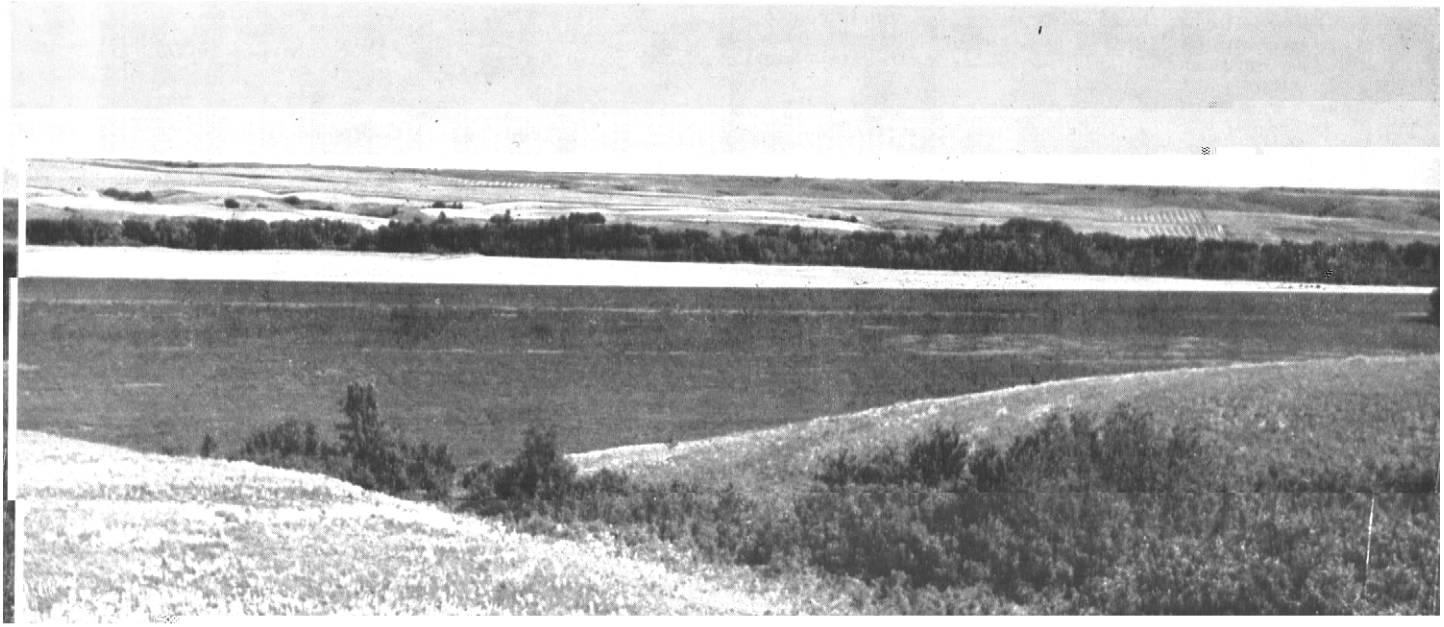


Figure 16.—**Area of bottom lands along the Souris River. The soils are Velva loam, LaDelle silty clay loam, and Ludden silty clay.**

channels it is gently sloping. At the channel edge, this soil has short and abrupt slopes. The soil has somewhat irregular relief, and in places there are swales and low ridges that remain after the stream channel changes.

Runoff is slow. This soil is flooded for a few days in spring in some years.

Nearly all the acreage is cultivated. These soils are well suited to all crops commonly grown in the county.

Representative profile of Williams loam, 1 to 3 percent slopes, 1,600 feet north and 525 feet east of the southwest corner of sec. 32, T. 158 N., R. 86 W., in a native pasture.

A1—0 to 4 inches, very dark brown (10YR 2/2) loam, dark

loam and 5 to 14 inches thick. It has strong, medium or coarse, prismatic structure parting to strong, fine or medium, angular blocky. The Cca horizon has diffuse lime and few to many soft masses of lime.

Williams soils are near Max and Zahl soils. They have a B2t horizon, which is lacking in Max and Zahl soils, and they have a thicker solum than Zahl soils.

WmA—Williams loam, 1 to 3 percent slopes. This soil is nearly level and is on smooth till plains. It has the profile described as representative of the series. Included with it in mapping were a few small areas of deep, dark-colored soils in swales and a few depressions in which Tonka silt loam occurs.

Runoff is slow. Soil blowing is a slight hazard, but it is easily controlled.

Nearly all the acreage is cultivated. The soil is well suited to all crops commonly grown in the county. The main concern of management is maintaining the content of organic matter and fertility. Capability unit IIc–6; windbreak suitability group 3.

WmB—Williams loam, 3 to 6 percent slopes. This soil is undulating and is on smooth till plains. Included with it in mapping were a few small areas of Tonka soils in basins and a few areas where slopes are more than 6 percent.

Runoff is medium. Water erosion is a moderate hazard, and soil blowing is a slight hazard.

Most areas are cultivated. The soil is well suited to all crops commonly grown in the county. The main concerns of management are controlling erosion and maintaining the content of organic matter and fertility. Capability unit IIe–6; windbreak suitability group 3.

Wyndmere Series

The Wyndmere series consists of deep, somewhat poorly drained, nearly level soils. These soils are in slightly depressed basins. They formed in glacial outwash.

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The underlying material, to a depth of about 44 inches, is grayish-brown fine sandy loam and loamy fine sand that is mottled and in the upper part of which lime has accumulated. Below this, to a depth of 60 inches, it is mottled gray very fine sandy loam.

Permeability is moderately rapid, and the available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium. In spring, the water table is near the surface. These soils are highly susceptible to soil blowing.

Most areas are used for crops. These soils are suited to all crops commonly grown in the county.

Representative profile of Wyndmere fine sandy loam, 1 to 3 percent slopes, 1,720 feet west and 210 feet south of the northeast corner of sec. 27, T. 163 N., R. 84 W., in

vescence; moderately alkaline; gradual, wavy boundary.

C2—26 to 44 inches, grayish-brown (2.5Y 5/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; weak, fine, subangular blocky structure; soft, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; clear, wavy boundary.

IIC3—44 to 60 inches, gray (5Y 5/1) very fine sandy loam, light brownish gray and light yellowish brown (2.5Y 6/2 and 6/4) when dry; many, medium, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline.

The A1 horizon is black or very dark gray and ranges from 7 to 12 inches in thickness. In places there is an A12ca horizon. The Cca horizon is grayish brown or gray and, in most places, is mottled. Mottles below the Cca horizon range from few to many and faint to prominent. Fine- or coarse-textured material is at a depth of more than 40 inches in places.

Wyndmere soils are near Arveson and Tiffany soils. They are better drained than Arveson soils and are shallower to an accumulation of lime than Tiffany soils.

WyA—Wyndmere fine sandy loam, 1 to 3 percent slopes. This soil is nearly level and is in slightly depressed basins. Included with this soil in mapping were small areas of Arveson soils.

Runoff is slow. In most years the water table is 3 to 5 feet below the surface during the growing season, but is nearer the surface and is ponded for short periods during unusually wet seasons. This soil is highly susceptible to soil blowing. Spring seeding is delayed by wetness in most years.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Wetness and soil blowing are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Zahl Series

The Zahl series consists of deep, well-drained, rolling to very steep soils that have a thin combined surface layer and subsoil. These soils are on slopes and crests of valley breaks and narrow drainage divides. They formed in glacial till. They have convex or plane slopes.

In a representative profile (fig. 17) the surface layer is very dark brown loam about 5 inches thick. The underlying material, to a depth of 13 inches, is very dark grayish-brown loam that has concentrated lime. Below this, to a depth of 60 inches, it is dark grayish-brown loam, in the upper part of which lime has accumulated.

Permeability is moderate in the surface layer and moderately slow in the underlying material. The available water capacity is high. Runoff is rapid. The content of organic matter is moderately low, and fertility is medium. These soils are susceptible to water erosion.

Nearly all the areas are in native grass used for pasture. These soils are too steep to be suited to cultivated crops.

ZaD—Zahl-Max loams, 9 to 15 percent slopes. The soils making up this complex are rolling and are in valley breaks and narrow drainage divides. About 45 percent of the complex is Zahl loam, 40 percent is Max loam, and 15 percent is included areas of Svea loam. The Zahl soil is on upper side slopes and crests of breaks, the Max soil is on midslopes and broad ridgetops, and the included Svea soil is in swales. The Zahl and Max soils have the profiles described as representative of their series. The Zahl soil is shallower to underlying material than the Max and Svea soils. The Max soil is not so dark colored to so great a depth as the Svea soil.

Runoff is rapid. The hazard of water erosion is severe in cultivated areas.

Most areas of this complex are used for native pasture. These soils are too steep and too erodible to be suited to crops. Capability unit VIe-5; Zahl soil in windbreak

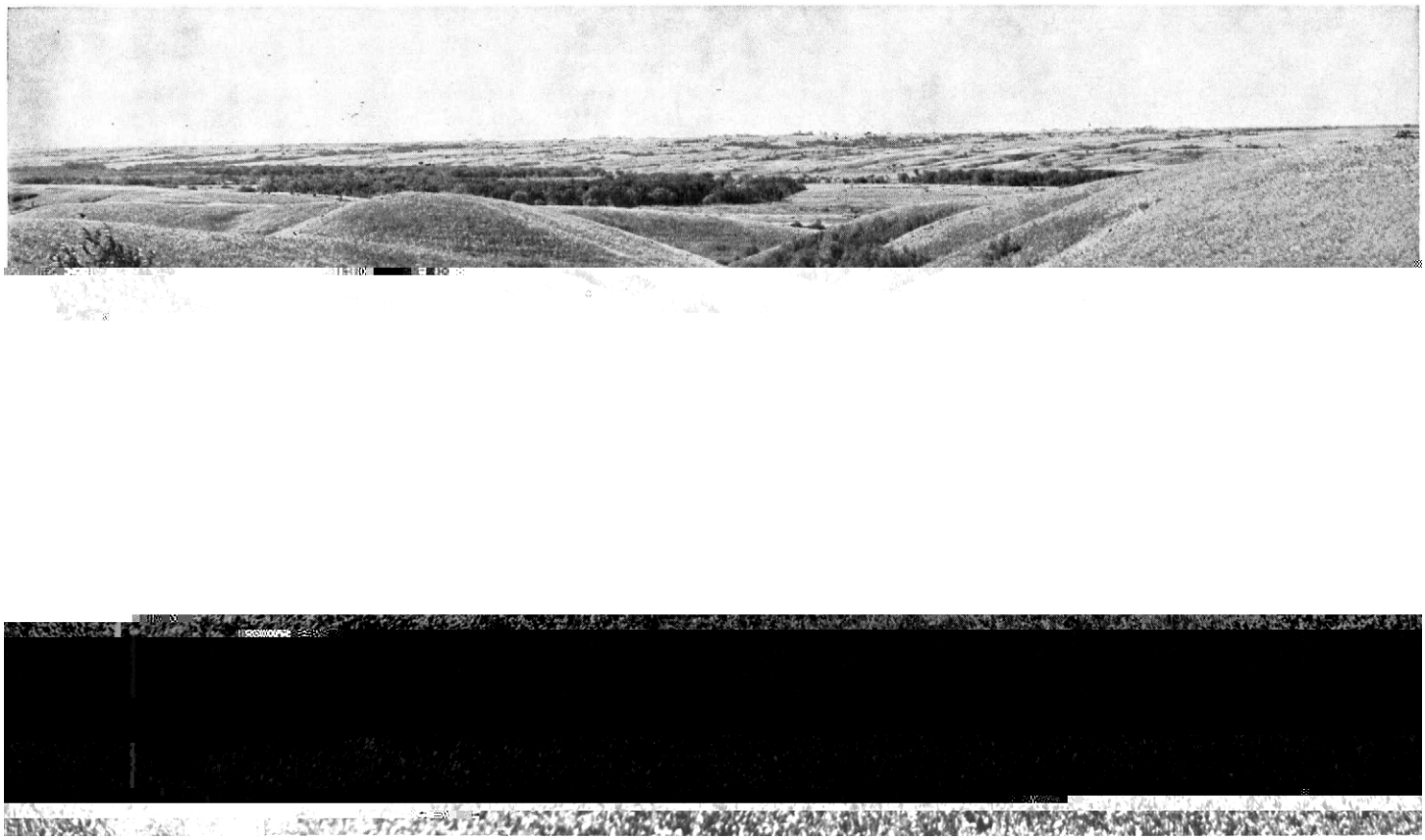


Figure 18.—**Drainageway leading to bottom lands along the Souris River. The soils are Zahl-Max loams, 15 to 60 percent slopes.**

managing cultivated soils in Renville County are conserving moisture, controlling soil blowing, and maintaining fertility. Drainage and removal of stones are also needed in places.

In dryfarmed areas conserving moisture generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Stubble mulching, contour farming, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, use of crop residue, and application of fertilizer are beneficial. Fallow helps to control weeds and build up the moisture content.

Among the measures that help to control erosion are cover crops, stripcropping, buffer strips, windbreaks, contour farming, diversions, waterways, minimum tillage, timely tillage, emergency tillage, and 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,

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 that require 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 groups are described in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I to VIII. The numerals indicate

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range,

Permeability is moderate, and the available water capacity is high. The content of organic matter is moderate and the fertility is high. Soil blowing is a moderate hazard in cultivated areas, but it can be controlled by stubble mulching and using crop residue. In some areas grassed

Figure 19.—Soil blowing on a large field.

Figure 20.—An area where a grassed waterway is needed to reduce erosion and siltation.

ping, windbreaks, cover crops, and buffer strips also help to control erosion. The response of crops to applications of

throughout, but the Great Bend and LaDelle soils have a surface layer and subsoil of silty clay loam, and the Tonka

at a depth of 10 to 20 inches. The Barnes soil has slopes of 6 to 9 percent, and the Renshaw soil 3 to 6 percent.

Both soils in this unit have a moderate content of organic matter. Permeability is moderately slow in the Barnes soil and moderate in the subsoil and very rapid below the subsoil in the Renshaw soil. The available water capacity is high in the Barnes soil and moderate in the Renshaw soil. The fertility is high in the Barnes soil and medium in the Renshaw soil. The hazards of soil blowing and water erosion are moderate.

The soils in this unit are suited to all locally grown crops. The Renshaw soil is droughty and better suited to early maturing crops than to others.

Good use of crop residue is necessary to control soil blowing and water erosion. The amount of residue is not adequate for protection of fallowed soils, and stripcropping or the use of windbreaks, cover crops, or buffer strips is essential. The Barnes soil should be tilled on the contour. Grassed waterways are needed in places where water accumulates. Including grass and legumes in the cropping system also helps to control erosion.

using crop residue are the main practices used to control soil blowing. Stripcropping and windbreaks are alternative measures.

CAPABILITY UNIT IIIw-6

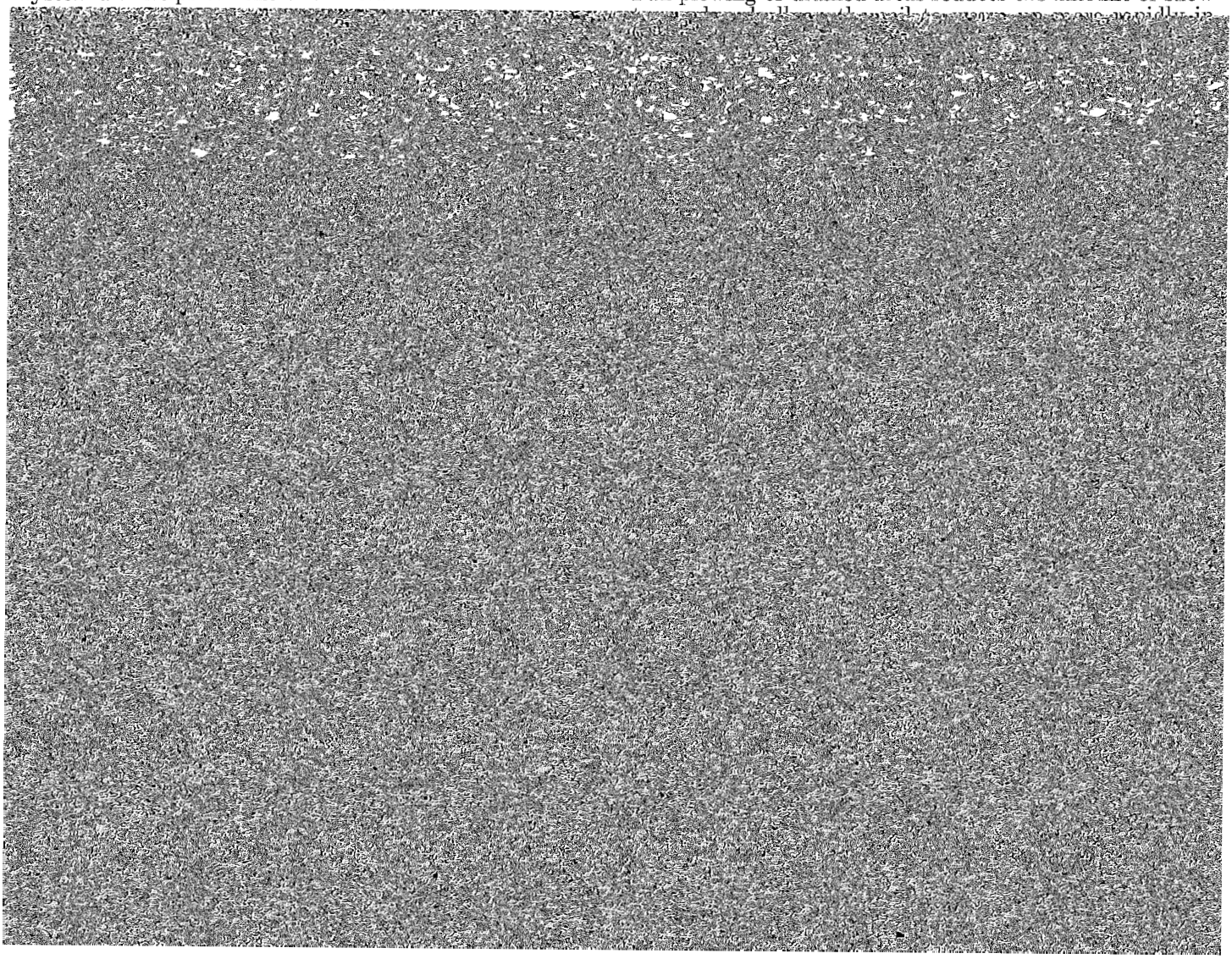
This unit consists of deep, level, poorly drained and very poorly drained soils of the Fulda and Parnell series. The surface layer is silty clay loam, and the subsoil is silty clay.

Permeability is slow, and the available water capacity is high. The content of organic matter and the fertility are high. These soils are not easily eroded. They are frequently ponded for extended periods of time.

If not drained, the soils in this unit are well suited only to water-tolerant grasses, but if drained, they are well suited to grasses, legumes, small grain, and flax.

Grasses and legumes are needed in the crop rotation to use up excess moisture and to maintain permeability and tilth. Sweetclover seeded with small grain or flax is also beneficial.

Summer fallow should be used as little as possible. Fall plowing of drained areas reduces the amount of snow



Stripcropping is needed to control soil blowing because the amount of crop residue is so small in dry years. Summer fallow does little good because the soil has

The soils in this unit are used for all locally grown crops.

Intensive use of crop residue and stubble mulching are needed to control erosion. Stripcropping and windbreaks

CAPABILITY UNIT Vw-4

This unit consists of deep, poorly drained and very poorly drained soils of the Colvin, Fargo, and Ludden series. Excess water is on or near the surface of these soils during much of the growing season. The Colvin soil has a surface layer of silt loam and a subsoil of silty clay loam. The Fargo and Ludden soils have a surface layer and subsoil of silty clay.

All the soils in this unit have high available water capacity and high fertility. Permeability is moderately slow in the Colvin soil and slow in the Fargo and Ludden soils. The content of organic matter is high in the Colvin and Fargo soils and moderate in the Ludden soil.

The soils in this unit are not suitable for cultivation, but they are well suited to grass. In some years water is ponded deep enough that cattails and bulrushes grow instead of grass. Areas that are surrounded by cropped fields and that are too small to fence for use as pasture are used for hay or for fall grazing.

The growth of grass is not readily affected by periods of drought, nor is the grass likely to be overgrazed. Hay should be mowed early enough to allow time for some regrowth before the ground freezes. After mowing, there should be several inches of stubble in the field.

CAPABILITY UNIT VIe-5

This unit consists of deep, well-drained soils of the Zahl and Max series. These soils have a surface layer and subsoil of loam.

Permeability is moderate in the upper part of the profile and moderately slow in the underlying material. The available water capacity is moderate in the Max soils and high in the Zahl soils. The content of organic matter is moderately low in the Zahl soils. The fertility is high in the Max soils and medium in the Zahl soils.

The soils in this unit are too steep for cultivation. They are highly susceptible to erosion.

CAPABILITY UNIT VIe-6

This unit consists of deep soils of the Svea and Velva series. The surface layer is loam. The Svea soil has a subsoil of loam, and the Velva soil has a subsoil of silt loam. The Svea soil is moderately well drained, and the Velva soil is well drained.

Both soils in this unit have high available water capacity and high fertility. Permeability is moderate in the subsoil and moderately slow in the underlying material of the Svea soil, and it is moderate in the Velva soil. The content of organic matter is high in the Svea soil and moderate in the Velva soil.

These soils are so cut up by meandering stream channels and uncrossable drainageways that it is seldom possible or practical to farm them. They are often subject to flooding in spring.

CAPABILITY UNIT VIs-6

Only Sioux soils are in this unit. The surface layer is loam, and the subsoil is coarse sand and gravel. These soils are excessively drained.

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

CAPABILITY UNIT VIIs-6

Only Barnes and Buse very stony loams, 3 to 15 percent slopes, are in this unit. These are deep, well-drained soils. The surface layer and subsoil are loam.

Permeability is moderate in the upper part of the profile and moderately slow in the underlying material, and the available water capacity is high. The content of organic matter is moderate in the Barnes soil and moderately low in the Buse soil. The fertility is high in the Barnes soil and medium in the Buse soil.

The soils in this unit are too stony to be cultivated, but they can be used for range.

CAPABILITY UNIT VIIIw-1

This unit consists entirely of areas of Marsh, which is covered by water most of the time. Except in dry years, Marsh is normally wet throughout the summer. Plants are mainly bulrushes and wetland sedges.

These areas have no value for farming, but they provide food and cover for ducks and other wildlife. In many places shallow ditches provide more permanent water.

CAPABILITY UNIT VIIIs-1

This unit consists only of Gravel pits. These areas have no value for farming. They are a source of sand and gravel and, when abandoned, often become good areas for wildlife habitat.

Predicted yields

Predicted yields of the principal crops grown in Renville County, under two levels of management, are shown in table 2. These predictions are based on information obtained from farmers, local farm workers, and the North Dakota Agricultural Experiment Station. They are averages for a period long enough to include years when temperature and moisture supply during the growing season were both favorable and unfavorable.

Woodland and Windbreaks [3]

Renville County has 4,200 acres of native woodland. The native woody vegetation is used mainly for livestock protection, wildlife habitat, recreational purposes, and watershed protection. Most of the trees and shrubs grow on the Velva, LaDelle, and Ludden soils on bottom lands along the Souris River. They also grow on the Svea and Max soils in natural draws leading into valleys of the Souris and Des Lacs Rivers. The principal trees and shrubs are boxelder, American elm, green ash, eastern cottonwood, willow, chokecherry, juneberry, wild plum, snowberry, wild rose, and aspen.

Windbreaks have been planted since the days of the early settlers. In most places the early planting protected the farmstead and livestock (fig. 21). A need for these kinds of plantings still exists on many farms. Increasingly windbreaks are planted to help control soil bowing in cultivated fields where it is a serious hazard. On thousands of acres in Renville County, some form of protection from wind is still needed.

[3] By David L. Hintz, woodland conservationist, Soil Conservation Service, Huron, S.D.

TABLE 2.—*Predicted average yield per acre*

[Yields in columns A can be expected under average management, and those in columns B can be expected under improved management. Dashes indicate that the crop is not suited to the soil. Only arable soils are listed]

Soil	Wheat		Barley		Oats		Rye		Flax		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*
Arveson loam	12	19	16	20	22	28	13	20	5	9	----	----
Arvilla sandy loam, 6 to 9 percent slopes	7	11	9	12	13	16	6	11	3	6	0.8	1.3
Arvilla-Sioux sandy loams, 1 to 3 percent slopes	10	15	13	17	18	23	12	16	5	8	1.1	1.6
Arvilla-Sioux sandy loams, 3 to 6 percent slopes	8	13	10	14	14	18	10	15	4	7	1.0	1.5
Barnes loam, 1 to 3 percent slopes	20	30	26	34	36	46	19	28	8	12	1.2	1.8
Barnes loam, 3 to 6 percent slopes	19	29	25	32	34	44	18	27	7	11	1.1	1.7

Figure 21.—**A good farmstead windbreak that provides protection for buildings. The soil is Barnes loam.**

in all of these groups. If good management practices are applied, the growth response for adapted trees and shrubs is generally the same for all of the soils within one group.

Several factors are used in grouping soils into windbreak suitability groups, but the dominant and most critical factor is the amount and seasonal availability of soil moisture to trees. In most windbreak groups the soils have a rather wide range of slope and of texture of the surface layer. These two soil characteristics largely determine the degree of hazards of water erosion and soil blowing. The degree of slope also determines the need for water and soil conservation practices on soils that have no other limiting characteristics.

The degree of susceptibility to soil blowing is determined by texture of soils used for windbreaks, as follows: soil that is coarse textured has a very high susceptibility; moderately coarse textured, high; medium textured, moderate to slight; moderately fine textured, slight; and fine textured, high. The degree of susceptibility to water erosion is determined by slope of soils used for windbreaks [illegible] have additional critical limitations to use for growing trees and shrubs.

Table 3 lists most of the trees and shrubs used in windbreak plantings and shows their estimated average height and vigor in well-managed plantings at 20 years of age. Considered in making the ratings in the columns headed "Vigor" were density of foliage, freedom from damaging insects or plant disease, and general appearance of the tree.

Good means that the plant generally exhibits leaves or needles that are normal in color and growth; only a small amount of deadwood (tops, branches, and twigs) within the live crown; limited evidence of damage from plant diseases, insects, or climate; or only slight evidence, in places, of stagnation or suppression. The plant may exhibit more than one of those features.

Fair means that the plant exhibits leaves or needles that are obviously abnormal in color and growth; a substantial amount of deadwood (tops, branches, and twigs) [illegible]

In the following pages the windbreak suitability groups in Renville County are described.

WINDBREAK SUITABILITY GROUP 1

This group consists of deep, nearly level to sloping, well-drained to poorly drained, loamy or clayey soils of the Divide, Embden, Fargo, Great Bend, Hamerly, Hamlet, Hecla, LaDelle, Ludden, Svea, Velva, and Wyndmere series. These soils have favorable soil moisture for the survival and growth of trees and shrubs. The water table in the Divide, Hamerly, and Wyndmere soils is within the reach of tree roots. The Fargo, Great Bend, Hamlet, and Svea soils receive runoff from surrounding higher areas.

These soils are well suited to all kinds of windbreak plantings.

With the exception of a serious hazard of soil blowing on some soils, no other hazards or limitations to planting trees and shrubs on the soils in this group are serious.

WINDBREAK SUITABILITY GROUP 2

This group consists of deep, nearly level, poorly drained and very poorly drained, loamy or clayey soils of the Arveson, Colvin, Fulda, Marysland, Parnell, Tiffany, Tonka, and Vallers series. These soils are ponded or have a high water table. Unless drained, they are either poorly suited or not suited to trees and shrubs.

These soils are well suited to all kinds of windbreak plantings if adequate drainage is installed. The number of adapted trees and shrubs is more limited on the Arveson, Colvin, Marysland, and Vallers soils than on other soils in this group.

The hazard of soil blowing is serious on Colvin, Marysland, and Vallers soils because they have a high content of lime. Soil blowing is also a hazard on the clayey soils. Wetness is the only critical limitation, but to a lesser extent, high content of lime is also a limitation.

WINDBREAK SUITABILITY GROUP 3

This group consists of deep, nearly level to hilly, well-drained, loamy soils of the Barnes, Max, Svea, and Williams series.

These soils are well suited to all kinds of windbreak plantings. If proper care is given to conserving moisture, nearly all adapted trees and shrubs can be grown on these soils.

With the exception of a hazard of soil blowing or water erosion on some soils, other hazards or limitations to the planting of trees and shrubs on the soils in this group are not serious. On most of these soils a hazard of soil blowing is only slight.

WINDBREAK SUITABILITY GROUP 4

This group consists of deep, nearly level, moderately well drained, loamy soils of the Cresbard series. These soils have a clayey subsoil.

These soils are suited to all kinds of windbreak plantings if the trees and shrubs are carefully selected. Only a limited number of tree and shrub species do well on these soils.

The hazards of soil blowing and water erosion are slight. The only critical limitation is the clayey texture of the subsoil.

WINDBREAK SUITABILITY GROUP 5

This group consists of deep, nearly level to gently undulating, moderately well drained, sandy soils of the Swenoda series. Most of the precipitation is absorbed by these soils, but some is lost through runoff. The available water capacity is moderate.

These soils are suited to all kinds of windbreak plantings if trees and shrubs are carefully selected. Only a limited number of trees and shrubs do well.

The hazard of erosion is serious on these soils. The moderate available water capacity is the main limitation.

WINDBREAK SUITABILITY GROUP 6

This group consists of nearly level to sloping, somewhat excessively drained, loamy or sandy soils of the Arvilla and Renshaw series. These soils are shallow to sand and gravel. Most of the precipitation is absorbed by these soils, but it moves very rapidly through the sand and gravel underlying material. The available water capacity is low or moderate.

The hazard of erosion is slight to serious. The low available water capacity and a restricted root zone are the critical limitations.

These soils are poorly suited to all kinds of windbreak plantings. Some plantings can be established in areas where optimum survival, growth, and vigor should not be expected and if the proper plants are selected.

WINDBREAK SUITABILITY GROUP 7

This group consists of deep, nearly level to gently undulating, moderately well drained, sandy soils of the Lohnes series.

Most of the precipitation is absorbed by these soils, but little is retained. The available water capacity is low.

These soils are poorly suited to field windbreaks. They are suited to plantings for wildlife, recreation, and beautification in areas where optimum survival, growth, and vigor are not required or expected, but only a limited number of trees or shrubs can be selected.

Soil blowing is a serious hazard and water erosion a slight to moderate hazard. The low available water capacity is the main limitation.

WINDBREAK SUITABILITY GROUP 8

This group consists of deep, gently undulating to steep, well-drained, loamy soils of the Buse and Zahl series. Much of the precipitation runs off these soils. The available water capacity is high, but because runoff is excessive, the amount of water available to trees and shrubs is limited.

These soils are not suited to field windbreaks. They are suited to plantings for wildlife, recreation, and beautification in areas where optimum survival, growth, and vigor are not required or expected.

Erosion is a very serious hazard. Slope is the main limitation; consequently, runoff is excessive and water intake is low.

WINDBREAK SUITABILITY GROUP 9

This group consists of deep, nearly level, moderately well drained, loamy soils of the Cavour series. These soils have a dense claypan subsoil. A nonsodic and nonsaline root zone is generally less than 20 inches thick. The available water capacity is moderate.

TABLE 3.—*Height and vigor of trees and*

Trees and shrubs	Windbreak suitability group [1]		
	1	2	3

shrubs by windbreak suitability group

Windbreak suitability group [1]—Continued									
4		5		6		7		8	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Ft		*Ft*		*Ft*		*Ft*		*Ft*
Fair	15–19	Fair	15–19	Fair	14–18	Poor	----------	Poor	----------
Fair	15–18	Poor	----------	Poor	----------	Poor	----------	Poor	----------
Good	6–8	Good	8–10	Fair	7–9	Fair	5–7	Fair	5–7
Good	8–10	Good	8–10	Fair	7–9	Poor	----------	Poor	----------
Poor	----------	Poor	----------	Poor	----------	Poor	----------	Poor	----------
Good	10–12	Good	9–11	Fair	8–10	Fair	7–9	Fair	7–9
Good	16–20	Fair	15–19	Fair	14–18	Poor	----------	Fair	14–18
Good	6–8	Good	7–9	Fair	6–8	Poor	----------	Poor	----------
Good	17–19	Good	15–20	Fair	14–18	Fair	12–15	Fair	11–14
Fair	12–15	Fair	11–14	Fair	11–14	Poor	----------	Fair	11–14
Good	22–26	Good	20–25	Fair	17–22	Fair	14–18	Fair	14–18
Good	7–9	Good	7–9	Fair	6–8	Poor	----------	Poor	----------

shrubs.

The elements of wildlife habitat in table 4 were selected and weighed for openland, rangeland, and wetland wildlife. Those elements selected and weighed for openland wildlife were grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs; those for rangeland wildlife were wild herbaceous plants and shrubs; and those for wetland wildlife are wetland plants and shallow water areas.

Openland or farmland wildlife are generally introduced wildlife or other wildlife that tolerate or depend upon areas where soil has been disturbed or annual plants are growing. Among these are gray partridge, pheasant, cottontail rabbit, red fox, goldfinch, and ground squirrel.

Rangeland wildlife are animals that depend on range plants. Among these are white-tailed deer, sharp-tailed grouse, horned lark, and jackrabbit.

Wetland wildlife are animals that normally depend on areas of natural wetland. Among these are ducks, herons, shorebirds, mink, muskrat, geese, and coot.

Suitability as a habitat for woodland wildlife is not shown because there is only a limited acreage of natural woodland in the county. These small wooded tracts provide habitat for animals and birds that need only small habitat niches. Among these are thrushes, vireos, and tree squirrels.

Recreation

Most recreation development in Renville County is at Mohall State Park and Mouse River State Park. Other recreation developments are limited. The major activities at these two parks are swimming, ice skating, outdoor games, trap shooting, and golfing. No public facilities are provided in the county for hiking, paths and trails, of the soils in Renville County that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails are given in table 5. The degree of limitation to the specified uses of the soils are given as slight, moderate, or severe. It is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. *Moderate* means that the limitation can be overcome or modified by planning, design, or special maintenance. *Severe* means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, are not subject to flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry.

Picnic areas are natural or landscaped tracts that withstand heavy foot traffic. Most of the vehicular traffic is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stoniness that can greatly increase the cost of leveling or the building of access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy

nland dlife	Rangeland wildlife	Wetland wildlife
------	Fair-------	Fair.
------	Poor-------	Very poor.
d------	Fair-------	Very poor.
d------	Fair-------	Very poor.
d------	Fair-------	Very poor.
d------	Fair-------	Very poor.
-------	Fair-------	Very poor.
-------	Fair-------	Very poor.
-------	Poor-------	Poor.
d------	Fair-------	Good.
-------	Poor-------	Good.
-------	Poor-------	Good.
-------	Fair-------	Poor.
-------	Fair-------	Poor.
d------	Fair-------	Very poor.
-------	Poor-------	Fair.
-------	Poor-------	Fair.
-------	Poor-------	Good.
r poor---	Poor-------	Very poor.
d------	Fair-------	Poor.

d	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
d	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
	Good	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
d	Good	Good	Poor	Poor	Poor	Good	Fair	Poor.
	Good	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
d	Good	Fair	Very poor	Poor	Good	Fair	Poor	Fair.
poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Fair.
poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair.
	Fair	Good	Fair	Very poor	Very poor	Fair	Fair	Very poor.
poor	Very poor	Good	Fair	Very poor	Very poor	Poor	Fair	Very poor.
	Fair	Fair	Poor	Good	Good	Fair	Poor	Good
	Fair	Fair	Poor	Very poor	Very poor	Fair	Poor	Very poor.
	Poor	Poor	Poor	Very poor	Very poor	Poor	Poor	Very poor.
d	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
d	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
	Fair	Good	Fair	Poor	Very poor	Fair	Fair	Very poor.
	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
	Fair	Good	Fair	Fair	Fair	Fair	Fair	Fair.
d	Good	Fair	Fair	Good	Good	Good	Fair	Good.
d	Good	Fair	Fair	Good	Good	Good	Fair	Good.
d	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
	Fair	Good	Fair	Poor	Very poor	Fair	Fair	Very poor.
	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
	Good	Good	Fair	Fair	Fair	Good	Fair	Fair.
	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.
poor	Very poor	Fair	Fair	Very poor	Very poor	Poor	Fair	Very poor.

TABLE 5.—*Soil interpretations for recreation*

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Arveson: Ar	Severe: poor drainage and water table.	Severe: poor drainage and water table.	Severe: poor drainage and water table.	Severe: poor drainage and water table.
Arvilla:				
AvC	None to slight	None to slight	Severe: slope	None to slight.
AwA	None to slight	None to slight	None to slight	None to slight.
AwB	None to slight	None to slight	Moderate: slope	None to slight.
Barnes:				
BaA, BfA, BhA. For Cresbard part of BfA and Hamlet part of BhA, see those series.	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
BaB, BdB, BgB, BhB. For Hamerly part of BgB and Hamlet part of BhB, see those series.	Moderate: permeability.	None to slight	Moderate: slope	None to slight.
BaC, BdC	Moderate: permeability.	None to slight	Severe: slope	None to slight.
BaD	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
BbB	Moderate: cobbles	Moderate: cobbles	Severe: cobbles	Moderate: cobbles.
BnD	Severe: stones	Moderate: stones	Severe: stones	Severe: stones.
Buse: Mapped only with Barnes soils. See BdB, BdC, and BnD under Barnes series.				
Cavour: CaA	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
Colvin:				
Co, Cp	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Cr	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Cresbards: Mapped only with Barnes and Cavour series. See Cavour series.				
Divide: DdA	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Embden:				
EmB	None to slight	None to slight	Moderate: slope	None to slight.
EoA. For Tiffany part, see that series.	None to slight	None to slight	None to slight	None to slight.
Fargo:				
Fa	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.
Fb	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Fulda: Fu	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Gravel pits: Gp	Severe: slope and cobbles.	Severe: slope and cobbles.	Severe: slope and cobbles.	Severe: slope and cobbles.
Great Bend: GrA	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	Moderate: permeability.	Moderate: flood hazard.	Moderate: permeability.	None to slight.

TABLE 5.—*Soil interpretations for recreation*—Continued

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails

TABLE 5.—*Soil interpretations for recreation*—Continued

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Williams:				
WmA	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
WmB	Moderate: permeability.	None to slight	Moderate: slope and permeability.	None to slight.
Wyndmere: WyA	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Zahl:				
ZaD	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
ZaF	Severe: slope	Severe: slope	Very severe: slope	Moderate to severe: slope.

need little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have [illegible] rocks or stones on the surface.

6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

[illegible] of this information in this section is presented in

Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, SP–SM.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system a soil is placed in one of seven basic groups that range from A–1 to A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing

take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil,

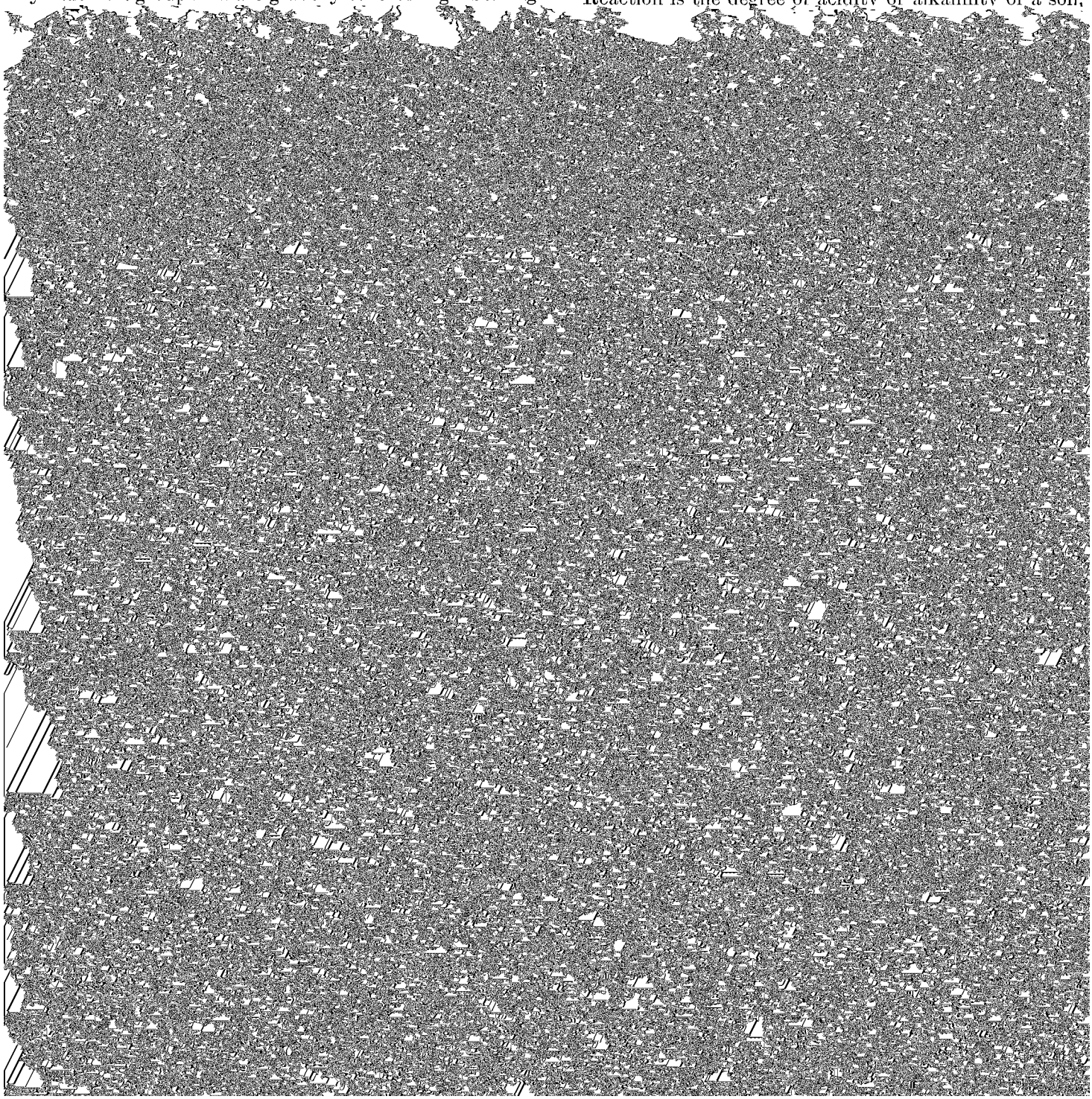


TABLE 6.—*Estimated engineering*

[Bedrock is at a depth of more than 6 feet in all soils.

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Arveson: Ar	[1] 1–3	0–14	Loam	ML	A–4	100	100
		14–23	Sandy loam	SM	A–2–4, A–4	100	100
		23–60	Sand	SP–SM	A–3, A–2–4	100	100
Arvilla: AvC, AwA, AwB. For Sioux parts of AwA and AwB, see that series.	>5	0–15	Sandy loam	SM	A–2–4	90–100	85–100
		15–60	Gravel and sand	SP–SM	A–1	85–95	60–80
Barnes: BaA, BaB, BaC, BaD, BdB, BdC, [illegible]	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100

properties of the soils

The symbol > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
85–95	60–75	15–35	[2] NP–10	0. 6–2. 0	0. 20–0. 22	7. 4–8. 4	None to low	Low	High	Low.
60–70	30–40	[2] NP	NP	2. 0–6. 0	0. 12–0. 14	7. 4–7. 8	None	Low	High	Low.
50–70	5–12	NP	NP	6. 0–20	0. 05–0. 07	7. 4–7. 8	None	Low	High	Low.
60–70	30–35	NP	NP	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	None	Low	High	Low
30–50	5–10	NP	NP	>20	0. 03–0. 05	7. 4–7. 8	None	Low	Moderate	Low.
85–95	60–75	25–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
50–60	25–50	25–40	5–20	0. 2–2. 0	0. 15–0. 17	7. 4–8. 4	None [3]	Moderate	High	Low.
85–95	60–75	25–40	5–20	0. 6–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
85–95	60–75	25–40	5–20	0. 2–2. 0	0–17. 0. 19	7. 4–7. 8	None	Moderate	High	Low.
90–100	75–95	40–60	20–40	0. 06–0. 2	0. 13–0. 15	8. 5–9. 0	Moderate to high.	High	High	Moderate to high.
90–100	70–80	30–50	10–30	<0. 06	0. 14–0. 16	7. 9–9. 0	Moderate to high.	Moderate to high.	High	Moderate to high.
90–100	70–90	25–40	5–20	0. 6–2. 0	0. 22–0. 24	7. 4–7. 8	None or low.	Moderate	High	Low.
95–100	85–95	30–50	10–30	0. 2–0. 6	0. 16–0. 20	7. 9–8. 4	None or low.	High	High	Low to moderate.
85–95	60–75	25–40	5–20	0. 2–2. 0	0. 20–0. 22	6. 6–7. 3	None	Moderate	High	Low.
90–100	70–80	30–50	10–30	0. 2–0. 6	0. 14–0. 16	7. 4–9. 0	Low to moderate.	Moderate to high.	High	Moderate to high.
85–95	60–75	25–40	10–20	0. 2–0. 6	0. 17–0. 19	8. 5–9. 0	Low to moderate.	Moderate	High	Moderate to high.
85–95	60–75	20–40	5–20	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	None to low.	Moderate	High	Low.
45–55	30–40	NP	NP	0. 6–2. 0	0. 12–0. 14	7. 9–8. 4	None to low.	Low	High	Low.
15–40	12–25	NP	NP	>20	0. 03–0. 05	7. 4–8. 4	None	Low	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Great Bend: GrA	>5	0–24	Silty clay loam	CL	A–7 or A–6	100	100
		24–60	Clay loam	CL	A–6 or A–7	95–100	90–100
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	3–5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Hamlet: HhA, HmA. For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Hecla: HoA. For Lohnes part, see that series.	>5	0–40	Loamy sand	SM	A–2–4	100	100
		40–60	Medium and fine sand.	SM, SP–SM	A–2–4 or A–3	100	100
LaDelle: LaA. Below a depth of 40 inches, properties are too variable to be estimated; onsite investigation is needed.	[1] >5	0–26	Silty clay loam	CL	A–6 or A–7	100	100
		26–40	Loam, very fine sandy loam.	ML	A–4	100	100
Lohnes: LoB	>5	0–15	Loamy sand	SM	A–2–4	100	95–100
		15–60	Coarse and medium sand.	SP or SP–SM	A–1	80–100	40–60
Ludden: Lu, Ly	[1] 1–3	0–60	Silty clay	CH	A–7	100	100
Marsh: Ma. Properties are too variable to be							

properties of the soils—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
95–100	85–95	30–50	10–30	0. 6–2. 0	0. 18–0. 23	6. 6–8. 4	None	High	High	Low.
90–100	70–80	30–50	10–30	0. 6–2. 0	0. 14–0. 16	7. 9–8. 4	None [3]	Moderate to high.	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 9–8. 4	None to low.	Moderate	High	Low.
85–95	60–75	20–40	5–20	0. 06–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
50–75	15–30	NP	NP	6. 0–20	0. 09–0. 11	6. 6–8. 4	None	Low	High	Low.
50–80	5–15	NP	NP	6. 0–20	0. 05–0. 07	7. 9–8. 4	None	Low	High	Low.
95–100	85–95	30–50	10–30	0. 6–2. 0	0. 18–0. 23	6. 6–7. 8	None	High	High	Low.
85–100	60–75	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	None	Low to moderate.	High	Low.
50–75	15–30	NP	NP	6. 0–20	0. 10–0. 12	6. 6–7. 8	None	Low	High	Low.
20–40	0–12	NP	NP	6. 0–20	0. 04–0. 06	7. 9–8. 4	None	Low	Moderate	Low.
95–100	90–95	50–80	25–50	0. 06–0. 2	0. 14–0. 17	7. 4–8. 4	None	High	High	Low.
90–100	70–90	15–40	5–20	0. 6–2. 0	0. 22–0. 24	7. 9–8. 4	None to low.	Low to moderate.	High	Low to moderate.
20–40	12–25	NP	NP	>20	0. 03–0. 05	7. 9–8. 4	None	Low	High	Low.
85–95	60–75	25–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
95–100	85–95	30–50	10–30	0. 2–0. 6	0. 18–0. 23	6. 6–7. 3	None	High	High	Low.
95–100	90–95	50–80	20–50	0. 06–0. 2	0. 14–0. 17	6. 6–7. 8	None	High	High	Low.
90–100	70–80	30–50	10–30	0. 2–0. 6	0. 14–0. 16	7. 4–7. 8	None	High	High	Low.
70–90	50–70	20–35	5–20	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	High	Low.
8–40	5–12	NP	NP	>20	0. 03–0. 05	7. 4–7. 8	None	Low	Moderate	Low.
65–90	50–70	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	Moderate	Low.
8–40	0–25	NP	NP	>20	0. 03–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
70–85	40–50	NP	NP	2. 0–6. 0	0. 16–0. 18	6. 6–7. 3	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2–0. 6	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low.

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TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Tiffany: Tf	[1] 2–5	0–32	Sandy loam, fine sandy loam.	SM	A–2 or A–4	100	100
		32–46	Very fine sandy loam	ML	A–4	100	100
		46–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Tonka: To	[1] 1–3	0–14	Silt loam	ML	A–4	100	100
		14–36	Clay loam	CL	A–7 or A–6	100	100
		36–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Vallers: Va	[1] 1–3	0–60	Loam	CL–ML or CL	A–4 or A–6	95–100	90–100
Velva: Vb, Vd	[1] >5	0–8	Loam	ML	A–4	100	100
		8–19	Silt loam	ML	A–4	100	100
		19–60	Very fine sandy loam.	ML	A–4	100	100
Williams: WmA, WmB	>5	0–60	Loam	CL–ML or CL	A–4 or A–6	95–100	90–100
Wyndmere: WyA	[1] 3–5	0–26	Fine sandy loam	SM	A–4	100	100
		26–46	Loamy fine sand	SM	A–2	100	100
		46–60	Very fine sandy loam.	ML	A–4	100	100
Zahl: ZaD, ZaF For Max part, see that series.	>5	0–60	Loam	CL–ML or CL	A–4 or A–6	90–100	90–100

[1] Subject to flooding or ponding.
[2] NP means nonplastic.

properties of the soils—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
60–70	30–45	NP	NP	0. 6–2. 0	0. 12–0. 14	6. 6–7. 3	None	Low	High	Low.
85–95	50–65	20–35	NP–10	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	None	Low	High	Low.
85–95	60–75	15–40	5–20	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low to moderate.
90–100	70–90	20–40	5–10	0. 6–2. 0	0. 22–0. 24	6. 6–7. 3	None	Moderate	High	Low.
90–100	70–80	30–50	10–30	0. 06–0. 6	0. 15–0. 19	6. 6–7. 8	None	Moderate to high.	High	Moderate.
85–95	60–75	25–40	5–20	0. 2–0. 6	0. 17–0. 19	7. 9–8. 4	None [3]	Moderate	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 9–8. 4	None to low.	Moderate	High	Low.
85–100	60–75	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	High	Low.
90–100	70–90	25–35	5–10	0. 6–2. 0	0. 20–0. 24	7. 4–7. 8	None	Low	High	Low.
85–95	50–65	20–35	NP–10	2. 0–6. 0	0. 17–0. 19	7. 4–7. 8	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
70–85	35–50	15–30	NP–10	2. 0–6. 0	0. 16–0. 18	7. 4–8. 4	None	Low	High	Low.
50–75	15–30	NP	NP	6. 0–2. 0	0. 09–0. 11	7. 4–7. 8	None	Low	High	Low.
85–95	50–65	20–35	NP–10	2. 0–6. 0	0. 17–0. 19	7. 4–7. 8	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low.

[3] Crystals and nests of gypsum are common in the lower horizons.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Arveson: Ar	Severe: seasonal high water table.	Severe: seasonal high water table; moderately rapid to rapid permeability.	Severe: poorly drained.	Severe: poorly drained; seasonal high water table above a depth of 30 inches.

of engineering properties

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: poorly drained; seasonal high water table above a depth of 20 inches.	Severe: poorly drained.	Severe: poorly drained.	Poor: poorly drained.	Fair to poor for sand only: water table.	Poor: poorly drained.
Slight	Severe: very rapid permeability; soil texture.	Slight	Good	Fair	Poor: material too thin.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Generally slight, but severe where stony.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Generally slight, but severe where very stony.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Poor: material too thin.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Moderate: clay loam.	Moderate: modate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Poor: material too thin; soluble salts.
Severe: poorly drained.	Severe: water table; poorly drained.	Severe: poorly drained.	Poor: poorly drained; high frost action potential.	Unsuited	Poor: poorly drained.
Moderate: moderate frost action potential: moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; somewhat poorly drained.	Severe: water table.	Moderate: moderate frost action potential; somewhat poorly drained.	Moderate: moderate frost action potential; somewhat poorly drained.	Fair to poor: layers may be too thin; water table.	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential.	Severe: permeability.	Moderate: moderate frost action potential.	Fair: moderate frost action potential.	Poor for sand only	Good.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: high shrink-swell potential.	Unsuited	Poor: poorly drained; silty clay.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: poorly drained.	Unsuited	Poor: poorly drained.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Gravel pits: Gp. No interpretations made; properties too variable; onsite investigation needed.				
Great Bend: GrA	Moderate: moderate permeability.	Slight	Slight	Moderate: moderate shrink-swell potential.
Hamerly: HaA, HbA For Tonka part of HbA, see that series.	Severe: seasonal high water table; moderately slow permeability.	Slight	Moderate: moderately well drained.	Moderate if water table is below a depth of 30 inches: moderately well drained; moderate shrink-swell potential. Severe if water table is above a depth of 30 inches.
Hamlet: HhA, HmA For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	Severe: slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent.	Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential.
Hecla: HoA For Lohnes part, see that series.	Slight	Severe: rapid permeability.	Severe: loamy sand.	Moderate: moderately well drained.
LaDelle: LaA	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: occasional to frequent flooding.
Lohnes: LoB	Slight	Severe: rapid permeability.	Severe: loamy sand.	Slight
Ludden: Lu, Ly	Severe: slow permeability; poorly drained.	Severe: subject to flooding.	Severe: poorly drained; clay.	Severe: poorly drained; subject to flooding; high shrink-swell potential.
Marsh: Ma. No interpretations made; properties too variable; onsite investigation needed.				
Marysland: Mb	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained.
Max	Severe: moderately slow permeability; steep.	Severe if slope is more than 9 percent.	Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Moderate if slope is less than 15 percent: moderate shrink-swell potential. Severe if slope is more than 15 percent.

See footnote at end of table.

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: high frost action potential.	Moderate: silty clay loam.	Severe: high frost action potential.	Poor: high frost action potential.	Unsuited	Fair: 8 to 16 inches of material; silty clay loam.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Severe: water table.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Slight	Severe: rapid permeability.	Slight	Good	Fair for sand only	Poor: loamy sand.
Severe: occasional to frequent flooding; high frost action potential.	Severe: subject to flooding.	Severe: high frost action potential.	Poor: high frost action potential.	Unsuited	Fair: silty clay loam.
Slight	Severe: rapid permeability.	Slight	Good	Fair for sand only	Poor: loamy sand.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: high shrink-swell potential.	Unsuited	Poor: poorly drained; silty clay.
Severe: poorly drained.	Severe: water table; poorly drained.	Severe: poorly drained.	Poor: poorly drained.	Fair: water table	Poor: poorly drained.
Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Slight if slope is less than 15 percent. Moderate if slope is 15 to 25 percent. Severe if slope is more than 25 percent.	Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Fair if slope is less than 25 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 25 percent.	Unsuited	Fair if slope is less than 15 percent: 8 to 16 inches of material. Poor if slope is more than 15 percent.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Parnell: Pa	Severe: slow permeability; very poorly drained.	Severe: seasonal high water table.	Severe: very poorly drained.	Severe: very poorly drained.
Renshaw: RnA, RnB	Slight: very rapid permeability; hazard of pollu-	Severe: very rapid permeability.	Severe: very gravelly material.	Slight

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: very poorly drained.	Severe: water table; very poorly drained.	Severe: very poorly drained.	Poor: very poorly drained.	Unsuited	Poor: very poorly drained.
Slight	Severe: very rapid permeability; soil texture.	Slight	Good	Fair	Fair: 8 to 16 inches of material.
Slight if slope is less	Severe: very rapid	Slight if slope is less	Good	Fair	[illegible]

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Zahl: ZaD, ZaF. For Max parts, see that series.	Severe: moderately slow permeability; steep.	Severe if slope is more than 9 percent.	Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Moderate if slope is less than 15 percent: moderate shrink-swell potential. Severe if slope is more than 15 percent.

[1] Onsite deep studies of the underlying strata, water table, and hazards of aquifer pollution and drainage into ground water need to be made for landfills of more than 5 or 6 feet.

In table 7 soil suitability is rated by the terms *good*, *fair*, and *poor*, which have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope. If the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified soil classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet; for example, excavations for pipelines, sewerlines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Trench-type sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the limitations in table 7 apply only to a depth of about 6 feet; therefore, limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Roads and streets have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the shrink-swell potential indicate the traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings—Con. without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Slight if slope is less than 15 percent. Moderate if slope is 15 to 25 percent. Severe if slope is more than 25 percent.	Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Fair if slope is less than 25 percent: moderate frost action potential; moderate shrink-swell potential. Poor if slope is more than 25 percent.	Unsuited	Poor: material too thin.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 7 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials or the quality of the deposit.

Topsoil is used for topdressing an area where plants are to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are characteristics that affect suitability. Also considered in the ratings is damage that can result at the area from which topsoil is taken.

Following are explanations of some of the columns in table 8.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among the unfavorable factors.

Drainage is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; and depth of root zone. It is also affected by the rate of water intake at the surface, permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water, amount of water held available to plants, and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope, depth to bedrock or other unfavorable material, presence of stones, permeability, and resistance to erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff, and establishing a plant cover is not difficult.

Grassed waterways are natural or constructed waterways that are seeded to grass as protection against erosion. Features that affect the suitability of the soil for grassed waterways are those that affect the establishment, growth, and maintenance of plants or that hinder the layout and construction of the waterway.

Formation and Classification of the Soils

This section describes the factors of soil formation and shows the classification of the soils in Renville County by higher categories.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are

TABLE 8.—*Soil features affecting land uses*

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Arveson: Ar	Rapid permeability; water table.	Good to poor stability; fair compaction characteristics; moderate to rapid permeability; poor resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately rapid permeability; moderate available water capacity.	Not needed	Not needed.
Arvilla: AvC, AwA, AwB. For Sioux part of AwA and AwB, see that series.	Very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability.	Not needed	Moderately rapid permeability over very rapid permeability; low available water capacity.	Less than 20 inches to gravel and sand; hazard of erosion.	Sandy loam; hazard of erosion; less than 20 inches to gravel and sand; low available water capacity.
Barnes: BaA, BaB, BaC, BaD, BbB, BdB, BdC, BfA, BgB, BhA, BhB, BnD. For Buse part of BdB, BdC, and BnD, Cresbard part of BfA, Hamerly part of BgB, Hamlet part of BhA and BhB, and for Tonka part of BhA and BhD, see those series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability; some steep, complex slopes.	Short, complex slopes; steep.	All features favorable, except on steep slopes.
Buse	Slope	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderate permeability; complex slopes.	Short, complex slopes; moderate permeability; steep.	Steep; thin surface layer.
Cavour: CaA. For Cresbard part, see that series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Very slow permeability; moderate available water capacity; salinity.	Not needed	Not needed.
Colvin: Co, Cp, Cr	Water table; suitable for dugouts; moderately slow permeability.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately low permeability.	Not needed	Not needed.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Cresbard	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderately slow permeability.	Not needed	Not needed.
Divide: DdA	Water table; suitable for dugouts; very rapid permeability.	Good stability; fair to good compaction characteristics; low to moderate permeability; medium compressibility; fair resistance to piping.	Water table; may not have outlets available.	Water table; moderate permeability over very rapid permeability; low available water capacity; moderately slow permeability below a depth of 40 inches.	Not needed	Not needed.
Embden: EmB, EoA For Tiffany part of EoA, see that series.	Moderately rapid to rapid permeability.	Good stability; fair to good compaction characteristics; [illegible]	Not needed	Moderately rapid permeability; moderate [illegible]	Complex slopes; hazard of erosion.	Fine sandy loam; hazard of erosion.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Seasonal high water table.	Moderately slow permeability.	Not needed	All features favorable.
Hamlet: HhA, HmA. For Hamerly part of HhA and for Tonka part of HhA and HmA, see those series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Slow permeability.	Not needed	All features favorable.
Hecla: HoA. For Lohnes part, see that series.	Rapid permeability.	Good to poor stability; fair compaction characteristics; moderate to high permeability; poor resistance to piping.	Not needed	Rapid permeability; low available water capacity.	Loamy sand; rapid permeability; hazard of erosion.	Loamy sand; hazard of erosion; low available water capacity.
LaDelle: LaA	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed; flooding caused by stream overflow.	Susceptible to stream overflow.	Not needed	All features favorable.
Lohnes: LoB	Rapid permeability.	Fair stability; fair compaction characteristics; high permeability; fair resistance to piping.	Not needed	Rapid permeability; low available water capacity.	Loamy sand; rapid permeability; hazard of erosion.	Loamy sand; hazard of erosion; low available water capacity.
Ludden: Lu, Ly	All features favorable.	Fair to poor stability; fair to poor compaction characteristics; high compressibility.	Surface ponding; slow permeability.	Slow permeability; susceptible to stream overflow.	Not needed	Not needed.
Marsh: Ma. No interpretations made; properties too variable; on-site investigation needed.						
Marysland: Mb	Water table; suitable for dugouts; very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; fair to poor resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderate permeability over very rapid permeability; moderate available water capacity.	Not needed	Not needed.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Max	Slope	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderately slow permeability; steep.	Moderately slow permeability; steep, complex slopes; hazard of erosion.	Steep.
Parnell: Pa	Water table	Fair stability; fair compaction characteristics; low permeability; high compressibility; good resistance to piping.	Water table; may not have outlets available; surface ponding.	Very poorly drained; slow permeability.	Not needed	Not needed.
Renshaw: RnA, RnB	Very rapid permeability.	Good stability; fair to good compaction	Not needed	Moderate permeability over very	Less than 20 inches to gravel and	Less than 20 inches to gravel and

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Tiffany: Tf	Seasonal high water table.	Good stability; fair to good compaction characteristics; moderate to low permeability; slight to high compressibility; poor resistance to piping in upper 46 inches.	Water table; may not have outlets available.	Poorly drained; moderate permeability; moderate available water capacity.	Not needed	Fine sandy loam; hazard of erosion.
Tonka: To	All features favorable.	Fair to good stability; fair to good compaction characteristics; medium to high compressibility.	May not have outlets available; surface ponding; slow permeability.	Slow permeability; surface ponding.	Not needed	Not needed.
Vallers: Va	Water table	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately slow permeability.	Not needed	Not needed.
Velva: Vb, Vd	Moderate permeability to moderately rapid permeability.	Poor stability; poor compaction characteristics; moderate permeability; medium compressibility; poor resistance to piping.	Not needed; flooding caused by stream overflow.	Susceptible to stream overflow.	Not needed	All features favorable.
Williams: WmA, WmB	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability.	Short, complex slopes; moderately slow permeability.	All features favorable.
Wyndmere: WyA	Water table; moderately rapid permeability.	Good stability; fair to good compaction characteristics;	Water table; may not have outlets available.	Somewhat poorly drained; moderately	Not needed	Not needed.

determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effect of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effect on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

All the soils in Renville County formed in glacial material derived from preglacial rocks consisting of granite, gneiss, sandstone, shale, limestone, and basalt. The glacier picked up these materials, ground and mixed them

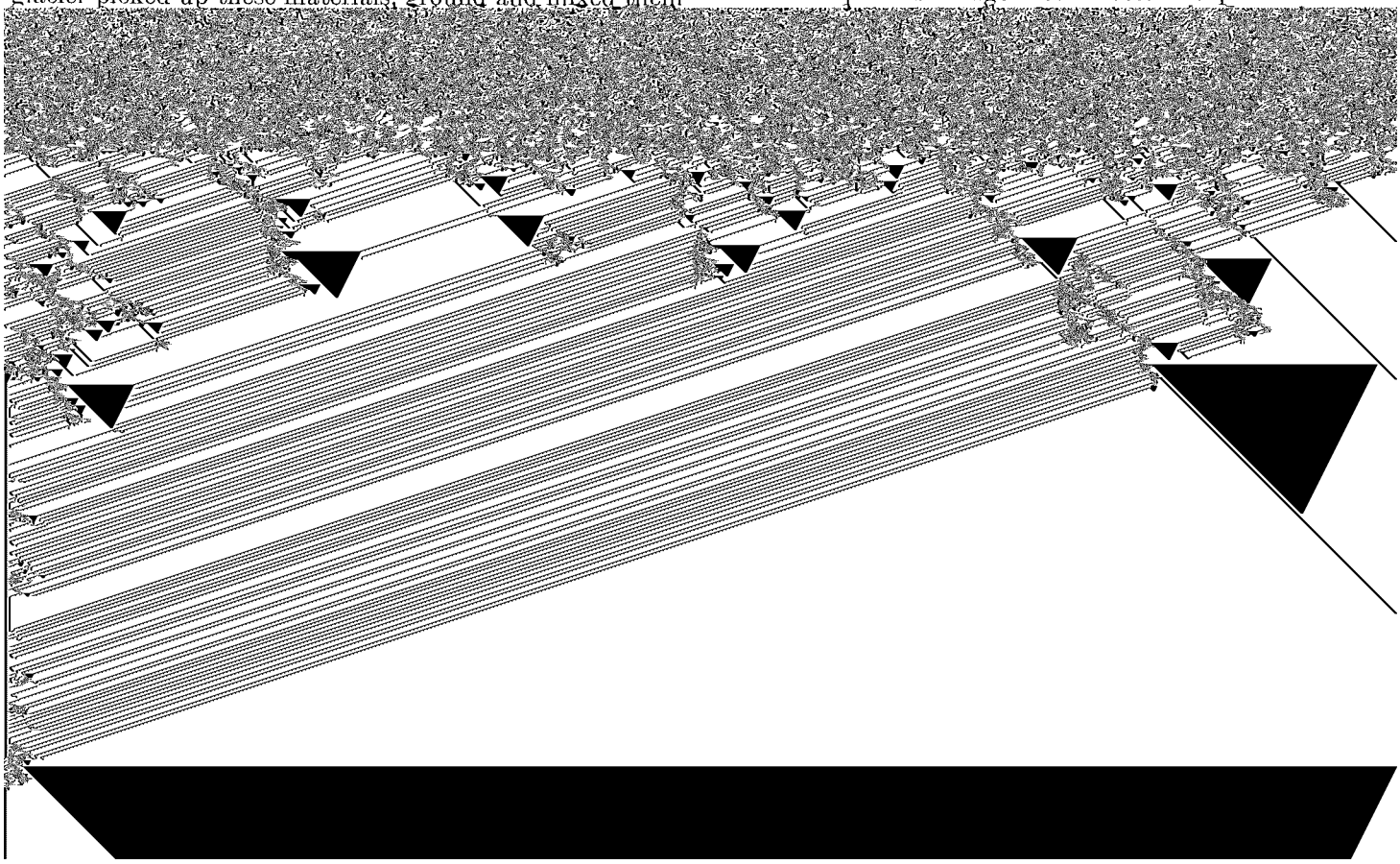
warm-season grasses grow where the soils receive extra moisture.

Plant roots loosen the soil material and bring minerals from the parent material upward toward the surface. As the plants die and decay, they contribute organic matter, and bacteria and other micro-organisms help to decompose the organic matter. Thus, nutrients leached out of the surface layer are replaced, and a good supply is maintained for growth of other plants.

The activity of animals seems to be of less importance to soil formation in this county than the growth of plants. Earthworms and burrowing animals help to mix the soil material from various horizons and bring some fresh parent material to the surface layer. The activities of man, particularly in altering drainage, maintaining fertility, and changing the kinds of vegetation, have an important effect on both the rate and the direction of soil formation.

Relief

Relief influences the formation of soils through its effect on runoff and drainage. If other soil-forming factors are equal, relief largely determines the degree of profile development, mainly because it controls the amount of moisture in the soil. Because of excessive drainage, only a little water is held in the more sloping and coarser textured soils, and vegetation is sparse; consequently, profile development is slow. Among the soils affected in this way are Buse, Zahl, and Sioux soils. Excessive water in areas that have poor drainage also affects the process of soil

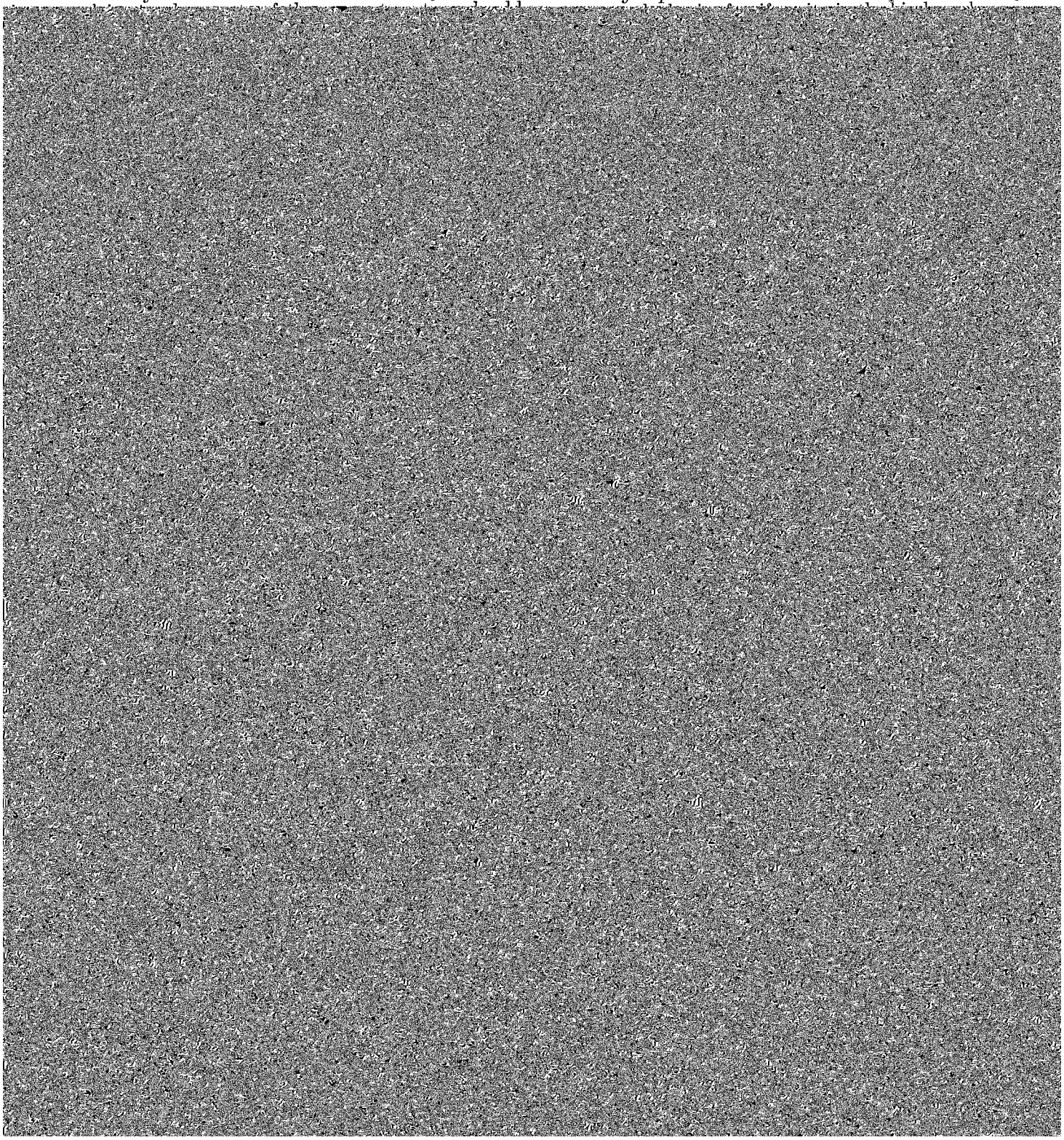


classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because the system is under continual study, readers

climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquent* (*Aqu*, meaning water or wet; and *ent*, from Entisol).

Great group.—Soil suborders are separated into great



Family.—Soil families are established within a subgroup mainly on the basis of properties important to the growth of plants or on the behavior of soils when used for en-

Runoff from surrounding areas provides extra moisture for the growth of plants in depressions and swales. Wet areas have a thick, dark-colored, highly organic surface

TABLE 10.—*Temperature and precipitation data*

[All data from Mohall for the period 1930–65]

Month	Temperature				Precipitation			
	Average daily	Average daily	Average highest	Average lowest	Average	One year in 10 will have—	Days that have snow	Average depth of snow on

TABLE 12.—*Probability of precipitation during the growing season*

[All data are for Bottineau. Absence of data means that the probability is less than 10 percent]

	Probability in percent for receiving precipitation of											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Firm.—When moist, crushes under moderate pressure between

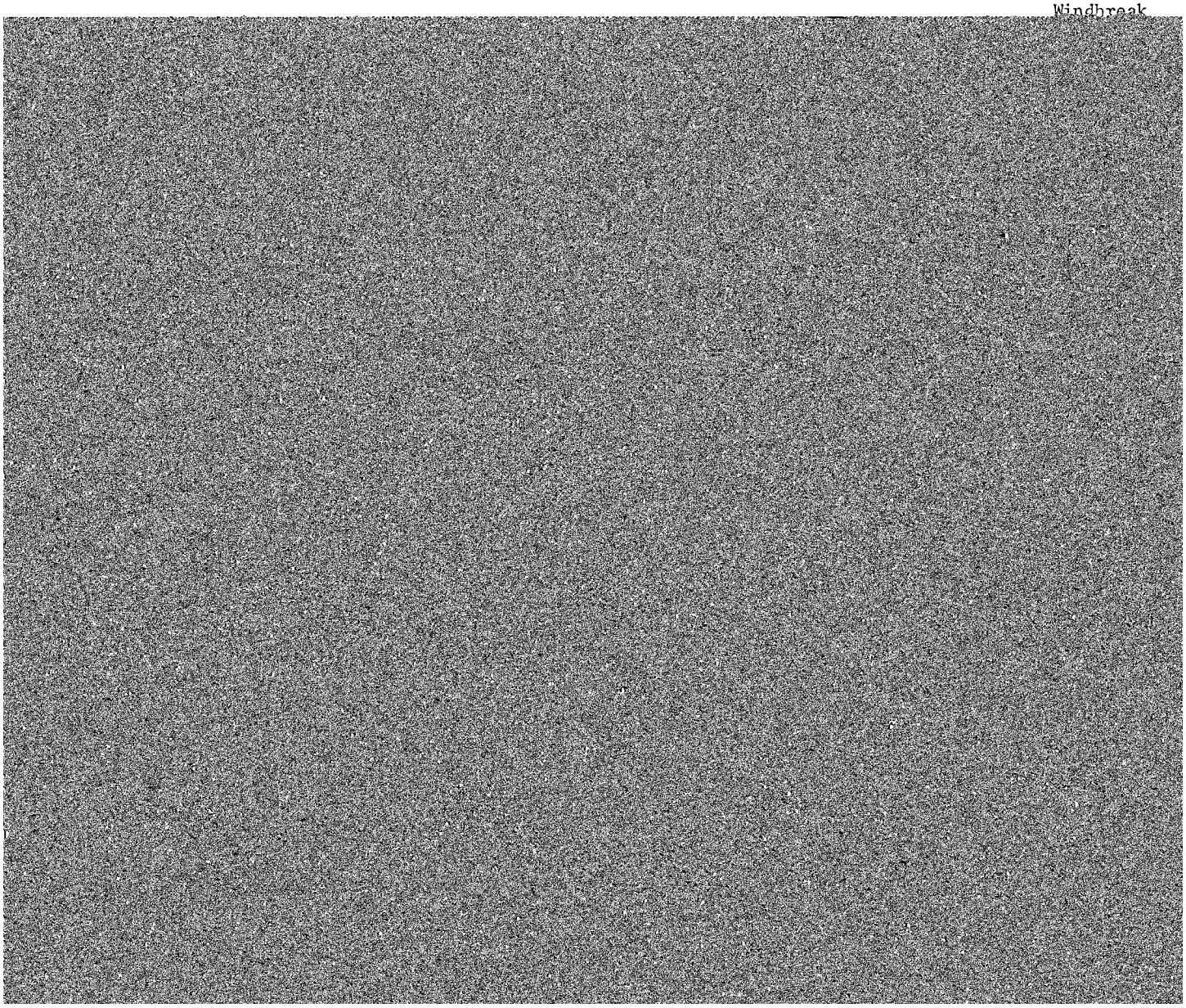
millimeters (about 0.2 inch) in diameter along the greatest

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit, read the introduction to the section it is in for general information about its management.

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ar	Arveson loam	6	IIIw-5	38	2	43
AvC	Arvilla sandy loam, 6 to 9 percent slopes	6	IIIes-3	38	6	43
AwA	Arvilla-Sioux sandy loams, 1 to 3 percent slopes	7	IIIes-3	38	--	--
	Arvilla part	7	-------	--	6	43
	Sioux part	7	-------	--	10	44
AwB	Arvilla-Sioux sandy loams, 3 to 6 percent slopes	7	IIIes-3	38	--	--
	Arvilla part	7	-------	--	6	43
	Sioux part	7	-------	--	10	44
BaA	Barnes loam, 1 to 3 percent slopes	8	IIc-6	37	3	43
BaB	Barnes loam, 3 to 6 percent slopes	8	IIe-6	35	3	43
BaC	Barnes loam, 6 to 9 percent slopes	8	IIIe-6	37	3	43
BaD	Barnes loam, 9 to 12 percent slopes	8	IVe-6	39	10	44
BbB	Barnes cobbly loam, 1 to 6 percent slopes	8	IIe-6	35	3	43
BdB	Barnes-Buse loams, 3 to 6 percent slopes	9	IVe-4L	39	--	--
	Barnes part	9	-------	--	3	43
	Buse part	9	-------	--	8	43
BdC	Barnes-Buse loams, 6 to 9 percent slopes	9	IVe-4L	39	--	--
	Barnes part	9	-------	--	3	43
	Buse part	9	-------	--	8	43
BfA	Barnes-Cresbard loams, 1 to 3 percent slopes	9	IIIs-6P	39	--	--
	Barnes part	9	-------	--	3	43
	Cresbard part	9	-------	--	4	43
BgB	Barnes-Hamerly loams, 3 to 6 percent slopes	10	IIe-6	35	--	--
	Barnes part	10	-------	--	3	43
	Hamerly part	10	-------	--	1	43
BhA	Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes	10	IIc-6	37	--	--
	Barnes part	10	-------	--	3	43
	Hamlet part	10	-------	--	1	43
	Tonka part	10	-------	--	2	43
BhB	Barnes-Hamlet-Tonka loams, 3 to 6 percent slopes	10	IIe-6	35	--	--
	Barnes part	10	-------	--	3	43

Windbreak



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