SOIL SURVEY OF

Pembina County, North Dakota

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

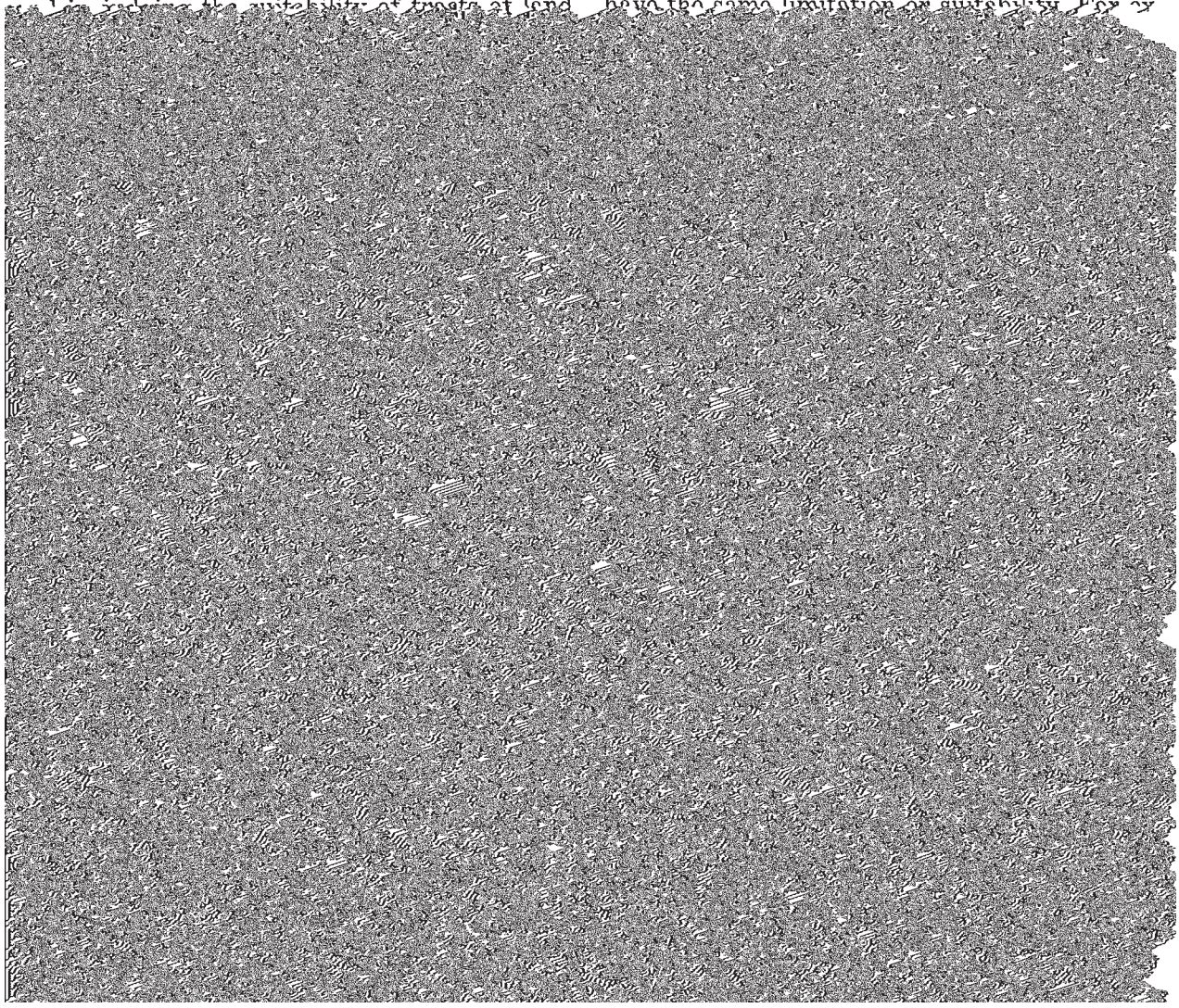
This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1964–71. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1971. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Pembina County Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; [illegible] the suitability of tracts of land for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For ex-



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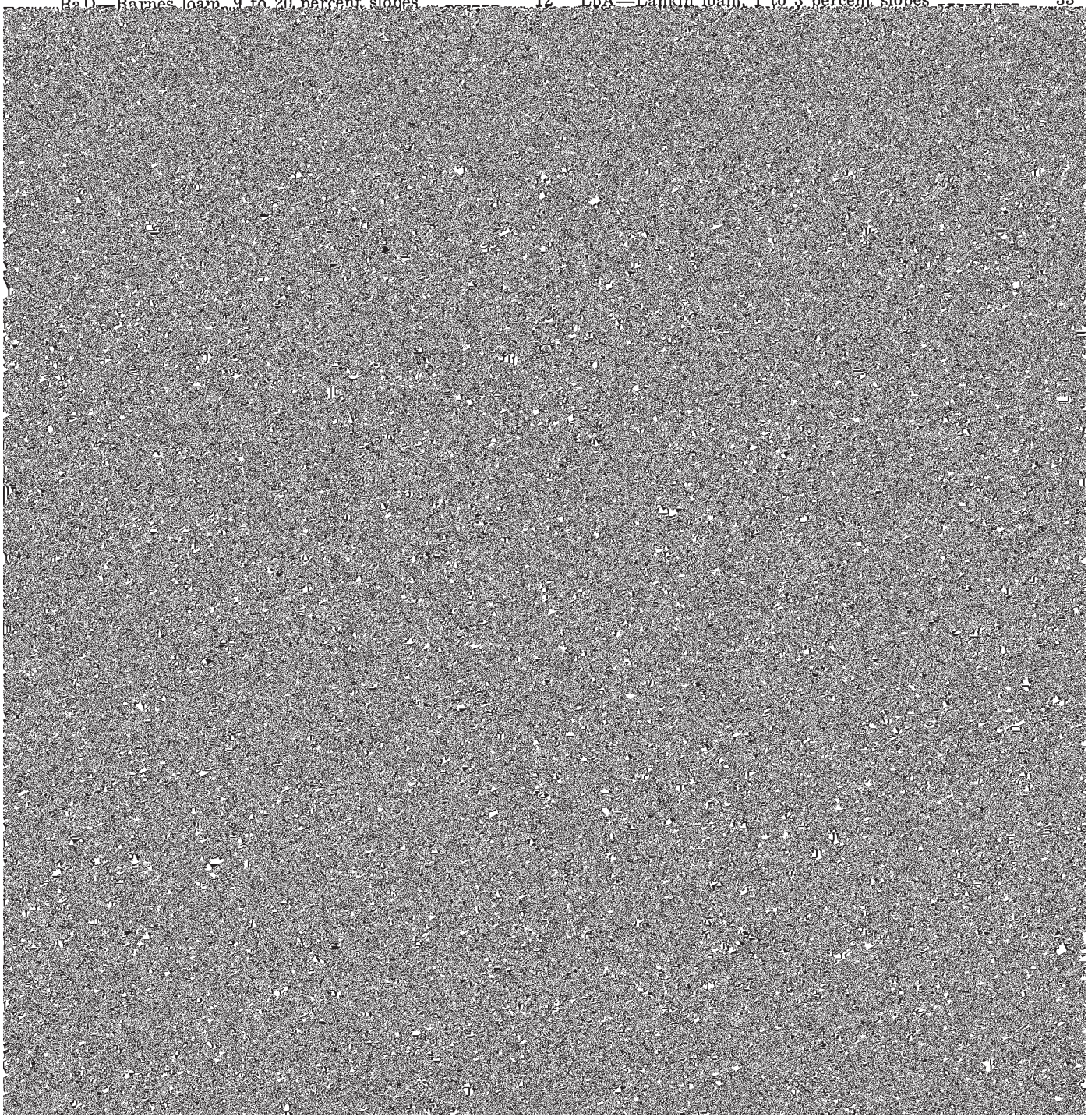

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SOIL SURVEY OF PEMBINA COUNTY, NORTH DAKOTA

BY KENNETH W. THOMPSON, AND ROBERT L. HETZLER, SOIL CONSERVATION SERVICE

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

PEMBINA COUNTY is in the extreme northeastern corner of North Dakota (fig. 1). It has a total area of 719,360 acres or 1,124 square miles. The county extends about 38 miles from east to west and about 31 miles from north to south. Its northern boundary is the Dominion of Canada, and its eastern boundary is the State of Minnesota. Cavalier is the county seat. According to the 1975 census, the population of Pembina County was 10,728 persons, most of whom made their living directly from agriculture.

Ninety-three percent of the total land area is farmed, and about 85 percent is cultivated. Small-grain farming is the main enterprise. Spring wheat is the main crop, but barley, oats, and flax are grown extensively, and potatoes, sugar beets, and sunflowers are other important crops. The raising of livestock has declined rapidly in importance in the last few years. Beef cattle is the main livestock enterprise.

How This Survey Was Made

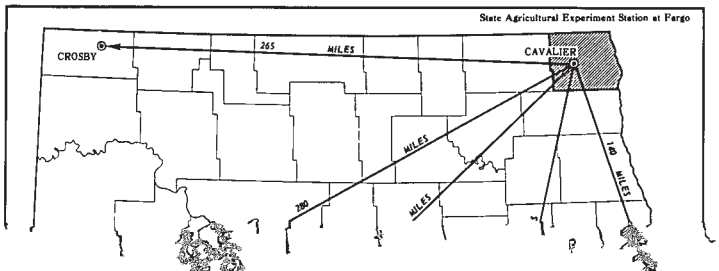
Soil scientists made this survey to learn what kinds of soil are in Pembina County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length,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

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

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

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Bearden silty clay loam, 1 to 3 percent slopes, is one of several phases within the Bearden series.

After a guide for classifying and naming the soils had been worked out, the soil scientists [illegible]



ping 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 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 Pembina County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed 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. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Bearden-Colvin silty clay loams is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Bearden and Glyndon silt loams, 1 to 3 percent slopes, is an undifferentiated group in Pembina County.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been 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. Clayey breaks is a land type in this survey.

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

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or to its high water table. They see that streets, road pavements, and foundations for houses are cracked on a particular soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current 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 the survey area. 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 showing 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 on a watershed, a wooded tract, or a wildlife area or for broad planning of recreational 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 or 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 soil associations in Pembina County do not in all places join the soil associations of adjacent Walsh County, because similar soils differ in extent in the two counties and in places are negligible in one county and prominent in the other.

The soil associations in this survey area have been grouped into general kinds of landscapes for broad interpretative purposes. Each of the broad groups and the soil associations in it are described in the following paragraphs.

Soils on Glacial Lake Plains

Soils on glacial lake plains are in the eastern two-thirds of Pembina County. The soil areas are mostly nearly level with low ridges and shallow depressions. Some of these areas are flooded when snow melts rapidly, when streams overflow, or when rainfall is heavy.

The lake sediment of very fine sand, silt, and silty clay was deposited mainly in the western part of the lake plain. The lake sediment of clay and silty clay was deposited mainly in the eastern part of the lake plain, where slope is only a few feet per mile. Seven soil associations are in this group.

1. Hegne-Fargo association

Nearly level and gently sloping, poorly drained, fine-textured soils

This association consists of a glacial lake plain

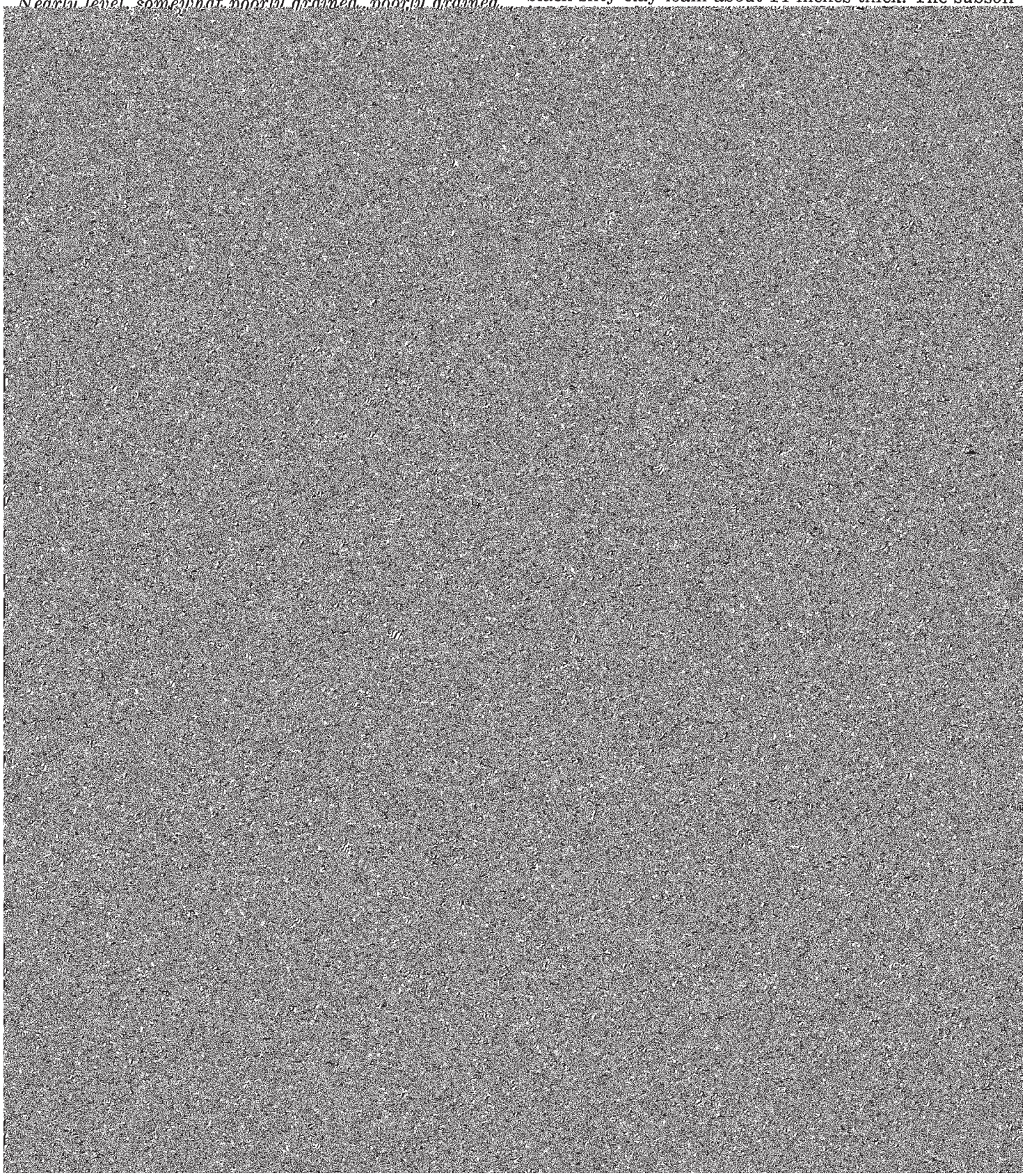
made up of convex and concave surfaces that have relief of 1 to 2 feet. Numerous shallow and deep da-

convex slopes. Wheatville soils have a silty clay sub-structure at a depth of 20 to 40 inches and a gravel-level

4. Bearden-Colvin association

Nearly level, somewhat poorly drained, poorly drained

moderately well drained. The surface layer is typically black silty clay loam about 14 inches thick. The subsoil



gray in the lower 4 inches. Below this is dark grayish-brown silt loam, about 13 inches thick, that is high in content of lime. The underlying material is olive-brown, calcareous, mottled very fine sandy loam.

The minor soils in this association are in the Colvin and Wheatville series. Colvin soils are poorly drained and very poorly drained and occupy shallow depressions. The nearly level Wheatville soils have a very fine sandy loam surface layer and a silty clay substratum. They are in areas of concave and convex slopes.

Small grains, potatoes, sugar beets, sunflowers, pinto beans, and hay grow well on these soils. They are high in organic-matter content and have high available and Perella series. The nearly level Ojata soils are strongly saline. They are in areas of convex side slopes. Perella soils lack lime close to the surface and occupy deep depressions.

Small grains and hay are grown on these soils, but crops are affected by salinity in many places. The main concerns of management are salinity and improvement of drainage. These soils are high in organic-matter content and have high available water capacity. The Bearden and Colvin soils are medium in fertility, and the Glyndon soils are high in fertility.

About half of this association is used for cultivated crops and about half for pasture and hay. The main enterprise is growing cash crops, and most of the

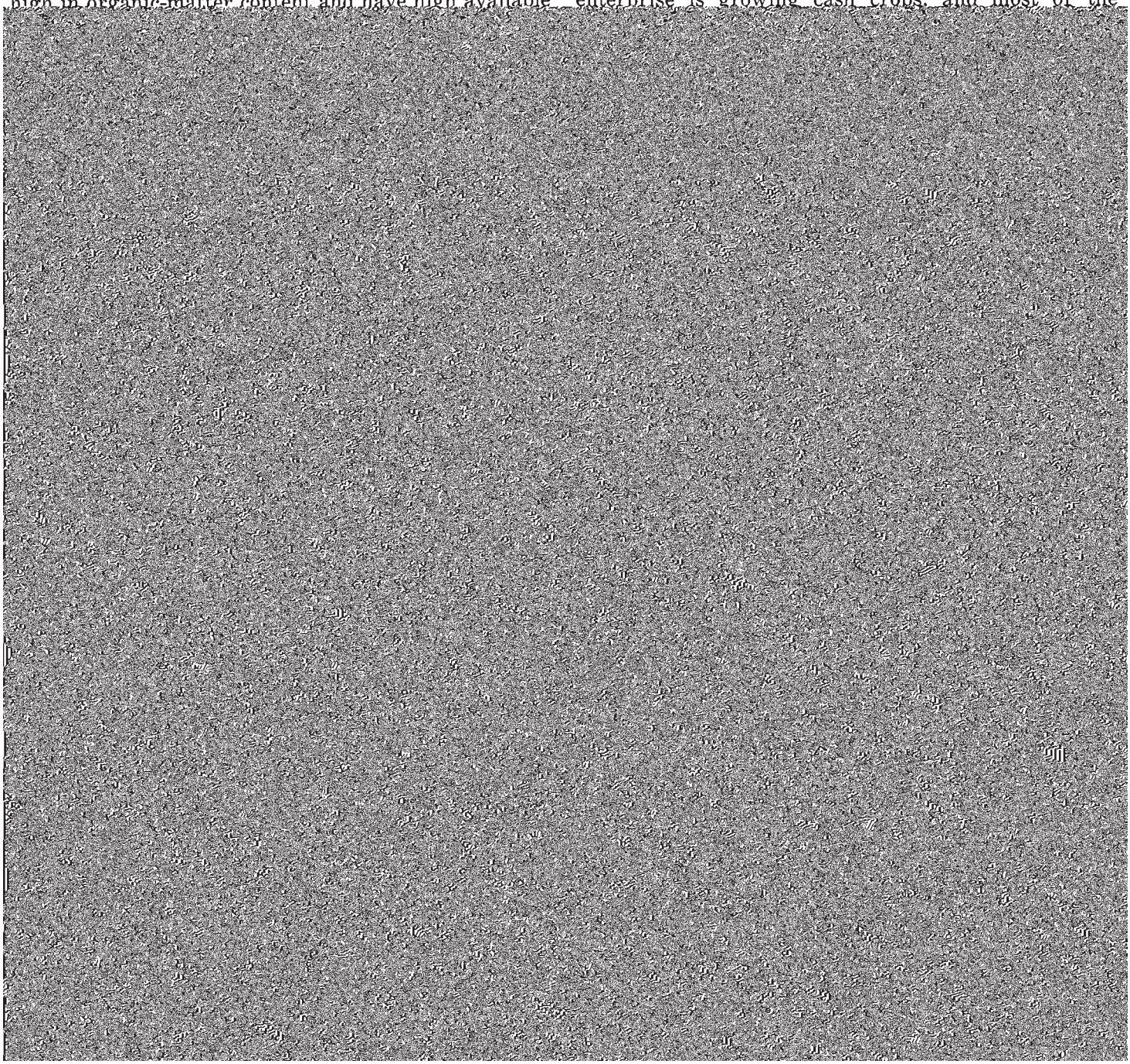


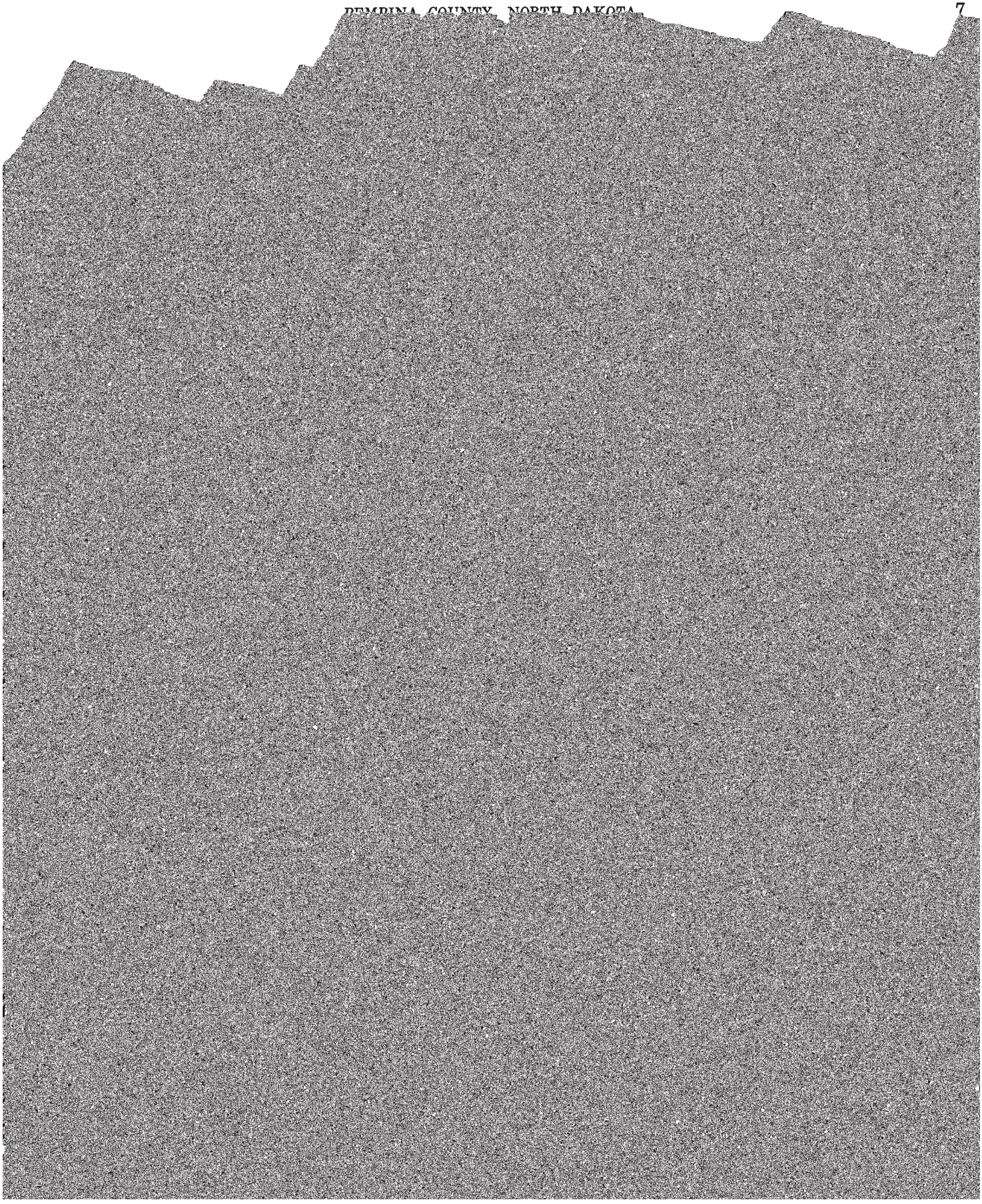
Figure 2.—**This area of the La Prairie-Fairdale association along the Tongue River was covered by native trees until large areas were cleared for cultivated crops. Native trees still cover the steeper slopes on riverbanks and abandoned stream channels. The multiple-row shelterbelt in the foreground was planted to protect the farmstead from wind and snow.**

calcareous, dark grayish-brown, mottled, stratified silt and sandy loam.

The minor soils in this association are in the Lamoure and Rauville series. Lamoure soils are poorly drained, and Rauville soils are very poorly drained. They occupy seep areas and depressions inaccessible due to abandoned stream channels are in native woods used for pasture or left for wildlife.

9. *Wahpeton-Cashel association*

Nearly level to steep, moderately well drained and somewhat poorly drained, fine-textured soils

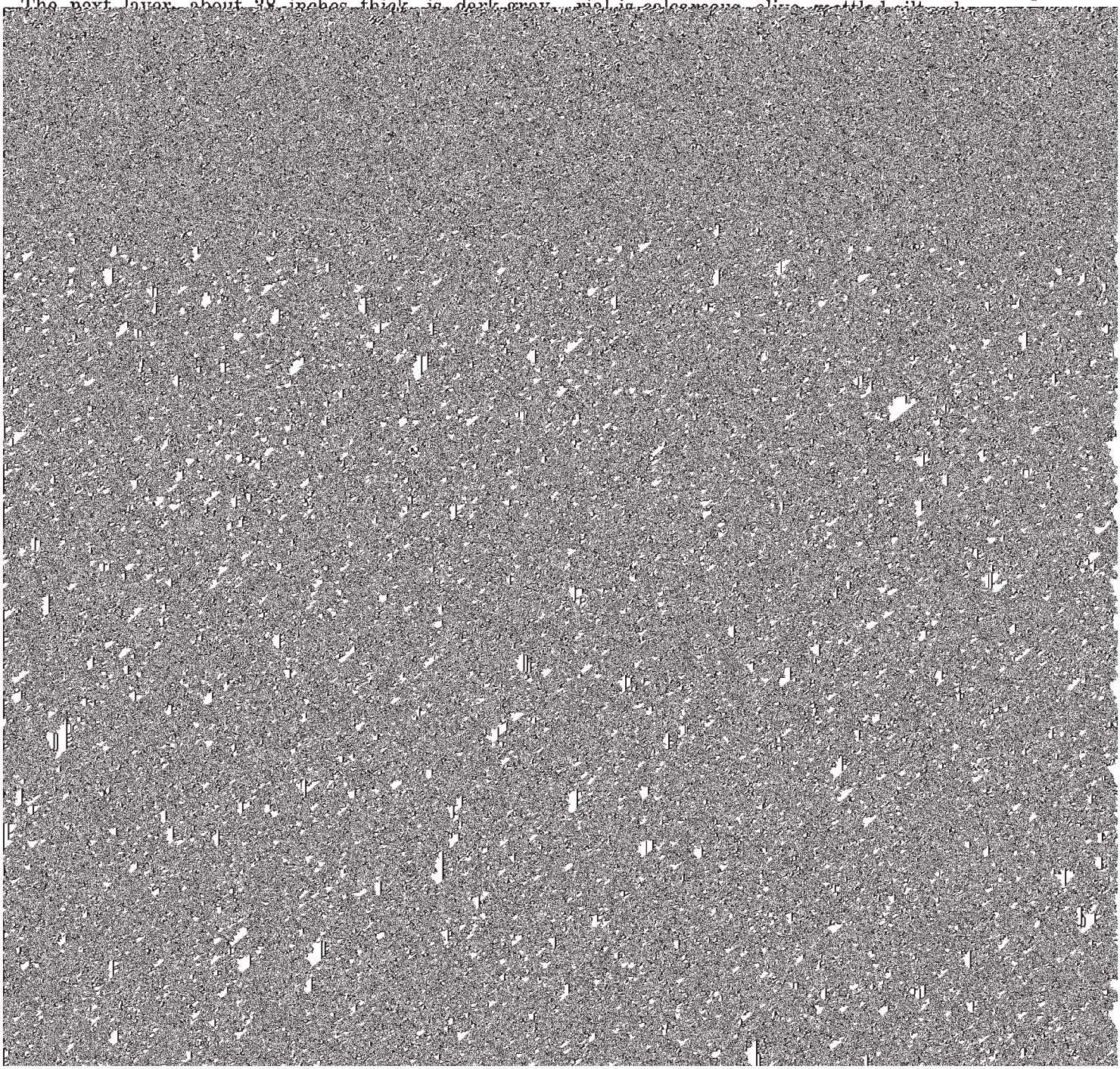


Vang soils, in areas of convex slopes, are well drained. They are nearly level in most places but gently sloping in some. The surface layer is typically black loam about 18 inches thick. The subsoil, about 8 inches thick, is very dark gray loam. The underlying material is very dark gray shaly gravel and coarse sand-sized shale particles.

Brantford soils, in areas of convex slopes, are nearly level in most places, but they range from nearly level to steep. They are well drained. The surface layer is typically black loam about 8 inches thick. The subsoil is very dark grayish brown loam about 4 inches thick. The next layer, about 38 inches thick, is dark gray, mi[illegible]

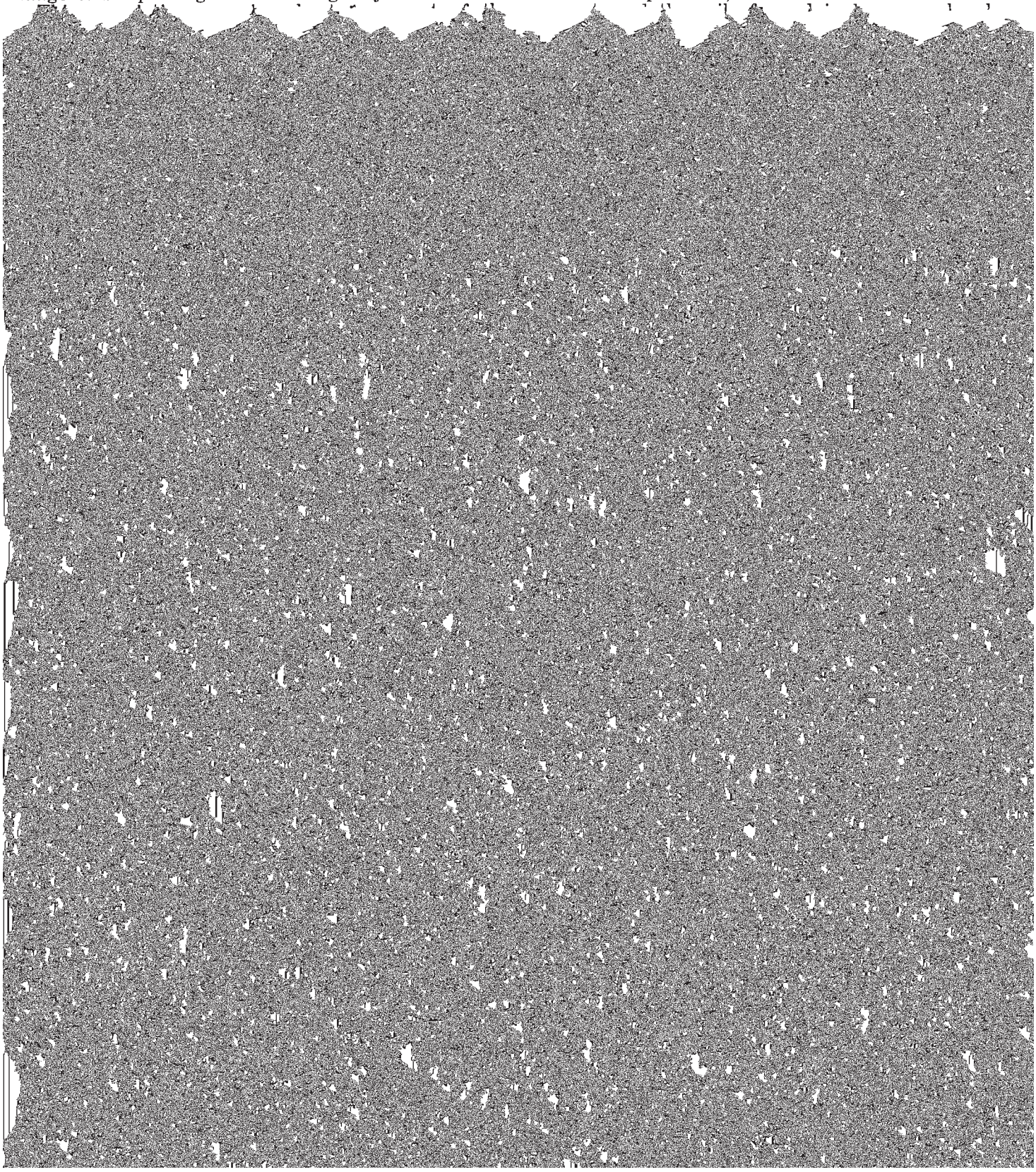
It is very dark grayish brown in the upper 8 inches, dark grayish brown and slightly acid in the next 16 inches, and very dark grayish brown in the lower 6 inches. The next layer is olive, calcareous sandy loam about 4 inches thick. It is underlain by olive and light-gray, calcareous clay loam.

Rolette soils, in areas of convex slopes, are nearly level and moderately well drained. The surface layer is typically black silty clay loam about 6 inches thick. The subsurface layer is very dark gray clay loam about 9 inches thick. The subsoil, about 20 inches thick, is dark grayish-brown silty clay. The underlying mate-



most of the area, but it is greater in some areas. Slopes are mostly nearly level and gently undulating, but they range to steep along some drainageways.

a thin layer of loamy lacustrine sediment, 20 to 40 inches thick, underlain by loam or clay loam glacial till. On steeper soils, the lacustrine sediment is not



tion of the mapping unit and the description of the soil series to which it belongs.

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

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Clayey breaks, for example, does not belong to a soil series; nevertheless, it is listed in alphabetic order with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and windbreak suitability group in which the mapping unit has been placed. The page on which each mapping unit is described can be found in the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*3*).[1]

The names of some soils are unlike those appearing in recently published surveys of adjacent counties. This is because of changes in concepts of soil series, to changes in application of the soil classification system, and to the differences in extent of some soils between two counties.

Arveson Series

The Arveson series consists of deep, nearly level, poorly drained and very poorly drained soils. These soils formed in moderately coarse textured deposits in seep areas and depressions on glacial lake plains and in low areas along drainageways.

In a representative profile the surface layer is calcareous, black sandy loam about 10 inches thick. Below this is dark-gray and dark grayish-brown, mottled sandy loam, about 7 inches thick, that is high in lime. The next layer is calcareous, grayish-brown, mottled loamy sand about 13 inches thick. Below this is multicolored, calcareous fine sand.

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

Most areas of Arveson soils are cultivated, but a few are in native woods, and others are used for hay and pasture. Some areas of very poorly drained soils in depressions are used as habitat by wildlife.

Representative profile of Arveson sandy loam that has 0 to 1 percent slopes, in a cultivated field; 390 feet west and 100 feet north of the SE. corner of sec. 5, T. 160 N., R. 55 W.

Ap—0 to 10 inches, black (10Y 2/1) sandy loam, dark gray (10YR 4/1) dry; weak, very fine, granular structure; hard, very friable, nonsticky and slightly plastic; slight effervescence; moderately alkaline; abrupt, smooth boundary.

Clcag—10 to 17 inches, dark-gray (N 4/0) and dark grayish-brown (2.5Y 4/2) sandy loam, gray (N 5/0) and light brownish gray (2.5Y 6/2) dry; many fine, distinct, dark-brown (10YR 3/3) mottles; weak, medium, angular blocky structure; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, broken boundary.

IIC2cag—17 to 30 inches, grayish-brown (2.5Y 5/2) loamy sand, light gray (2.5Y 7/2) dry; many medium, distinct, dark-brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

IIIC3g—30 to 36 inches, light olive-gray (5Y 6/2) fine sand, light gray (5Y 7/2) and pale yellow (5Y 7/3) dry; many coarse, distinct, brown (10YR 5/3) mottles; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIIC4g—36 to 48 inches, multicolored brown (10YR 5/3), light olive-gray (5Y 6/2), and strong-brown (7.5YR 5/6) fine sand; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline, smooth boundary.

IIIC5g—48 to 60 inches, light olive-gray (5Y 6/2) fine sand and silt, light gray (5Y 7/2) dry; many medium, distinct, yellowish-red (5YR 5/8) mottles; single grained; loose, nonsticky and slightly plastic; many coarse iron stains; strong effervescence; moderately alkaline.

The A horizon is 8 to 15 inches thick. It is mildly alkaline or moderately alkaline sandy loam, fine sandy loam, or loam. The Cca horizon is 6 to 20 inches thick. It is grayish-brown, dark grayish-brown, light olive-gray, dark-gray, or olive-gray loam, loamy fine sand, loamy sand, fine sandy loam, or sandy loam.

Arveson, Borup, and Glyndon soils have similar profiles, but Arveson soils have more fine and medium sand throughout. Arveson, Cormant, Hamar, Poppleton, and Tiffany soils formed in similar material, but Arveson soils have a more pronounced Cca horizon closer to the surface.

Av—Arveson loam (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains, in low areas along drainageways, and in seep areas adjacent to glacial lake beaches. The profile of this soil is similar to the one described as representative of the series, except the surface layer is loam.

Included with this soil in mapping are small areas of soils that have stones and boulders on the surface. These areas are denoted on the soil maps by spot symbols.

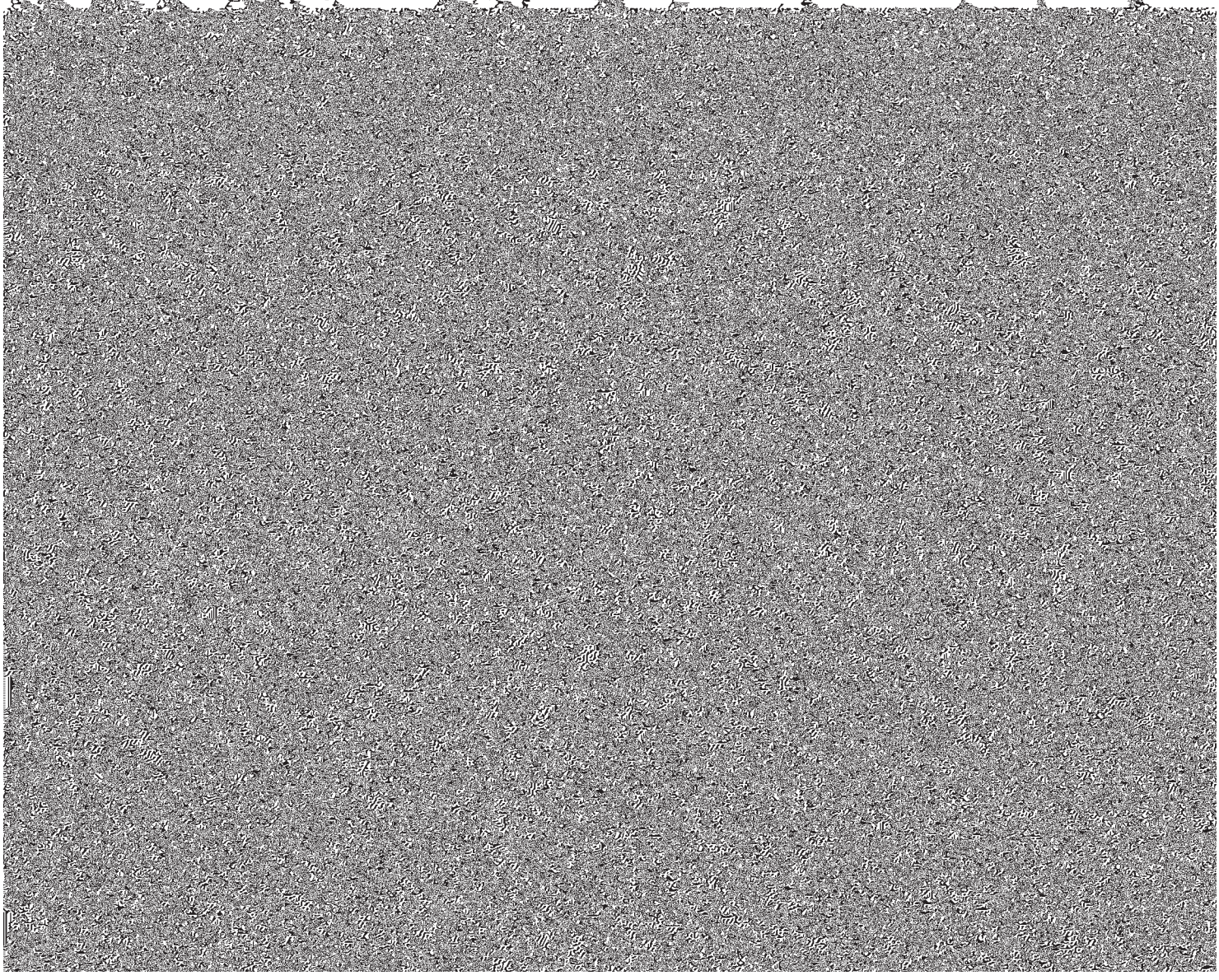
Surface runoff is very slow, and susceptibility to soil blowing is moderate. The water table is at or near the surface during wet periods.

This soil is suited to hay and pasture, and small grains can be grown if drainage is improved. Wetness, the chief management concern, delays spring seeding most years. Cultivated soils must be protected against soil blowing. Capability unit IIIw–5; windbreak suitability group 2.

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

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

Soil	Acres	Percent	Soil	Acres	Percent
Arveson loam	14,050	1.9	Lankin and Gilby stony loams, 1 to 3 percent slopes	4,550	0.6
Arveson sandy loam	14,000	2.0	La Prairie loam, 1 to 3 percent slopes	1,100	.2
Arveson soils, very wet	5,300	.7	La Prairie silty clay loam, 1 to 3 percent slopes	10,800	1.5
Barnes loam, 9 to 20 percent slopes	346	(1)	La Prairie silty clay loam, 3 to 6 percent slopes	690	.1
Bearden silty clay loam, 1 to 3 percent slopes	80,580	11.2	La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes	3,250	.5
Bearden silty clay loam, 3 to 6 percent slopes	476	.1	Maddock loamy sand, 1 to 3 percent slopes	3,350	.5
Bearden silty clay loam, saline, 1 to 3 percent slopes	11,800	1.6	Maddock loamy sand, 3 to 6 percent slopes	1,400	.2
Bearden-Colvin silty clay loams	1,950	.3	Maddock sandy loam, 1 to 3 percent slopes	2,400	.3
Bearden and Glyndon silt loams, 1 to 3 percent slopes	30,500	4.2	Maddock sandy loam, 3 to 6 percent slopes	1,200	.2
Binford sandy loam, 1 to 3 percent slopes	2,800	.4	Maddock loamy sand, thin surface variant, 1 to 6 percent slopes	4,350	.6
Binford sandy loam, 3 to 6 percent slopes	600	.1	McDonaldsville silty clay	3,050	.4
Borup silt loam	11,800	1.6	Nahon silt loam	970	.1
Brantford loam, 1 to 3 percent slopes	3,200	.4	Neche silty clay loam	4,350	.6
Brantford loam, 3 to 6 percent slopes	800	.1	Neche silty clay	3,800	.5
Brantford loam, 6 to 9 percent slopes	207	(1)	Ojata silt loam	530	.1
Brantford loam, 9 to 25 percent slopes	339	.1	Olga silty clay loam, 3 to 6 percent slopes	1,600	.2
Cashel silty clay, 1 to 3 percent slopes	7,100	1.0			



Aw—Arveson soils, very wet (0 to 1 percent slopes). These soils are in depressions on glacial lake plains. They are in low areas along drainageways and in seep areas adjacent to glacial lake beaches. The profile of these soils is similar to the one described as representative of the series, but these soils are more poorly

The A horizon is loam or silt loam 4 to 9 inches thick. The B horizon is loam or light clay loam 4 to 6 inches thick. In some places many stones and boulders are throughout the soil and on the surface.

Barnes and Lankin soils have similar profiles, but Barnes soils are better drained.

BaD—Barnes loam, 9 to 20 percent slopes. This soil

C1ca—18 to 28 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; moderate, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C2—28 to 36 inches, olive-brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; few fine, faint, gray (5Y 5/1) and few fine and medium, prominent, very dark brown (10YR 2/2) mottles; weak, coarse, subangular blocky structure parting to moderate, fine and very fine, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C3g—36 to 46 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common medium and fine, distinct, gray (5Y 5/1) and common medium, prominent, dark yellowish-brown (10YR 4/4) mottles; laminated; very hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C4—46 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common medium, distinct, gray (5Y 5/1) and many fine and medium, prominent, dark yellowish-brown (10YR 4/4) and strong-brown (7.5YR 5/6) mottles; laminated; very hard, firm, sticky and plastic; strong effervescence; moderately alkaline.

The A horizon is silty clay loam, clay loam, or silt loam 6 to 14 inches thick. The ACca horizon, typically 4 to 14 inches thick, is silty clay loam, clay loam, or silt loam. It is not present in some places. The Cca horizon is 8 to 16 inches thick. It is light olive-brown, olive-brown, dark grayish-brown, or grayish-brown silty clay loam or silt loam.

Bearden, Glyndon, and Hegne soils have similar profiles. Bearden soils contain more clay between depths of 10 to 40 inches than Glyndon soils, and they are better drained and contain less clay throughout than Hegne soils. Bearden, Overly, and Perella soils formed in similar parent material. Bearden soils are not so well drained and contain more lime throughout than Overly soils, and they are better drained and contain more lime throughout than Perella soils.

BnA—Bearden silty clay loam, 1 to 3 percent slopes. This soil is on glacial lake plains. Slopes are slightly convex. This soil has the profile described as representative of the series.

Included with this soil in mapping, in depressions, are Colvin and Perella soils in areas too small to map separately. These soils and small areas of saline soils are denoted on the soil maps by spot symbols. Also included in mapping is a small area of Bearden silty clay loam underlain by gravel in the southwest corner of section 34, T. 159 N., R. 54 W. This area is adjacent to the Pembina-Walsh county line, and it is included in mapping because it is too small to map separately.

Susceptibility to soil blowing is moderately high. Runoff is slow, and water collects in shallow depressions that remain wet during spring and during periods of high rainfall. This soil has a water table within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, sugar beets, hay, and pasture. Wetness because of ponded water and susceptibility to soil blowing are the chief management concerns. Cultivated areas of this soil must be protected against soil blowing. Capability unit IIe–4L; windbreak suitability group 1.

BnB—Bearden silty clay loam, 3 to 6 percent slopes. This soil is on glacial lake beaches and ridges and along drainageways. Slopes are convex.

Included with this soil in mapping are a few areas of soils that have a thinner surface layer than the one in this soil. Also included, in some areas, are Colvin soils in shallow depressions at the bases of slopes.

Runoff is medium, and susceptibility to soil blowing is moderately high. In some areas there are shallow depressions in which water ponds during wet periods. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Wetness in depressions delays spring seeding or interferes with tillage operations in some years. Capability unit IIe–4L; windbreak suitability group 1.

BrA—Bearden silty clay loam, saline, 1 to 3 percent slopes. This soil is on glacial lake plains. Slopes are convex and concave. The profile of this soil is similar to the one described as representative of the series, but this soil contains appreciable amounts of soluble salts.

Susceptibility to soil blowing is moderately high. Runoff is slow, and water collects in shallow depressions. The water table is within 3 to 5 feet of the surface during wet periods. Available water capacity is moderate. It has been reduced by salinity.

This soil is suited to small grains, hay, and pasture, but salinity restricts crop growth. Wetness and salinity are the chief management concerns of this soil, and the use of salt-tolerant crops and green manure crops is a necessary part of good management. Cultivated soils must be protected against soil blowing. Wetness delays spring seeding in some years. Capability unit IIIws–4L; windbreak suitability group 10.

Bs—Bearden-Colvin silty clay loams (0 to 1 percent slopes). The Bearden soils are level or have convex slopes, and the Colvin soils are in depressions. These soils are on glacial lake plains that have very little local relief. Bearden soils occupy about 60 percent of this unit, and Colvin soils, about 40 percent.

Included with these soils in mapping are a few small areas of poorly drained Perella soils in deeper depressions.

Runoff is very slow, and susceptibility to soil blowing is moderately high. Water ponds on the Colvin soils during wet periods. Both the Bearden and Colvin soils have a water table within 3 to 5 feet of the surface during wet periods.

These soils are suited to hay and pasture. Sugar beets, small grains, and potatoes can be grown if drainage is improved. Wetness, the chief management concern, delays spring seeding in some years. Cultivated soils must be protected against soil blowing. Capability unit IIIw–4L; windbreak suitability group 1.

BvA—Bearden and Glyndon silt loams, 1 to 3 percent slopes. These soils are on glacial lake plains that have very little local relief. Slopes are convex and concave. The mapped areas are nearly 100 percent Bearden soils in some places and nearly 100 percent Glyndon soils in others. Both the Bearden and Glyndon soils have profiles similar to the ones described as representative of their respective series, except that the surface layer is silt loam, and the underlying layers have a high content of silt.

Susceptbility to soil blowing is moderately high.

Runoff is slow, and water ponds in small, shallow depressions. The water table is within 3 to 5 feet of the surface during wet periods.

These soils are suited to small grains, potatoes, sugar beets, hay, and pasture. Soil blowing and wetness that delays spring seeding are the chief management concerns. Erosion must be controlled in cultivated areas. Capability unit IIe–4L; windbreak suitability group 1.

Binford Series

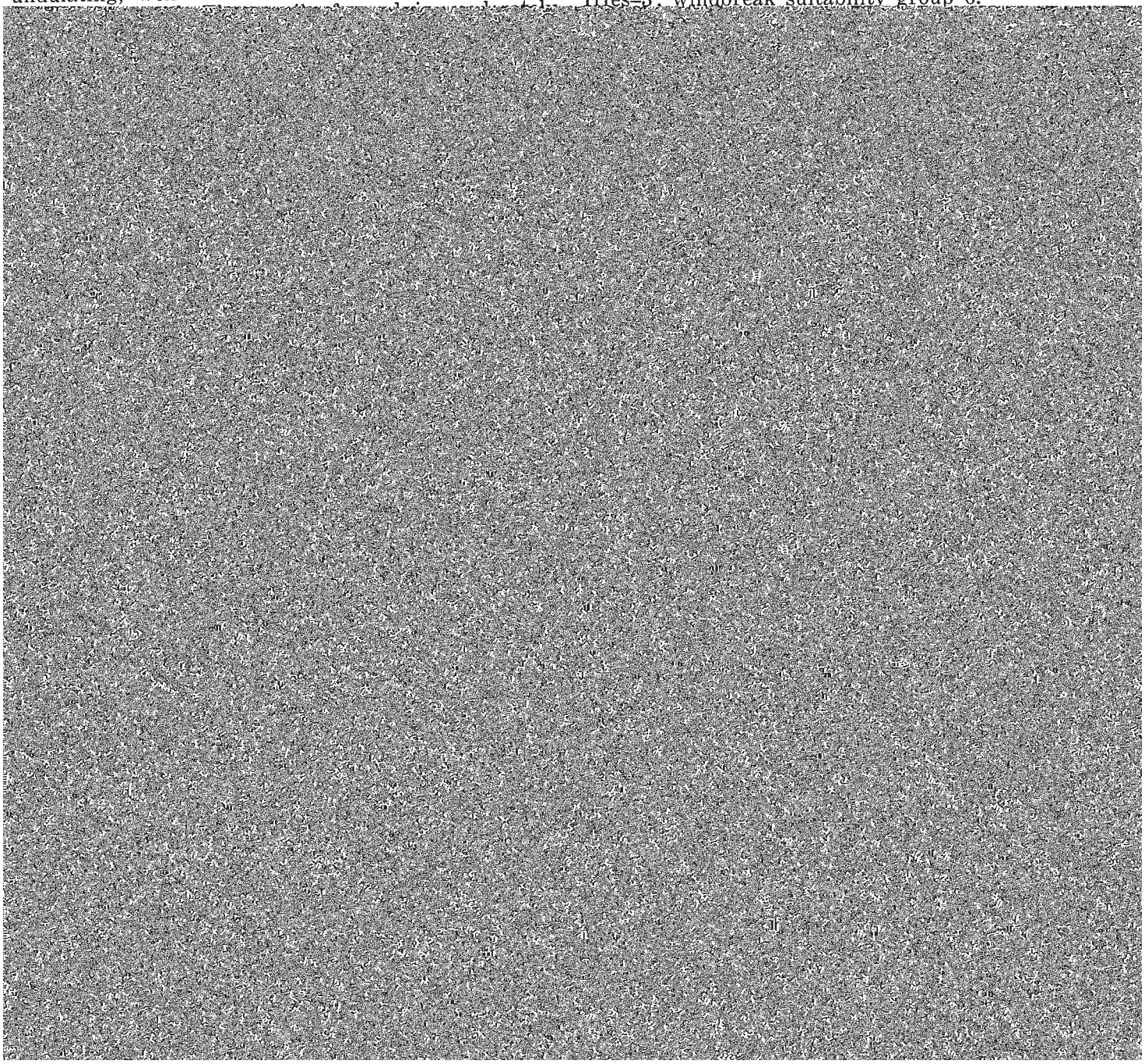
The Binford series consists of nearly level to gently undulating, well-drained soils that are shallow over

of the low available water capacity are the chief management concerns. Erosion must be controlled in cultivated areas. Capability unit IIIes–3; windbreak suitability group 6.

BwB—Binford sandy loam, 3 to 6 percent slopes. This soil is on glacial lake beaches and along drainageways. Slopes are convex.

This soil is highly susceptible to soil blowing and slightly susceptible to water erosion. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and droughtiness because of the low available water capacity are the chief management concerns. Cultivated soils need to be protected against soil blowing and water erosion. Capability unit IIIes–3; windbreak suitability group 6.



fine, distinct, light-gray (5Y 6/1) mottles; weak, fine, angular blocky structure; slightly hard, very friable, sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC4g—38 to 50 inches, light olive-brown (2.5Y 5/4) loamy very fine sand, pale yellow (2.5Y 7/4) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and fine, prominent, light-gray (5Y 6/1) mottles and few fine, distinct, dark reddish-brown (5YR 3/2) mottles; single grained; loose, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

IIC5g—50 to 60 inches, olive (5Y 5/3) loamy very fine sand, pale olive (5Y 6/3) dry; many coarse, prominent, gray (5Y 6/1) and fine, prominent, yellowish-brown (10YR 5/4) and strong-brown (7.5YR 5/6) mottles and few, fine, distinct, dark reddish-brown (5YR 3/2) mottles; single grained; loose, slightly sticky and slightly plastic; strong effervescence; moderately alkaline.

The A horizon ranges from 6 to 16 inches in thickness, and it is silt loam, loam, or very fine sandy loam. The Cca horizon is silt loam or very fine sandy loam.

Borup, Gardena, and Glyndon soils formed in similar material. Borup soils are more poorly drained than Glyndon and Gardena soils and contain lime closer to the surface than Gardena soils. The Borup, Arveson, and Colvin soils have similar profiles, but Borup soils have more silt and very fine sand throughout than Arveson soils and have less clay throughout than Colvin soils.

Bx—Borup silt loam (0 to 1 percent slopes). This soil is on convex glacial lake beaches and deltas. It has feet west of the NE. corner of the NW. quarter of sec. 15, T. 159 N., R. 56 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; clear, smooth boundary .

B2—8 to 12 inches, very dark grayish-brown (2.5Y 3/2) loam, dark grayish brown (2.5Y 4/2) dry; moderate, medium, subangular blocky structure; hard, very friable, slightly sticky and plastic; mildly alkaline; clear, wavy boundary.

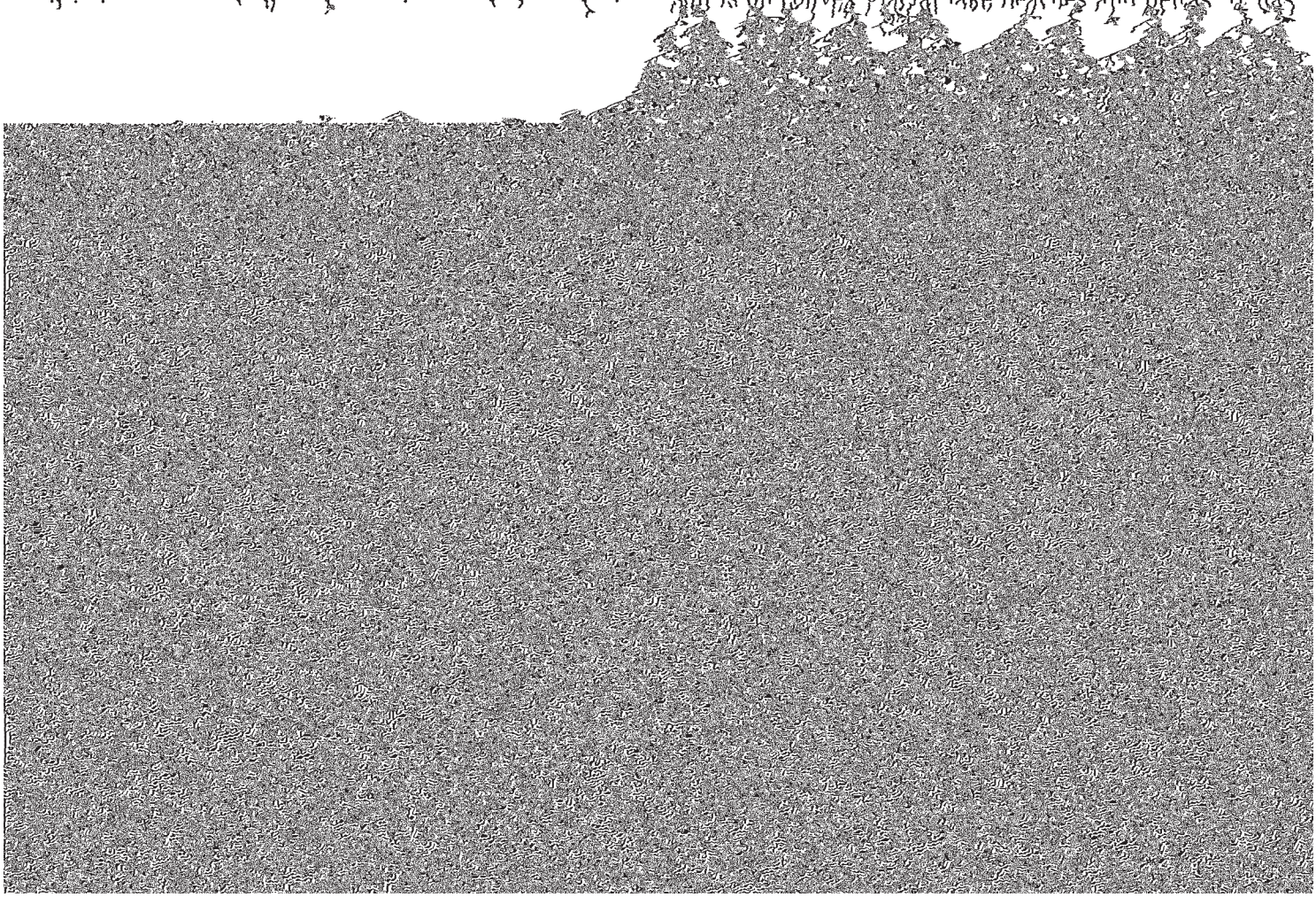
IIC1—12 to 50 inches, dark-gray (5Y 4/1) very gravelly sand, gray (5Y 5/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, wavy boundary.

IIC2—50 to 60 inches, dark-gray (5Y 4/1) coarse sand, light gray (5Y 6/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; about 10 percent gravel.

Depth to sand and gravel ranges from 12 to 20 inches. The A horizon is black or very dark gray loam or gravelly loam. The B horizon is very dark gray, very dark grayish-brown, or dark grayish-brown loam or clay loam. The IIC horizon is stratified gravel and sand-sized shale particles.

Brantford, Binford, Renshaw, Vang, and Walsh soils all have IIC horizons of sand and gravel. Brantford soils have more silt and clay above the IIC horizon than Binford soils, are not so deep to sand and gravel as Vang and Walsh soils, and have more shale in the IIC horizon than Renshaw soils.

ByA—Brantford loam, 1 to 3 percent slopes. This soil is on convex glacial lake beaches and deltas. It has



Susceptibility to soil blowing is moderate. Susceptibility to water erosion is high, and runoff is rapid.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and water erosion and droughtiness caused by low available water capacity are the chief management concerns. Erosion needs to be controlled where these soils are cultivated. Capability unit IIIe–5; windbreak suitability group 6.

ByD—Brantford loam, 9 to 25 percent slopes. This soil is along streams. Slopes are convex.

Included with this soil in mapping are soils that have a thinner surface layer and, consequently, sand and

C3—26 to 42 inches, olive-gray (5Y 4/2) silty clay, light olive gray (5Y 6/2) dry; many medium, faint, dusky-red (2.5YR 3/2) mottles; weak, very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C4—42 to 53 inches, olive (5Y 4/3) silty clay, light olive gray (5Y 6/2) and pale olive (5Y 6/3) dry; many coarse, distinct, dusky-red (2.5YR 3/2) mottles; strong, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C5—53 to 60 inches, multicolored dark-gray (5Y 4/1), gray (5Y 5/1), olive (5Y 5/3), strong-brown

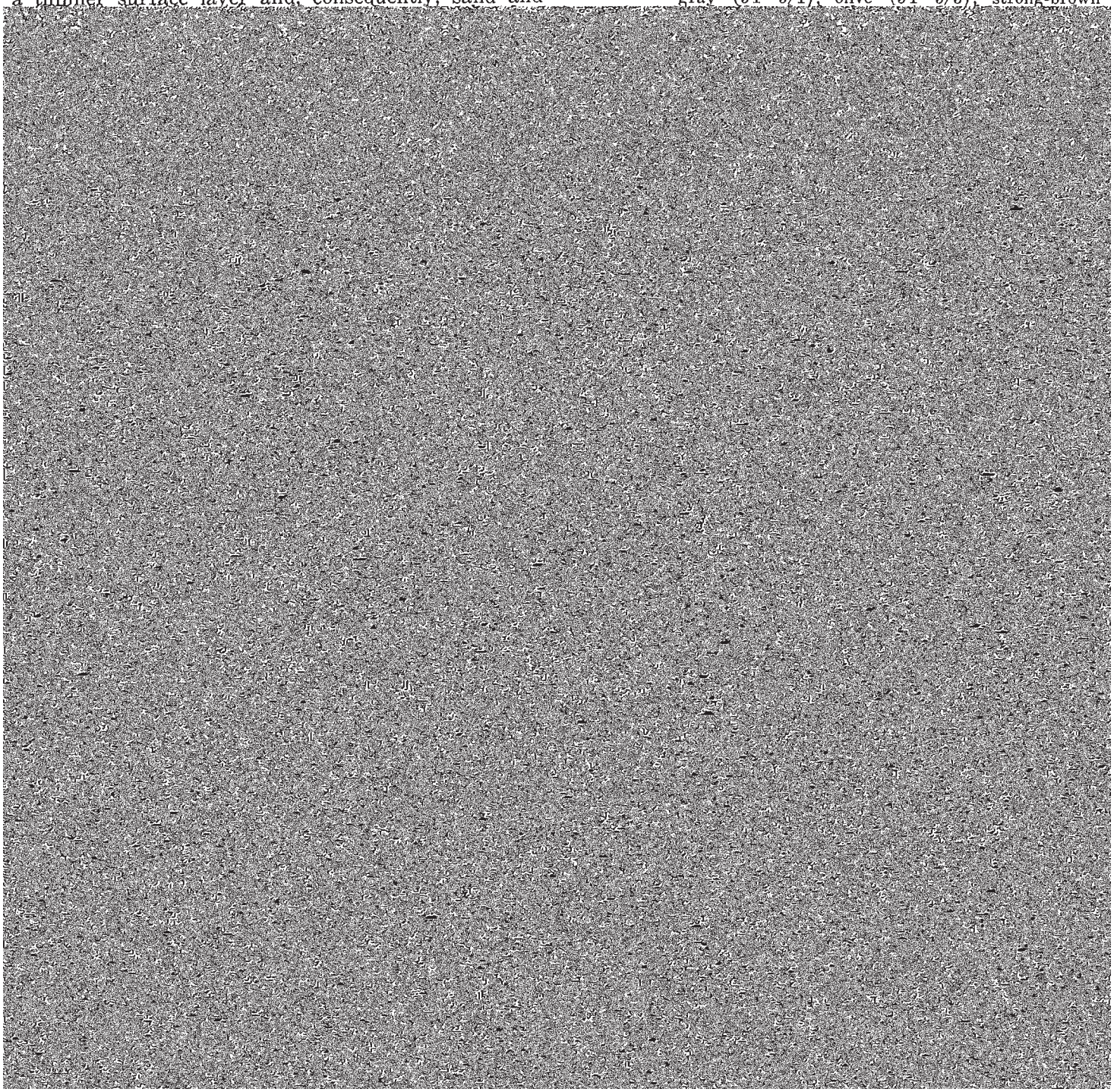


Figure 3.—**Native trees were preserved to protect this farmstead on Cashel silty clays. Native trees were cleared from the Cashel soils in background, and field windbreaks were planted to control soil blowing. Trees grow well on these soils.**

Claire Series

The Claire series consists of deep, nearly level and gently sloping, excessively drained soils that formed in coarse-textured deposits on glacial lake plains, outwash plains, and glacial lake beaches.

In a representative profile the surface layer is loamy coarse sand about 8 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The underlying material is brown coarse sand.

Permeability is rapid. Available water capacity is very low. Organic-matter content is low. Natural fertility is very low.

Most of these Claire soils are used for small grains, but a few areas are in pasture, hay, and native woods.

Representative profile of Claire loamy coarse sand, 1 to 6 percent slopes, in grass; 120 feet north and 270 feet west of the SE. corner of sec. 32, T. 162 N., R. 55 W.

A1—0 to 5 inches, very dark brown (10YR 2/2) loamy coarse sand, dark grayish brown (10YR 4/2) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

AC—5 to 8 inches, very dark grayish-brown (10YR 3/2) loamy coarse sand, grayish brown (10YR 5/2) dry; single grained; loose nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C1—8 to 30 inches, brown (10YR 5/3) stratified coarse sand with a few thin strata of gravel, pale brown (10YR 6/3) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C2—30 to 60 inches, brown (10YR 5/3) coarse sand with a few thin strata of gravel, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline.

The A horizon is 4 to 10 inches thick. It is black, very dark gray, or very dark brown loamy coarse sand, loamy sand, sand, or sandy loam. The C horizon is medium or coarse sand. In places a thin strata of granitic or shaly gravel is in the C horizon.

Claire, Hamar, Hecla, Maddock, and Serden soils occupy similar landscape positions and formed in similar material. Claire soils have more medium and coarse sand throughout than the other soils, and they are better drained than Hamar, Hecla, and Maddock soils.

CbB—Claire loamy coarse sand, 1 to 6 percent slopes. This soil is on glacial lake beaches and outwash plains. Slopes are convex.

Included with this soil in mapping are small areas of soils that have a sandy loam surface layer and other

areas of soils that are underlain by gravel. The soils underlain by gravel are denoted on the maps by spot symbols. Also included is an area of glacial lake beaches east of Gardar. These beaches have soils containing a large amount of lime near the surface. Included in the southwest quarter of section 33, T. 159 N., R 56 W., the southeast quarter of section 31, and the southwest quarter of section 32, T. 159 N., R. 55 W., are areas of soils that are very shallow to shallow over gravel. These areas are adjacent to the Pembina-Walsh county line. They are included in mapping in Pembina County because they are of too limited extent to map separately.

Susceptibility to soil blowing is very high. Surface runoff is slow or very slow.

This soil is suited to hay and pasture. The very high susceptibility to soil blowing and droughtiness because of very low available water capacity make this soil unsuitable for cultivated crops. Capability unit VIe-2; windbreak suitability group 10.

Clayey Breaks

Cd—Clayey breaks (9 to 25 percent slopes). This land type is moderately steep and steep on escarpments and steeper along streams. The soil material of this land type normally consists of about 4 inches of slightly acid loam underlain by about 12 inches of slightly acid

has 0 to 1 percent slopes, in a cultivated field; 125 feet east and 138 feet north of the SW. corner of sec. 34, T. 159 N., R. 51 W.

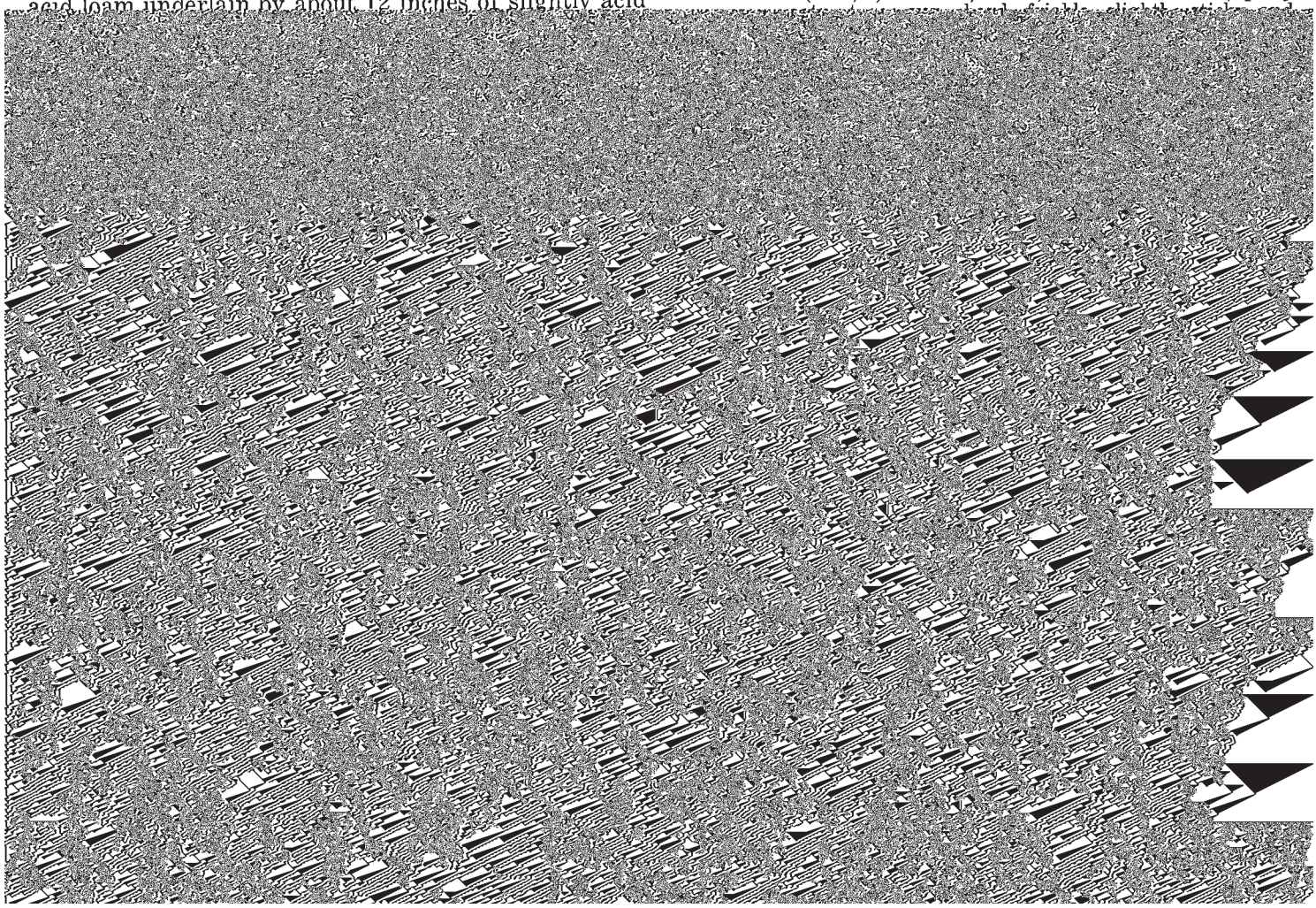
Ap—0 to 10 inches, black (N 2/0) silty clay loam, dark gray (N 4/0) dry; moderate, medium and fine, granular structure; very hard, firm, sticky and plastic; strong effervescence; moderately alkaline; gradual, irregular boundary.

C1g—10 to 13 inches, very dark gray (5Y 3/1) silty clay loam, light olive gray (5Y 6/2) dry; strong, fine, granular structure; very hard, very firm, very sticky and very plastic; slight effervescence; moderately alkaline; abrupt, broken boundary.

C2cag—13 to 18 inches, olive-gray (5Y 5/2) silty clay loam, light gray (5Y 7/1) dry; common fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to moderate, very fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, irregular boundary.

C3cag—18 to 31 inches, olive-gray (5Y 5/2) silty clay loam, light olive gray (5Y 6/2) dry; many medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, very coarse, prismatic structure parting to moderate, very fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline.

C4g—31 to 48 inches, olive-brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common fine, distinct, brown (10YR 5/3) and gray (N 6/0) mottles; weak, medium and thin, platy



mapping are a few small areas of nonsaline Colvin soils.

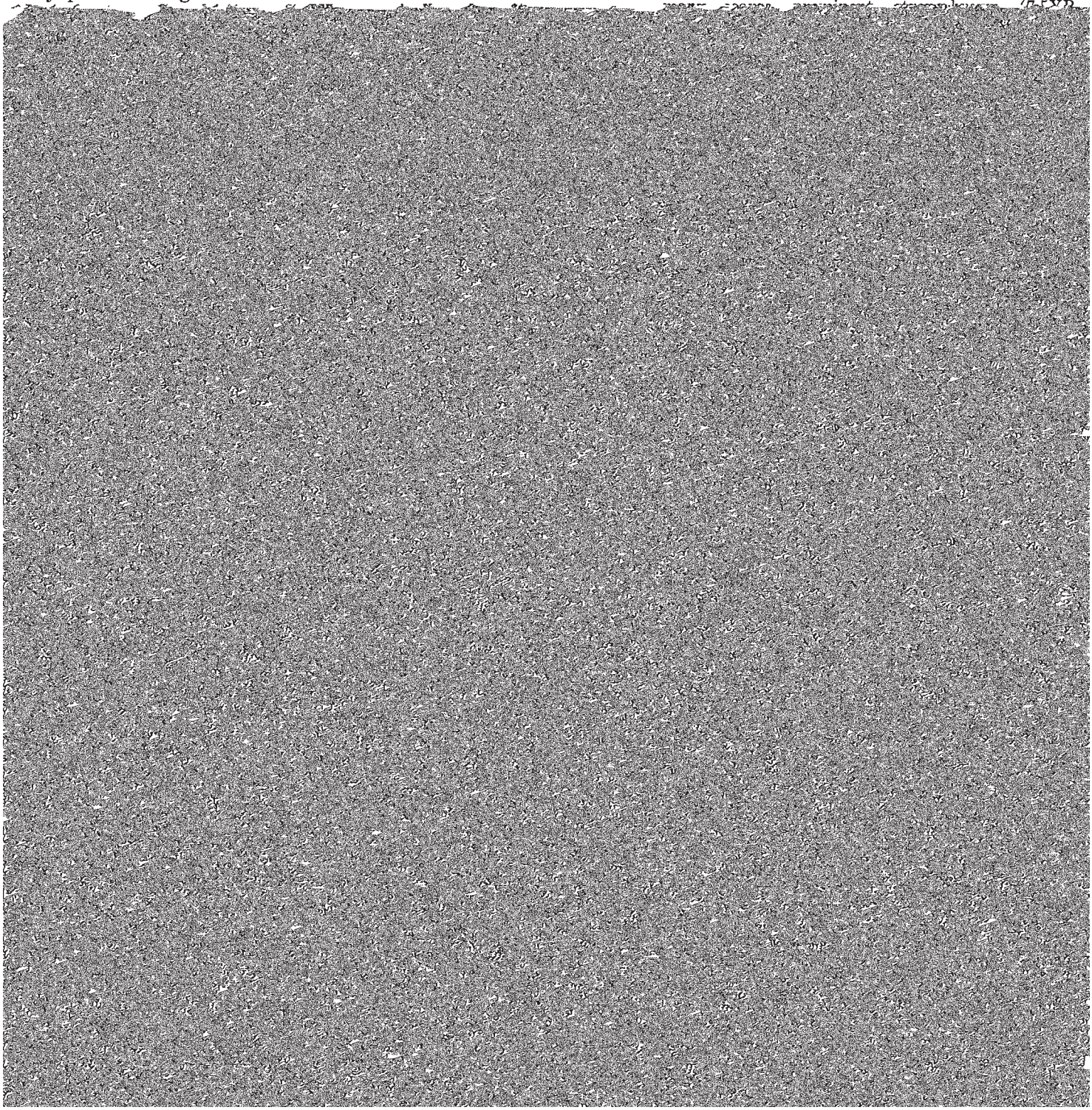
Susceptibility to soil blowing is moderately high. During wet periods the soil is covered by ponded water or has a water table within 1 to 3 feet of the surface. Available water capacity is moderate.

This soil is suited to salt-tolerant grasses. Salinity is the chief management concern, and salinity and very poor drainage make this soil unsuitable for cul-

nonsticky and nonplastic; slightly acid; clear, smooth boundary.

C1g—5 to 16 inches, grayish-brown (2.5Y 5/2) loamy sand, light gray (2.5Y 7/2) dry; common medium, distinct, dark yellowish-brown (10YR 4/4) and common fine, prominent, brown (7.5YR 4/4) mottles; weak, coarse, angular blocky structure; loose, nonsticky and nonplastic; slightly acid; gradual, wavy boundary.

C2g—16 to 24 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) loamy sand, light gray (2.5Y 7/2) dry;



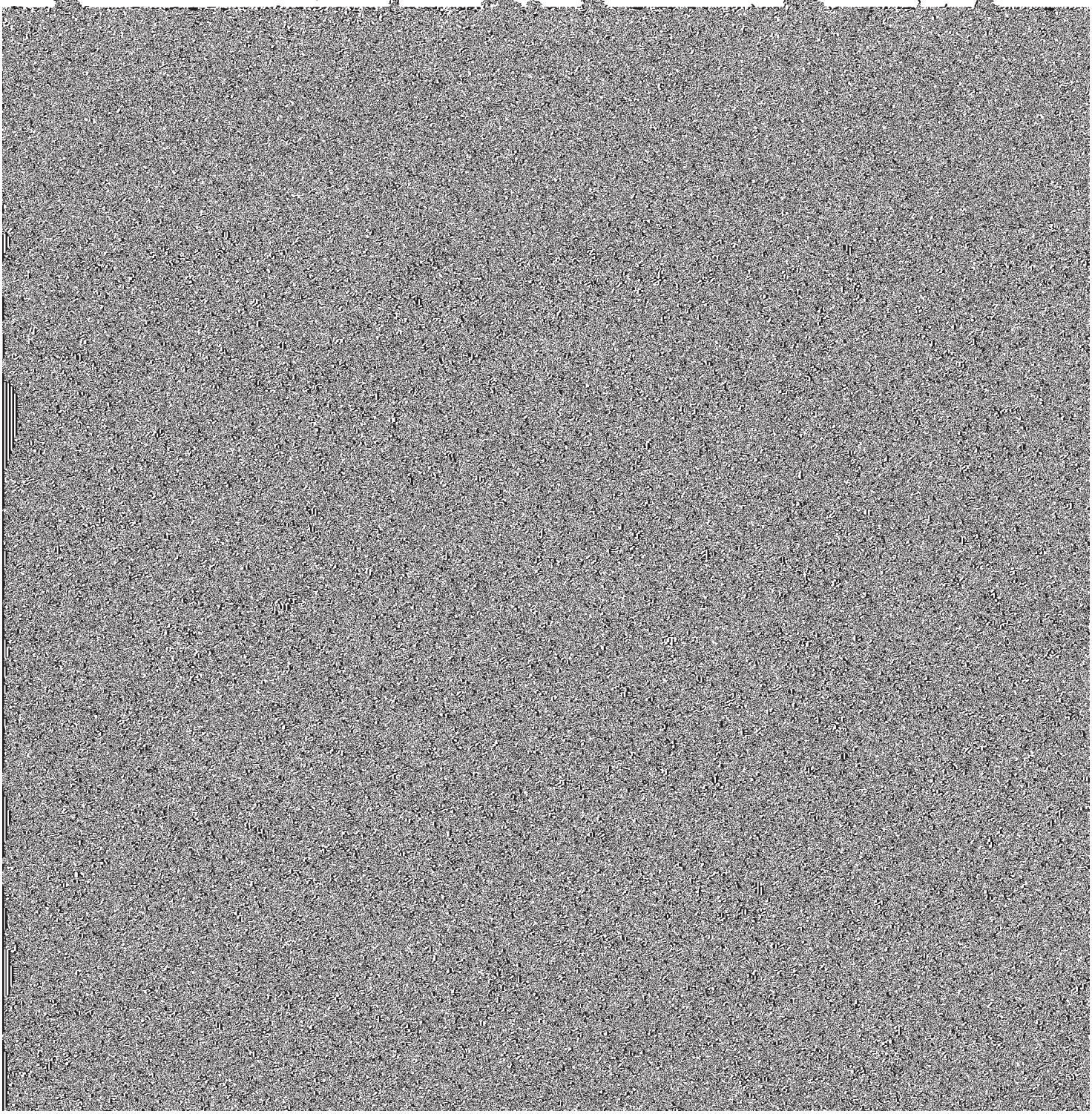
and gravel. These soils formed in medium-textured alluvium underlain by shaly gravel and sand-sized particles of shale on glacial lake beaches.

In a representative profile the surface layer is calcareous loam about 16 inches thick. It is black in the upper part and very dark gray in the lower part. The next layer is dark-gray loam, about 14 inches thick, that is high in content of lime. The underlying material

soils formed in fine-textured lacustrine deposits in shallow to deep depressions on glacial lake plains.

In a representative profile the surface layer is black silty clay, about 40 inches thick, that is mottled below a depth of 6 inches. The subsoil is olive-gray, mottled silty clay about 20 inches thick.

Permeability is very slow. Available water capacity, organic-matter content, and natural fertility are high.



crops are to be grown. The water table is within 0 to 3 feet of the surface during wet periods.

This soil is suited to hay and pasture. Wetness is the chief concern, but small grains can be grown where the soils have been drained. Cultivated soils must be protected against soil blowing. Capability unit IIIw–4; windbreak suitability group 2.

Egeland Series

The Egeland series consists of deep, nearly level to gently sloping, well-drained soils that formed in medium-textured and moderately coarse textured outwash deposits on glacial deltas.

In a representative profile the surface layer is black loam about 8 inches thick. The subsoil, about 20 inches thick, is very dark grayish-brown loam in the upper part and dark grayish-brown sandy loam in the lower part. The layer below it is olive loamy sand about 20 inches thick. Below this is light olive-brown, calcareous sand.

Permeability is moderately rapid, and available water capacity is moderate. Organic-matter content is moderate. Natural fertility is medium.

Most of the acreage of Egeland soils is used for small grains and sunflowers.

Representative profile of Egeland loam, 1 to 3 percent slopes, in a cultivated field; 460 feet west and 70 feet south of the NE. corner of the NW. quarter of sec. 17, T. 162 N., R. 56 W.

Included with this soil in mapping are a few areas of soils that have a leached subsurface layer. In cultivated areas this leached layer is mixed with the plow layer.

Susceptibility to soil blowing is moderate. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness due to moderate available water capacity is a limitation in years of extended dry periods. Capability unit IIe–5; windbreak suitability group 5.

EgB—Egeland loam, 3 to 6 percent slopes. This soil is along drainageways and around depressions. Slopes are convex.

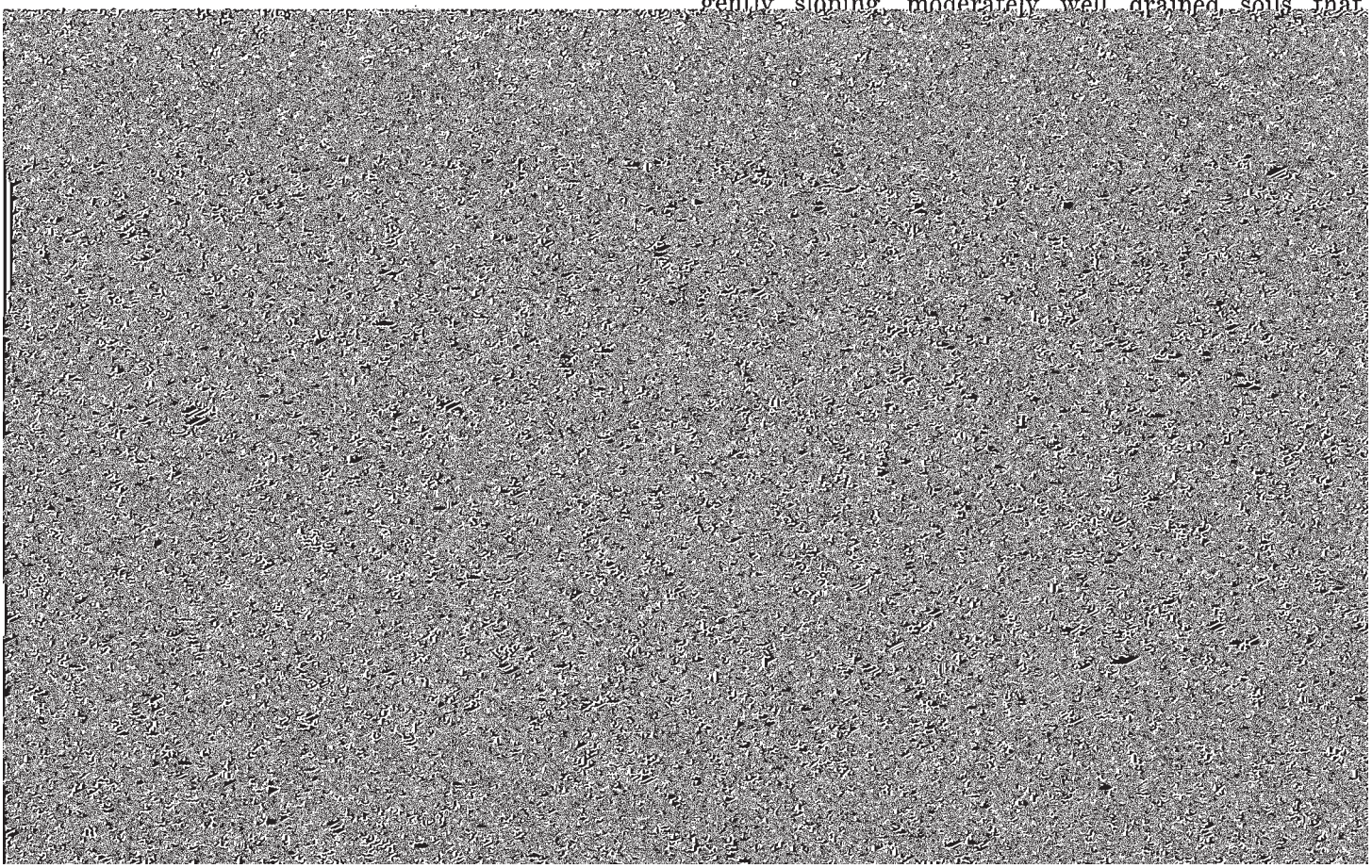
Included with this soil in mapping are a few areas of soils that have a leached subsurface layer. In cultivated areas this leached layer is mixed with the plow layer.

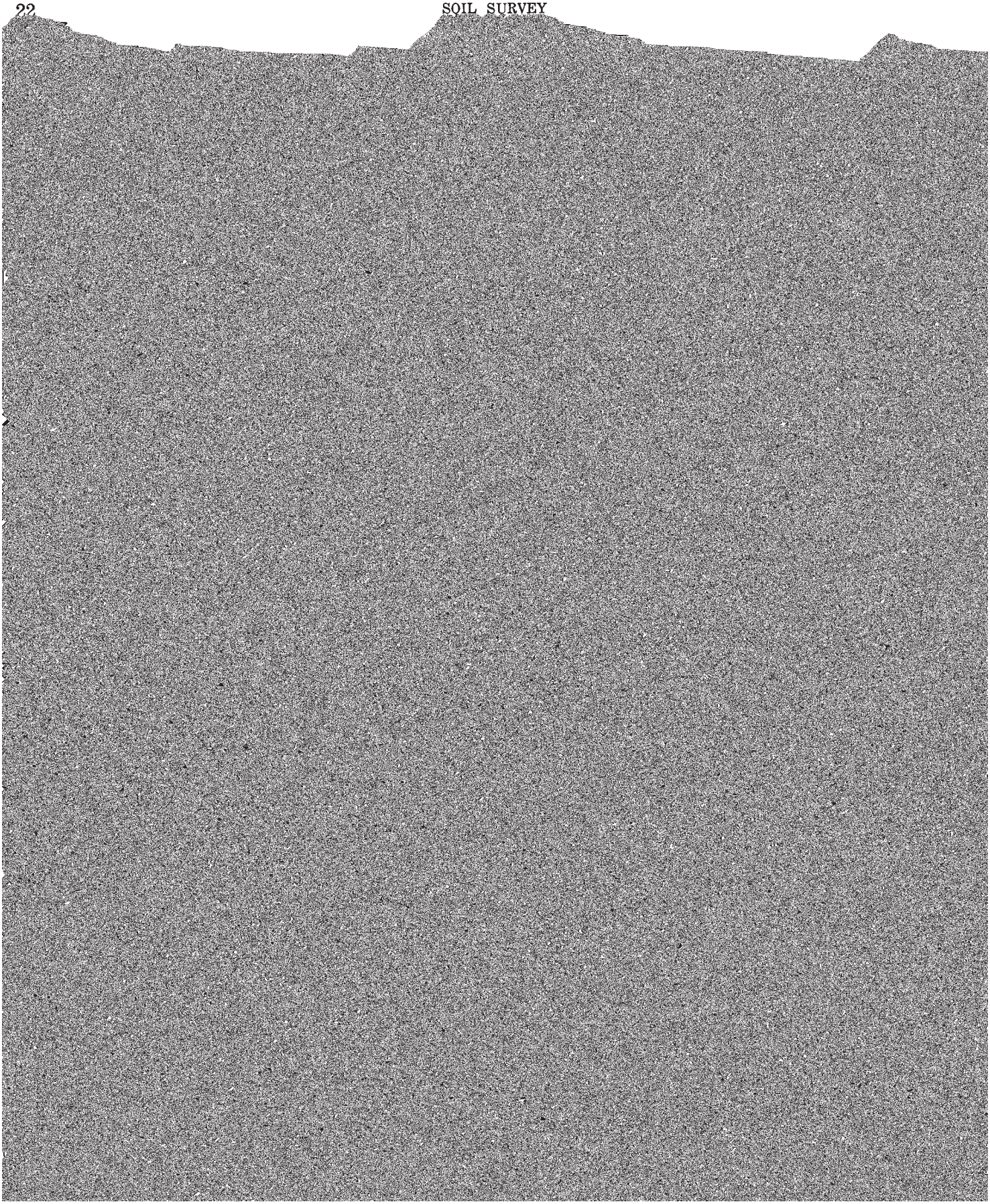
Susceptibility to soil blowing is moderate. Runoff is medium. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. Soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness caused by the moderate available water capacity is a limitation in years of extended dry periods. Capability unit IIe–5; windbreak suitability group 5.

Embden Series

The Embden series consists of deep, nearly level to gently sloping, moderately well drained soils that





dale soils that have a silt loam surface layer, and some small, abandoned stream channels.

Runoff is slow. Flooding from stream overflow occurs, but floodwaters generally recede in time for spring planting.

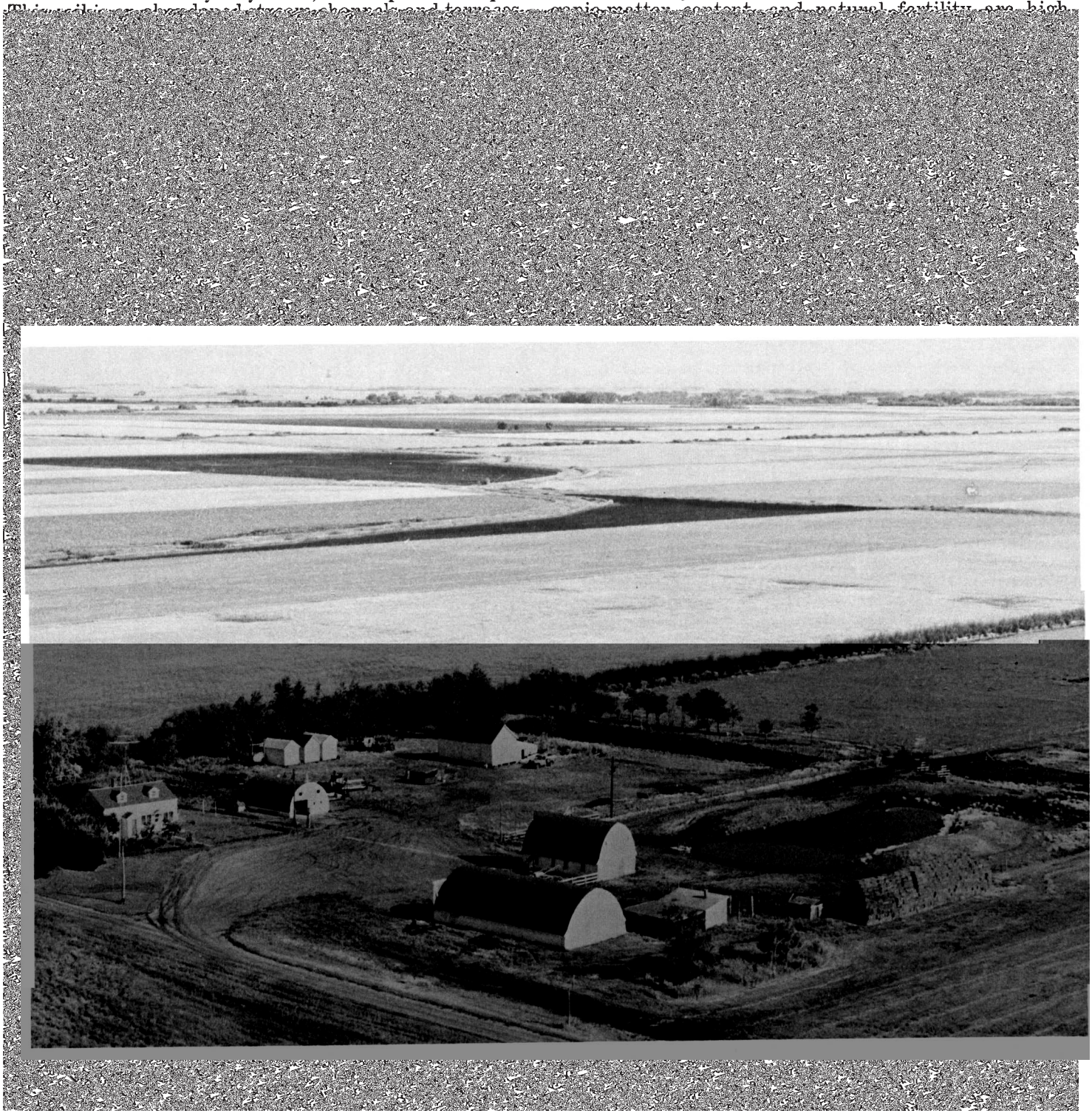
This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Capability IIc–7; windbreak suitability group 1.

FaB—Fairdale silty clay loam, 3 to 6 percent slopes. This soil is on slightly dissected stream channels and terraces. [illegible] organic matter content, and natural fertility are high.

drained soils that formed in fine-textured deposits in shallow depressions on the glacial lake plains.

In a representative profile the surface layer is black silty clay about 9 inches thick. The subsoil, about 8 inches thick, is very dark gray silty clay. The underlying material is calcareous silty clay that is gray in the upper 13 inches, light brownish gray and mottled in the next 14 inches, and olive and mottled below.

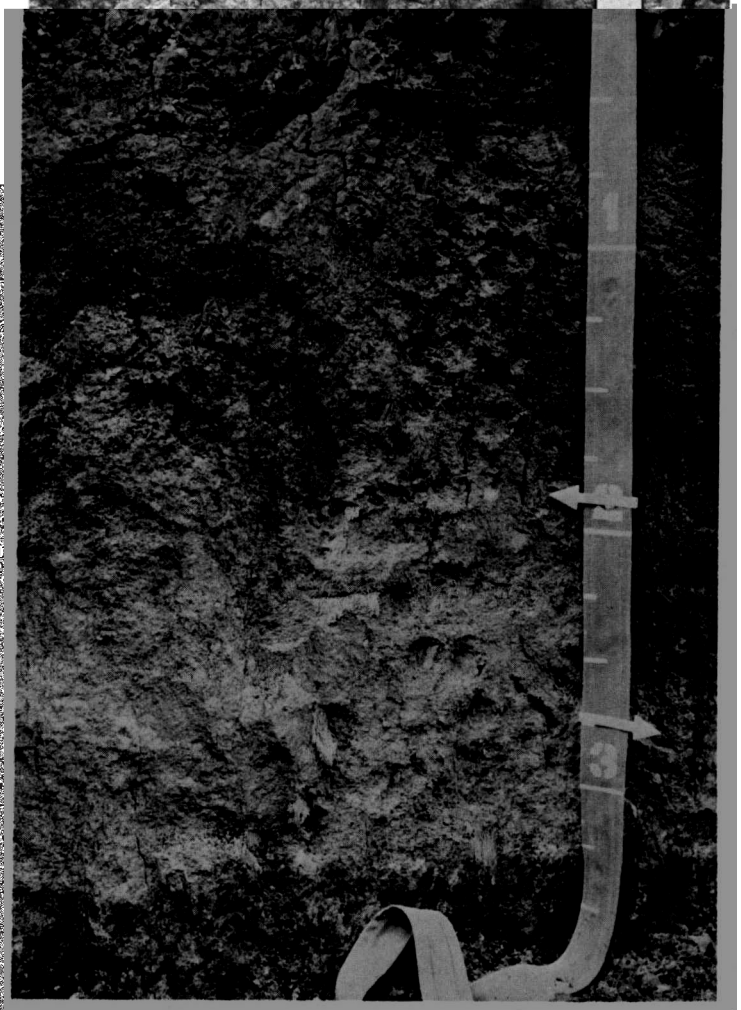
Permeability is slow. Available water capacity, or-



lar blocky structure; very hard, friable, very sticky and very plastic; tongues of material from the A horizon extend through this horizon; mildly alkaline; gradual, irregular boundary.

C1cag—17 to 30 inches, gray (5Y 5/1) silty clay, light gray (5Y 7/1) dry; moderate, very fine, granular structure; hard, friable, very sticky and very plastic; tongues of material from the A horizon extend into this horizon to a depth of 21 inches; strong effervescence; strongly alkaline; clear, wavy boundary.

C2g—30 to 44 inches, light brownish gray (2.5Y 6/2) silty clay, light gray (5Y 7/2) dry; common fine, distinct, light olive-brown (2.5Y 5/6) and gray (5Y 5/1) mottles; moderate, very fine, granular structure; very hard, firm, very sticky and very plastic; strong effervescence; strongly alkaline; clear,



ular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; abrupt, smooth boundary.

A12—6 to 15 inches, black (10YR 2/1) very fine sandy loam, very dark gray (10YR 3/1) dry; moderate, medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

B2—15 to 19 inches, very dark gray (10YR 3/1) very fine sandy loam, dark gray (10YR 4/1) dry; moderate, medium, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; moderately alkaline; gradual, wavy boundary.

C1ca—19 to 28 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, smooth boundary.

C2—28 to 36 inches, brown (10YR 4/3) very fine sandy loam, pale brown (10YR 6/3) dry; single grained; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

C3—36 to 52 inches, yellowish-brown (10YR 5/4) very fine sandy loam, very pale brown (10YR 7/4) dry; single grained; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; few small iron concretions; gradual, smooth boundary.

C4—52 to 60 inches, yellowish-brown (10YR 5/4) very fine sandy loam, very pale brown (10YR 7/4) dry; many medium, distinct, gray (10YR 6/1) mottles and many medium, prominent, strong-brown (7.5YR 5/6) and fine, prominent, brown (7.5YR 4/4) mottles; single grained; very hard, very friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline.

The A horizon is very fine sandy loam, silt loam, or loam 12 to 20 inches thick. The B horizon is very dark gray, dark-brown, or very dark grayish-brown very fine sandy loam, silt loam, and loam 4 to 15 inches thick. The C horizon is dark grayish-brown, brown, yellowish-brown, or

In a representative profile the surface layer is calcareous loam that is black in the upper 10 inches and very dark gray and high in content of lime in the lower 6 inches. The next layer is gray clay loam, about 11 inches thick, that is high in content of lime. Below this is about 6 inches of mottled, light olive-brown, calcareous sandy loam. It is underlain by calcareous loam that is light gray and mottled in the upper 7 inches and grayish brown and mottled below.

Permeability is moderate in the upper part and moderately slow in the underlying glacial till. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Gilby soils are used for pasture and small grains, but some are used for hay.

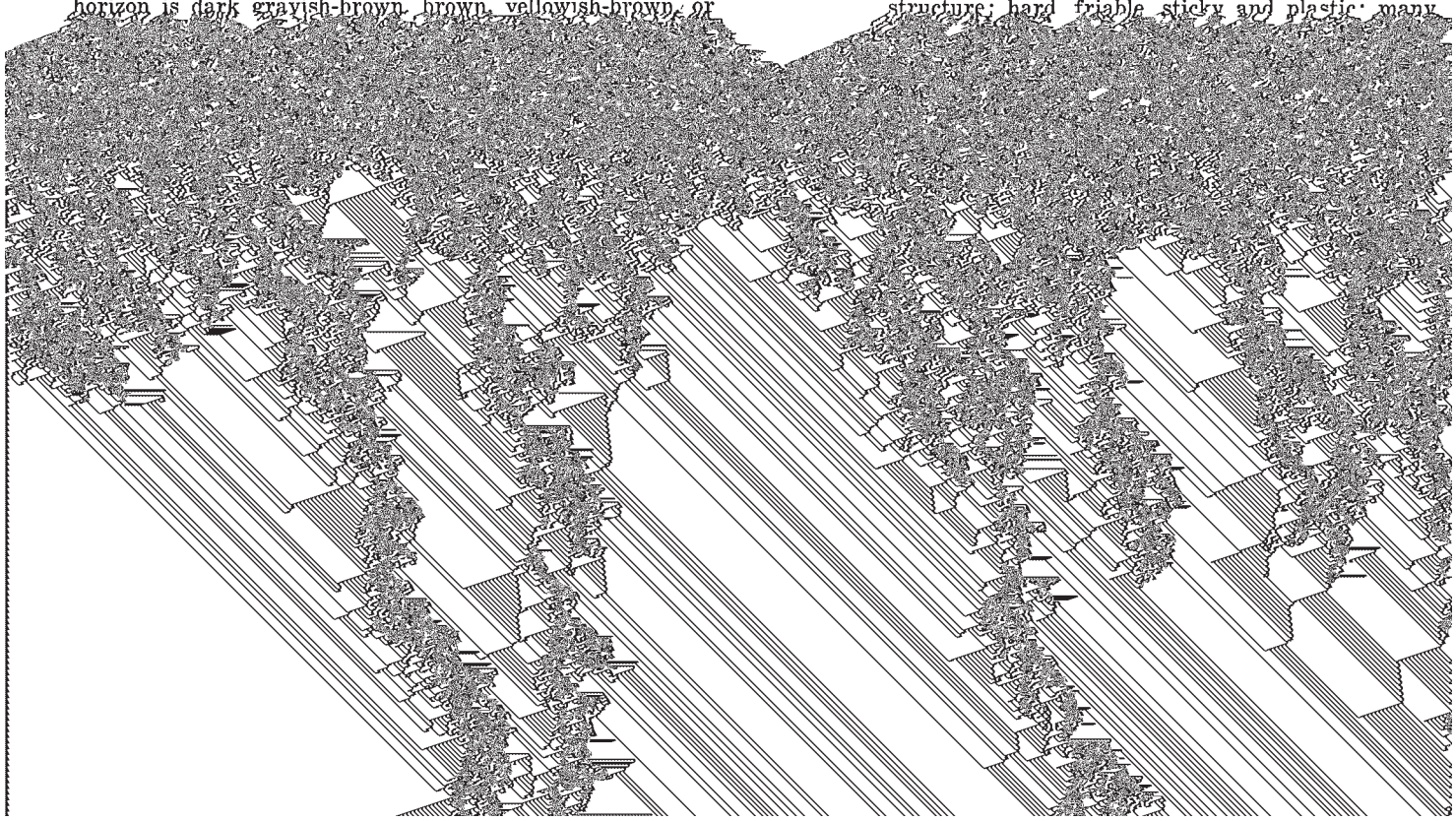
Representative profile of Gilby loam, 1 to 3 percent slopes, in a cultivated field; 486 feet east and 75 feet south of the NW. corner of the NE. quarter of sec. 34, T. 160 N., R. 56 W.

Ap—0 to 6 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, friable, slightly sticky and plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, very coarse, angular blocky structure; hard, friable, slightly sticky and plastic; few white salt flecks; strong effervescence; moderately alkaline; gradual, wavy boundary.

ACca—10 to 16 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak, coarse, angular blocky structure; slightly hard, very friable, sticky and plastic; many white salt flecks; strong effervescence; moderately alkaline; gradual, wavy boundary.

C1cag—16 to 27 inches, gray (5Y 5/1) clay loam, light gray (5Y 6/1) dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; many



areas of soils that have a clay surface layer. Also in- It is black or very dark gray silt loam, loam, very fine

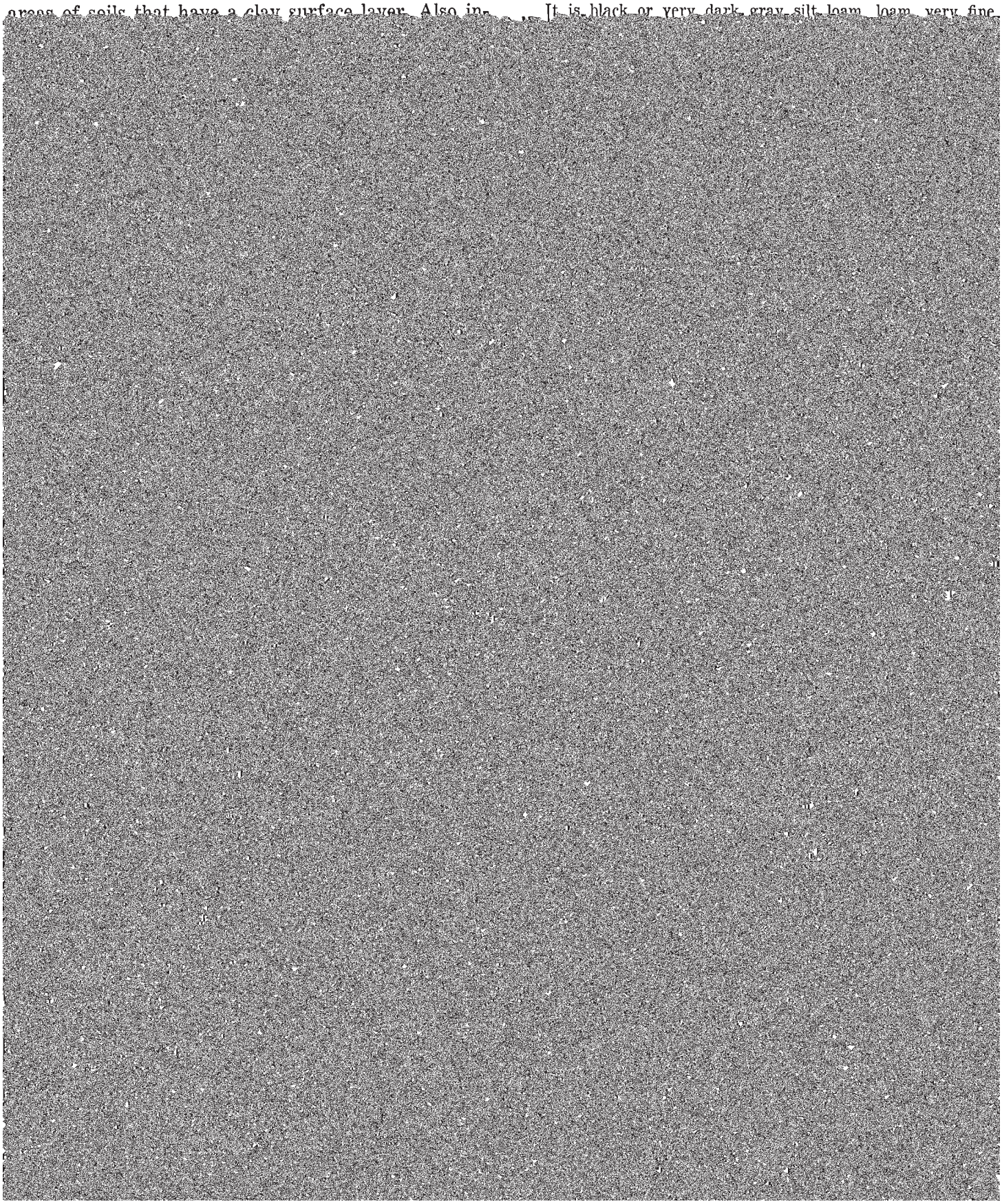


Figure 6.—**Farmstead and field windbreaks on Glyndon loamy very fine sand. These soils are highly susceptible to soil blowing, but trees planted in them make excellent growth.**

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 2 feet of the surface during wet periods. Available water capacity is moderate.

0 to 1 percent slopes, in a cultivated field; 120 feet north and 345 feet east of the SW. corner of sec. 14, T. 160 N., R. 52 W.

Ap—0 to 12 inches, black (N 2/0) silty clay, very dark

and is silty clay or clay. The Cca horizon is dark gray, light olive gray, olive gray, or gray. In places greenish-gray mottles are in the Cca horizon. The C horizon is silty clay or clay. Mottling occurs at depths ranging from 10 to 25 inches.

Grano, Dovray, Fargo, and Hegne soils formed in similar material. Grano soils are more poorly drained than Hegne and Fargo soils and have more lime throughout than Dovray soils.

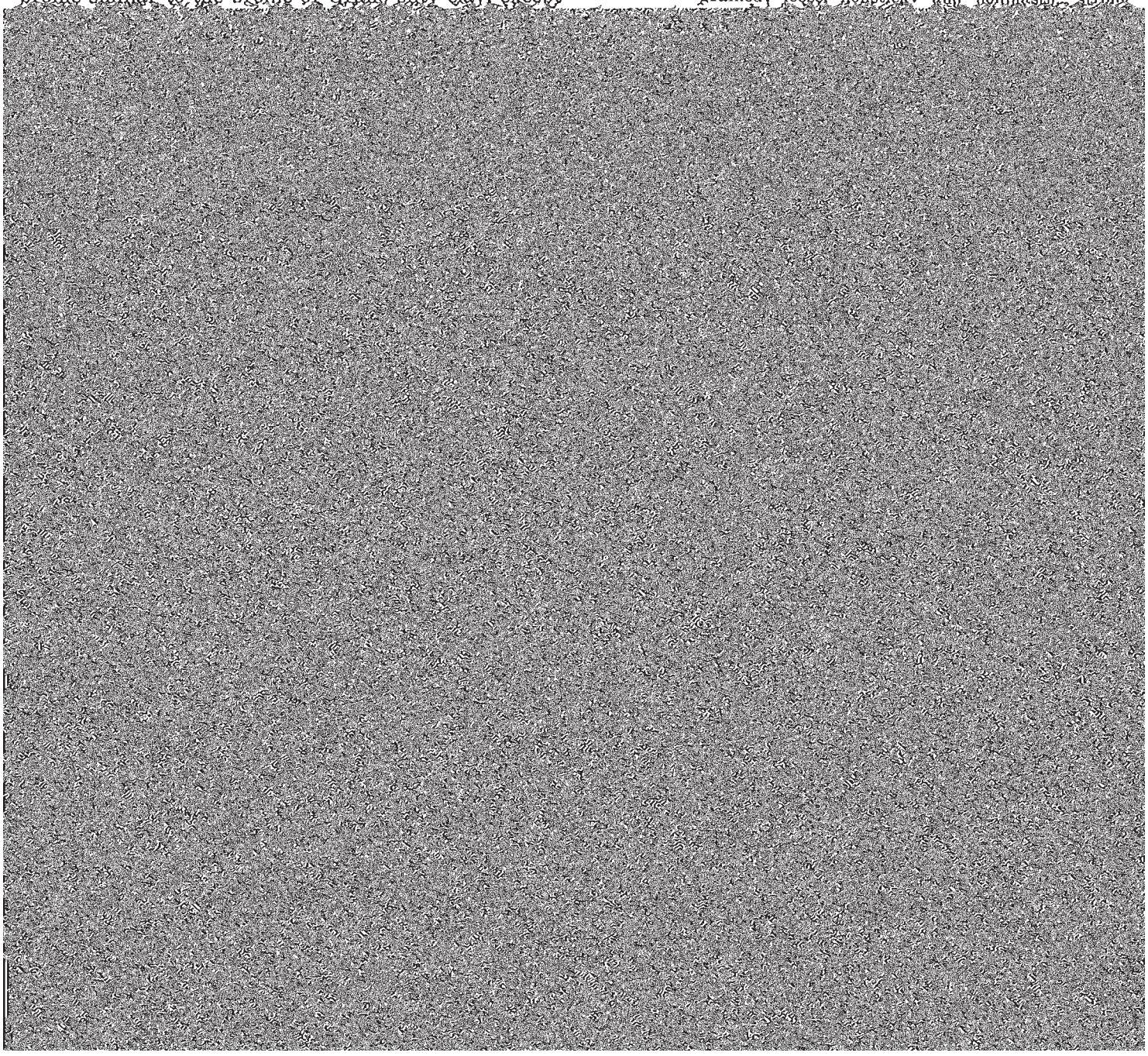
Gr—Grano silty clay (0 to 1 percent slopes). This soil is in deep depressions on glacial lake plains. It has the profile described as representative of the series.

Included with this soil in mapping are Fargo, Hegne, and Dovray soils, which make up about 15 percent of this mapping unit. Also included are soils having a profile similar to the profile of Grano silty clay, except has 0 to 1 percent slopes, in a cultivated field; 480 feet east and 165 feet north of the SW. corner of the SE. quarter of sec. 2, T. 160 N., R. 55 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand, dark gray (10YR 4/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

A12—8 to 21 inches, very dark grayish-brown (2.5Y 3/2) sand, grayish brown (2.5Y 5/2) dry; many fine, prominent, yellowish-brown (10YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; few small manganese concretions; mildly alkaline; clear, smooth boundary.

C1g—21 to 42 inches, olive-gray (5Y 4/2) loamy fine sand, light gray (5Y 7/2) dry; many medium, distinct, olive (5Y 5/4) and gray (5Y 6/1) mottles; single grained; loose, nonsticky and nonplastic; strong



tivated areas need to be protected against soil blowing. Susceptibility to soil blowing is very high (fig. 7).

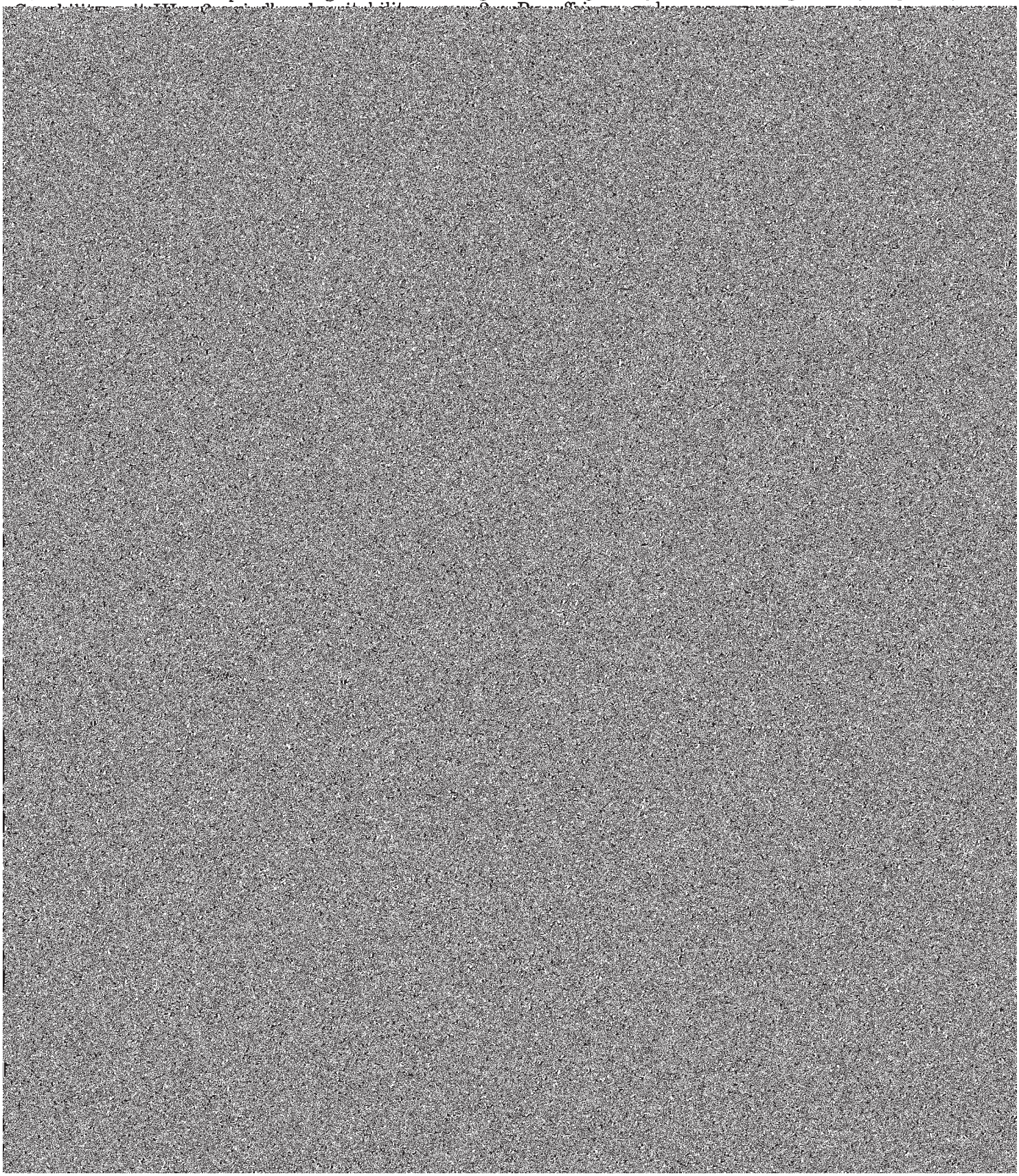


Figure 7.—**This Hecla loamy fine sand is very highly susceptible to soil blowing. Native trees supplemented by windbreak planting and stripcropping help to control soil blowing.**

Hegne Series

The Hegne series consists of deep, nearly level to gently sloping, poorly drained soils. These soils formed in fine-textured lacustrine deposits on the glacial lake plains.

In a representative profile the surface layer is calcareous silty clay about 14 inches thick. It is black in the upper part and very dark gray in the lower part. The next layer, about 14 inches thick, is olive-gray, mottled silty clay that is high in content of lime. Below this is calcareous, olive, mottled silty clay.

Permeability is slow. Available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content and natural fertility are high.

Most of the acreage of Hegne soils is cultivated and used for small grains and sugar beets.

Representative profile of Hegne silty clay in an area of Hegne-Fargo silty clays, 1 to 3 percent slopes, in a cultivated field; 260 feet south and 80 feet west of the NE. corner of sec. 3, T. 163 N., R. 52 W.

Ap—0 to 7 inches, black (N 2/0) silty clay, very dark gray (N 3/0) dry; moderate, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A12ca—7 to 14 inches, very dark gray (5Y 3/1) silty clay, very dark gray (N 3/0) and gray (5Y 5/1) dry; strong, very fine, subangular blocky structure; extremely hard, very friable, very sticky and very plastic; tongues of material from the Ap horizon extend into and through this horizon; strong effervescence; moderately alkaline; diffuse, irregular boundary.

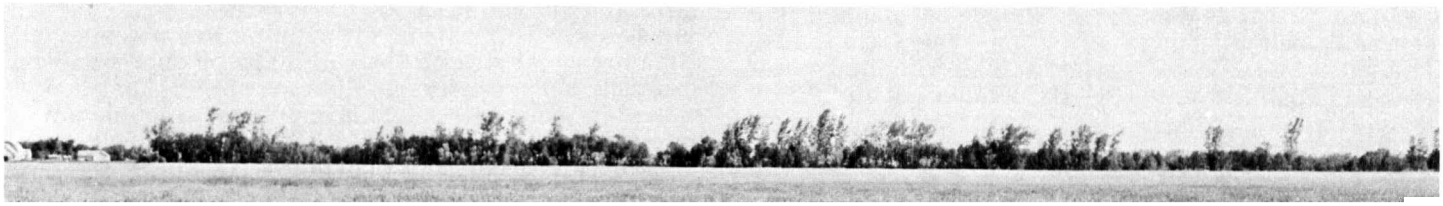
C1cag—14 to 28 inches, olive-gray (5Y 5/2) silty clay, light olive gray (5Y 6/2). and light gray (5Y 7/1) dry; many fine, distinct, pale-olive (5Y 6/3) mottles; moderate, very fine, subangular blocky structure; very hard, very friable, very sticky and very plastic; tongues of material from the A1 horizon extend into this horizon; violent effervescence; moderately alkaline; diffuse, irregular boundary.

C2g—28 to 48 inches, olive (5Y 4/3) silty clay, light olive gray (5Y 6/2) and pale olive (5Y 6/3) dry; many fine, distinct, light olive-brown (2.5Y 5/6) and many fine, prominent, gray (N 5/0) mottles; moderate, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; many small nests of calcium sulphate crystals; strongly effervescent; moderately alkaline; clear, wavy boundary.

C3—48 to 60 inches, olive (5Y 5/3) silty clay with thin layers of silt and very fine sand, pale yellow (5Y 7/3) dry; many coarse, prominent, light-gray (5Y 6/1) and many fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; extremely hard,

friable, sticky and very plastic; many large, soft lime masses; few small iron concretions; strong

This soil is suited to salt-tolerant grasses and small grains. Salinity and wetness are the chief management



and Fargo soils, except they have sand in the lower part of the profile.

Susceptibility to soil blowing is moderately high. Runoff is slow to very slow, and the water table is within 1 to 4 feet of the surface during wet periods.

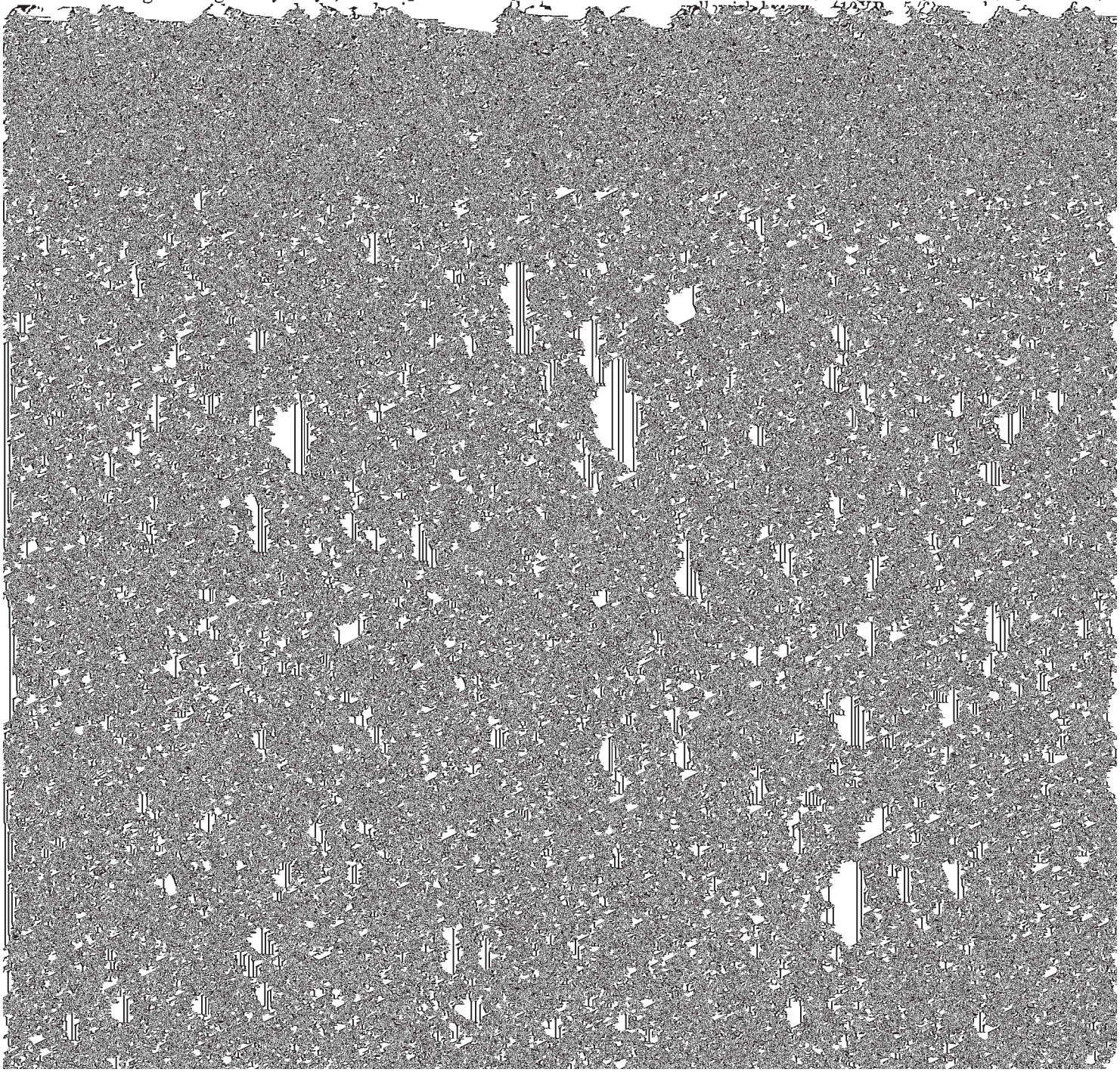
These soils are suited to small grains, potatoes, sugar beets, hay, and pasture. Wetness is the chief management concern, and spring seeding is delayed in some years. Cultivated areas need to be protected against soil blowing. Capability unit IIw–4L; windbreak suitability group 1.

HmB—Hegne-Fargo silty clays, 3 to 6 percent slopes.

B2g—28 to 36 inches, very dark gray (5Y 3/1) clay loam, gray (5Y 5/1) dry; moderate, very fine, subangular blocky structure; very hard, very friable, very sticky and very plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1g—36 to 48 inches, olive-gray (5Y 4/2) clay loam, light olive gray (5Y 6/2) dry; many fine, prominent, black (N 2/0) and few coarse, prominent, greenish-gray (5G 5/1) mottles; massive; very hard, friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C2g—48 to 60 inches, greenish-gray (5G 5/1) stratified silt and clay loam, greenish gray (5G 6/1) and white (5Y 8/1) dry; many coarse, prominent,



Ap—0 to 5 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—5 to 12 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; moderate, medium, prismatic structure; slightly hard, very friable, sticky and plastic; neutral; gradual, wavy boundary.

B2—12 to 21 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; moderate, medium, prismatic structure parting to moderate, fine, angular blocky; very hard, very friable, sticky and plastic; moderately alkaline; gradual, wavy boundary.

C1ca—21 to 27 inches, olive-gray (5Y 5/2) loam, light gray (5Y 7/2) dry; many medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC2—27 to 48 inches, pale-yellow (5Y 7/3) clay loam, white (5Y 8/1) dry; many medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; extremely hard, very firm, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIIC3—48 to 60 inches, light olive-brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) dry; many

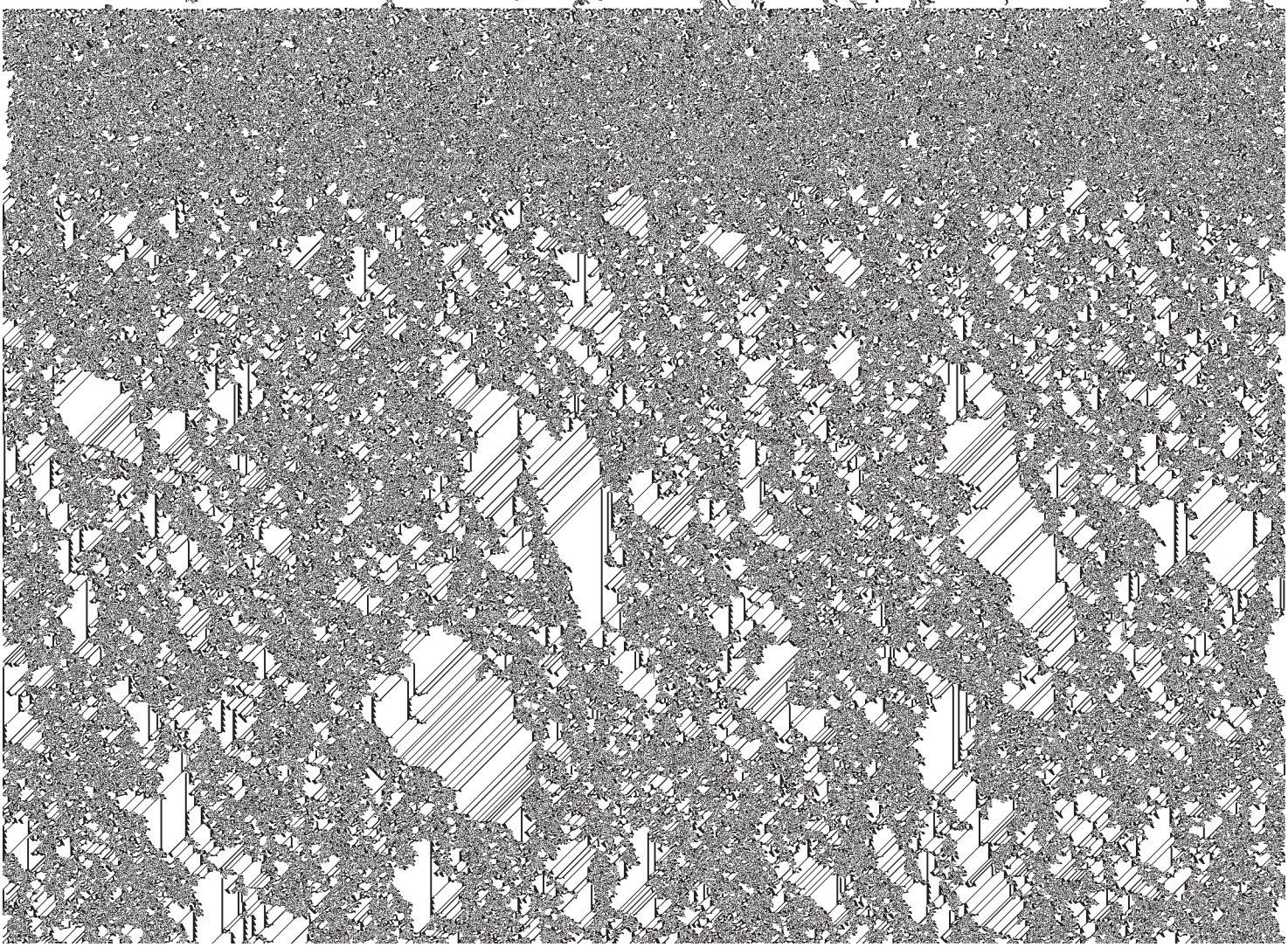
soils mapped in adjacent Walsh County as Vallers-Hamerly stony loams. These soils are in section 36, T. 159 N., R. 56 W., adjacent to the Pembina-Walsh county line. Also included is a small area of soils mapped in adjacent Walsh County as Barnes-Svea stony loams. These soils are in the southwest quarter of section 31, T. 159 N., R. 56 W., adjacent to the Pembina-Walsh county line. These soils are included with these Lankin and Gilby soils in mapping because they are of such limited extent in Pembina County.

Numerous stones and boulders limit the use of these soils to hay and pasture. Capability unit VIIs–6; windbreak suitability group 10.

La Prairie Series

The La Prairie series consists of deep, nearly level to steep, moderately well drained soils. These soils formed in recent, moderately fine textured alluvium on flood plains, terraces, alluvial fans, and slopes of abandoned stream channels.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil, about 21 inches thick, is very dark gravish-brown



loam, or clay loam. The B horizon is dark-brown, very dark grayish-brown, or very dark gray silty clay loam, silt loam, or loam 10 to 21 inches thick. This soil has one or more buried horizons or irregular vertical distribution of organic matter.

La Prairie, Fairdale, Lamoure, and Neche soils formed in recent alluvium on flood plains and terraces along streams. La Prairie soils have a thicker A horizon than Fairdale and Neche soils, and they are better drained than Lamoure soils.

LpA—La Prairie loam, 1 to 3 percent slopes. This soil is on stream terraces and alluvial fans. It has a profile similar to the one described as representative of the series, except the surface layer and subsoil are loam.

Included with this soil in mapping are a few small areas of Fairdale soils.

Runoff is slow. Flooding from stream overflow occurs, but floodwaters recede in most years in time for spring seeding.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Although the chief management concern is soil blowing, susceptibility to soil blowing is slight. Erosion must be controlled in cultivated areas. Capability unit IIc–6; windbreak suitability group 1.

LrA—La Prairie silty clay loam, 1 to 3 percent slopes. This soil is on alluvial fans and stream terraces. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Fairdale soils.

Surface runoff is slow. Flooding from stream overflow occurs, but floodwaters recede in time for spring seeding in most years.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Capability unit IIc–7; wind-

steep slopes make the soils unsuitable for cultivated crops. Capability unit VIe–6; windbreak suitability group 10.

Maddock Series

The Maddock series consists of deep, nearly level to steep, well drained soils. These soils formed in coarse-textured and lacustrine deposits on glacial lake beaches, deltas, and glacial lake plains.

In a representative profile the surface layer is loamy sand about 15 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil, about 16 inches thick, is dark grayish-brown, slightly acid loamy sand. Below this is about 17 inches of calcareous dark grayish-brown medium and fine sand underlain by calcareous, light brownish-gray, mottled sand.

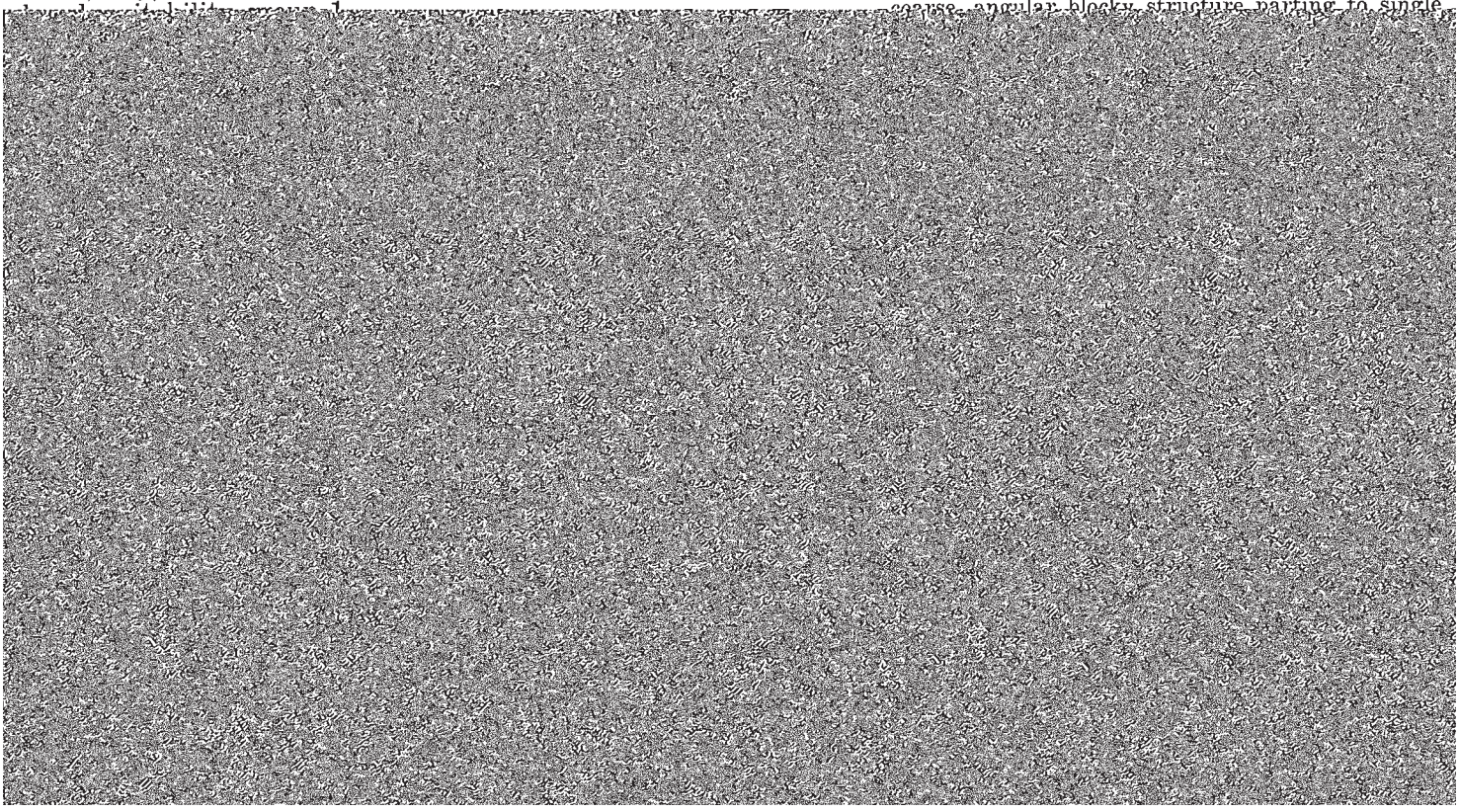
Permeability is rapid, and available water capacity is low. Organic-matter content is moderate. Natural fertility is low.

Most of the acreage of this soil is used for small grains. Some areas are used for pasture or hay; others are left in native woods and are used as wildlife habitat.

Representative profile of Maddock loamy sand, 1 to 3 percent slopes, in a cultivated field; 330 feet west and 100 feet south of the NE. corner of sec. 5, T. 160 N., R. 55 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) dry; single grained; loose, nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—8 to 15 inches, very dark grayish brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) dry; weak, coarse, angular blocky structure parting to single



lake plains. Slopes are convex. This soil has the profile described as representative of the series.

Included with this soil in mapping, and making up about 10 percent of the mapped areas, is Hecla loamy sand.

Susceptibility to soil blowing is very high. Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion needs to be controlled where these soils are cultivated. Droughtiness caused by low available water capacity is a limitation in years with extended dry periods. Capability unit IVe–2; windbreak suitability group 5.

MaB—Maddock loamy sand, 3 to 6 percent slopes. This soil is on glacial lake beaches and plains. Slopes are convex.

Susceptibility to soil blowing is very high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion needs to be controlled in cultivated areas. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IVe–2; windbreak suitability group 5.

MbA—Maddock sandy loam, 1 to 3 percent slopes. This soil is on glacial lake beaches, deltas, and plains. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for a sandy loam surface layer.

Included with this soil in mapping are Hecla soils that make up about 10 percent of this unit.

Susceptibility to soil blowing is high. Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion must be controlled where this soil is cultivated. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 5.

MbB—Maddock sandy loam, 3 to 6 percent slopes. This soil is on glacial lake beaches and deltas. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for a sandy loam surface layer. Included in mapping are a few areas of steeper soils.

Susceptibility to soil blowing is high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management

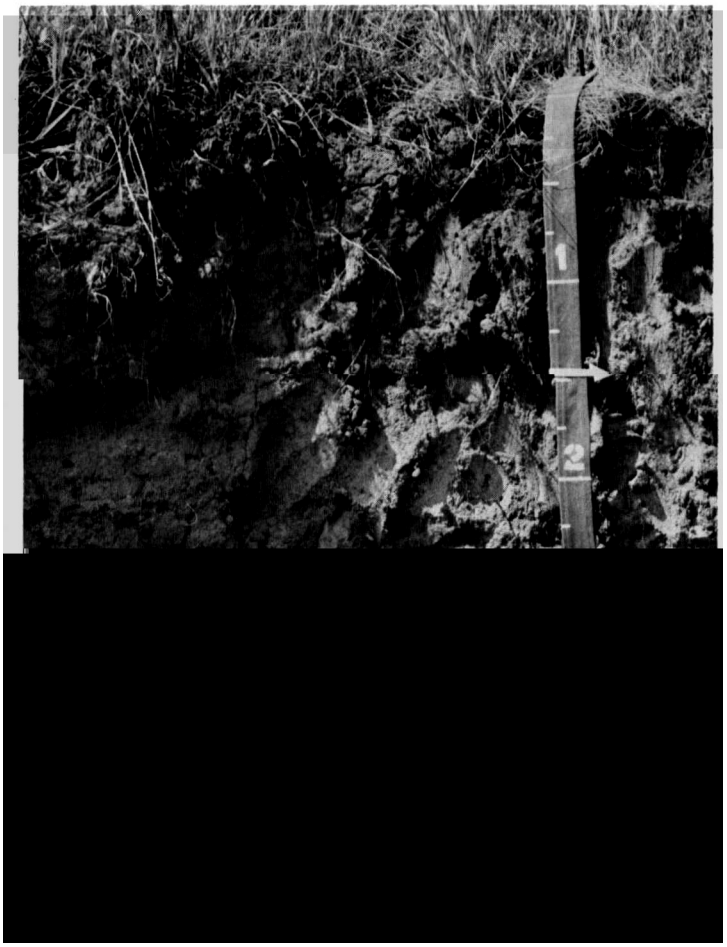
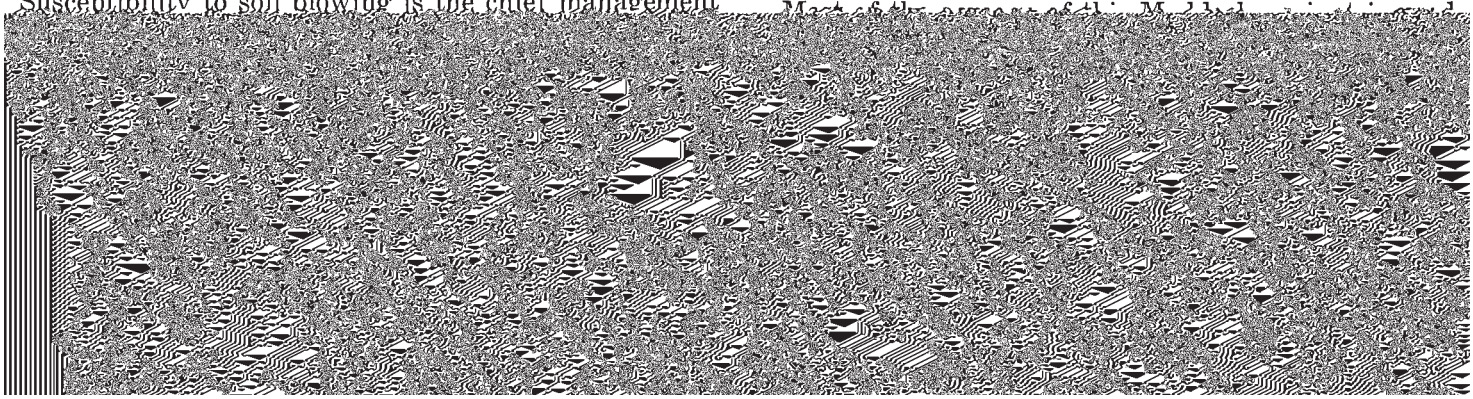


Figure 9.—**Profile of Maddock loamy sand, thin surface variant, 1 to 6 percent slopes. The dark layer in the lower part of the profile is cemented.**

is loamy sand about 9 inches thick. It is very dark gray and black and mostly strongly acid in the upper part and very dark grayish brown and slightly acid in the lower part. The next layer, about 27 inches thick, is dark grayish brown, neutral sand. Below this is about 12 inches of brown, mottled, slightly acid sand. This layer is underlain by dark yellowish-brown, mottled slightly acid sand.

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



nonsticky and nonplastic; strongly acid; gradual, smooth boundary.

A13—5 to 9 inches, very dark grayish-brown (10YR 3/2) loamy sand, light brownish gray (10YR 6/2) dry; single grained; loose, nonsticky and nonplastic; slightly acid; abrupt, smooth boundary.

C1—9 to 24 inches, dark grayish-brown (10YR 4/2) sand, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

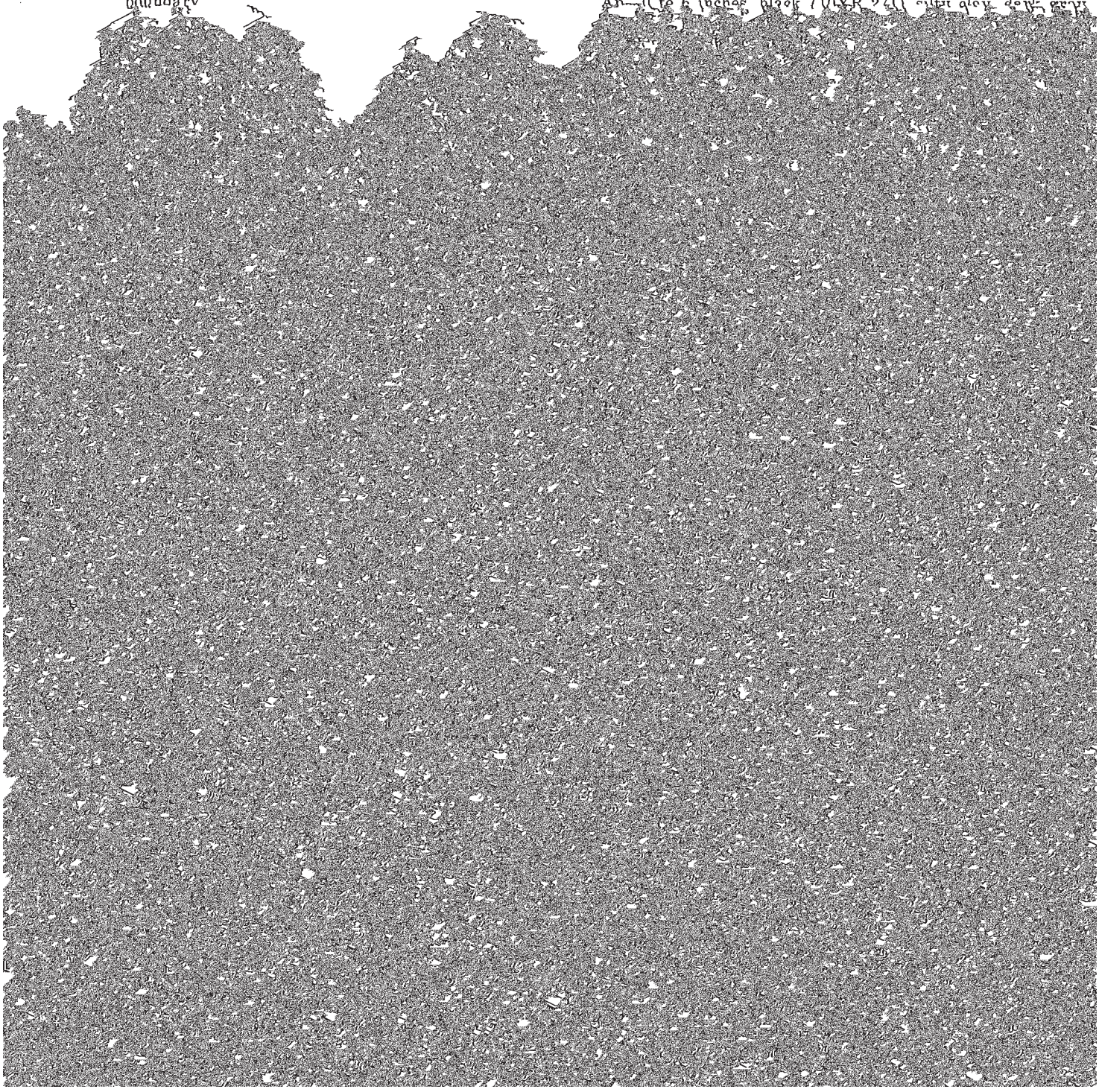
C2—24 to 36 inches, dark grayish-brown (10YR 4/2) sand, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary

Permeability is slow in the upper part and rapid in the underlying sandy horizons. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of McDonaldsville soils is used for small grains. Sugar beets are grown in some areas.

Representative profile of McDonaldsville silty clay that has 0 to 1 percent slopes, in a cultivated field; 300 feet south and 250 feet east of the NW. corner of the SW. quarter of sec. 36, T. 161 N., R. 56 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay, dark gray



and pasture. Wetness is the chief management concern. It delays spring seeding during wet years. Cultivated soils need to be protected against soil blowing. Capability unit IIw–4; windbreak suitability group 2.

Nahon Series

The Nahon series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in fine-textured deposits in depressions on flood plains of intermittent streams that cross the glacial lake plains.

In a representative profile the surface layer, about 8 inches thick, is black silt loam. The subsurface layer is very dark gray silt loam about 6 inches thick. The subsoil is black silty clay about 12 inches thick. The underlying material is calcareous silty clay. It is olive gray in the upper 10 inches and olive below.

Permeability is very slow, and available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Nahon soils is used for small grains and potatoes, but some is used for pasture and sunflowers.

Representative profile of Nahon silt loam that has 0 to 1 percent slopes, in a pasture; 210 feet south and 45 feet west of the NE. corner of sec. 11, T. 163 N., R. 56 W.

A1—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak, fine, subangular blocky structure; hard, very friable, sticky and plastic; moderately alkaline; clear, smooth boundary.

A2—8 to 14 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, thin, platy structure; slightly hard, very friable, sticky and plastic; moderately alkaline; gradual, smooth boundary.

B2t—14 to 26 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; strong, coarse, columnar structure; very hard, firm, very sticky and very plastic; moderately alkaline; gradual, wavy boundary.

C1cs—26 to 45 inches, olive-gray (5Y 5/2) silty clay, light

Susceptibility to soil blowing is moderately high. In places runoff does not occur, and the surface becomes ponded; in other places it ranges to slow. This soil is high in content of magnesium and sodium salts that contribute to the formation of a claypan. Permeability is very slow. A seasonal water table is within 3 to 5 feet of the surface.

This soil is suited to small grains, hay, and pasture. Wetness, very slow permeability, and droughtiness caused by a shallow root zone are the chief management concerns. Cultivated areas need to be protected against soil blowing. Capability unit IVs–4; windbreak suitability group 9.

Neche Series

The Neche series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in moderately fine textured, recent deposits on stream terraces and alluvial fans.

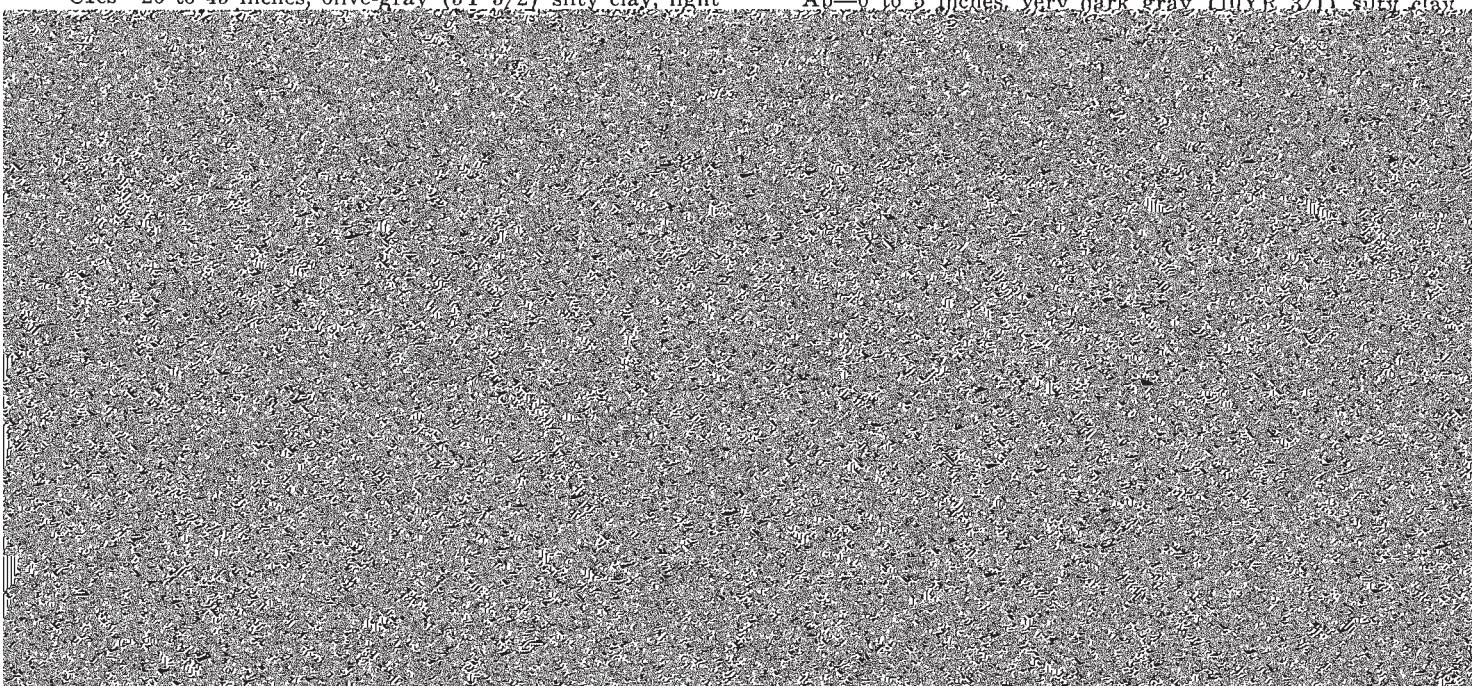
In a representative profile the surface layer is very dark gray silty clay loam about 10 inches thick. Below it is about 5 inches of very dark grayish-brown clay loam; 8 inches of dark grayish-brown, mottled silty clay loam; 10 inches of black clay loam; 9 inches of calcareous, dark grayish-brown silty clay loam; and 11 inches of calcareous, very dark brown silt loam underlain by calcareous, dark grayish brown, mottled loam.

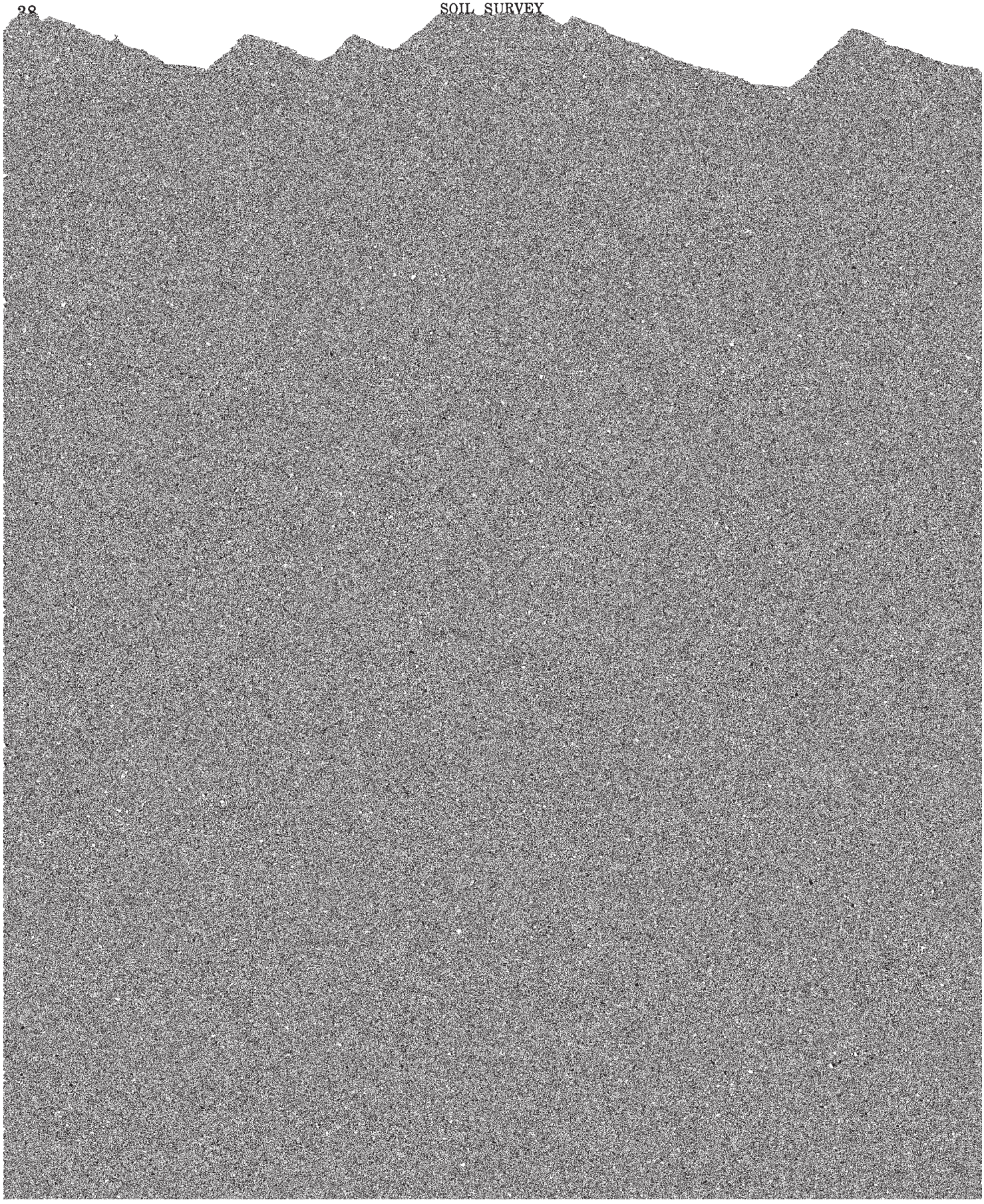
Permeability is moderately slow, and available water capacity is high. Organic-matter content is moderate. Natural fertility is high.

Most of the acreage of this soil is used for small grains and sugar beets. Potatoes, pinto beans, and hay are grown in places.

Representative profile of Neche silty clay loam that has 0 to 1 percent slopes, in a cultivated field; 486 feet north and 90 feet west of the SE. corner of the NE. quarter of sec. 34, T. 162 N., R. 54 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay





residuum from clayey shale. They are on glacial till plains and escarpments and slopes along streams.

In a representative profile there is a 1–inch layer of organic matter on the surface. The surface layer is slightly acid, black silty clay loam about 3 inches thick. The subsurface layer, about 7 inches thick, is medium acid, very dark brown silty clay loam. The subsoil is silty clay about 32 inches thick. It is very dark grayish brown and medium acid in the upper 9 inches, dark grayish brown and strongly acid in the next 12 inches, and olive brown and strongly acid in the lower part. The underlying material is dark grayish brown silty clay.

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

About half of the acreage of this soil is used for small grains. The rest is used for wooded pasture or left for wildlife.

Representative profile of Olga silty clay loam, 9 to 25 percent slopes, in wooded pasture; 540 feet west and 160 feet north of the SE. corner of the SW. quarter of sec. 31, T. 161 N., R. 56 W.

O1—1 inch to 0, partly decomposed organic matter consisting of tree leaves and matted grass and roots.

A1—0 to 3 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) and gray (10YR 5/1) dry; strong, fine, subangular blocky structure parting to moderate, fine, granular; very hard, friable, sticky and plastic; slightly acid; clear, smooth boundary.

A2—3 to 10 inches, very dark brown (10YR 2/2) crushed

similar to the one described as representative of the series, but it is shallower to silty clay sediment.

Included with this soil in mapping are a few small areas of soils with slopes of 6 to 9 percent and a few areas of soils that are moderately eroded. Also included are a few areas of soils with slopes of less than 3 percent.

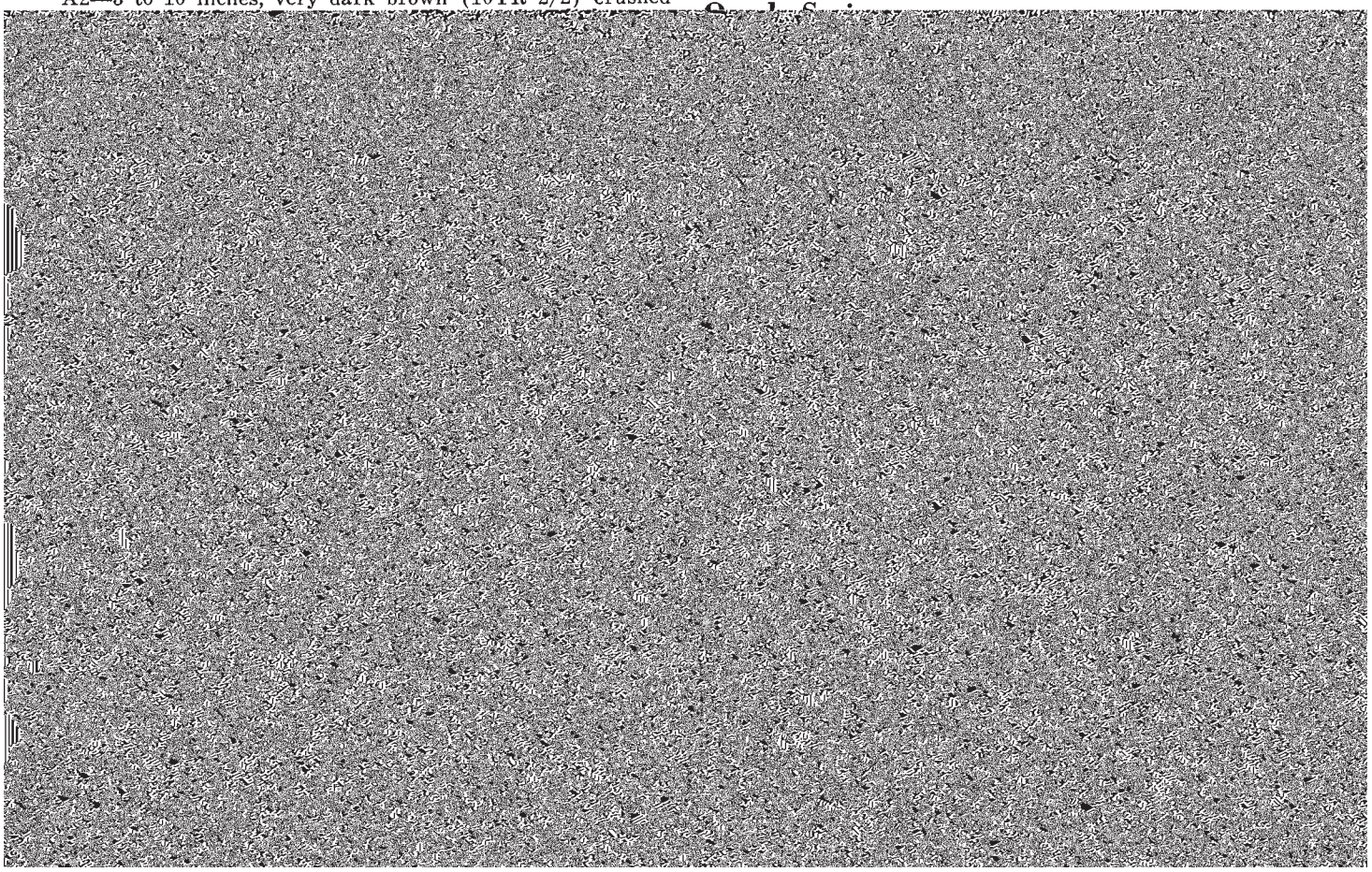
Susceptibility to soil blowing is moderately high. Runoff is medium, and susceptibility to water erosion is moderate.

This soil is suited to small grains, alfalfa, hay, and pasture. The chief management concerns are susceptibility to soil blowing and water erosion. Erosion needs to be controlled in cultivated areas. Capability unit IIIe–4; windbreak suitability group 4.

OgE—Olga silty clay loam, 9 to 25 percent slopes. This soil is on escarpments and side slopes along streams. It has the profile described as representative of the series. Most slopes are 15 percent or greater. Included in mapping are a few areas where slopes are 25 to 50 percent.

Susceptibility to soil blowing is moderately high. Runoff is very rapid, and susceptibility to water erosion is extreme.

This soil is suited to pasture and wildlife habitat. Because this soil is moderately steep and steep and susceptible to water erosion, it is unsuitable for cultivated crops. Capability unit VIe–4; windbreak suitability group 10.



B3—22 to 26 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; moderate, fine, prismatic structure; very hard, friable, sticky and very plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1ca—26 to 36 inches, light brownish gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) dry; many fine, distinct, brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; very hard, friable, sticky and very plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

Perella Series

The Perella series consists of deep, nearly level, poorly drained soils. These soils formed in medium-textured and moderately fine textured deposits in deep depressions on the glacial lake plains.

In a representative profile the surface layer is silty clay loam about 14 inches thick. It is black in the upper 9 inches and very dark gray and mottled in the lower 5 inches. The subsoil is silty clay loam [illegible]

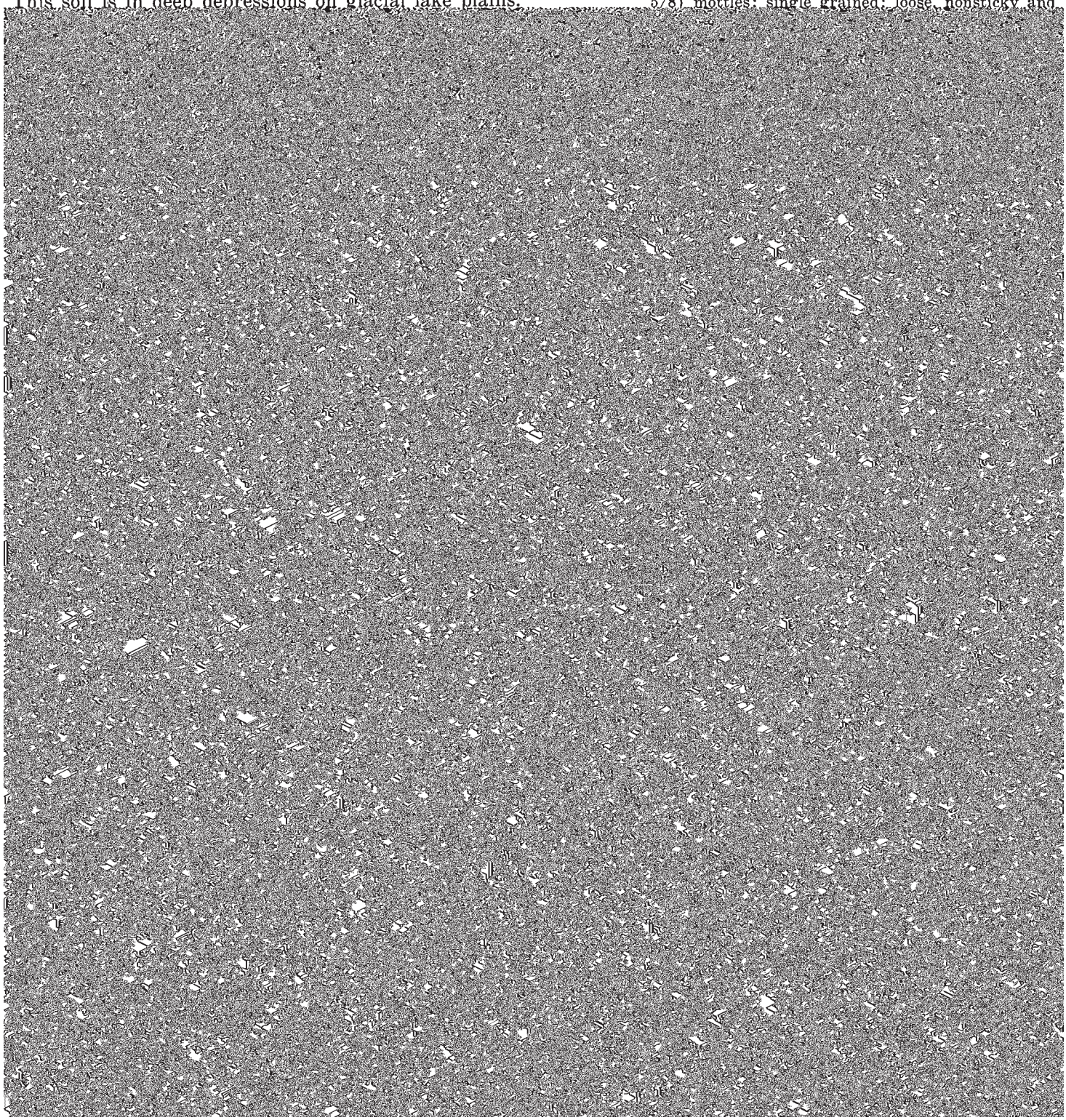
or silty clay loam. The Cg horizon is silt, silt loam, or silty clay loam.

Perella, Bearden, Colvin, Dovray, and Fargo soils formed in similar parent material on glacial lake plains. Perella soils have less clay throughout than Fargo and Dovray soils and lack the high lime content near the surface that is characteristic of Colvin and Bearden soils.

Pu—Perella silty clay loam (0 to 1 percent slopes). This soil is in deep depressions on glacial lake plains.

C1g—35 to 48 inches, grayish-brown (2.5Y 5/2) fine sand and sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; single grained; loose, nonsticky and nonplastic; many small manganese concretions; slightly acid; gradual, wavy boundary.

C2g—48 to 60 inches, light brownish gray (2.5Y 6/2) fine sand and sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; single grained; loose, nonsticky and



effervescence; moderately alkaline; gradual, smooth boundary.

A12g—7 to 13 inches, black (10YR 2/1) silty clay loam, gray (N 5/0) dry; many medium, faint, gray (5Y 5/1) and many fine, faint, dark reddish-brown (5YR 3/3) mottles; weak, medium, angular blocky structure; very hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, smooth boundary.

A13g—13 to 19 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (N 4/0) dry; many fine, faint, dark reddish-brown (5YR 3/2) mottles; weak, fine, angular blocky structure; hard, friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

A14g—19 to 28 inches, very dark gray (2.5Y 3/1) silty clay loam, gray (N 5/0) dry; many fine, faint, dark-brown (10YR 3/3) mottles; weak, fine, angular blocky structure; very hard, friable, sticky

Representative profile of Renshaw loam, 1 to 3 percent slopes, in native grass; 2,240 feet east and 1,305 feet north of the SW. corner of sec. 20, T. 159 N., R. 56 W.

A1—0 to 7 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; about 5 percent coarse sand and gravel; mildly alkaline; clear, smooth boundary.

B2—7 to 16 inches, very dark brown (10YR 2/2) gravelly loam, grayish brown (10YR 5/2) dry; strong, coarse, prismatic structure; hard, very friable, sticky and plastic; mildly alkaline; gradual, wavy boundary.

IIC1—16 to 27 inches, dark grayish-brown (2.5Y 4/2) very gravelly sand, light brownish gray (2.5Y 6/2) dry; single grained; loose, nonsticky and

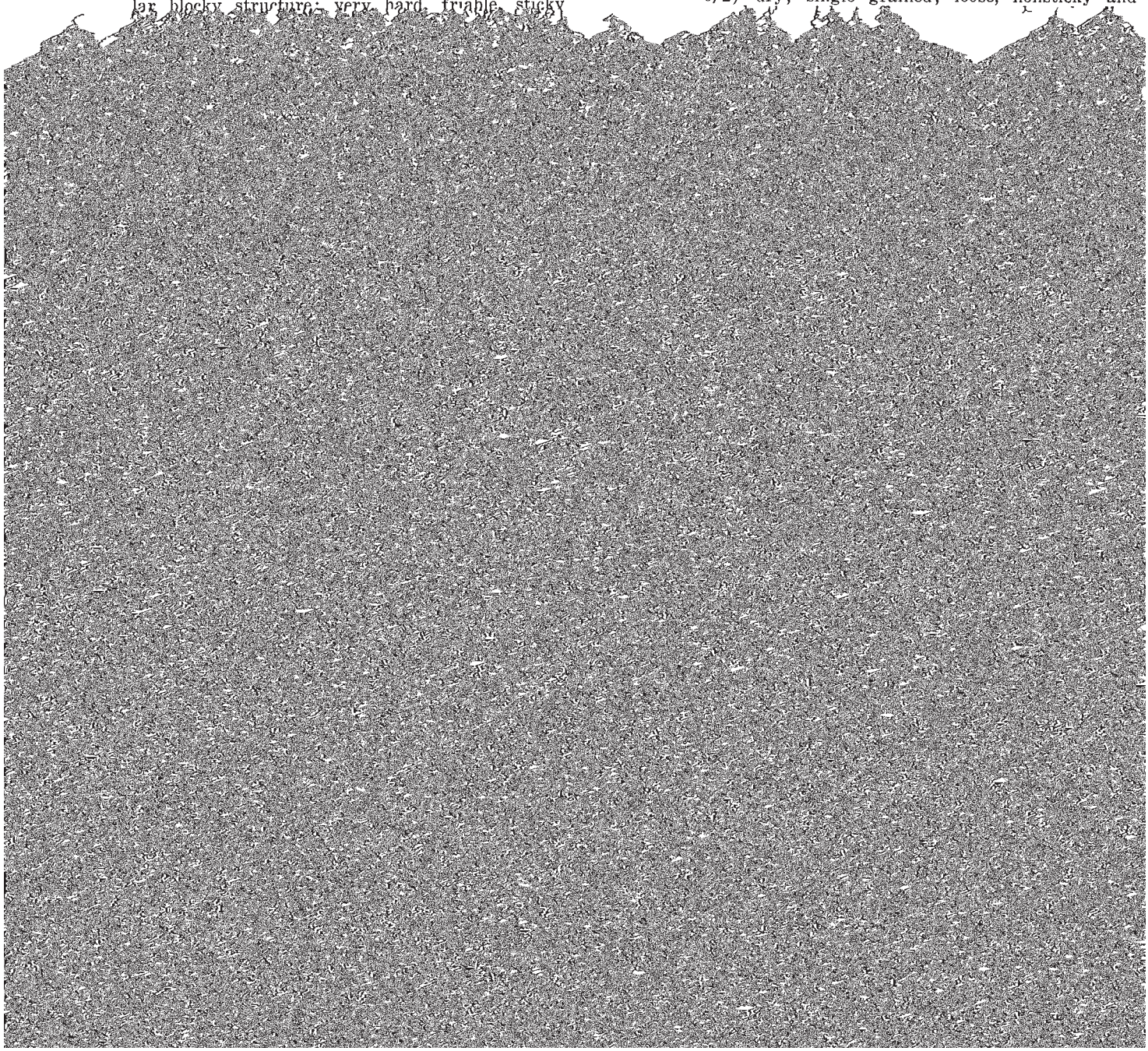


Figure 10.—**Profile of Renshaw loam, 1 to 3 percent slopes. This soil consists of about 15 inches of loam underlain by sand and gravel.**

The underlying material is calcareous, olive, mottled silty clay.

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

Most of the acreage of Rolette soils is used for small grains, but some areas are in native woods.

Representative profile of Rolette silty clay loam, 1 to 3 percent slopes, in native woods; 90 feet east and 60 feet north of the SW. corner of the NW. quarter of sec. 18, T. 161 N., R. 56 W.

O1—2 inches to 0, very dark brown (10YR 2/2) partly decomposed organic matter, mostly tree and shrub leaves; many roots, very friable; abrupt, smooth boundary.

A1—0 to 6 inches, black (10YR 2/1) silty clay loam, dark gray and gray (10YR 4/1 and 5/1) dry; weak, fine, subangular blocky structure parting to moderate, very fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

A2—6 to 15 inches, very dark gray (10YR 3/1) clay loam, faces of some peds coated with gray (10YR 6/1) bleached sand and silt, dark gray and gray (10YR 4/1 and 5/1) dry; weak, fine, subangular blocky structure parting to strong, fine, granular; very hard, very friable, sticky and plastic; neutral; gradual, smooth boundary.

A&B—15 to 18 inches, very dark gray (10YR 3/1) clay loam with dark grayish brown (10YR 4/2) coatings on peds, gray (10YR 5/1) dry; strong, fine and very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; neutral; gradual, wavy boundary.

B21t—18 to 22 inches, dark grayish brown (2.5Y 4/2) silty clay, faces of peds coated with thin, black (10YR 2/1) clay films; light brownish gray (2.5Y 6/2) and light gray (2.5Y 7/2) dry; moderate, medium and fine, prismatic structure parting to strong, fine, subangular blocky; extremely hard, very firm, very sticky and very plastic; neutral; gradual, smooth boundary.

B22t—22 to 38 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; strong, medium and fine, prismatic structure parting to strong, coarse and medium, subangular blocky; extremely hard, very firm, very sticky and very plastic; thin clay films on faces of peds; neutral; gradual, wavy boundary.

C—38 to 60 inches, olive (5Y 4/3) silty clay; light olive gray (5Y 6/2) dry; many fine, distinct, strong-brown (7.5YR 5/8) and many fine, faint, olive (5Y 5/3) mottles; moderate, medium, angular blocky structure; extremely hard, very firm, very sticky and very plastic; soft shale particles in the lower part; slight effervescence; mildly alkaline.

The A1 horizon is black or very dark gray silty clay loam, clay loam, or silty clay 5 to 12 inches thick. The A2 horizon is very dark gray or dark-gray silty clay loam or clay loam 2 to 10 inches thick. The A&B horizon is very dark gray or dark-gray silty clay loam or clay loam 2 to 5 inches thick. The B2t horizon is very dark gray, very dark grayish-brown, dark grayish-brown, dark-brown, dark-gray, dark olive-gray, olive-gray, or olive silty clay or clay. Depth to carbonates ranges from 20 to more than 60 inches.

Rolette and Olga soils formed in similar material, but Rolette soils are not so well drained. Rolette and Walsh soils have similar profiles, but Rolette soils have more clay in the B horizon and lack a IIC horizon of sand and gravel.

RoA—Rolette silty clay loam, 1 to 3 percent slopes. This soil is on the glacial lake plains. Slopes are convex, and relief is low.

Included with this soil in mapping are a few areas of Vang and Olga soils.

Susceptibility to soil blowing is moderately high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Capability unit IIe–4; windbreak suitability group 4.

Rough Broken Land

Rp—Rough broken land (15 to 50 percent slopes). This land type occupies steep and very steep land ad-

jacent to the Pembina River. It is dissected by numerous intermittent streams, and geologic erosion is visibly active (fig. 11). The soil material on this land type generally consists of about 4 inches of loam underlain by shaly gravel and sandsized shale particles.

Runoff is very rapid, and available water capacity is very low.

This land type is mostly in native woods left for wildlife habitat. Because it is steep and very steep, it is unsuitable for cultivated crops. Capability unit VIIe–3; windbreak suitability group 10.

Ryan Series

The Ryan series consists of deep, nearly level, poorly drained soils that have a claypan. These soils formed in fine-textured sediment on the glacial lake plains.

In a representative profile the surface layer is black silty clay about 4 inches thick. The subsoil, about 32 inches thick, is dark olive-gray clay in the upper 11 inches and calcareous, black and dark olive-gray silty clay in the next 21 inches. The next layer is calcareous, dark olive-gray silty clay about 6 inches thick. Below this is about 12 inches of calcareous, olive-gray clay underlain by calcareous, olive-gray and olive, mottled clay.

Permeability is very slow, and available water capacity is moderate. Organic-matter content is high. Natural fertility is low.

Most of the acreage of Ryan soils is used for small grains.

Representative profile of Ryan silty clay in an area of Ryan-Fargo silty clays that have 0 to 1 percent slopes, in a cultivated field; 1,450 feet west and 165 feet north of the SE. corner of sec. 30, T. 164 N., R. 52 W.

Ap—0 to 4 inches, black (10YR 2/1) silty clay, gray (N 5/0) dry; strong, coarse, prismatic structure parting to strong, medium, angular blocky; extremely hard, very firm, sticky and very plastic, moderately alkaline; abrupt, smooth boundary.

B2t—4 to 15 inches, dark olive-gray (5Y 3/2) clay, dark gray (5Y 4/1) dry; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; clear, smooth boundary.

B31—15 to 20 inches, black (5Y 2/1) and dark olive-gray (5Y 3/2) silty clay, dark gray (N 4/0 and 5Y 4/1) dry; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate

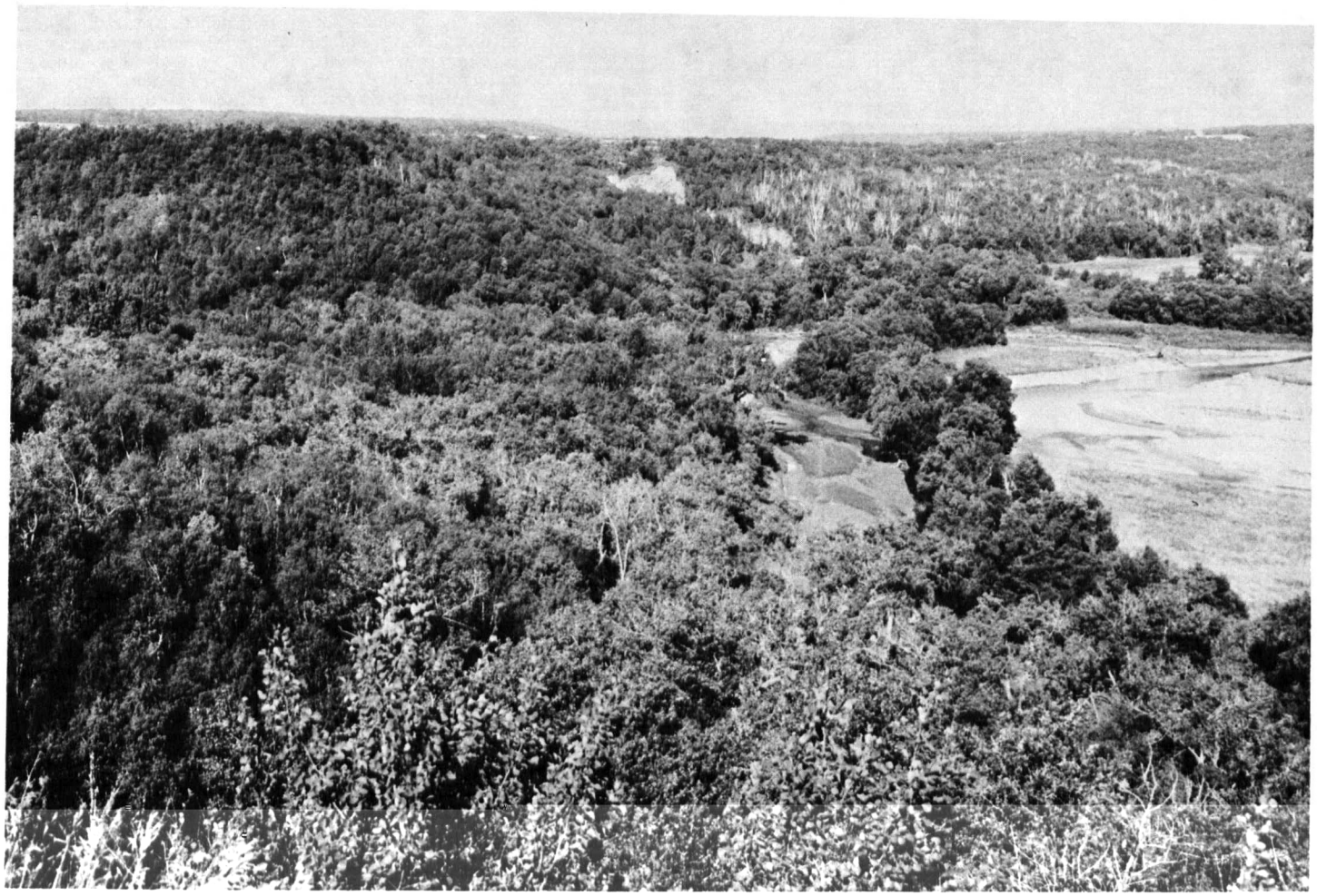


Figure 11.—**Bare areas on side slopes of Rough broken land are caused by recent landslides. Landslides are common even though the area is protected by native vegetation.**

crystals; slight effervescence; moderately alkaline; clear, smooth boundary.

B32—20 to 36 inches, black (5Y 2/2) and dark olive-gray (5Y 3/2) silty clay, dark gray (5Y 4/1) dry; moderate, medium, subangular blocky structure; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate crystals; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1g—36 to 42 inches, dark olive-gray (5Y 3/2) silty clay, dark gray (5Y 4/1) dry; massive; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate crystals; slight effervescence; moderately alkaline; gradual, wavy boundary.

C2g—42 to 54 inches, olive-gray (5Y 4/2) clay, light gray (5Y 6/1) and olive gray (5Y 5/2) dry; massive; extremely hard, very firm, sticky and very plastic; a few small lime masses; many large nests of calcium sulfate crystals; strong effervescence; moderately alkaline; gradual, wavy boundary.

C3g—54 to 60 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay, light gray (5Y 7/2) dry; few fine, distinct dark yellowish-brown (10YR 4/4) mot-

formed in coarse-textured deposits on stabilized sand dunes.

In a representative profile the surface layer is slightly acid, very dark brown sand about 2 inches thick. The underlying material is slightly acid, dark yellowish-brown sand.

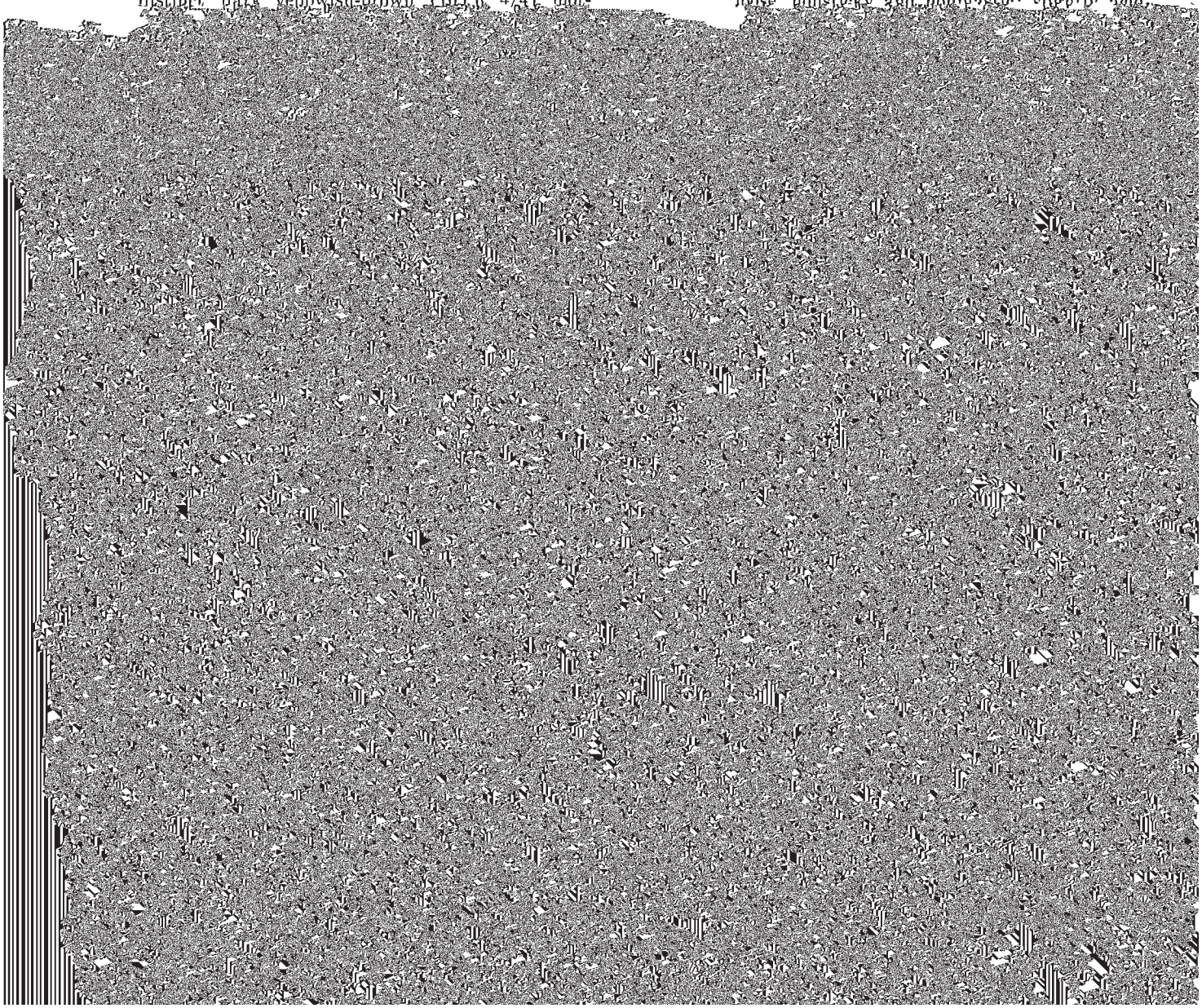
Permeability is rapid. Available water capacity, organic-matter content, and natural fertility are low.

Most of the acreage of Serden soils is used for wildlife habitat, but some is used for pasture.

Representative profile of Serden sand, 6 to 15 percent slopes, in native grass; 530 feet north and 80 feet west of the SE. corner of sec. 22, T. 161 N., R. 55 W.

A1—0 to 2 inches, very dark brown (10YR 2/2) sand, very dark grayish brown (10YR 3/2) dry; single grained, loose, nonsticky and nonplastic; slightly acid; abrupt, smooth boundary.

C—2 to 60 inches, dark yellowish-brown (10YR 3/4) sand, yellowish brown (10YR 5/4) dry; single grained; loose, nonsticky and nonplastic; slightly acid.



west and 75 feet south of the NE. corner of sec. 6, T. 160 N., R. 55 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, very friable, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

B21—10 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam, gray (10YR 5/1) dry; weak, coarse textured deposits in shallow depressions on glacial lake plains.

In a representative profile the surface layer is slightly acid, black fine sandy loam about 13 inches thick. The next layer, about 13 inches thick, is dark grayish brown, mottled fine sandy loam. Below this is calcareous light brownish gray, mottled fine sandy loam about 9 inches thick. The next layer is about 15 inches of cal-

Susceptibility to soil blowing is high. Runoff is very slow. The water table is within 1 to 3 feet of the surface.

This soil is suited to small grains, hay, and pasture. Wetness and susceptibility to soil blowing are the chief management concerns. Erosion needs to be controlled where this soil is cultivated. Capability unit IIIw–3; windbreak suitability group 2.

Vang Series

The Vang series consists of nearly level to gently sloping, well-drained soils that are moderately deep over sand and gravel. These soils formed on glacial lake beaches and deltas in medium-textured alluvium underlain by shaly gravel and sand-sized shale particles.

In a representative profile the surface layer is black loam about 18 inches thick. The subsoil, about 8 inches thick, is very dark gray loam. The underlying material is very dark gray shaly gravel and coarse sand-sized shale particles.

Permeability is moderate in the upper part of these soils and rapid in the underlying gravel layers. Available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Vang soils is used for small grains, but some areas are used for hay and pasture.

VbA—Vang clay loam, 1 to 3 percent slopes. This soil has convex slopes on glacial alluvial fans and deltas. It has a profile similar to the one described as representative of the series, except it has a clay loam surface layer and a gravelly clay loam subsoil.

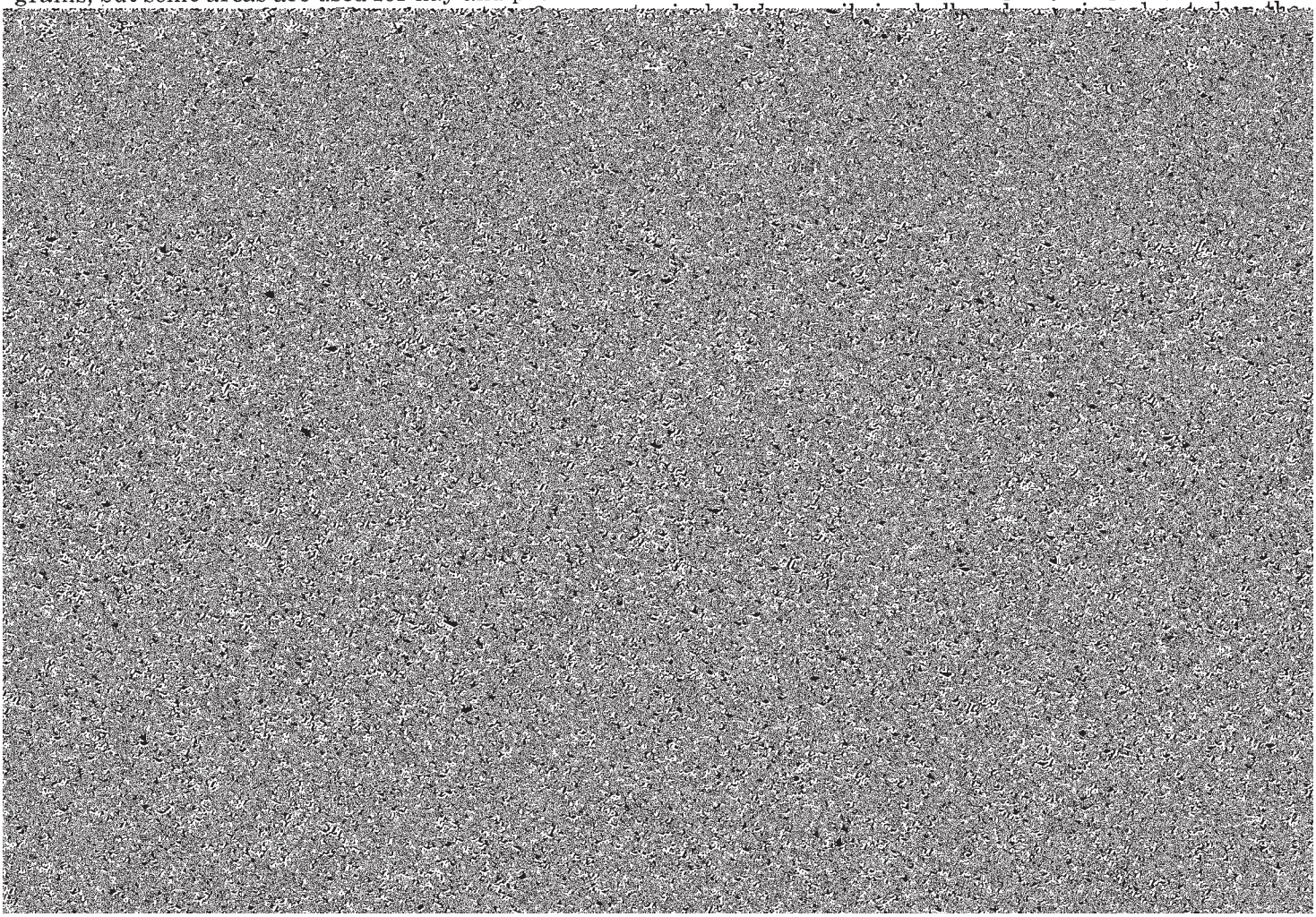
Included with this soil in mapping are soils in a few shallow depressions denoted on the soil map by a spot symbol.

Susceptibility to soil blowing is slight. Runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concern is droughtiness caused by the moderately deep root zone and moderate available water capacity. Erosion must be controlled in cultivated areas. Capability unit IIs–6; windbreak suitability group 3.

VwA—Vang-Walsh loams, 1 to 3 percent slopes. These soils are on glacial deltas. Slopes are convex and concave. The Vang soils have a profile similar to the one described as representative of the Vang series, except they contain more coarse sand and fine gravel. They make up about 65 percent of the mapped areas. The Walsh soils have the profile described as representative of the Walsh series. They make up about 35 percent of the mapped areas.

Included with these soils in mapping are small eroded areas denoted on the soil maps by a spot symbol. Also



Vang Variant

The Vang variant soils are deep, nearly level, and poorly drained. They are moderately deep over sand and gravel. These soils formed on glacial deltas in medium-textured and moderately fine textured deposits underlain by shaly gravel and sand-sized shale particles.

In a representative profile the surface layer is very dark gray loam about 12 inches thick. The subsoil is very dark brown, calcareous clay loam about 8 inches thick. Below this is about 10 inches of very dark grayish-brown, mottled, calcareous sandy clay loam. The next layer is dark grayish-brown, mottled coarse sandy loam about 5 inches thick. It is underlain by olive, mottled sand and gravel that is calcareous in the upper 8 inches.

Permeability is moderate in the upper part and rapid in the underlying layers of sand and gravel. Available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of this soil is used for small grains and pasture.

Representative profile of Vang loam, wet variant, that has 0 to 1 percent slopes, in a cultivated field; 240 feet east and 155 feet north of the SW. corner of the SE. quarter of sec. 17, T. 161 N., R. 56 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; abrupt, smooth boundary.

A12—6 to 12 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak, fine, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

B2—12 to 20 inches, very dark brown (10YR 2/2) clay loam, grayish brown (10YR 5/2) dry; moderate, medium, subangular blocky structure; very hard, friable, sticky and slightly plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1—20 to 30 inches, very dark grayish-brown (10YR 3/2) sandy clay loam, pale olive (5Y 6/3) and gray (10YR 6/1) dry; light olive-brown (2.5Y 5/6) and black (10YR 2/1) streaks; weak, fine, angular blocky structure; hard, very friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

IIC2—30 to 35 inches, dark grayish-brown (2.5Y 4/2) coarse sandy loam, light olive gray (5Y 6/2) dry; many fine, faint, olive (5Y 5/4) mottles; single grained; loose, slightly sticky and slightly plastic; moderately alkaline; gradual, wavy boundary.

IIC3—35 to 43 inches, olive (5Y 4/3) gravel and sand-sized shale particles, pale olive (5Y 6/3) dry; of granitic sand and gravel are present in the IIC horizon in places.

Vang variant and Vang soils formed in similar material and have similar profiles, but Vang variant soils are not so well drained. Vang variant soils are similar to Hamar soils in drainage, but they have a B horizon of clay loam, a IIC3 horizon of gravel and sand-sized shale particles, and a IIC4g horizon of sand-sized particles.

Vy—Vang loam, wet variant (0 to 1 percent slopes). This soil is on glacial outwash plains. Slopes are concave and convex.

Susceptibility to soil blowing is slight. Runoff is very slow, and the water table is at or near the surface during wet periods.

This soil is suited to hay and pasture. Wetness is the chief management concern; it delays spring seeding in most years. Small grains can be grown if drainage is improved. Cultivated soils must be protected against soil blowing. Capability unit IIIw–6; windbreak suitability group 2.

Wahpeton Series

The Wahpeton series consists of deep, nearly level to sloping, moderately well drained soils. These soils formed in fine-textured, recent alluvium on terraces and natural levees of major streams and rivers.

In a representative profile the surface layer is silty clay about 33 inches thick. It is black in the upper 11 inches and very dark gray in the lower 22 inches. Below this is about 7 inches of dark olive-gray and olive-gray, mottled silty clay. The next layer is calcareous silty clay loam, about 9 inches thick, that is mottled gray, white, yellowish brown, and dark reddish brown in the upper part and gray and mottled in the lower part. Below this is about 5 inches of dark-gray and gray, mottled calcareous silty clay. It is underlain by dark olive-gray, mottled calcareous silty clay.

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

Most of the acreage of Wahpeton soils is used for small grains and sugar beets.

Representative profile of Wahpeton silty clay, 1 to 3 percent slopes, in a cultivated field; 960 feet south and 160 feet west of the NE. corner of sec. 2, T. 163 N., R. 53 W.

Ap—0 to 4 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry, weak, fine, granular structure; extremely hard, firm, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—4 to 11 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; strong, [illegible]

(5Y 6/1) and white (N 8/0) dry; moderate, fine, angular blocky structure; extremely hard, firm, sticky and plastic; few small lime masses; strong effervescence; moderately alkaline; clear, smooth boundary.

C2 45 to 49 inches, [illegible]

material, but Wahpeton soils are better drained and have a thicker A horizon.

WaA—Wahpeton silty clay, 1 to 3 percent slopes. This soil is on stream terraces and flood plains of major

Flooding occurs from stream overflow, but floodwaters recede in time for spring seeding in most years. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled in cultivated areas. Capability unit IIe–4; windbreak suitability group 1.

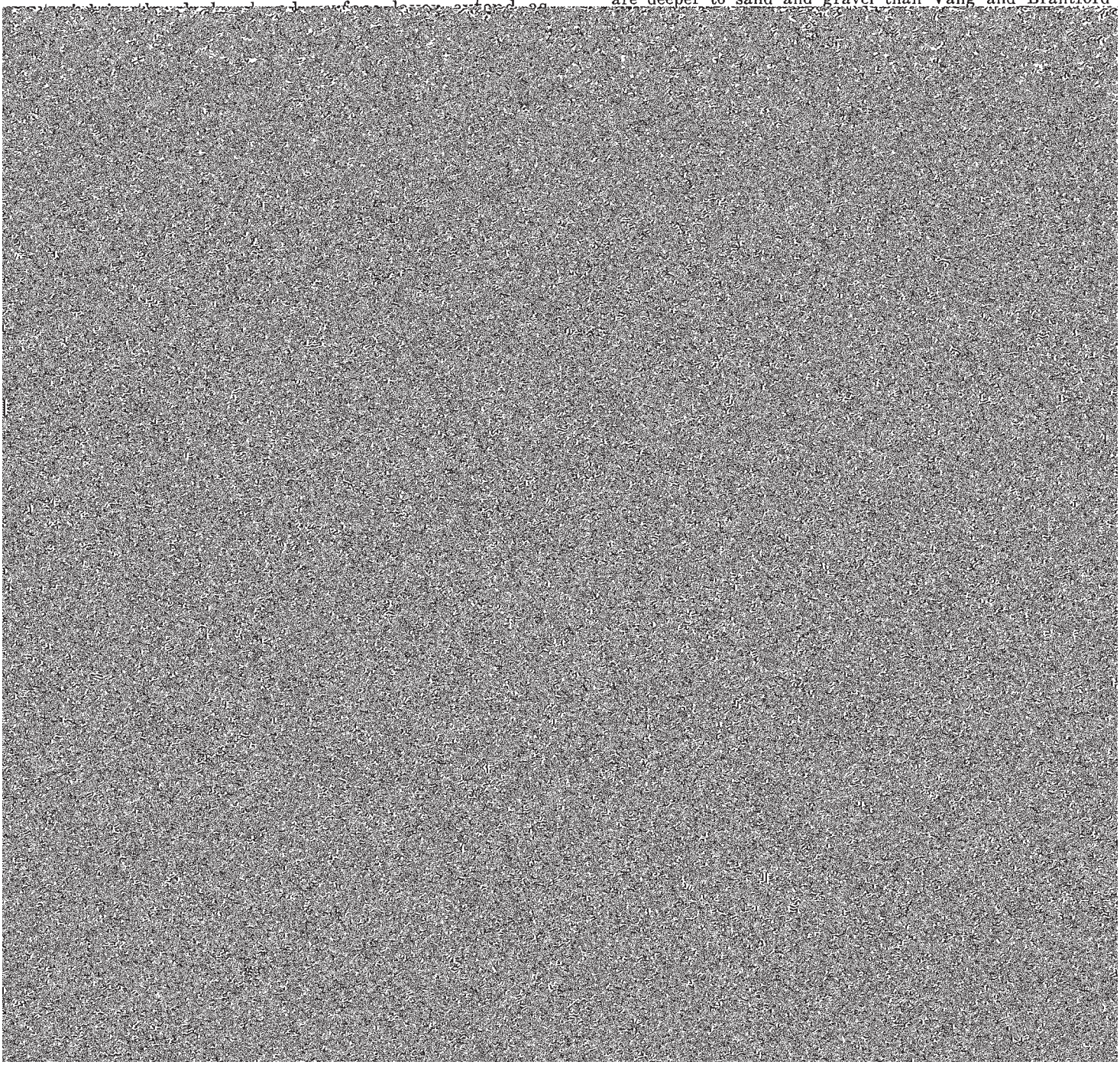
WaC—Wahpeton silty clay, 6 to 9 percent slopes. This soil is on stream terraces and along narrow side slopes adjacent to streams. The profile of this soil differs from the one described as representative of the series in that it has a thinner surface layer and calcareous material closer to the surface. Tongues of the

medium, prismatic structure; hard, very friable, very sticky and very plastic; medium acid; gradual, wavy boundary.

IIC2—44 to 60 inches, olive-gray (5Y 4/2), coarse, sand-sized shale particles, light gray (5Y 7/2) dry; single grained; loose, nonsticky and nonplastic; slightly acid.

The A horizon is loam, silt loam, clay loam, or silty clay loam 8 to 10 inches thick. The B horizon is very dark grayish-brown or very dark brown clay loam, silt loam, or loam. It is 12 to 24 inches thick. Depth to the IIC horizon ranges from 40 to more than 60 inches. In places the lower part of the IIC horizon is calcareous.

Walsh, Brantford, and Vang soils all have IIC horizons of shaly gravel and sand-sized shale particles. Walsh soils are deeper to sand and gravel than Vang and Brantford



Waukon Series

The Waukon series consists of deep, nearly level to moderately steep, well-drained soils. These soils formed in moderately fine textured glacial till on glacial till plains.

In a representative profile a thin layer of partly decomposed organic matter about 2 inches thick is on the surface. The surface layer is very dark gray loam about

O1—2 inches to 0, black (10YR 2/1) organic material, very dark gray (10YR 3/1) dry; abrupt, smooth boundary.

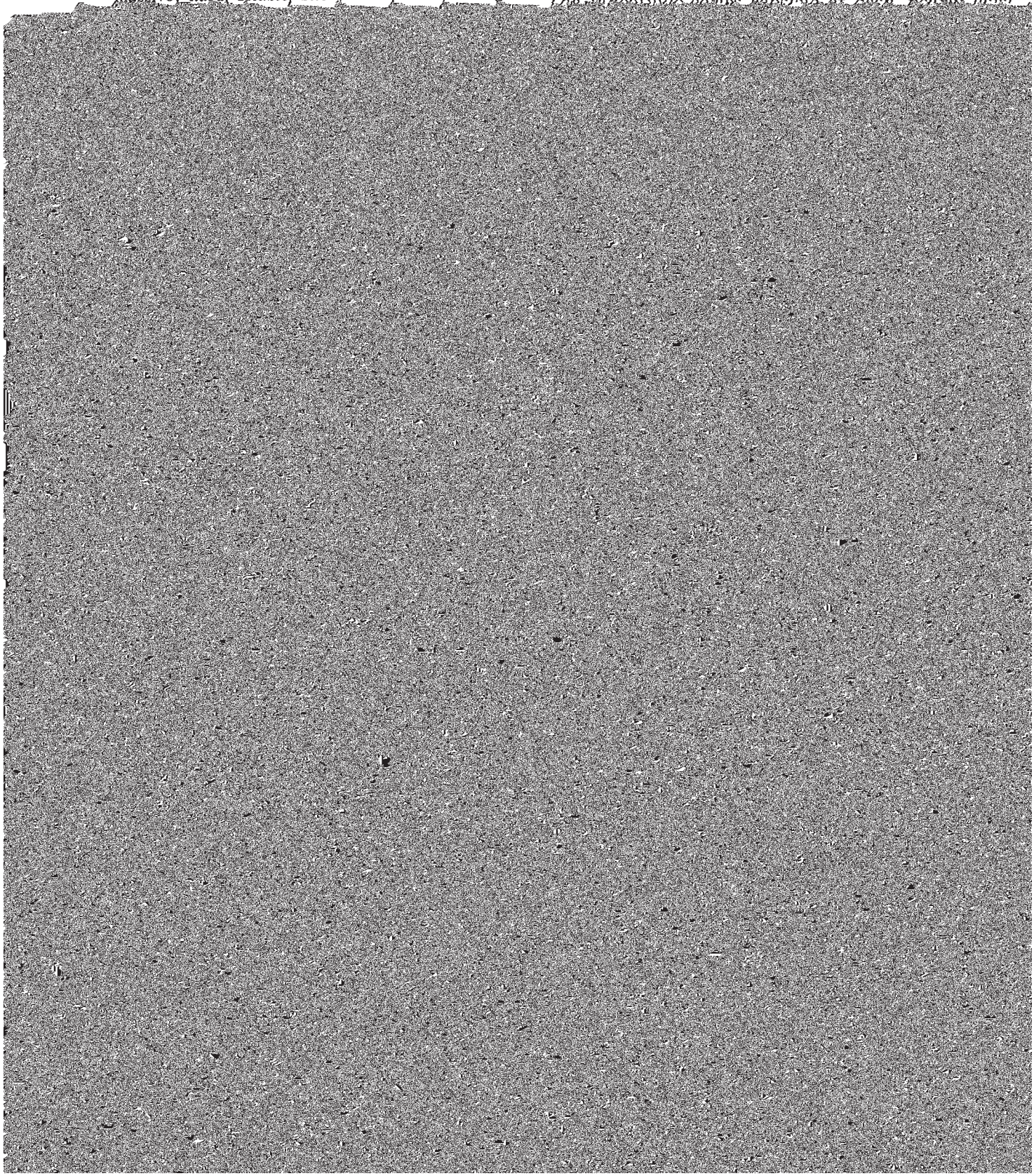
A1—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; moderate, fine, granular structure; soft; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B1—6 to 14 inches, very dark grayish-brown (10YR 3/2) clay loam, light brownish gray (10YR 6/2), light gray (10YR 7/2), and gray (10YR 5/1) dry;

IIIC2ca—40 to 60 inches, olive (5Y 5/3) and light-gray (5Y 7/2) clay loam, pale yellow (5Y 7/3) dry; massive; hard, friable, sticky and plastic; strong

Wheatville Series

The Wheatville series consists of deep, poorly-level



soil has the profile decribed as representative of the series.

Included with this soil in mapping are a few areas of soils that have a sandy loam surface layer.

Susceptibility to soil blowing is moderately high. Runoff is very slow. The clay in the lower part of the profile is slowly permeable, creating a perched water table that is at or near the surface during wet periods.

This soil is suited to small grains, potatoes, sugar beets, sunflowers, pinto beans, hay, and pasture. The chief management concerns are susceptibility to soil blowing on cultivated soils and wetness during periods of high precipitation. Wetness delays spring seeding in some years. Capability unit IIe–4L; windbreak suitability group 1.

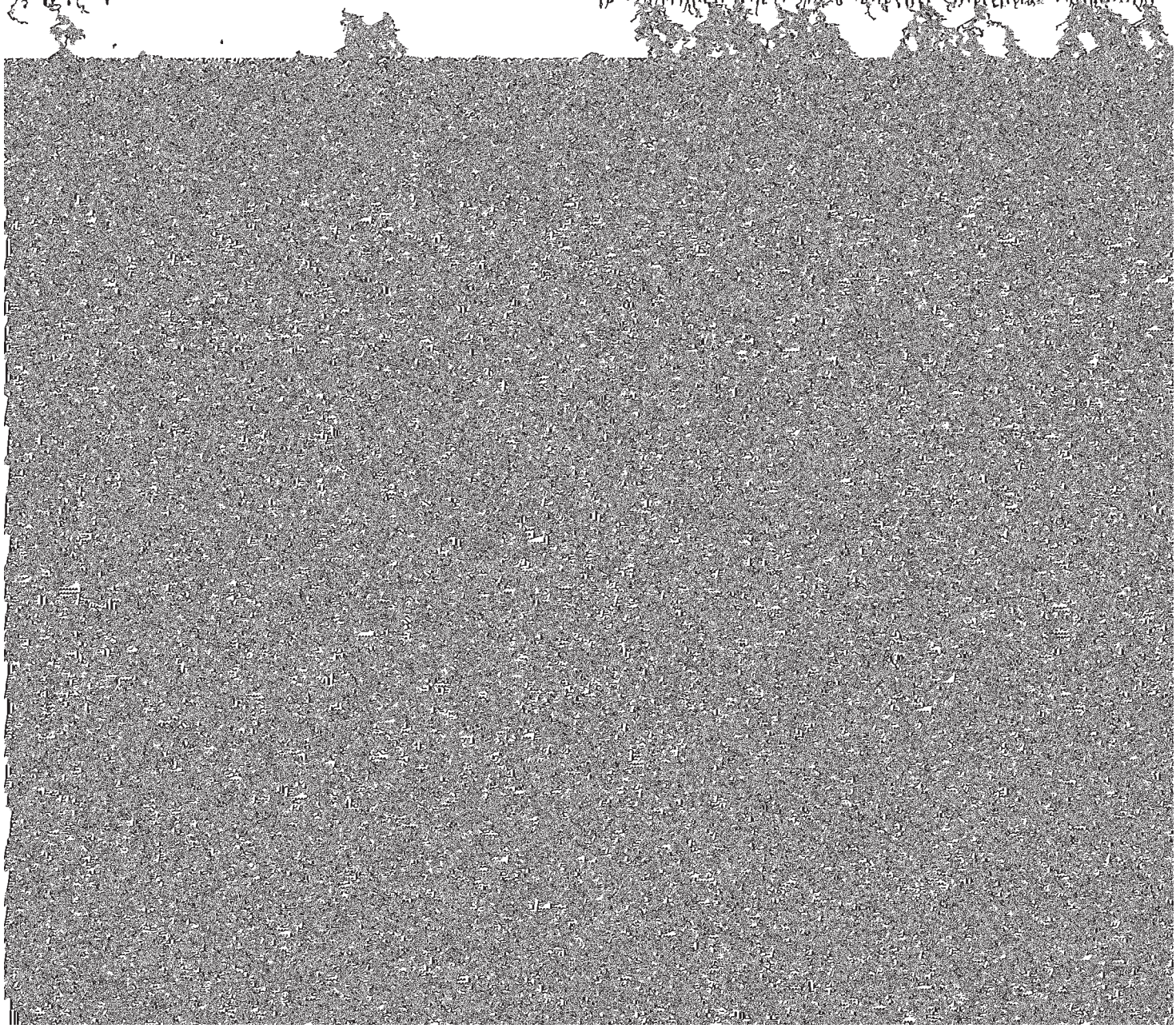
or silt loam. The C horizon is very fine sandy loam or silt loam.

Zell, Gardena, and Glyndon soils formed in similar material. Zell soils are better drained than Glyndon soils and lack the B horizon of Gardena soils.

ZgC—Zell-Gardena very fine sandy loams, 6 to 9 percent slopes. These soils are along streams. Slopes are complex. The Zell soils have the profile described as representative of the series. They occupy 65 percent of the mapped areas, and Gardena soils occupy 35 percent.

Susceptibility to soil blowing is moderately high. Runoff is rapid, and susceptibility to water erosion is high.

These soils are suited to small grains, hay, and pasture. The chief management problems are susceptibility to water erosion and soil blowing. Erosion needs to be controlled where these soils are cultivated. Capability



Stripcropping, planting cover crops and windbreaks, contour farming, establishing diversions and grassed waterways, using buffer strips, using minimum tillage and emergency tillage methods, tilling at the proper time, and leaving crop residue after harvest help control erosion. Generally a combination of several measures is used.

Applying chemical fertilizer (according to results of soil tests), green manure, and barnyard manure and using cover crops, grasses, legumes, and summer fallow in the cropping system help to maintain fertility. If erosion is controlled, fertility is conserved.

Drainage, removal of stones, and reduction of salinity may be needed to offset unfavorable soil characteristics.

Capability grouping

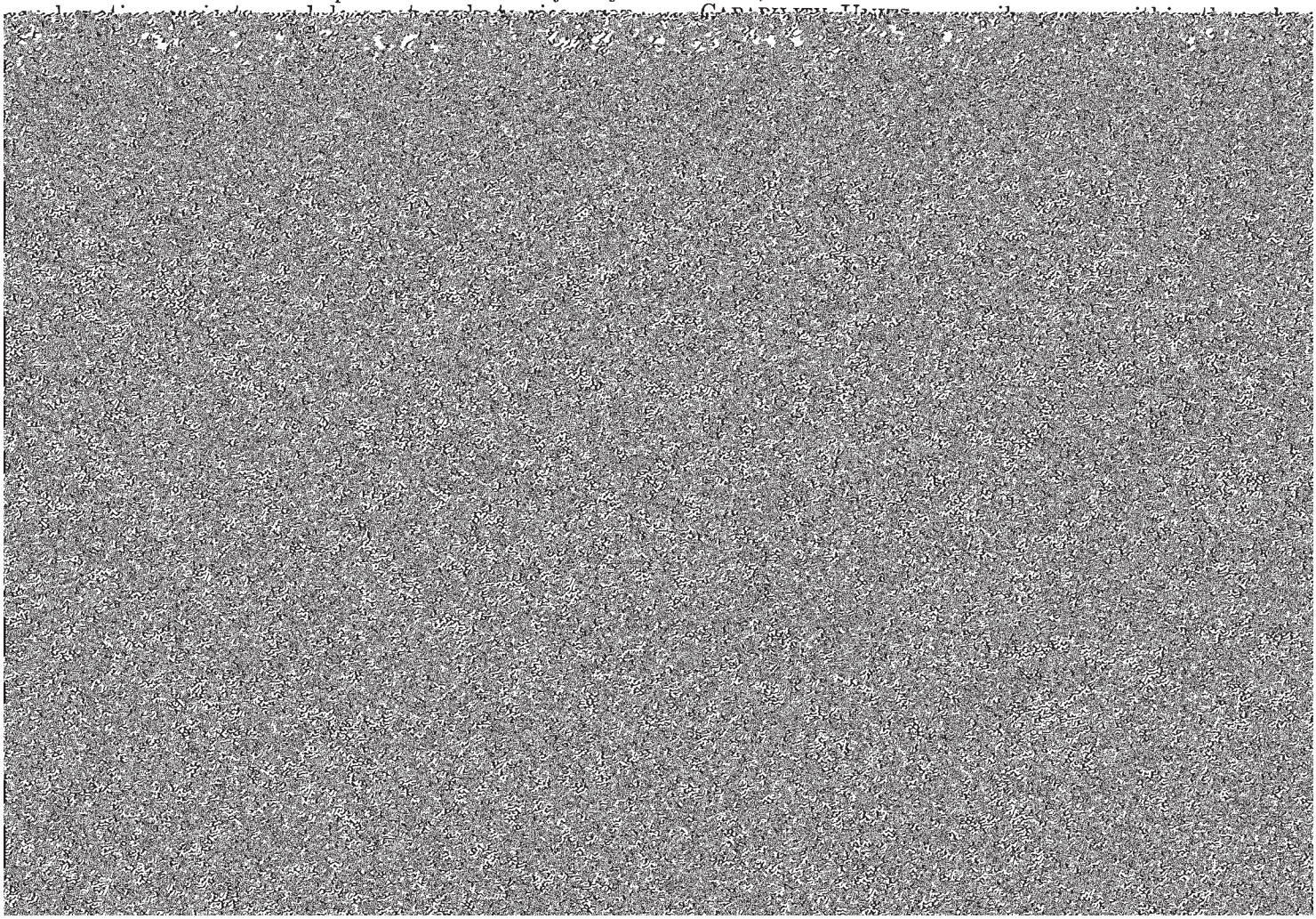
Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major

strict their use largely to pasture, range, woodland, or wildlife.

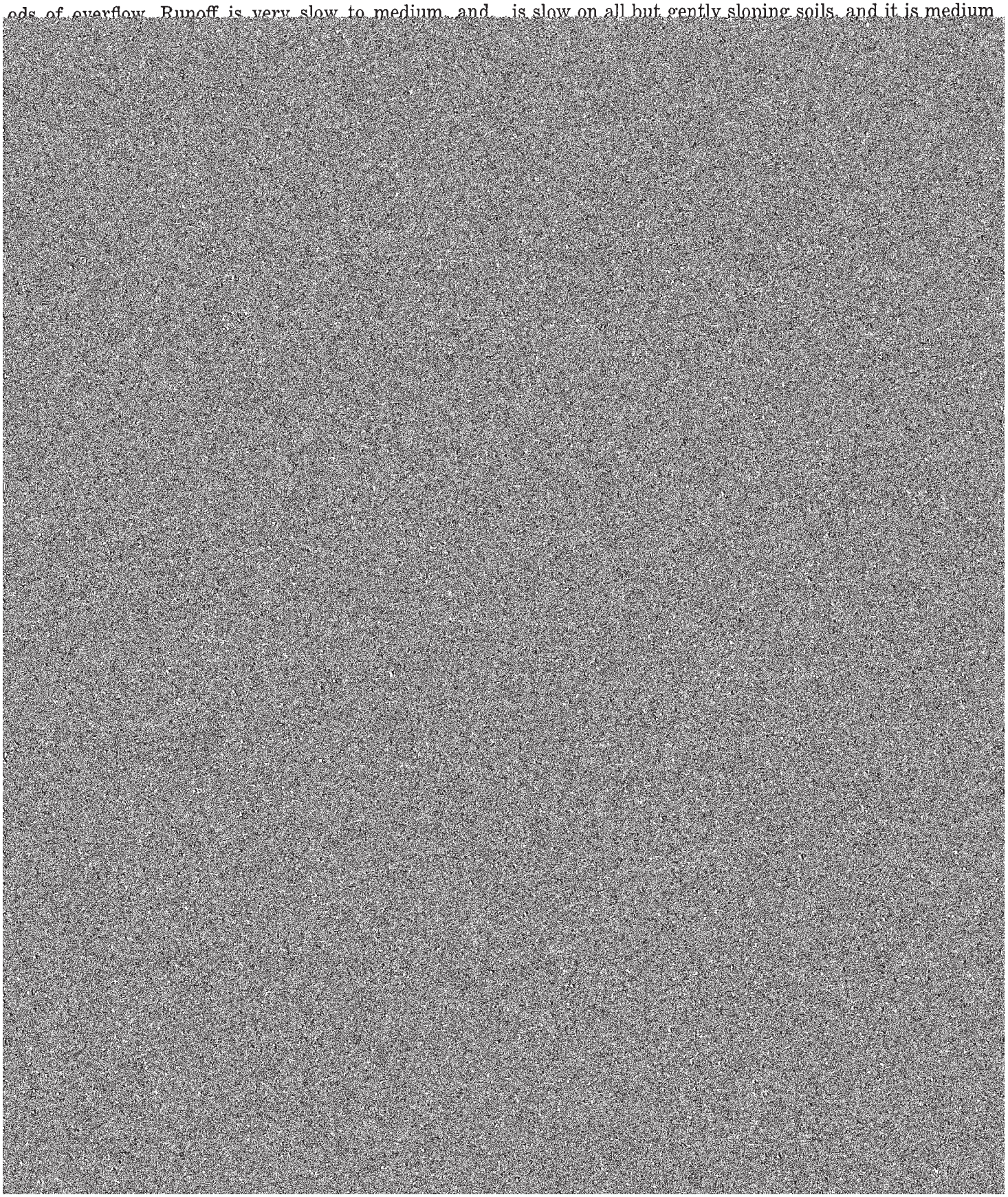
Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or esthetics. (None in Pembina County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.



ods of overflow. Runoff is very slow to medium, and is slow on all but gently sloping soils, and it is medium



soils. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, and establishing grassed waterways.

CAPABILITY UNIT IIw–4

This unit consists of deep, moderately well drained to poorly drained, nearly level soils. Most soils have a fine-textured surface layer and subsoil, but some are coarse textured in the lower part of the substratum.

Available water capacity is high, and organic-matter content is moderate or high. Permeability is moderate to slow, and runoff is very slow or slow. Runoff water ponds in shallow depressions, and in places the water table is within 3 to 5 feet of the surface during wet periods. Some areas adjacent to streams are subject to flooding. Susceptibility to soil blowing is moderately high.

The soils of this unit are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, potatoes, and sugar beets. If the soils are worked when wet, they become extremely hard upon drying.

Susceptibility to soil blowing and wetness caused by ponding of runoff water, a high water table, or flooding are the main limitations to the use of the soils. Surface drains remove ponded water and aid tillage operations where outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips and emergency tillage methods, and tilling at the proper time.

CAPABILITY UNIT IIw–4L

This unit consists of deep, poorly drained and very poorly drained, nearly level and gently sloping soils. The dominant soils have a calcareous, medium-textured to fine-textured surface layer underlain by a medium-textured to fine-textured layer that is high in content of lime. Some of the fine-textured soils are noncalcareous to a depth of 1½ feet or more.

Available water capacity is high in most soils and moderate in a few. Organic-matter content is high, and fertility is medium or high. Permeability ranges from moderately rapid to slow. Runoff is very slow or slow in most areas, but it is medium on gently sloping soils. Runoff water ponds on the soils of this unit and delays or prevents spring seeding in most years. A water table less than 4 feet below the surface during wet periods makes the soil even wetter. A few areas adjacent to streams are subject to flooding by stream overflow.

The soils of this unit are suited to the crops commonly grown in the county, and they are tilled in most areas. The main crops are small grains, sugar beets, and potatoes. Most undrained soils are used for hay or pasture or left idle. Tilth is good in the medium-textured soils, but the moderately fine textured and fine textured soils are hard to work, and good soil tilth is difficult to maintain.

Wetness and susceptibility to soil blowing are the main limitations to the use of these soils. Surface drainage aids tillage operations, but outlets for drains are difficult to find. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips and emergency tillage methods, and tilling at the proper time.

CAPABILITY UNIT IIw–7

The only soil in this unit is Perella silty clay loam. It is a deep, poorly drained, and nearly level soil that has a moderately fine textured surface layer and subsoil.

Available water capacity, organic-matter content, and fertility are high. Permeability is moderately slow, and a water table is less than 3 feet below the surface during wet periods. Runoff is very slow, and water ponds on this soil for long periods. The ponding delays spring seeding in most years.

This soil is suited to the crops commonly grown in the county. The main crops grown are small grains, potatoes, and sugar beets. Most undrained areas are used for hay or pasture or are left idle. This soil is hard to work, and soil tilth is difficult to maintain. If it is worked when wet, it becomes extremely hard upon drying.

Wetness caused by ponded water is the main limitation to the use of these soils. Surface drainage aids tillage operations, but outlets for drains are difficult to find. Good management includes such moisture-conservation and fertility-maintenance measures as tilling at the proper time, planting green manure crops, and conserving crop residue.

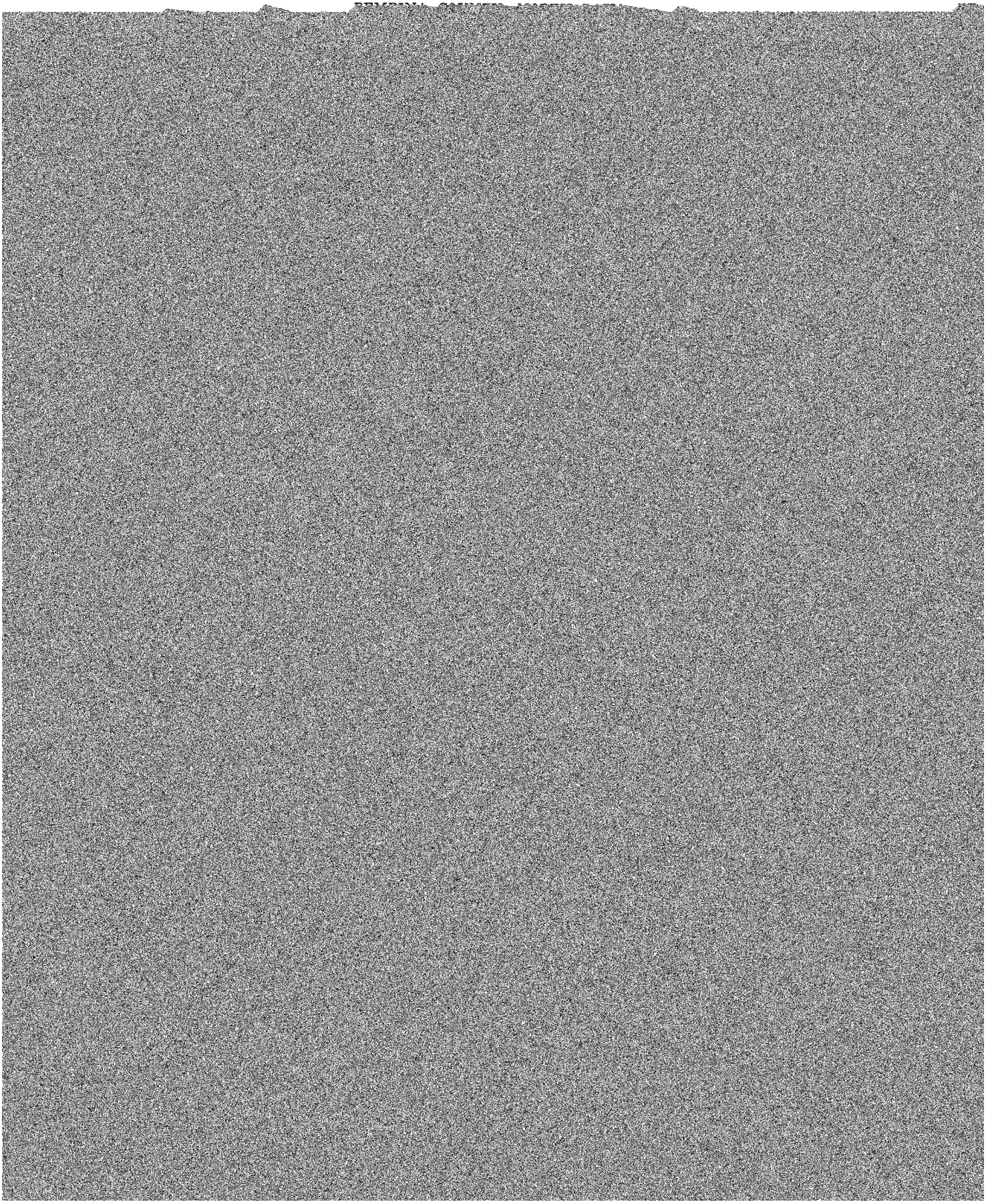
CAPABILITY UNIT IIs–6

This unit consists of moderately well drained and well drained, nearly level soils that are moderately deep and deep over sand and gravel. These soils have a medium-textured or moderately fine textured surface layer and subsoil. In some areas shaly gravel and sand-sized shale particles are less than 20 inches below the surface.

Available water capacity is moderate or high, fertility is medium or high, and organic-matter content is high. Permeability is moderate in the surface layer and subsoil and rapid in the underlying gravelly layers. Surface runoff is slow. Susceptibility to soil blowing is slight.

These soils are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains and potatoes. These soils are easy to work and have good tilth.

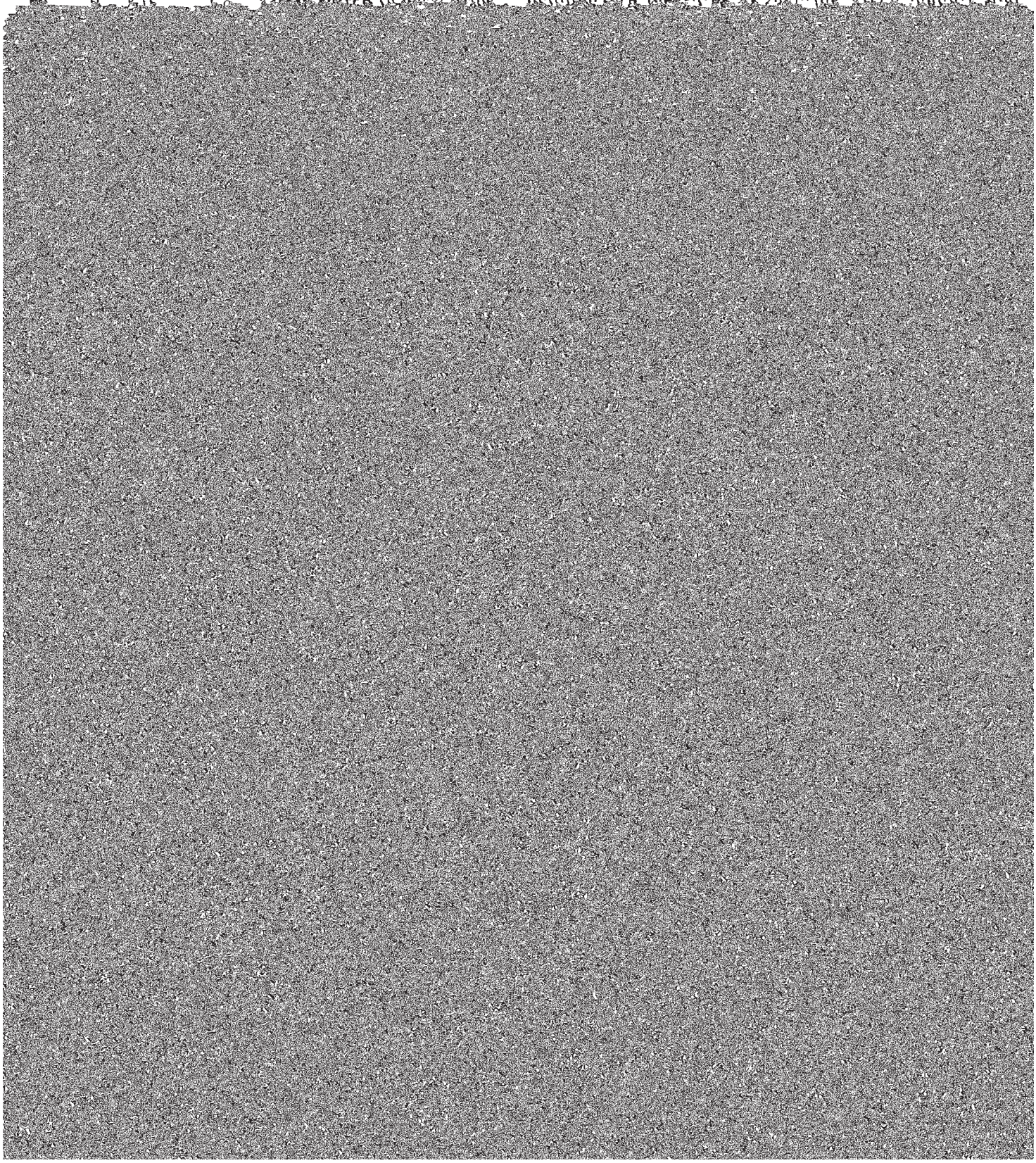
Soil blowing and droughtiness caused by moderate available water capacity in areas underlain by sand and gravel are the main limitations to the use of soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips, and emergency tillage methods and tilling at the proper time. Summer fallow stores moisture and helps control



ium to rapid. Susceptibility to water erosion is moderate to high, and susceptibility to soil blowing is moderate.

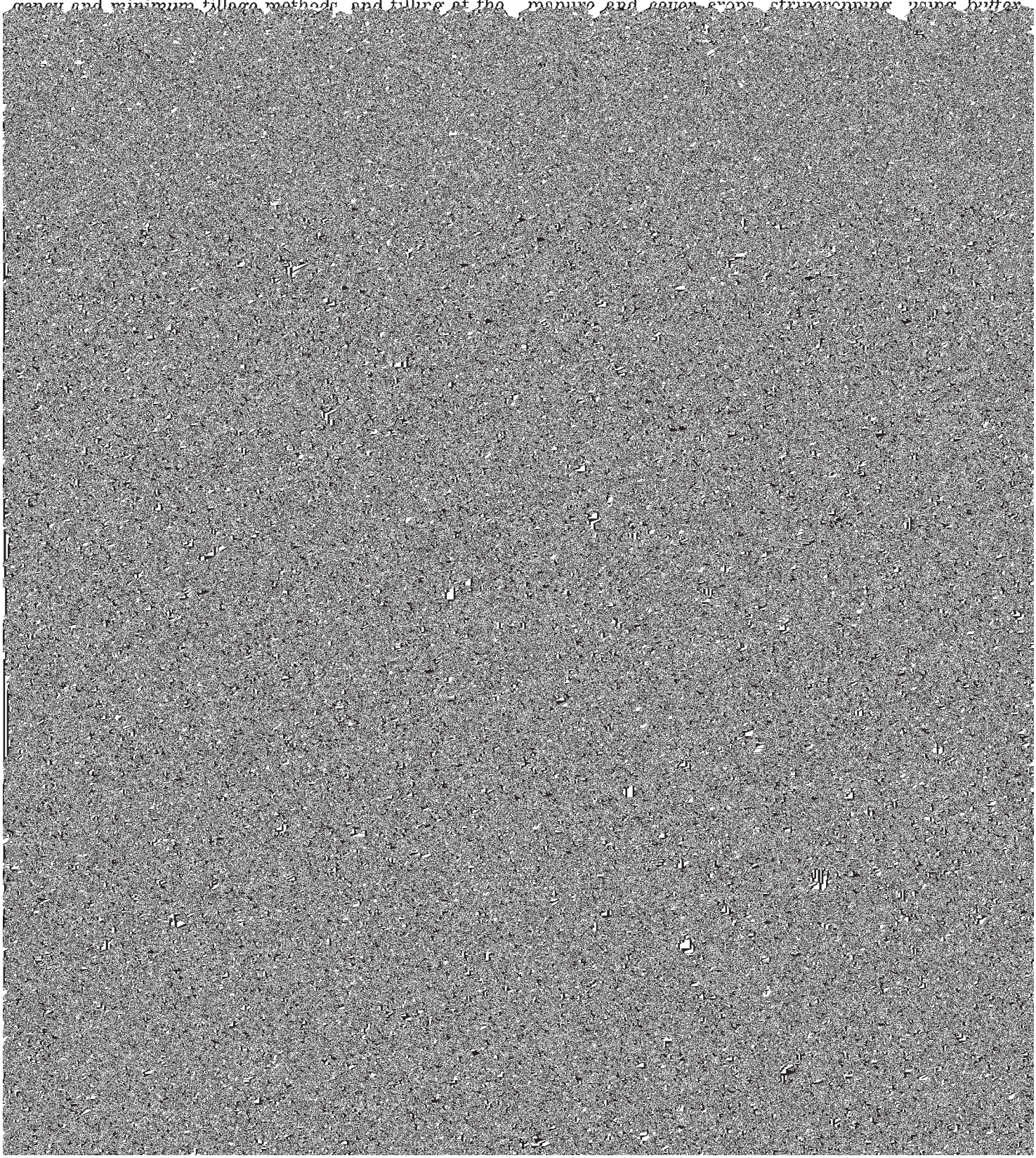
[illegible] better suited to close grow[illegible]

because of low available water capacity are the main limitations to use. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and

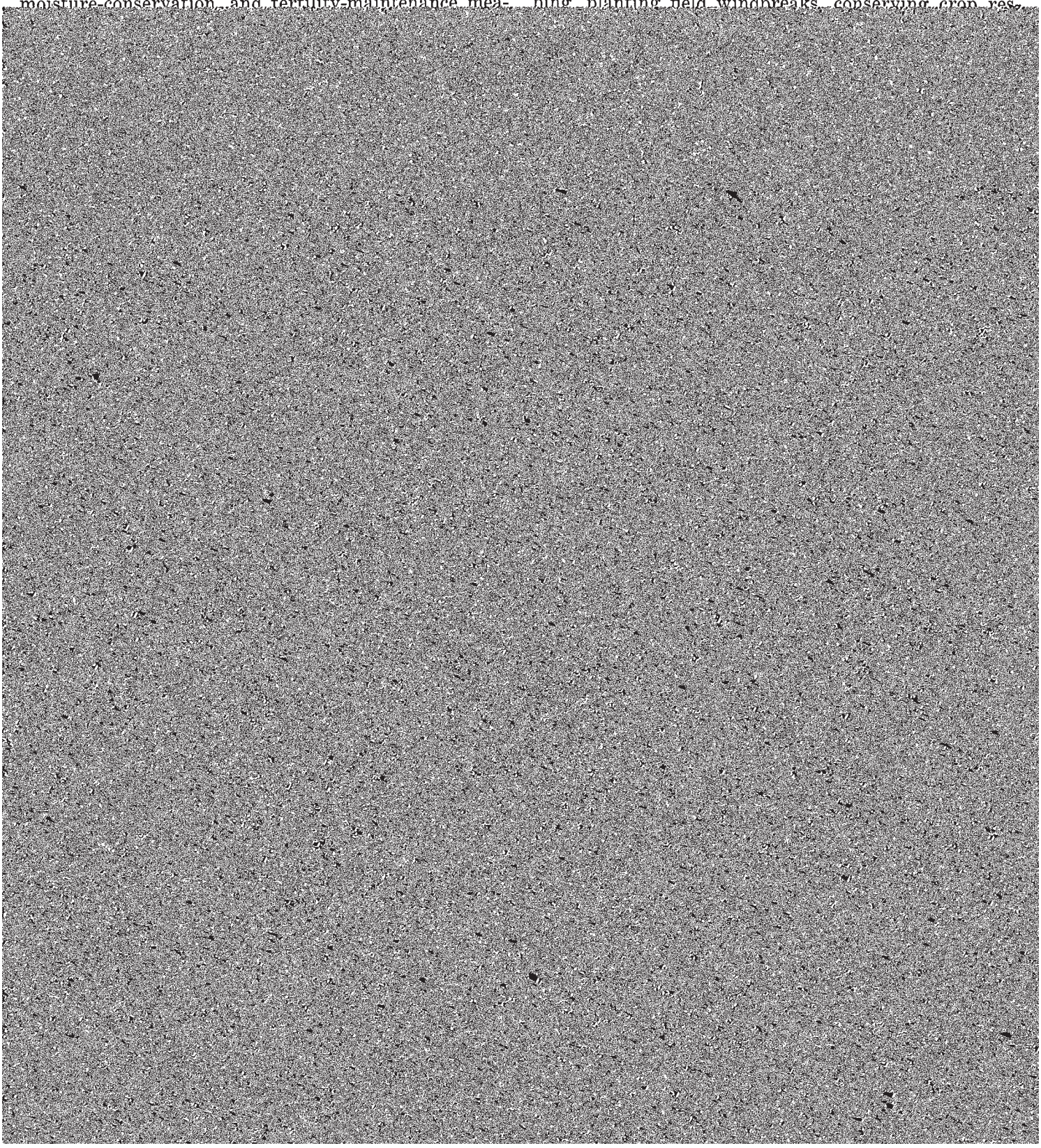


planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the

limitation during dry periods. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer



are the main limitations to the use of these soils. Surface drains aid tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, planting field windbreaks, conserving crop res-



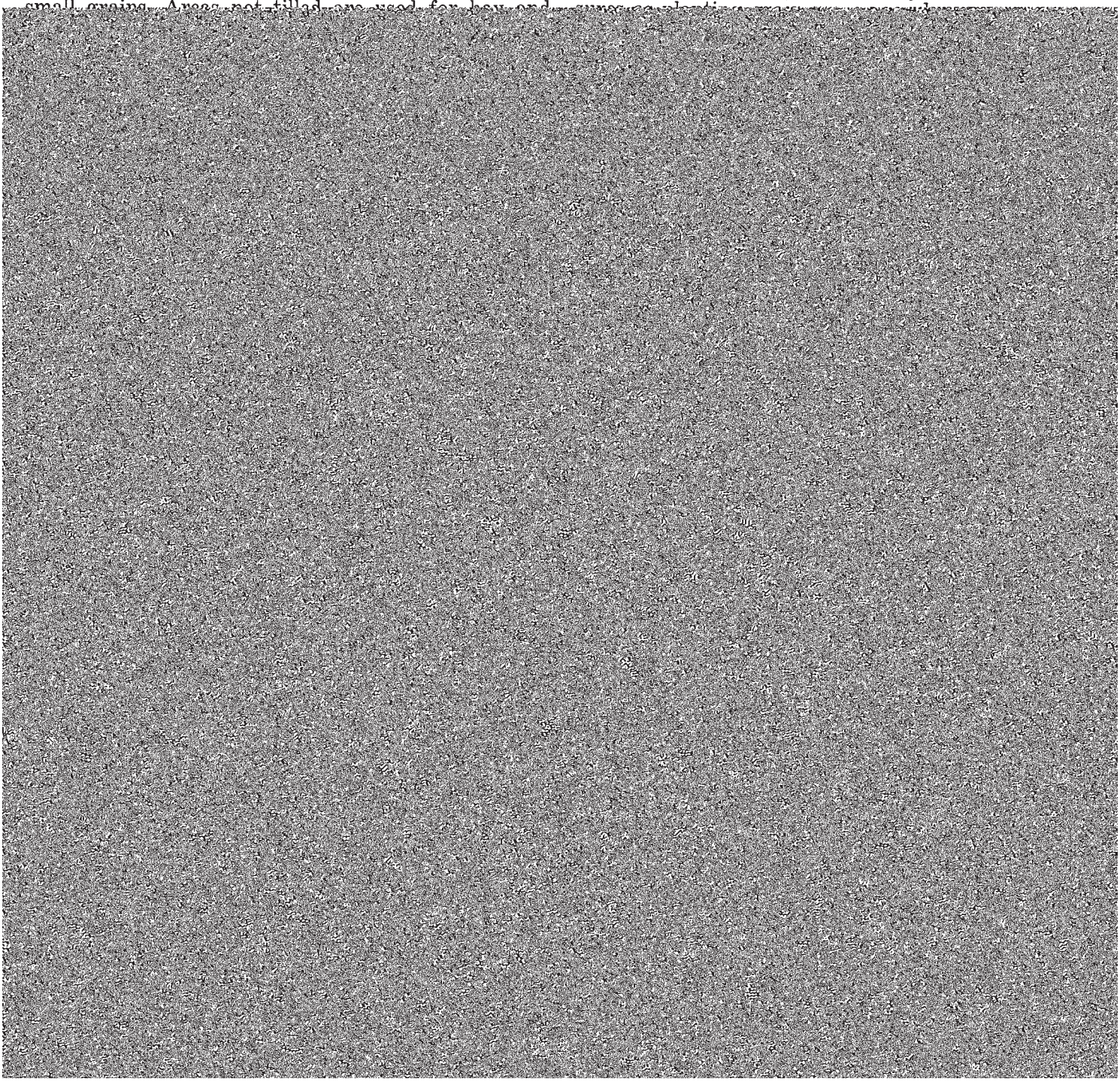
medium-textured surface layer that is calcareous in many areas. The underlying material is medium-textured, and it is commonly high in content of lime in the upper part.

Available water capacity is high, and organic-matter content is moderate to high. Fertility is low to high. Permeability is moderate. Runoff is rapid, and susceptibility to water erosion is high. Susceptibility to soil blowing is moderately high.

The soils in this unit are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay and

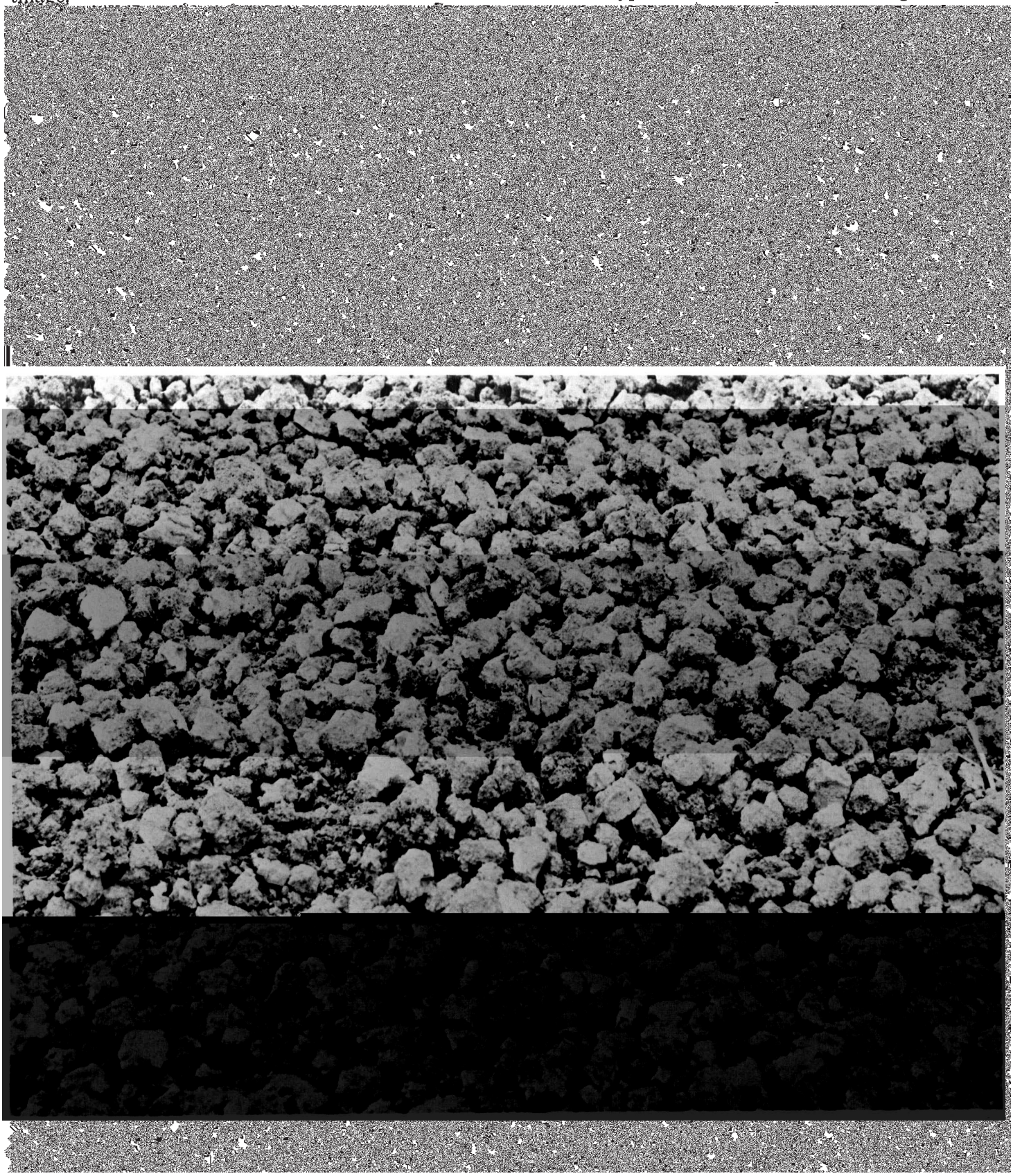
The soils of this unit are suited to close-growing crops if surface drainage is improved. Small grains are the main crops. Areas not tilled are used for hay or pasture or are left idle. The soils are easy to work when not too wet, but soil tilth deteriorates under tillage.

Susceptibility to soil blowing and wetness are the main limitations. Surface drains aid tillage operations if outlets are available. Droughtiness because of the low available water capacity is a limitation during dry periods. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance mea-



This soil is easy to work, but soil tilth deteriorates under tillage.

fine-textured subsoil. The dominant soils in this unit have a claypan subsoil that limits root growth and



strips, stripcropping, stubble mulching, and conserving crop residue. Surface drainage aids tillage operations, but drain outlets are seldom available. Deep-rooting legumes included in the cropping system improve soil tilth and help water and air move through the claypan subsoil. Summer fallow is of little value on these soils, and is better that it be used only to control weeds.

CAPABILITY UNIT Vw-7

The only soil in this unit is Peat. It is deep, very poorly drained, nearly level, and organic.

Available water capacity is low, and organic-matter content is very high. Fertility is medium, and permeability is moderately rapid. Runoff is very slow. The water table is at or near the surface most of the time.

Peat is better suited to wildlife habitat than to other uses. A few areas of it are used for pasture, but it is too wet for tilled crops.

Wetness is the main limitation to the use of this soil. Drainage is not feasible because drain outlets are not available.

CAPABILITY UNIT Vw-8

The only soil in this unit is Rauville silt loam. It is deep, very poorly drained, and nearly level, and it has a medium-textured surface layer and a moderately fine textured subsoil.

Available water capacity and organic-matter con-

soils have a coarse-textured surface layer and substratum.

Available water capacity is very low or low, organic-matter content is low to high, and fertility is very low to medium. Permeability is rapid, and susceptibility to soil blowing is very high.

The soils of this unit are suited to hay and pasture or are left idle for wildlife. They are not suitable for cultivated crops.

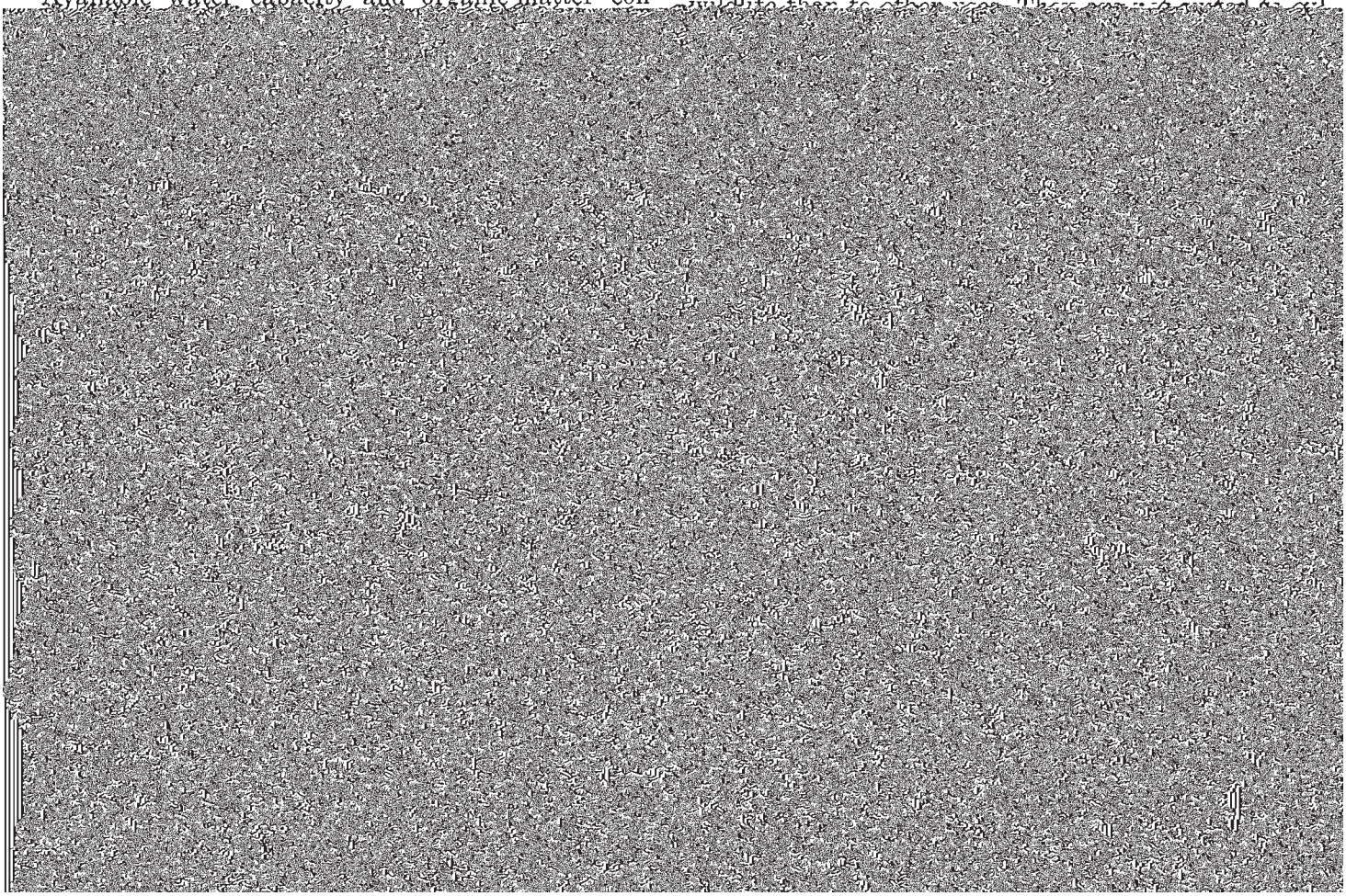
Slope, droughtiness, and susceptibility to soil blowing are the main limitations to the use of these soils. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

CAPABILITY UNIT VIe-4

This unit consists of deep, moderately well drained and well drained, moderately steep and steep soils. They have a medium-textured or moderately fine textured surface layer and a medium-textured or fine-textured subsoil. These soils are calcareous in some areas.

Available water capacity and organic-matter content are moderate or high. Fertility ranges from low to high, and permeability is moderate or slow. Runoff is rapid or very rapid, and susceptibility to water erosion is very high to extremely high. Susceptibility to soil blowing is moderately high.

The soils of this unit are better suited to pasture or



and a moderately fine textured or fine textured substratum. In some areas the soils are calcareous.

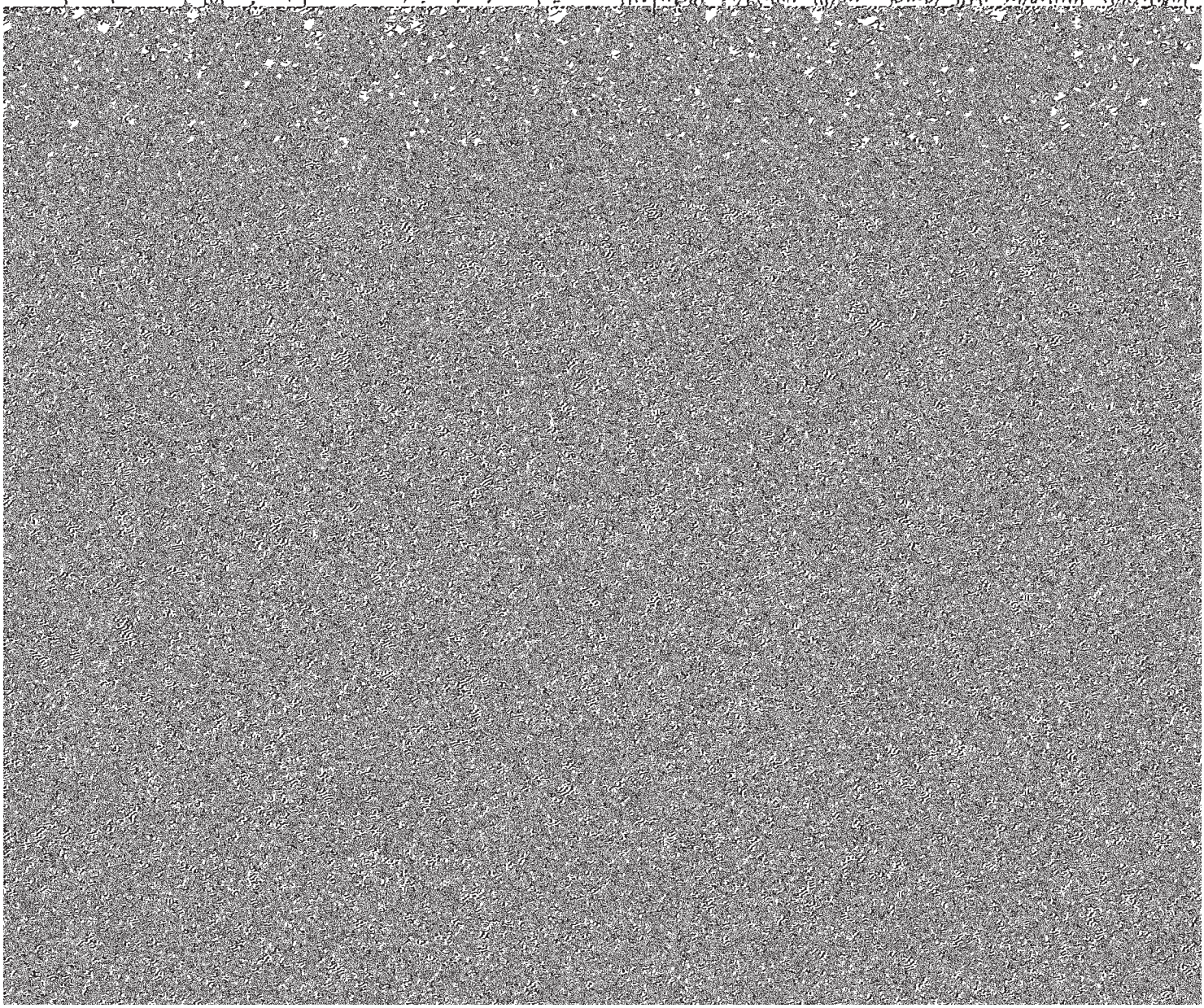
Available water capacity is low or moderate, and organic-matter content is high. Fertility is low to high, and permeability is moderately slow or slow. Susceptibility to soil blowing is moderately high.

The soils of this unit are better suited to hay or pasture than to other uses. They are unsuitable for cultivated crops.

Salinity and wetness are the main limitations to the use of these soils. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

CAPABILITY UNIT VIs–5

The only soil in this unit is Brantford loam, 9 to 25 percent slopes. It is well-drained, and it is shallow over



Susceptibility to soil blowing is moderately high. This soil is subject to flooding by stream overflow.

This soil is better suited to wildlife habitat than to other uses. Most areas are covered by thick stands of tall trees and very little grass. Some of the more open areas are used for pasture.

Short, sloping to steep, choppy slopes and frequent flooding are the main limitations to use of this soil. Deferred grazing and controlled water and salt distribution can regulate grazing to a preferable rate so that half or less of the annual growth of desirable plants is consumed.

CAPABILITY UNIT VIIs–6

This unit consists of somewhat poorly drained to somewhat excessively drained, nearly level and gently sloping, stony soils that are shallow over sand and gravel or deep. These soils all have a stony, medium-textured surface layer. Some are medium textured

tions more frequently, and commercial fertilizer is applied regularly according to soil tests.

The estimates given in the table are based on records kept by farmers, on data developed at the North Dakota State University at Fargo, and on information obtained in interviews with farmers and other informed persons.

Wheat yields are given for fields that have been fallowed. All yields are based on planted acres, not harvested acres.

Sunflowers, pinto beans, and other crops are grown, but yields on individual soils are not known.

Woodland and Windbreaks [3]

Approximately 4.4 percent of Pembina County, 31,000 acres, is native woodland. Most of the native trees and shrubs grow along the rivers and streams throughout the county and on the Pembina Escarpment and Pembina River Delta. The soils that commonly support native woody vegetation are Cashel, Cormant, Egeland, Fairdale, Maddock variant, La Prairie, Neche, Olga, Poppleton, Rolette, Walsh, Wahpeton, and Waukon soils. The land types that support this type of vegetation are Clayey breaks and Rough broken land.

The main tree and shrub species are eastern cottonwood, green ash, American elm, boxelder, basswood, trembling aspen, bur oak, pin cherry, balsam poplar, ironwood, speckled alder, paper birch, dwarf birch, chokecherry, hawthorn, wild plum, juneberry, redosier dogwood, wild rose, willows, highbush cranberry, smooth sumac, American hazel, silverberry, snowberry, and creeping juniper.

The early settlers used the trees for lumber, fenceposts, and fuel. Now trees and shrubs are used chiefly for livestock protection, wildlife habitat, recreation, esthetic purposes, erosion control, and watershed protection.

The number of acres in native woodland has steadily declined. When cleared, the land is used primarily for crops.

Windbreak management

Windbreaks have been planted in Pembina County since the days of the early settlers, mainly for the protection of farmsteads and livestock. Such plantings are still needed on thousands of acres in the county in cultivated areas where the hazard of soil blowing is severe.

Windbreaks distribute and hold snow, keeping it from drifting around the farmstead. They protect the buildings and livestock from cold, wintery winds, reducing fuel and feed costs. They protect field crops, gardens, and orchards from strong, damaging winds, reducing the hazards of erosion and evaporation. They provide habitat for birds and other wildlife, and they enhance the beauty of the rural home and its surroundings.

The purpose of planting, the suitability of the soils, the selection of suitable trees and shrubs, and the design of the windbreak are factors to be considered before planting.

The establishment of a windbreak and the growth of its trees depend on careful selection of the site, suitable preparation, and adequate maintenance. Grass and weeds have to be eliminated before the trees are planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed during the first 2 years.

Windbreak suitability groups

Ten windbreak suitability groups are designated in North Dakota, and all but groups 7 and 8 occur in Pembina County. Under good management, the growth response of suitable trees and shrubs is generally the same for all soils within a group.

Several factors are considered in grouping soils. The amount of soil moisture and the seasonal availability of water are the dominant and most critical factors. Slope and texture are also important, because they largely determine the degree of water erosion and soil blowing.

Conserving water is most important on soils that have slopes of more than 6 percent. Special site preparation, planting, and cultivation are needed to successfully establish and maintain plantings if soil blowing and water erosion are hazards. Soils in group 2 are ponded or have a high water table if they have not been drained. The lack of soil moisture is not a limitation in group 1, but the water table is beyond the reach of tree roots in all soils in groups 3 through 9 and in some soils in group 10. Some soils in group 10 are very wet during part of the year, and a few have additional limitations critical for growing trees and shrubs.

Table 3 lists the species of trees and shrubs commonly used in windbreak plantings in the county and gives the actual or estimated average height and the vigor, by windbreak group, of the various species at 20 years of age. All height measurements and vigor ratings have been based on well-managed plantings. No data are given for windbreak groups 9 and 10, because the soils in these groups are not suitable for tree and shrub plantings.

The ratings in the column headed "Vigor" refer to the density of foliage, the freedom from damage by insects or disease, and the general appearance of the tree. A rating of good indicates that leaves and needles are normal in color and growth and only a small amount of deadwood occurs within the live crown; little or no disease, insect, or climatic damage is apparent; and evidence of stagnation or suppression is only slight. A rating of fair indicates that leaves and needles are obviously abnormal in color and growth, and a substantial amount of deadwood occurs within the live crown; evidence of moderate disease, insect, or climatic damage is apparent; evidence of definite suppression or stagnation is apparent; and the current year's growth is obviously less than normal. A rating of poor indicates that leaves and needles are very abnormal in color and growth and a very large amount of deadwood occurs within the live crown; evidence of extensive disease, insect, or climatic damage is apparent; evidence of severe stagnation, suppression, and decadence is apparent; and the current year's growth is essentially negative. Plants that are rated poor are

[3] By DAVID L. HINTZ, forester, Soil Conservation Service.

TABLE 2.—*Estimated average yields per acre of*

[Columns A list yields to be expected under average management; columns B list yields that can be obtained under

Soil	Wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
Arveson sandy loam [1]	17	25	31	53
Arveson loam [1]	19	27	34	58
Arveson soils, very wet [1]	17	25	31	53
Barnes loam, 9 to 20 percent slopes				

principal crops under two levels of management

improved management. Absence of a yield figure indicates that the crop is not suitable or is not ordinarily grown]

Barley		Beets		Potatoes		Hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Tons*	*Tons*	*Cwt*	*Cwt*	*Tons*	*Tons*
22	40					2.0	2.8
25	43					2.0	2.8
22	40					2.0	3.0
						0.7	1.5
43	70	12.0	17.0	140	180	2.5	3.5
39	64	10.0	14.0	120	150	2.3	3.2
32	54	8.0	11.0	90	110	2.0	3.0
36	59	7.0	10.0	90	110	2.2	3.3
43	70	12.0	17.0	140	180	2.5	3.5
21	32					1.4	1.9
18	29					1.2	1.7
32	56	12.0	14.0	120	160	1.8	2.6
22	34					1.5	2.0
18	30					1.4	1.8
14	21					1.3	1.6
36	62	9.5	13.5	120	150	2.3	3.4
34	57					2.1	3.2
						1.3	1.8
30	51					2.0	3.0
						1.2	2.2
32	56	12.0	14.0			1.8	2.6
18	28					1.5	2.0
30	48			100	130	1.6	2.5
32	56					2.3	3.2
28	48			85	95	1.8	2.6
26	43					1.6	2.4
34	54	9.0	13.0	110	140	1.8	2.6
30	43					1.6	2.4
39	65	10.0	14.0	127	160	2.3	3.4
36	60	9.0	12.0	105	135	2.0	3.0
40	66	10.0	14.0	105	135	2.0	3.2
44	70	12.0	17.0	145	185	2.5	3.5
32	53					2.0	3.0
38	60	10.0	14.0	120	160	2.0	3.0
43	70	12.0	17.0	140	180	2.5	3.5
32	54	8.0	11.0	90	110	1.9	2.6
27	45					1.9	2.7
						1.3	2.3
22	35					1.9	2.6
27	43					1.9	2.6
22	37	6.0	8.5	75	95	1.4	2.2
18	29					1.2	2.0
27	45	7.0	10.0	90	110	1.7	2.5
22	35					1.5	2.3
25	41					1.8	2.5
35	57	10.0	14.0	90	110	2.3	3.3
32	54	9.0	13.0			2.0	3.0
34	53					2.2	3.0
43	69	12.0	17.0	140	180	2.1	3.3
						1.7	3.0
46	72	13.0	17.0	145	185	2.5	3.5
46	72	13.0	17.0	150	190	2.5	3.5
41	64	11.0	15.0	135	170	2.3	3.2
						2.5	3.5
21	32					1.2	1.7
16	24					1.1	1.5
25	40					1.4	2.0
21	34					1.2	
							1.9
12	16					0.8	1.2
39	64	9.5	13.5	105	135	2.3	3.4
24	42					1.1	1.7

TABLE 2.—*Estimated average yields per acre of principal*

Soil	Wheat		Oats	
	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*
Neche silty clay loam	32	41	57	90
Neche silty clay	31	40	55	88
Ojata silt loam				
Olga silty clay loam, 3 to 6 percent slopes	24	32	41	70
Olga silty clay loam, 9 to 25 percent slopes				
Overly silty clay loam, 1 to 3 percent slopes	35	45	63	98
Peat				
Perella silty clay loam [1]	26	36	47	79
Poppleton loamy sand, 1 to 3 percent slopes	16	20	29	44
Rauville silt loam				
Renshaw loam, 1 to 3 percent slopes	16	20	20	44
Renshaw very stony loam, 1 to 6 percent slopes				
Rolette silty clay loam, 1 to 3 percent slopes	30	40	54	88
Rough broken land				
Ryan-Fargo silty clays	16	22	29	48
Serden sand, 6 to 15 percent slopes				
Swenoda fine sandy loam, 1 to 3 percent slopes	28	35	50	77
Tiffany fine sandy loam [1]	23	33	41	72
Vang loam, 1 to 3 percent slopes	21	28	36	61
Vang clay loam, 1 to 3 percent slopes	16	23	29	50
Vang-Walsh loams, 1 to 3 percent slopes	24	32	40	70
Vang-Walsh loams, 3 to 6 percent slopes	21	28	36	64
Vang loam, wet variant [1]	21	30	36	66
Wahpeton silty clay, 1 to 3 percent slopes	33	42	59	92
Wahpeton silty clay, 3 to 6 percent slopes	31	40	55	88
Wahpeton silty clay, 6 to 9 percent slopes	25	32	45	72
Walsh loam, 6 to 9 percent slopes	20	28	35	60
Walsh loam, 9 to 15 percent slopes	14	19	25	42
Walsh clay loam, 1 to 3 percent slopes	34	45	60	98
Waukon loam, 1 to 3 percent slopes	30	39	54	86
Waukon loam, 3 to 6 percent slopes	28	36	50	86
Waukon loam, 6 to 9 percent slopes	21	28	36	61
Waukon loam, 9 to 15 percent slopes	16	22	29	48
Wheatville very fine sandy loam	30	40	54	88
Zell-Gardena very fine sandy loams, 6 to 9 percent slopes	16	23	29	50
Zell-Gardena very fine sandy loams, 9 to 15 percent slopes				

[1] Yields given are for drained areas only.

unsatisfactory for farmstead, feedlot, or field windbreaks but may be satisfactory as wildlife and beautification plantings.

WINDBREAK SUITABILITY GROUP 1

Soils in this group are nearly level to sloping and are poorly drained, somewhat poorly drained, or moderately well drained. They have a coarse-textured to fine-textured surface layer. These soils have adequate moisture for tree and shrub survival and growth. The water table is within the reach of tree roots in many of these soils.

These soils are well suited to all types of windbreaks and other woody plantings. No serious hazards or limitations for planting trees and shrubs exist, except on some soils where the hazard of soil blowing is severe.

WINDBREAK SUITABILITY GROUP 2

Soils in this group are nearly level and are poorly drained or very poorly drained. They have a coarse-textured to fine-textured surface layer. The subsoil or underlying material is low to moderate in salinity. These soils are ponded or have a high water table.

Without drainage, these soils are poorly suited to most tree and shrub species. With adequate drainage, they are well suited to all types of windbreaks and other woody plantings. The soil-blowing hazard is moderately high to very high on most soils in this group because of soil texture or the high content of lime. The soil-blowing hazard is slight or moderate on some soils. Wetness is the only critical limitation for tree and shrub growth, but to a lesser degree, the high content of lime is also a limiting factor.

WINDBREAK SUITABILITY GROUP 3

Soils in this group are nearly level to moderately steep and are moderately well drained to somewhat excessively drained. They have a medium-textured or moderately fine textured surface layer. If moisture is conserved, nearly all adapted trees and shrubs grow on these soils.

These soils are well suited to all types of windbreaks and other woody plantings. There are no serious haz-

crops under two levels of management—Continued

Barley		Beets		Potatoes		Hay	
A	B	A	B	A	B	A	B
Bu	*Bu*	*Tons*	*Tons*	*Cwt*	*Cwt*	*Tons*	*Tons*
41	66	11.0	15.0	135	170	2.5	3.5
40	64	10.0	14.0	120	150	2.5	3.5
						0.5	0.7
30	51					1.7	2.6
						1.0	1.7
46	72	12.0	17.0	150	190	2.5	3.5
34	57	9.0	15.0			1.8	2.6
21	32					1.4	2.0
						2.0	2.8
21	32					1.1	1.5
39	64					2.0	2.8
21	35					1.1	1.7
						0.7	1.2
36	56			110	135	1.5	2.0
30	53					2.0	3.0
27	45					1.7	2.3
21	37					1.5	2.0
32	51			80	110	1.7	2.3
27	45					1.7	2.3
27	48					1.7	2.3
43	67	11.5	16.0	110	140	2.5	3.5
40	64					2.3	3.3
32	53					1.7	2.5
26	45					1.8	2.7
18	30					1.2	2.0
45	70	9.0	12.0	126	156	2.0	3.0
39	63					1.7	2.5
36	57					1.4	2.3
27	45					1.0	2.1
21	35					0.7	1.5
39	64	12.0	17.0	140	180	2.0	3.0
21	37					1.2	1.9
						0.7	1.5

ards or limitations for planting trees and shrubs, except on some soils where the hazard of soil blowing is severe.

WINDBREAK SUITABILITY GROUP 4

Soils in this group are nearly level and gently sloping and moderately well drained or well drained. They have a moderately fine textured surface layer and a fine textured subsoil. Nearly all adapted tree and shrub species grow well on these soils.

These soils are well suited to windbreaks and other [illegible] other woody plantings, if tree and shrub species are properly selected. The soil blowing hazard is moderate to very high. The main limitation to tree and shrub growth is droughtiness caused by the moderate to low available water capacity.

WINDBREAK SUITABILITY GROUP 6

The soils in this group are nearly level to sloping and are well drained or somewhat excessively drained. The surface layer is moderately coarse textured to moderately fine textured. No trees or shrubs grow well on

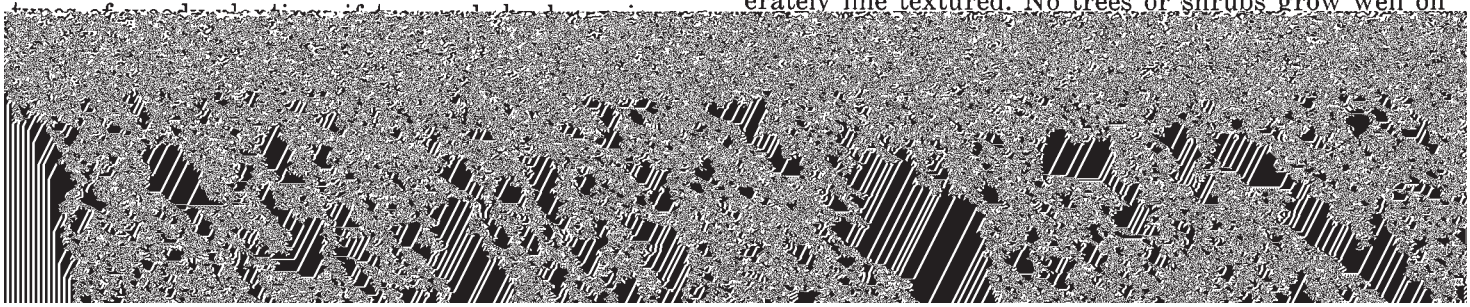


TABLE 3.—*Height and vigor of specified trees*

[Height measurements and vigor ratings are for trees at 20 years of age. Dashed lines

Windbreak group [1]	Eastern redcedar, Rocky Mountain juniper		Ponderosa pine		Black Hills spruce and Colorado blue spruce		Caragana		Chokecherry		Honeysuckle	
	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
		Feet		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*
1	Good	11–13	Good	18–22	Good	16–20	Good	9–11	Good	11–14	Good	8–10
2	Good	11–13	Good	20–22	Good	15–18	Fair	7–9	Good	9–11	Good	7–9
3	Good	12–15	Good	18–22	Good	15–18	Good	8–10	Good	10–12	Good	8–10
4	Good	10–12	Good	17–19	Fair	15–18	Good	6–8	Good	8–10	Good	6–8
5	Good	9–11	Good	15–20	Poor	----------	Good	8–10	Good	8–10	Good	7–9
6	Fair	8–10	Fair	14–18	Poor	----------	Fair	7–9	Fair	7–9	Fair	6–8
9	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
10	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

[1] Windbreak groups 7 and 8 are not represented in Pembina County.

WINDBREAK SUITABILITY GROUP 9

The soils in this group are nearly level and are somewhat poorly drained and poorly drained. They have a medium-textured or fine-textured surface layer. Their subsoil is a claypan. No trees or shrubs grow well on these soils.

These soils are not suited to any types of windbreaks.

fox squirrel. Also, remnant populations of the only introduced game species—the gray partridge—are in the county.

Artificial impoundments, a limited number of natural wetlands, and the river systems provide habitat for waterfowl and opportunity for hunting.

Furbearers of economic importance in the county

and shrubs, by windbreak suitability groups

indicate that the site is poorly suited or unsuited to the specified kind of tree or shrub]

Wild plum		American elm		Cottonwood		Green ash		Russian-olive		Dropmore elm, Siberian elm, Chinlota elm	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Feet		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*

TABLE 4.—*Suitability of the soils for wildlife*

[Ratings in the column "Rangeland wildlife" marked by an asterisk are for woodland wildlife]

Soil	Open-land wildlife	Rangeland wildlife	Wetland wildlife
Arveson sandy loam	Fair	Fair	Fair.
Arveson loam	Fair	Fair	Fair.
Arveson soils, very wet	Very poor	Poor	Fair.
Barnes loam, 9 to 20 percent slopes	Fair	Fair	Very poor.
Bearden silty clay loam, 1 to 3 percent slopes	Good	Fair	Fair.
Bearden silty clay loam, 3 to 6 percent slopes	Good	Fair	Fair.
Bearden silty clay loam, saline, 1 to 3 percent slopes	Fair	Fair	Fair.
Bearden-Colvin silty clay loams	Fair	Fair	Good.
Bearden and Glyndon silt loams, 1 to 3 percent slopes	Good	Fair	Fair.
Binford sandy loam, 1 to 3 percent slopes	Fair	Poor	Very poor.
Binford sandy loam, 3 to 6 percent slopes	Fair	Poor	Very poor.
Borup silt loam	Fair	Fair	Good.
Brantford loam, 1 to 3 percent slopes	Fair	Poor	Very poor.
Brantford loam, 3 to 6 percent slopes	Fair	Poor	Very poor.
Brantford loam, 6 to 9 percent slopes	Fair	Poor	Very poor.
Brantford loam, 9 to 25 percent slopes	Poor	Very poor	Very poor.
Cashel silty clay, 1 to 3 percent slopes	Good	Fair	Fair.
Cashel silty clay, 3 to 6 percent slopes	Fair	Poor	Very poor.
Cashel silty clay, channeled	Poor	Poor	Very poor.
Claire loamy coarse sand, 1 to 6 percent slopes	Fair	Good	Very poor.
Clayey breaks	Fair	Fair	Very poor.
Colvin silt loam	Good	Fair	Good.
Colvin silt loam, saline	Good	Fair	Good.
Colvin silty clay loam	Good	Fair	Good.
Cormant loamy sand, 1 to 3 percent slopes	Fair	*Fair	Poor.
Divide loam, 1 to 3 percent slopes	Good	Fair	Poor.
Dovray silty clay	Poor	Poor	Good.
Egeland loam, 1 to 3 percent slopes	Fair	Good	Very poor.
Egeland loam, 3 to 6 percent slopes	Fair	Good	Very poor.
Embden fine sandy loam, 1 to 3 percent slopes	Good	Fair	Poor.

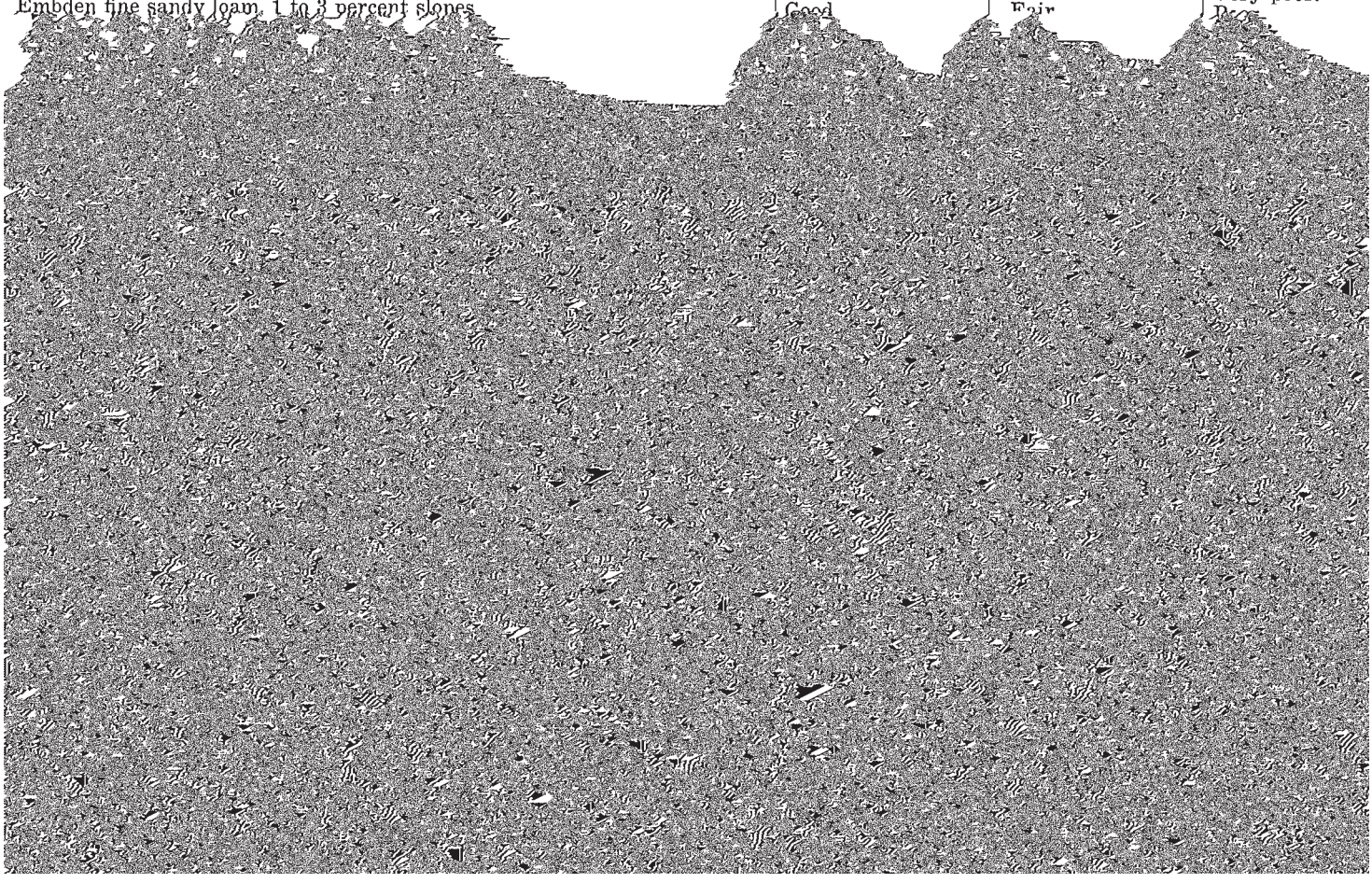


TABLE 4.–*Suitability of the soils for wildlife*—Continued

Soil	Open-land wildlife	Rangeland wildlife	Wetland wildlife
Peat	Very poor	Very poor	Good.
Perella silty clay loam	Good	Fair	Good.
Poppleton loamy sand, 1 to 3 percent slopes	Fair	*Poor	Poor.
Rauville silt loam	Poor	Poor	Good.
Renshaw loam, 1 to 3 percent slopes	Poor	Fair	Very poor.
Renshaw very stony loam, 1 to 6 percent slopes	Poor	Fair	Very poor.
Rolette silty clay loam, 1 to 3 percent slopes	Good	*Good	Poor.
Rough broken land	Poor	*Fair	Very poor.
Ryan-Fargo silty clays	Poor	Very poor	Fair.
Serden sand, 6 to 15 percent slopes	Poor	Fair	Very poor.
Swenoda fine sandy loam, 1 to 3 percent slopes	Good	Good	Poor.
Tiffany fine sandy loam	Fair	Fair	Fair.
Vang loam, 1 to 3 percent slopes	Good	Fair	Very poor.
Vang clay loam, 1 to 3 percent slopes	Fair	Fair	Very poor.
Vang-Walsh loams, 1 to 3 percent slopes	Good	Fair	Very poor.
Vang-Walsh loams, 3 to 6 percent slopes	Good	Fair	Very poor.
Vang loam, wet variant	Fair	Fair	Good.
Wahpeton silty clay, 1 to 3 percent slopes	Fair	Poor	Poor.
Wahpeton silty clay, 3 to 6 percent slopes	Fair	Poor	Very poor.
Wahpeton silty clay, 6 to 9 percent slopes	Fair	Poor	Very poor.

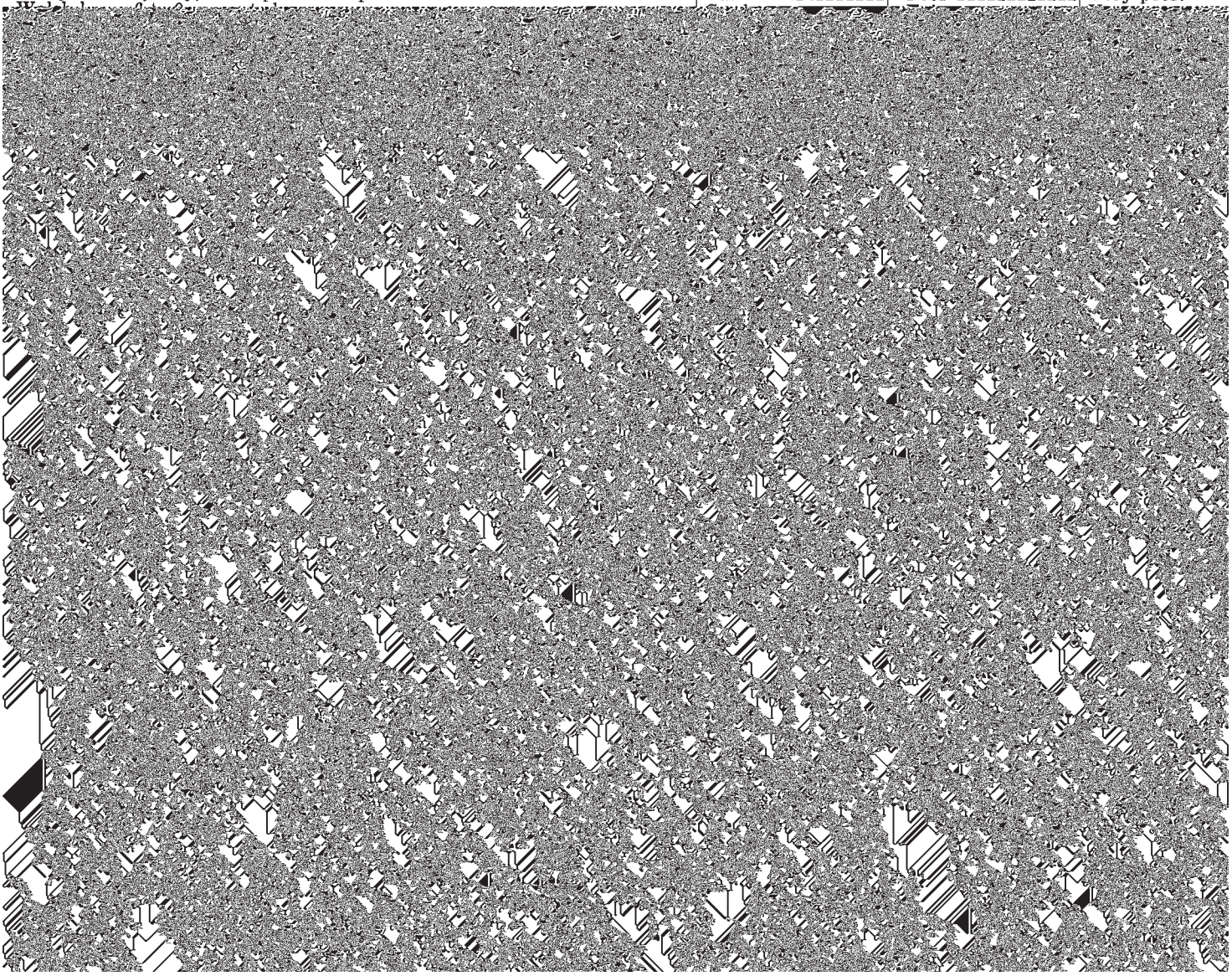


TABLE 5.—*Limitations of the soils for recreational uses*

Mapping unit	Camp areas	Picnic areas	Playgrounds	Paths and trails
Arveson sandy loam	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.
Arveson loam	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.
Arveson soils, very wet	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.
Barnes loam, 9 to 20 percent slopes	Moderate if slope is 9 to 15 percent; severe if 15 to 20.	Moderate if slope is 9 to 15 percent; severe if 15 to 20.	Severe: slope	None to slight if slope is 9 to 15 percent; moderate if 15 to 20.
Bearden silty clay loam, 1 to 3 percent slopes.	Moderate: somewhat poorly drained.	Moderate: silty clay loam texture.	Moderate: somewhat poorly drained.	Moderate: silty clay loam texture.
Bearden silty clay loam, 3 to 6 percent slopes.	Moderate: somewhat poorly drained.	Moderate: silty clay loam texture.	Moderate: somewhat poorly drained.	Moderate: silty clay loam texture.
Bearden silty clay loam, saline, 1 to 3 percent slopes	Moderate: somewhat poorly drained	Moderate: silty clay loam texture	Moderate: somewhat poorly drained	Moderate: silty clay loam

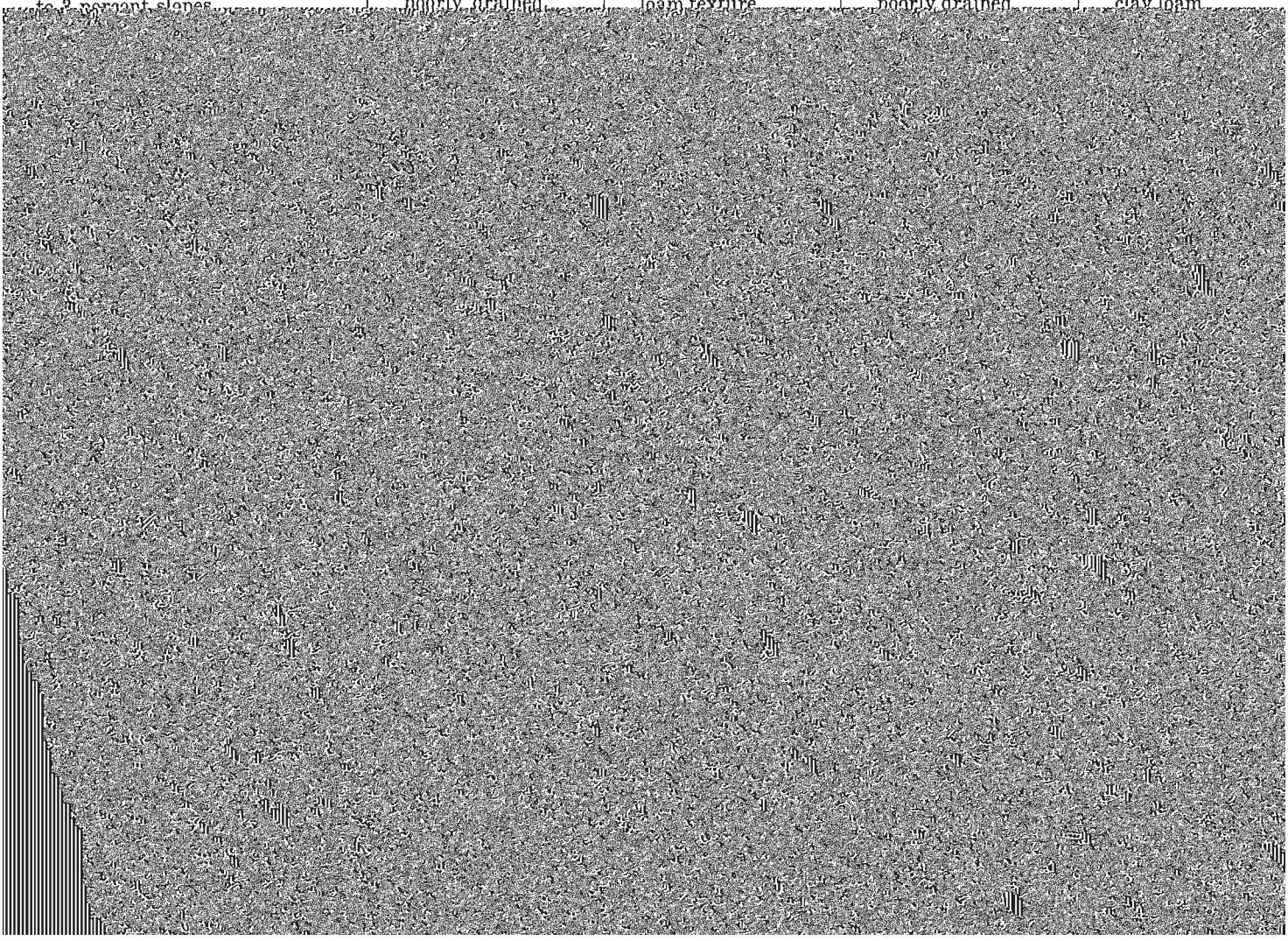


TABLE 5.—*Limitations of the soils for recreational uses*—Continued

Mapping unit	Camp areas	Picnic areas	Playgrounds	Paths and trails
Clayey breaks. Too variable to be rated.				
Colvin silt loam	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.
Colvin silt loam, saline	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.
Colvin silty clay loam	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.
Cormant loamy sand, 1 to 3 percent slopes.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Divide loam, 1 to 3 percent slopes	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Dowray silty clay	Severe: poorly	Severe: poorly	Severe: poorly	Severe: poorly

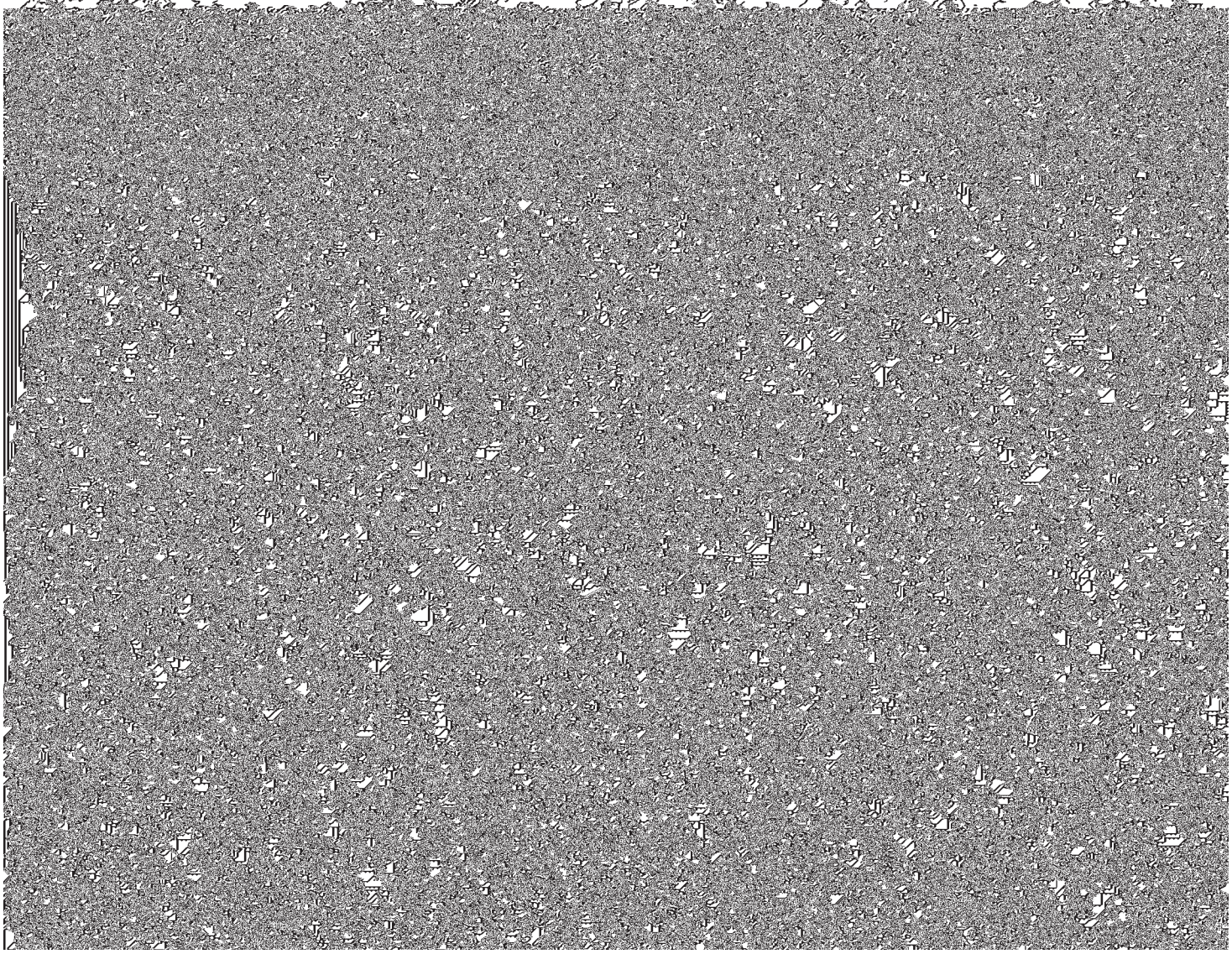


TABLE 5.—*Limitations of the soils for recreational uses*—Continued

Mapping unit	Camp areas	Picnic areas	Playgrounds	Paths and trails
Hamar fine sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Hecla loamy fine sand, 1 to 3 percent slopes.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
Hecla loamy fine sand, 3 to 6 percent slopes.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
Hecla sandy loam, 1 to 3 percent slopes.	None to slight	None to slight	None to slight	None to slight.
Hecla sandy loam, 3 to 6 percent slopes.	None to slight	None to slight	Moderate: slope	None to slight.
Hecla and Maddock soils, 9 to 25 percent slopes.	Moderate if slope is 9 to 15 percent; severe if 15 to 25.	Moderate if slope is 9 to 15 percent; severe if 15 to 25.	Severe: slope	Moderate: too sandy.
Hegne silty clay, saline	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.
Hegne-Fargo silty clays, 1 to 3 percent slopes.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.
Hegne-Fargo silty clays, 3 to 6 percent slopes.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.
Lamoure silt loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Lankin loam, 1 to 3 percent slopes	None to slight	None to slight	None to slight	None to slight.
Lankin and Gilby stony loams, 1 to 3 percent slopes.	Moderate: large stones.	None to slight	Moderate: large stones.	Moderate: large stones.
La Prairie loams, 1 to 3 percent slopes.	Moderate to severe: floods.	Slight to moderate: floods.	Slight to moderate: floods.	Slight to moderate: floods.
La Prairie silty clay loam, 1 to 3 percent slopes.	Moderate to severe: floods.	Slight to moderate: floods.	Slight to moderate: floods.	Slight to moderate: floods.
La Prairie silty clay loam, 3 to 6 percent slopes.	Moderate to severe: floods.	Slight to moderate: floods.	Slight to moderate: floods.	Slight to moderate: floods.
La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes.	Severe: floods	Moderate if slope is 9 to 15 percent; severe if more than 15.	Severe: slope	Moderate: slope.
Maddock loamy sand, 1 to 3 percent slopes.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
Maddock loamy sand, 3 to 6 percent slopes.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
Maddock sandy loam, 1 to 3	None to slight	None to slight	None to slight	None to slight

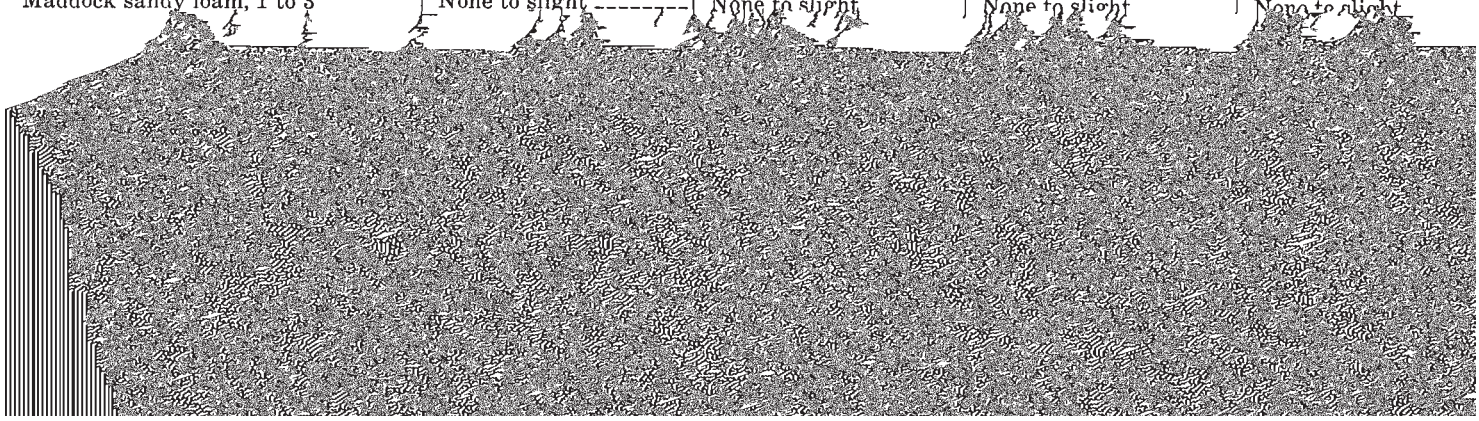


TABLE 5.—*Limitations of the soils for recreational uses*—Continued

Mapping unit	Camp areas	Picnic areas	Playgrounds	Paths and trails
Neche silty clay	Moderate: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture.
Ojata silt loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Olga silty clay loam, 3 to 6 percent slopes.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.	Moderate: silty clay loam texture.
Olga silty clay loam, 9 to 25 percent slopes.	Moderate if slope is 9 to 15 percent; severe if 15 to 25	Moderate if slope is 9 to 15 percent; severe if 15 to 25	Severe: slope	Moderate: silty clay loam

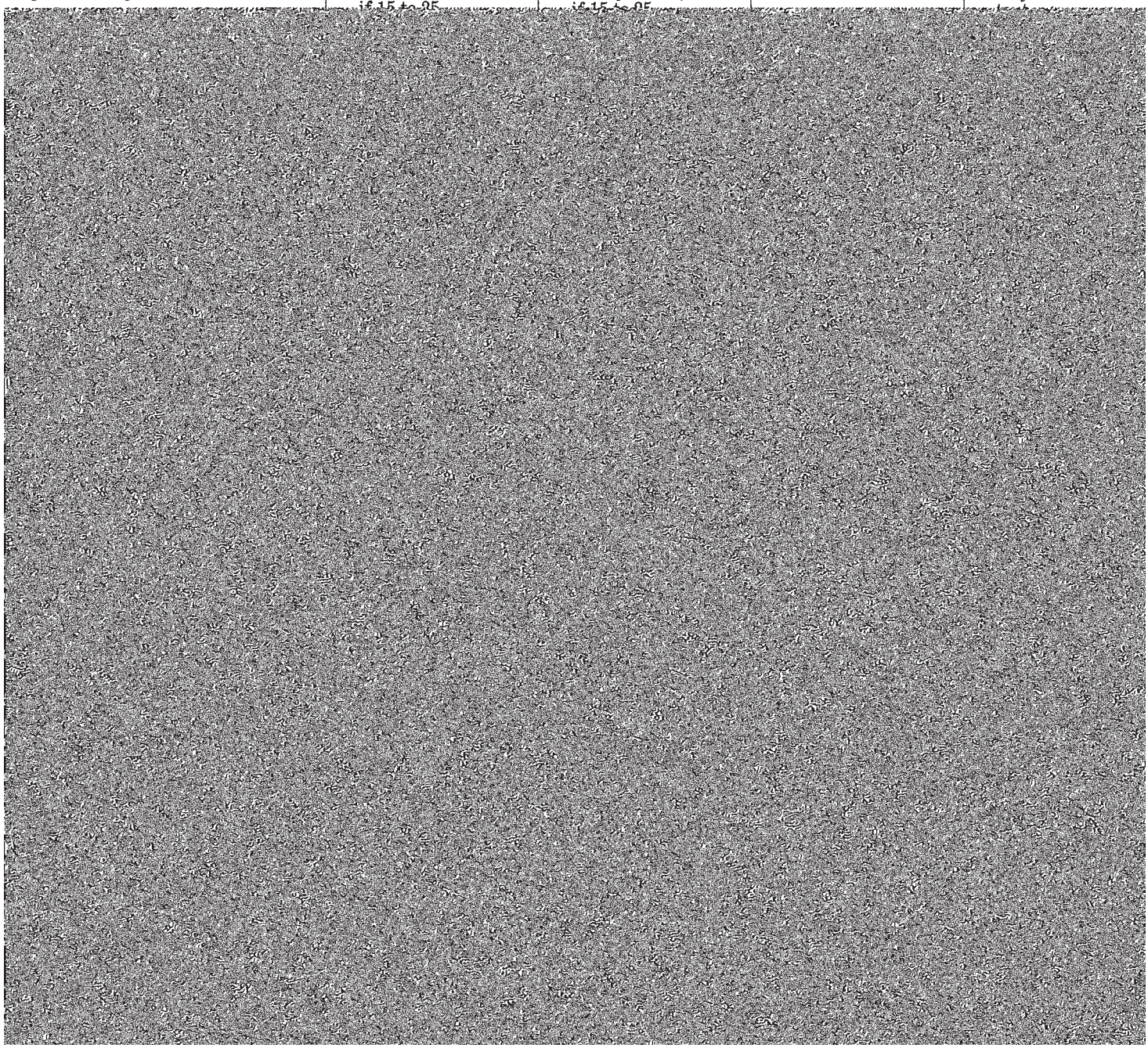


TABLE 5.—*Limitations of the soils for recreational uses*—Continued

Mapping unit	Camp areas	Picnic areas	Playgrounds	Paths and trails
Wahpeton silty clay, 6 to 9 percent slopes.	Severe: silty clay texture.	Severe: silty clay texture.	Severe: silty clay texture; slope.	Severe: silty clay texture.
Walsh loam, 6 to 9 percent slopes	None to slight	None to slight	Severe: slope	None to slight.
Walsh loam, 9 to 15 percent slopes	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
Walsh clay loam, 1 to 3 percent slopes.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.
Waukon loam, 1 to 3 percent slopes	None to slight	None to slight	None to slight	None to slight.
Waukon loam, 3 to 6 percent slopes	None to slight	None to slight	Moderate: slope	None to slight.
Waukon loam, 6 to 9 percent slopes	None to slight	None to slight	Severe: slope	None to slight.
Waukon loam, 9 to 15 percent slopes	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
Wheatville very fine sandy loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Zell-Gardena very fine sandy loams, 6 to 9 percent slopes.	None to slight if slope is 6 to 8 percent; moderate if 8 to 9.	None to slight if slope is 6 to 8 percent; moderate if 8 to 9.	Severe: slope	None to slight.
Zell-Gardena very fine sandy loams, 9 to 15 percent slopes.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.

samples of soils for engineering are the Unified system (*7*) used by the SCS engineers, Department of Defense, and others, and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building materials or for building foundations. Soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content, and they are grouped into 15 classes. Eight classes of coarse-grained soils are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of plasticity index. These are ML, MH, OL, and OH, all of which have a low plasticity index, and CL and CH, both of which are highly plastic. One class of highly organic soils, Pt, is in the system. Soils on the borderline between two classes are designated by symbols for both classes; for example CL–ML.

The AASHTO system is used to classify soils according to properties that affect their use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The estimated AASHTO classification, without index group numbers, is shown in table 5 for all soils mapped in the survey area.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary. Stones, cobbles, and gravel are used as textural modifiers where they are present in the soil.

Estimated soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 6. These estimates are made for each layer of representative profiles for each series having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Because bedrock is more than 5 feet below the surface of soils in Pembina County, no estimates have been made of their depth. In the following paragraphs are explanations of some of the columns in table 6.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in the standard terms used by the United States Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in the fraction of the soil that passes the 2 milli-

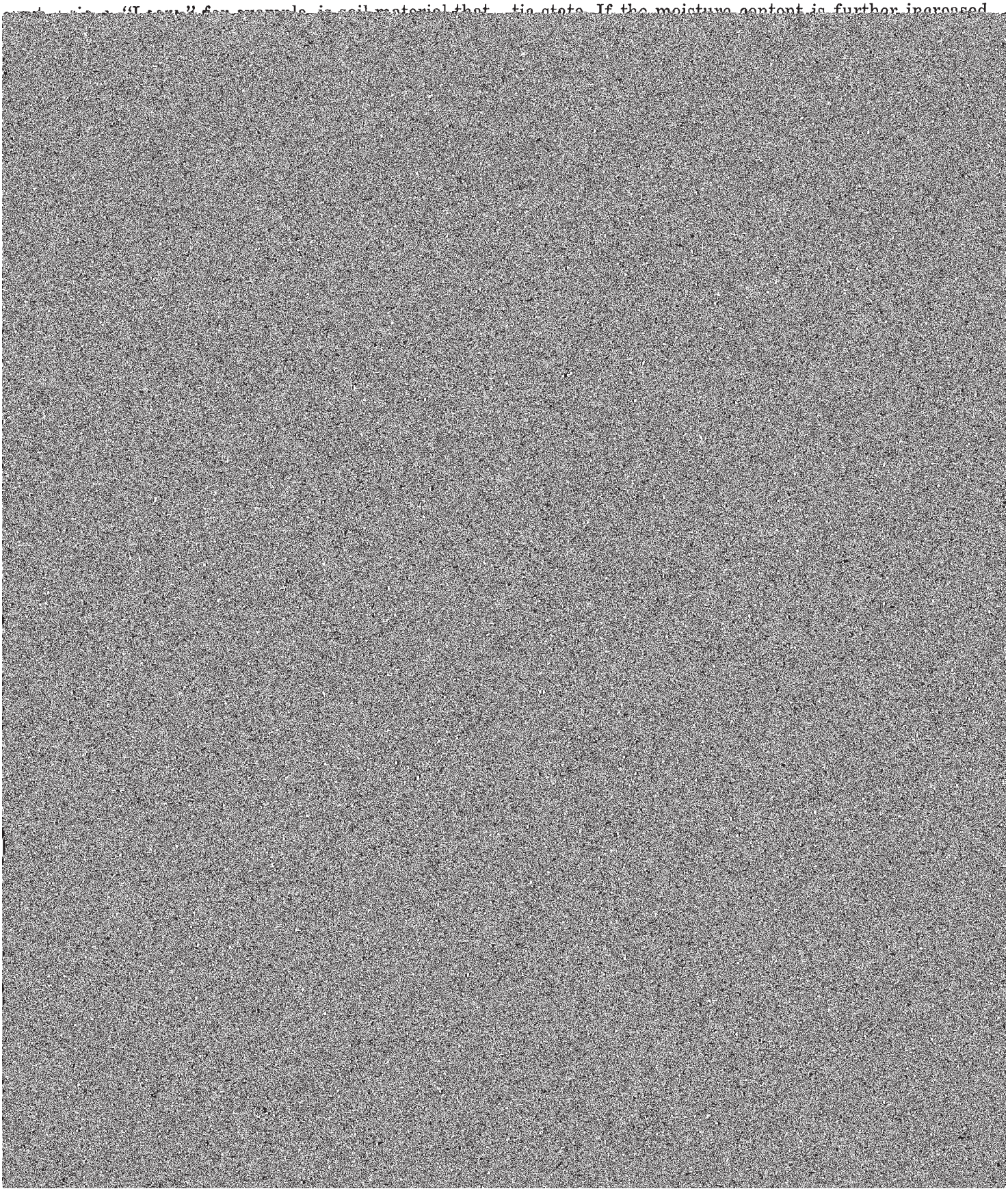
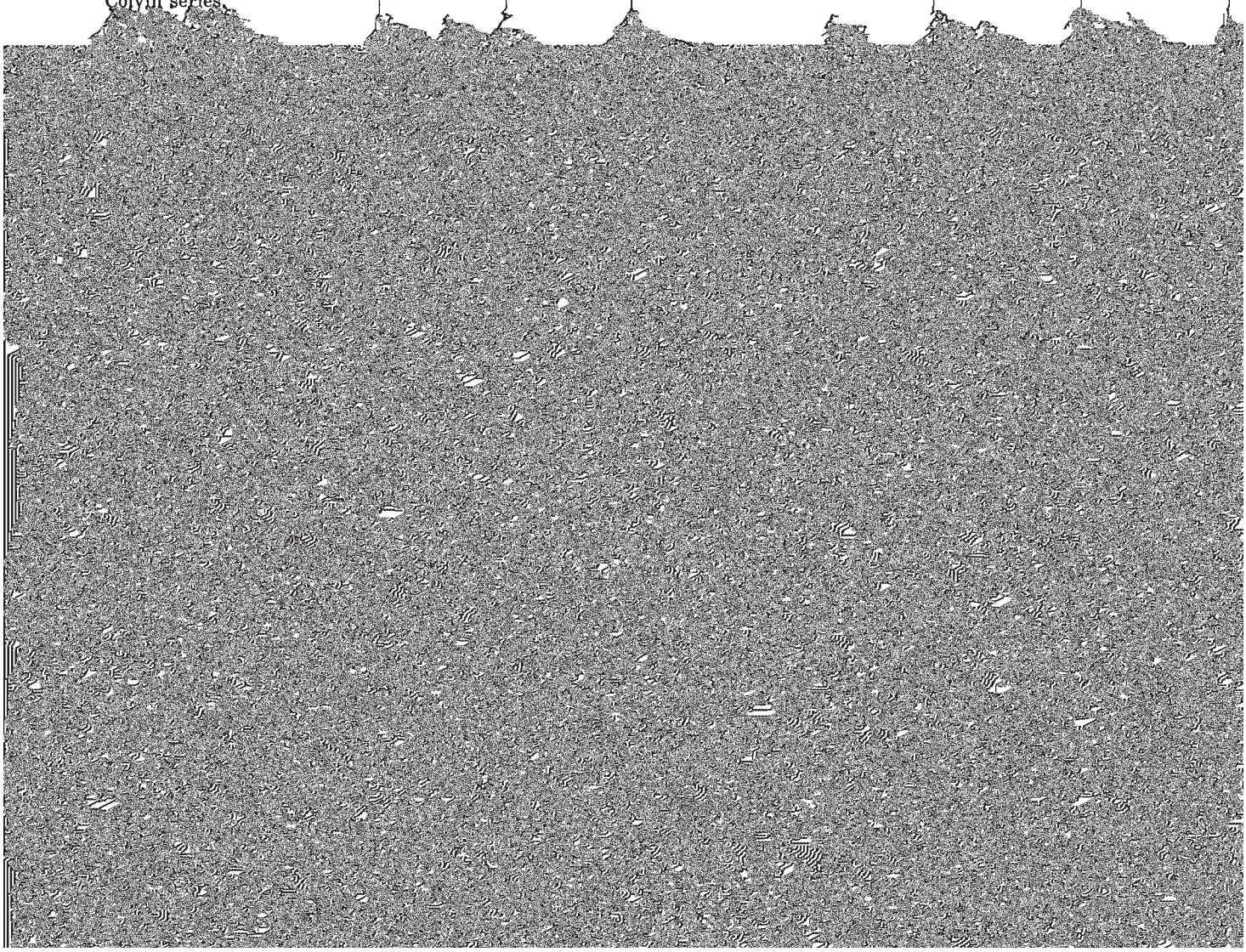


TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The instructions for referring to another series in the first column of this

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
Arveson: Ar, Av, Aw	0–3	0–17	Sandy loam, loam	SM, ML	A–2 or A–4
		17–30	Loamy sand	SM	A–2
		30–60	Fine sand	SM	A–2
Barnes: BaD	(2)	0–31	Loam	ML or CL	A–4 or A–6
		31–60	Loam	ML or CL	A–4 or A–6
*Bearden: BnA, BnB, Bs	3–5	0–60	Silty clay loam	CL	A–6 or A–7
For Colvin part of Bs, see Colvin series.					



significant in engineering

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the table. The symbol > means more than; the symbol < means less than.

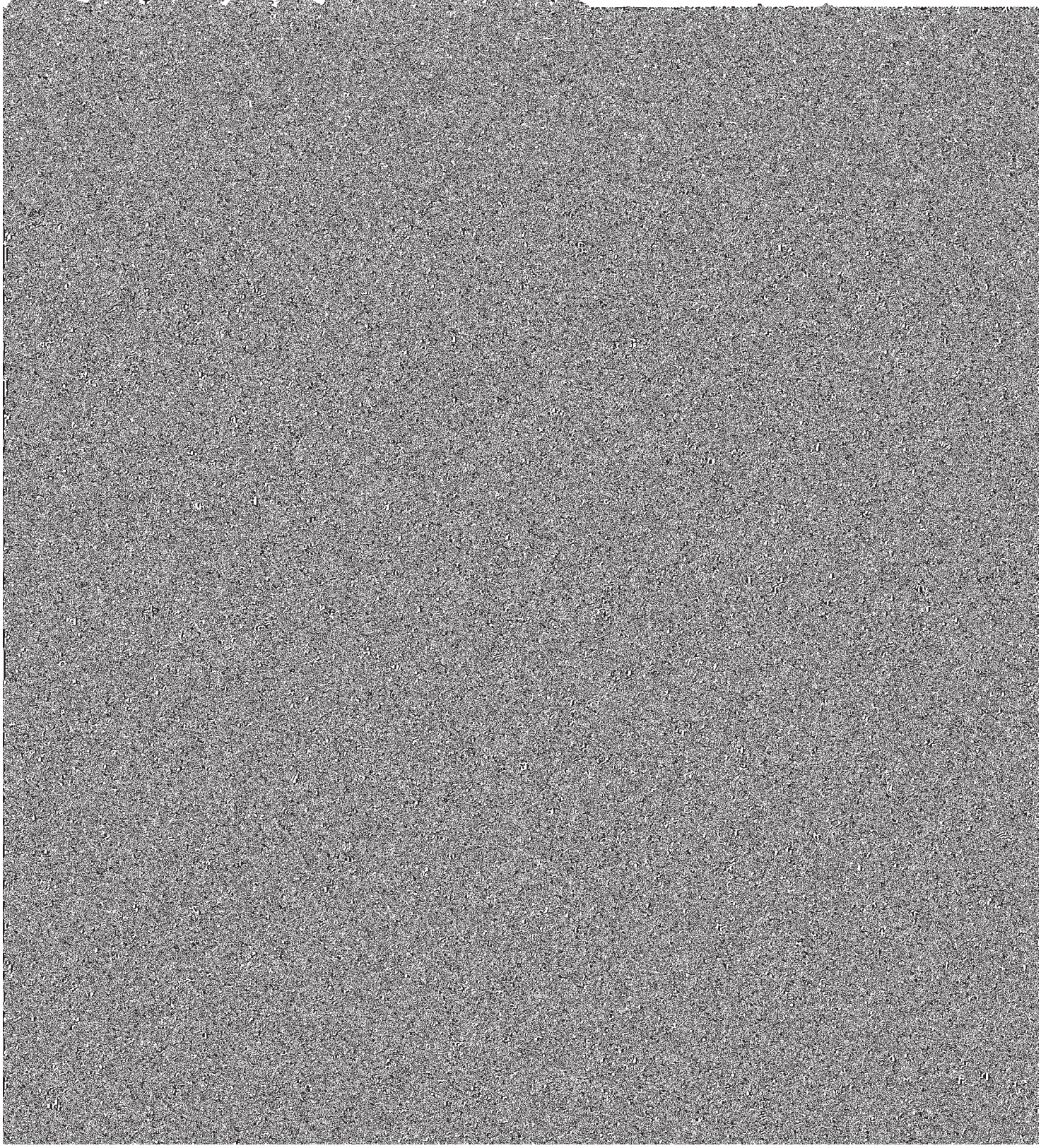


TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
Fairdale: FaA, FaB	(2)	0–38	Silty clay loam	CL	A–7
		38–46	Silt loam	ML or CL	A–4 or A–6
		46–60	Silt and sandy loam	SM or ML	A–2 or A–4
Fargo: Ff	3–5	0–60	Silty clay	CH	A–7
Gardena: GaA	(2)	0–60	Very fine sandy loam	ML	A–4

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—		Liquid limit	Plasticity index
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.047 mm)						Uncoated steel	Concrete		
				Inches per hour	*Inches per inch of soil*	*pH*						
	100	95–100	85–95	0.6–2.0	0.16–0.20	7.9–8.4	None	High	High	Low	40–50	15–30
	100	90–100	70–90	0.6–2.0	0.15–0.18	7.9–8.4	None	Moderate	High	Low	20–40	0–10
	100	65–95	35–95	0.6–2.0	0.15–0.18	7.9–8.4	None	Low to moderate.	High	Low	5–35	0–10
	100	95–100	85–100	0.06–0.2	0.15–0.19	7.4–8.5	None	High	High	Low	50–70	25–45
	100	85–95	50–65	0.6–2.0	0.17–0.20	7.4–8.4	None	Low	High	Low	20–35	0–10
[3] 95–100	90–100	80–95	60–75	0.6–2.0	0.16–0.19	7.9–8.4	Low	Low	High	Low	20–45	5–15
[illegible]	[illegible]	[illegible]	[illegible]	0.6–2.0	0.19–0.20	7.9–8.4	Moderate	Moderate	High	Low	30–45	10–30

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
Maddock: MaA, MaB, MbA, MbB	(2)	0–31	Sandy loam and loamy sand	SM	A–2
		31–60	Fine and medium sand	SM	A–2
Maddock variant: McB	3–5	0–60	Loamy sand and sand	SM	A–2 or A–3
McDonaldsville: Mf	3–5	0–30	Silty clay and clay	CH	A–7
		30–60	Loamy sand	SM	A–2
Nahon: Na	3–5	0–14	Silt loam	ML	A–4
		14–60	Silty clay	CH	A–7
Neche:					
Ng	(2)	0–42	Silty clay loam, clay loam	CL	A–6 or A–7
		42–60	Silt loam and loam	ML or CL	A–4 or A–6
Nh	(2)	0–13	Silty clay	CH	A–7
		13–18	Silt loam	ML	A–4
		18–25	Silty clay	CH	A–7
		25–31	Silt loam	ML	A–4
		31–60	Clay	CH	A–7
Ojata: Oa	3–5	0–8	Silt loam	ML or CL	A–4 or A–6
		8–60	Silty clay loam, silt, and clay	ML or CL	A–7
Olga: OgB, OgE	(2)	0–10	Silty clay loam	CL or CH	A–7
		10–60	Silty clay	CH	A–7
Overly: OvA	(2)	0–60	Silty clay loam	CL	A–7
Peat: Pa	0–3	0–60	Organic	----------	----------
Perella: Pu	0–3	0–24	Silty clay loam	CL	A–7
		24–52	Silt loam	ML or CL	A–6
		52–60	Silty clay loam	CL	A–7
Poppleton: PyA	2–4	0–25	Loamy sand	SM	A–2
		25–60	Fine and medium sand	SM	A–2
Rauville: Ra	0–2	0–40	Silt loam and silty clay loam	CL	A–6 or A–7
		40–60	Fine sandy loam, sandy loam, and sand.	SM	A–2 or A–4
Renshaw:					
RbA	(2)	0–7	Loam	ML	A–4
		7–16	Gravelly loam	ML	A–4
		16–60	Very gravelly sand	GM or GP	A–1
RfB	(2)	0–15	Loam	ML	A–4
		15–60	Very gravelly sand	GM or GP	A–1
Rolette: RoA	(2)	0–18	Silty clay loam and clay loam	CL or CH	A–6 or A–7
		18–60	Silty clay	CH	A–7
Rough broken land: Rp. Too variable for valid estimates.	(2)				
*Ryan: Rr	3–5	0–60	Silty clay and clay	CH	A–7
For Fargo part, see Fargo series.					
Serden: SnD	(2)	0–60	Sand	SP or SM	A–2 or A–3

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—		Liquid limit	Plasticity index
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.047 mm)						Uncoated steel	Concrete		
				Inches per hour	*Inches per inch of soil*	*pH*						
----	100	55–75	15–35	6.0–20.0	0.10–0.12	6.1–7.3	None	Low	Moderate	Low	NP	NP
100	95–100	55–75	15–35	6.0–20.0	0.07–0.09	7.4–7.8	None	Low	Moderate	Low	NP	NP
100	95–100	55–85	5–30	6.0–20.0	0.06–0.09	5.1–7.3	None	Low	Moderate	Low	NP	NP
----	100	95–100	85–95	0.06–0.2	0.16–0.18	6.1–8.4	None	High	High	Low	40–70	25–50
----	100	55–75	15–30	6.0–20.0	0.11–0.13	7.9–8.4	None	Low	High	Low	NP	NP
----	100	85–95	70–85	0.6–2.0	0.16–0.20	7.9–8.4	Low	Moderate	High	Moderate	25–40	0–10
----	100	95–100	90–95	<0.06	0.10–0.12	7.9–8.4	Moderate to high.	High	High	Moderate	50–70	25–50
----	100	95–100	85–95	0.2–0.6	0.15–0.20	7.4–8.4	None	High	High	Low	30–50	10–30
----	100	85–95	60–85	0.2–0.6	0.14–0.20	7.9–8.4	None	Moderate	High	Low	25–40	5–20
----	100	95–100	90–95	0.2–0.6	0.14–0.18	7.4–8.4	None	High	High	Low	50–70	25–40
----	100	100	90–100	0.2–0.6	0.16–0.17	7.4–8.4	None	Low	High	Low	25–40	0–10
----	100	95–100	90–95	0.2–0.6	0.14–0.18	7.9–8.4	None	High	High	Low	50–70	25–40
----	100	100	90–100	0.2–0.6	0.16–0.17	7.9–8.4	None	Low	High	Low	25–40	0–10
----	100	90–100	75–95	0.2–0.6	0.14–0.18	7.9–8.4	None	High	High	Low	50–70	25–40
----	100	90–100	70–90	0.06–0.2	0.05–0.10	7.9–8.4	Very high	Moderate	High	High	25–40	5–20
----	100	95–100	85–95	0.06–0.2	0.05–0.10	7.9–8.4	Very high	Moderate	High	High	40–50	10–25
95–100	95–100	90–100	85–90	0.2–0.6	0.16–0.23	5.6–6.5	None	High	High	Moderate	30–60	10–40
95–100	95–100	85–95	80–90	0.06–0.2	0.13–0.16	5.1–6.0	None	High	High	Moderate to high.	50–70	25–45
----	100	95–100	85–95	0.2–0.6	0.16–0.19	6.6–8.4	None	Moderate to high.	High	Low	40–50	15–35
----	----	----	----	2.0–6.0	0.05–0.10	7.9–8.4	None	----	Moderate	Low.		
----	100	95–100	85–95	0.2–0.6	0.18–0.20	6.6–7.8	None	Moderate	High	Low	40–50	15–30
----	100	90–100	70–90	0.2–0.6	0.16–0.20	7.4–8.4	None	Moderate	High	Low	25–40	10–30
----	100	95–100	85–95	0.2–0.6	0.16–0.18	7.9–8.4	None	Moderate	High	Low	40–50	15–30
----	100	50–75	15–30	6.0–20.0	0.08–0.10	5.6–6.5	None	Low	Moderate	Low	NP	NP
100	95–100	55–75	15–35	6.0–20.0	0.07–0.09	5.6–6.5	None	Low	Moderate	Low	NP	NP
----	100	95–100	85–95	0.06–0.2	0.10–0.22	7.4–8.4	None	High	High	Low	30–50	10–30
----	100	50–70	5–40	0.2–0.6	0.03–0.06	7.9–8.4	None	Low	High	Low	NP	NP
100	90–100	85–95	60–75	2.0–6.0	0.18–0.20	7.4–7.8	None	Low	Moderate	Low	20–35	0–10
70–90	65–85	60–75	50–60	2.0–6.0	0.13–0.15	7.4–7.8	None	Low	Moderate	Low	NP	NP
[3] 25–40	20–30	10–20	3–15	>20.0	0.03–0.06	7.9–8.4	None	Low	Moderate	Low	NP	NP
[4] 100	90–100	85–95	60–75	2.0–6.0	0.18–0.20	7.4–7.8	None	Low	Moderate	Low	20–35	0–10
[4] 25–40	20–30	10–20	3–15	>20.0	0.03–0.06	7.4–8.4	None	Low	Moderate	Low	NP	NP
----	100	90–100	70–95	0.6–2.0	0.16–0.20	6.6–7.3	None	High	Moderate	Low	40–70	20–40
----	100	95–100	90–95	0.2–0.6	0.15–0.17	6.6–7.8	None	High	Moderate	Low	50–70	25–45
----	100	95–100	90–95	<0.06	0.10–0.14	7.9–8.4	Moderate to high.	High	High	Moderate	50–70	25–45
----	100	50–70	5–15	6.0–20.0	0.05–0.07	6.1–6.5	None	Low	Moderate	Moderate	NP	NP

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
Swenoda: SwA	(2)	0–16	Sandy loam and fine sandy loam.	SM	A–4
		16–21	Loamy sand	SM	A–2
		21–35	Clay loam	CL	A–6 or A–7
		35–60	Very fine sandy loam, loamy sand, and sand.	SM	A–2 or A–3
Tiffany: Tf	1–3	0–35	Fine sandy loam	SM	A–4
		35–60	Fine and very fine sand	SM	A–2 or A–4
*Vang:					
VaA, VwA, VwB	(2)	0–26	Loam	ML	A–4
For Walsh parts of VwA and VwB, see Walsh series.		26–60	Gravel and coarse sand	GM or SM	A–1 or A–2
VbA	(2)	0–18	Clay loam	CL	A–6 or A–7
		18–26	Gravelly clay loam	CL	A–6 or A–7
		26–60	Gravel and coarse sand	GM or SM	A–1 or A–2
Vang variant: Vy	0–3	0–12	Loam	ML	A–4
		12–30	Clay loam and sandy clay loam.	CL or SC	A–6 or A–7
		30–60	Coarse sand and gravel	GM or SM	A–1 or A–2
Wahpeton: WaA, WaB, WaC	(2)	0–60	Silty clay and silty clay loam	CH	A–7
Walsh:					
WhC, WhD	(2)	0–10	Loam	ML or CL	A–4 or A–6
		10–44	Clay loam	CL	A–6 or A–7
		44–60	Coarse sand-sized shale particles.	SM	A–1 or A–2
WnA	(2)	0–60	Clay loam	CL	A–6 or A–7
Waukon: WoA, WoB, WoC, WoD	(2)	0–6	Loam	ML	A–4
		6–36	Clay loam	CL	A–6 or A–7
		36–40	Sandy loam	SM	A–4 or A–2
		40–60	Clay loam	CL	A–6 or A–7
Wheatville: Wv	1–4	0–30	Very fine sandy loam	ML	A–4
		30–60	Silty clay	CH	A–7
*Zell: ZgC, ZgD	(2)	0–34	Very fine sandy loam	ML	A–4
For Gardena part, see Gardena series.		34–60	Silt loam	ML	A–4

[1] Nonplastic.

[2] More than 5 feet.

ment. Those that affect the pond floor are permeability, organic matter, and slope; and if the floor needs to be leveled, depth to bedrock is important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification System and the amounts 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 5 feet; for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of large stones, and absence of flooding or a high water table.

Dwellings with basements, as rated in table 7, are houses not more than three stories high that 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

significant in engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—		Liquid limit	Plasticity index
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.047 mm)						Uncoated steel	Concrete		
				Inches per hour	*Inches per inch of soil*	*pH*						
100	90–100	70–85	35–50	2.0–6.0	0.10–0.14	7.9–8.4	None	Low	Moderate	Low	20–30	0–10
----	100	55–75	15–30	2.0–6.0	0.06–0.10	7.9–8.4	None	Low	Moderate	Low	NP	NP
----	100	90–100	70–80	0.2–0.6	0.16–0.18	7.9–8.4	None	Moderate	Moderate	Low	20–50	10–25
----	100	55–75	5–30	2.0–6.0	0.05–0.07	7.9–8.4	None	Low	Moderate	Low	NP	NP
100	90–100	70–85	35–50	0.6–2.0	0.15–0.17	6.1–8.4	None	Low	High	Low	20–40	0–10
----	100	65–85	20–45	2.0–6.0	0.08–0.12	7.9–8.4	None	Low	High	Low	NP	NP
95–100	95–100	80–90	55–70	0.6–2.0	0.17–0.22	6.6–7.3	None	Low	High	Low	20–40	0–10
30–70	25–65	20–60	10–30	6.0–20.0	0.06–0.09	6.6–7.3	None	Low	High	Low	NP	NP
95–100	90–95	80–90	60–75	0.6–2.0	0.17–0.19	6.1–6.5	None	Low	High	Low	30–50	10–30
85–100	80–90	70–80	60–75	0.6–2.0	0.17–0.19	6.6–7.8	None	Low	High	Low	20–45	10–30
30–70	25–65	20–60	10–30	6.0–20.0	0.04–0.06	6.6–7.3	None	Low	High	Low	NP	NP
----	100	85–95	60–75	0.6–2.0	0.17–0.20	7.4–7.8	None	Low	High	Low	20–40	0–10
95–100	90–100	80–100	40–80	0.6–2.0	0.17–0.19	7.9–8.4	None	Low	High	Low	30–45	10–30
30–70	25–65	20–60	10–30	6.0–20.0	0.04–0.06	7.9–8.4	None	Low	High	Low	NP	NP
----	100	95–100	90–95	0.6–2.0	0.15–0.18	7.4–8.4	None	High	High	Low	50–70	25–45
95–100	95–100	85–95	65–75	0.6–2.0	0.17–0.20	6.1–6.5	None	Moderate	Moderate	Low	25–40	5–20
90–100	90–95	85–95	60–80	0.6–2.0	0.17–0.19	5.6–6.5	None	Moderate	Moderate	Low	25–45	10–30
85–100	80–90	35–65	15–30	6.0–20.0	0.05–0.08	6.1–6.5	None	Low	Moderate	Low	NP	NP
90–100	90–95	85–95	60–80	0.6–2.0	0.17–0.19	6.1–7.3	None	Moderate	Moderate	Low	25–45	10–30
[3] 95–100	90–95	80–90	55–70	0.6–2.0	0.17–0.19	6.6–7.3	None	Low	High	Low	25–35	0–10
[3] 95–100	95–100	85–95	60–80	0.6–2.0	0.16–0.18	6.1–7.8	None	Moderate	High	Low	25–45	10–30
----	100	60–70	30–40	2.0–6.0	0.11–0.13	7.9–8.4	None	Low	High	Low	NP	NP
[3] 95–100	95–100	85–95	60–80	0.6–2.0	0.16–0.18	7.9–8.4	None	Moderate	High	Low	25–45	10–30
----	100	85–95	50–65	2.0–6.0	0.15–0.18	7.9–8.4	None	Low	High	Low	20–35	0–10
----	100	95–100	90–95	0.06–0.2	0.17–0.19	7.9–8.4	None	High	High	Low	50–70	25–45
----	100	85–95	50–65	0.6–2.0	0.15–0.18	7.9–8.4	None	Low	Moderate	Low	20–35	0–10
----	100	90–100	70–90	0.6–2.0	0.16–0.19	7.9–8.4	None	Low	Moderate	Low	25–40	0–10

[3] Five percent of material tested is larger than 3 inches.

[4] Contains up to 70 percent by volume of stones.

capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 5 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil

TABLE 7.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The instructions for referring to another

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Arveson: Ar, Av, Aw	Severe: high seasonal water table.	Severe: high seasonal water table; moderately rapid permeability.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained; high seasonal water table; moderately rapid permeability.	Severe: poorly drained and very poorly drained.
Barnes: BaD	Severe: moderately slow permeability in substratum.	Severe: slope	Moderate if slope is less than 15 percent; severe if more than 15.	Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent.	Slight if slope is less than 15 percent; moderate if more than 15.	Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent.
*Bearden: BnA, BnB, Bs, BvA. For Colvin part of Bs, see Colvin series. For Glyndon part of BvA, see Glyndon series.	Severe: moderately slow permeability; high seasonal water table.	Moderate: high seasonal water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high seasonal water table.	Severe: high potential frost action.
BrA	Severe: moderately slow permeability; high seasonal water table.	Moderate: high seasonal water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high seasonal water table.	Severe: high potential frost action.
Binford: BvA, BwB	Slight: no-	Severe: rapid	Severe:	Slight	Severe:	Slight

engineering properties of the soils

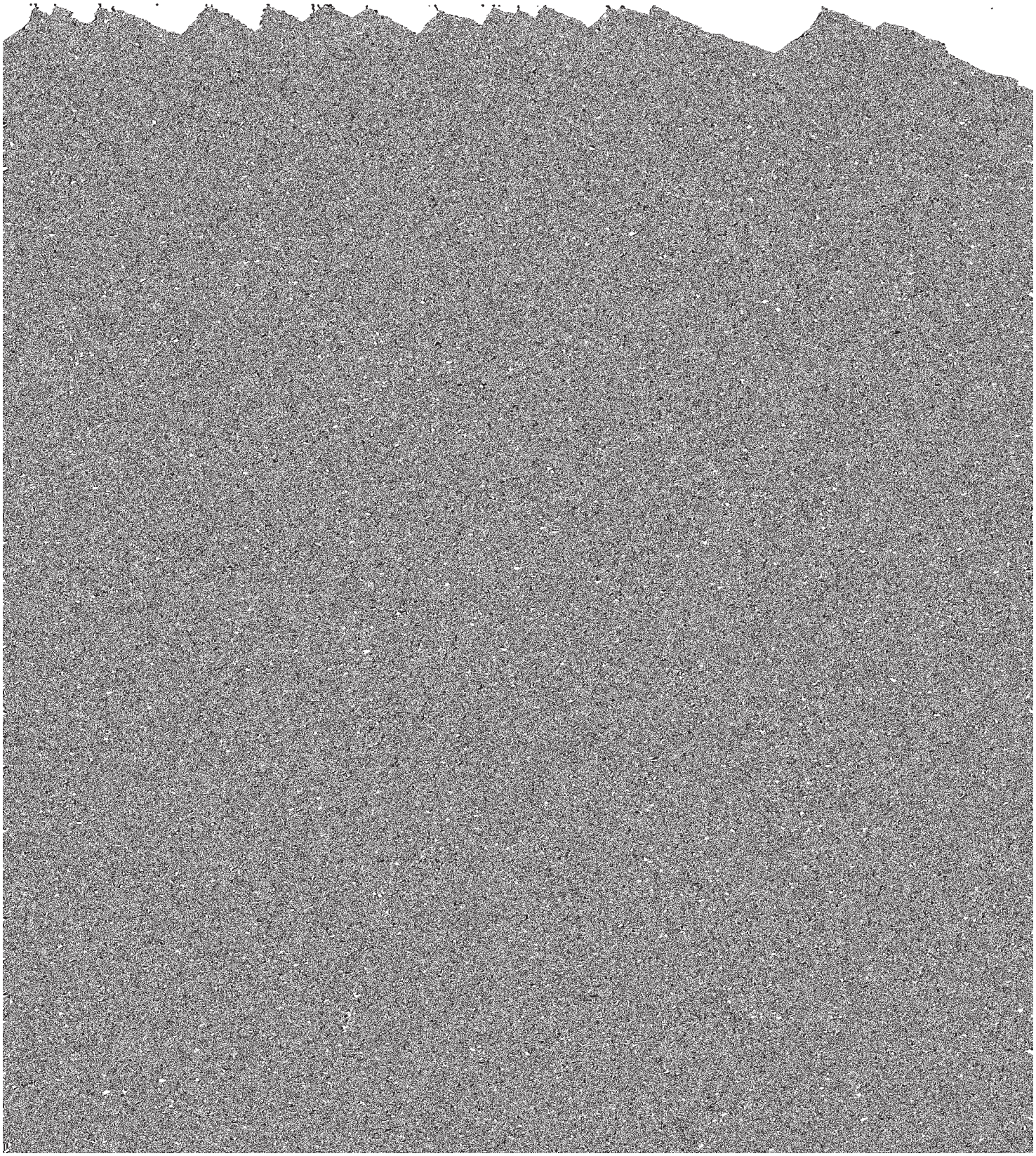


TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Cashel: Ca, CaA, CaB	Severe: subject to flooding; moderately slow permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding.	Severe: high shrink-swell potential; subject to flooding.
Claire: CbB	Slight: potential pollution hazard.	Severe: rapid permeability.	Slight	Slight	Severe: too sandy.	Slight
Clayey breaks: Cd. Too variable for valid interpretations.						
Colvin: Cf, Ch	Severe: high seasonal water table; moderately slow permeability.	Severe: high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.
Cg	Severe: high seasonal water table; moderately slow permeability.	Severe: high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.	Severe: poorly drained and very poorly drained; high seasonal water table.
Cormant: CoA	Severe: high seasonal water table.	Severe: high seasonal water table.	Severe: high seasonal water table.	Severe: high seasonal water table.	Severe: high seasonal water table.	Severe: poorly drained.
Divide: DdA	Moderate to severe; high seasonal water table.	Severe: very rapid permeability in substratum; high seasonal water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high seasonal water table.	Moderate: somewhat poorly drained.

engineering properties of the soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Poor: high shrink-swell potential.	Unsuited	Poor: clay texture.	Moderately slow permeability.	Fair to poor compaction characteristics; medium to low shear strength; high compressibility; high shrink-swell potential.	Subject to flooding.	Slow intake; moderately slow permeability; subject to flooding.	Clayey materials.	Not needed.
Good	Fair: excessive fines.	Poor: sandy texture.	Rapid permeability.	Susceptible to piping.	Not needed	Rapid permeability; very low available water capacity; slope is 1 to 6 percent.	Erodes easily.	Not needed.
Poor:	Unsuited	Poor:	High sea-	Medium to low	Poor outlets;	Moderately	Not	Not

TABLE 7.—*Interpretations of*

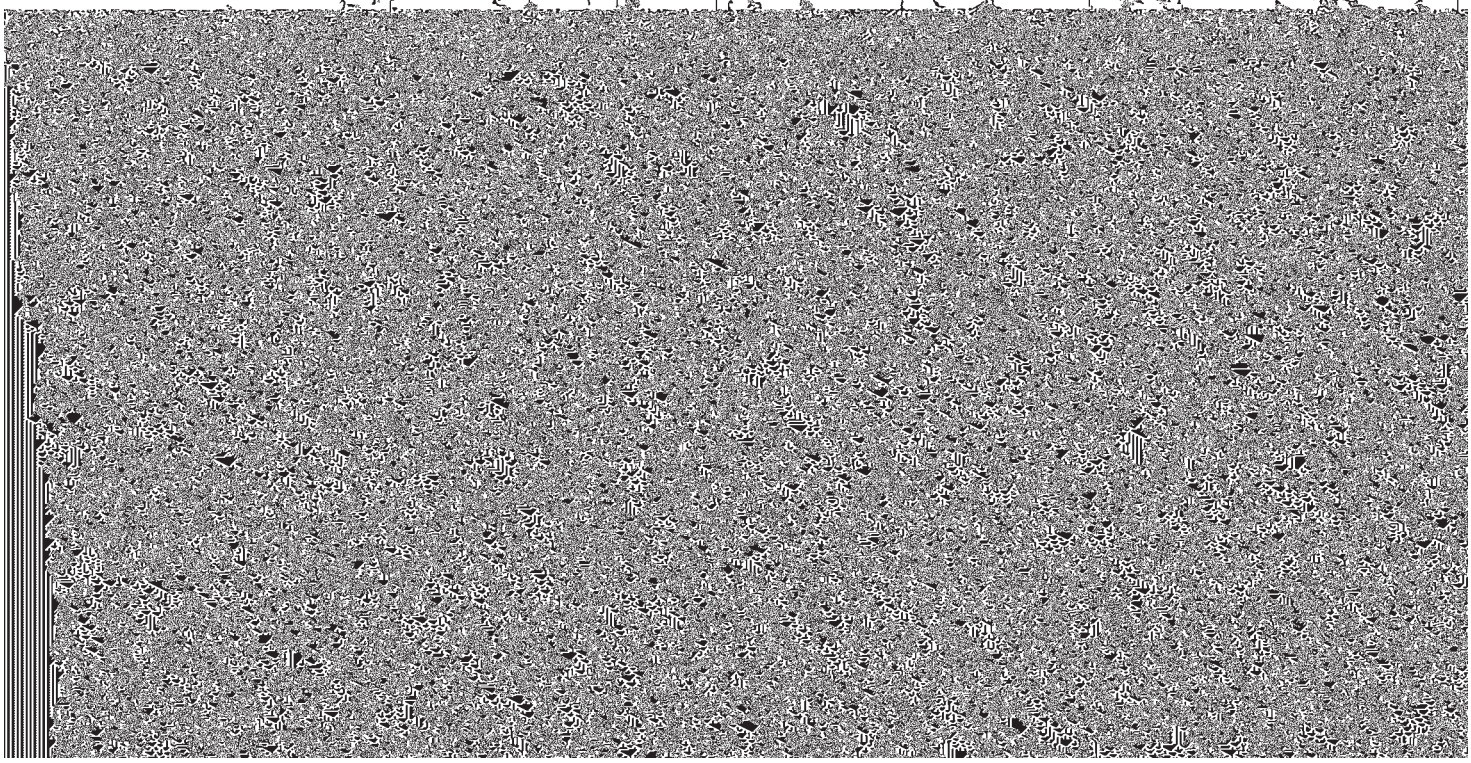
Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Dovray: Do	Severe: slow permeability.	Slight	Severe: poorly drained and	Severe: poorly drained and	Severe: poorly drained and	Severe: poorly drained and

engineering properties of the soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Poor: high shrink-swell potential.	Unsuited ____	Poor: poorly drained and	Slow permeability; frequently	High shrink-swell potential; medium	Frequently ponded; slow per-	Slow permeability; needs drain-	Clay texture; slow	Not needed.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Gilby: GbA	Severe: moderately slow permeability in substratum.	Moderate: high seasonal water table.	Severe: somewhat poorly drained; high seasonal water table.	Severe: somewhat poorly drained; high seasonal water table.	Severe: high seasonal water table.	Moderate: moderate potential frost action; moderate shrink-swell potential.
Glyndon: GdA, GfA	Severe: high seasonal water table.	Severe: high seasonal water table.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high seasonal water table.	Severe: high potential frost action.
Gm	Severe: high seasonal water table.	Severe: high seasonal water table.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high seasonal water table.	Severe: high potential frost action.
Grano: Gr	Severe: slow permeability.	Moderate: high seasonal water table.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: very poorly drained.
Gs	Severe: slow permeability.	Moderate: high seasonal	Severe: very poorly	Severe: very poorly	Severe: very poorly	Severe: very poorly



engineering properties of the soils—Continued

Suitability as source of—			Soil features affecting—					

TABLE 7.—*Interpretations of*

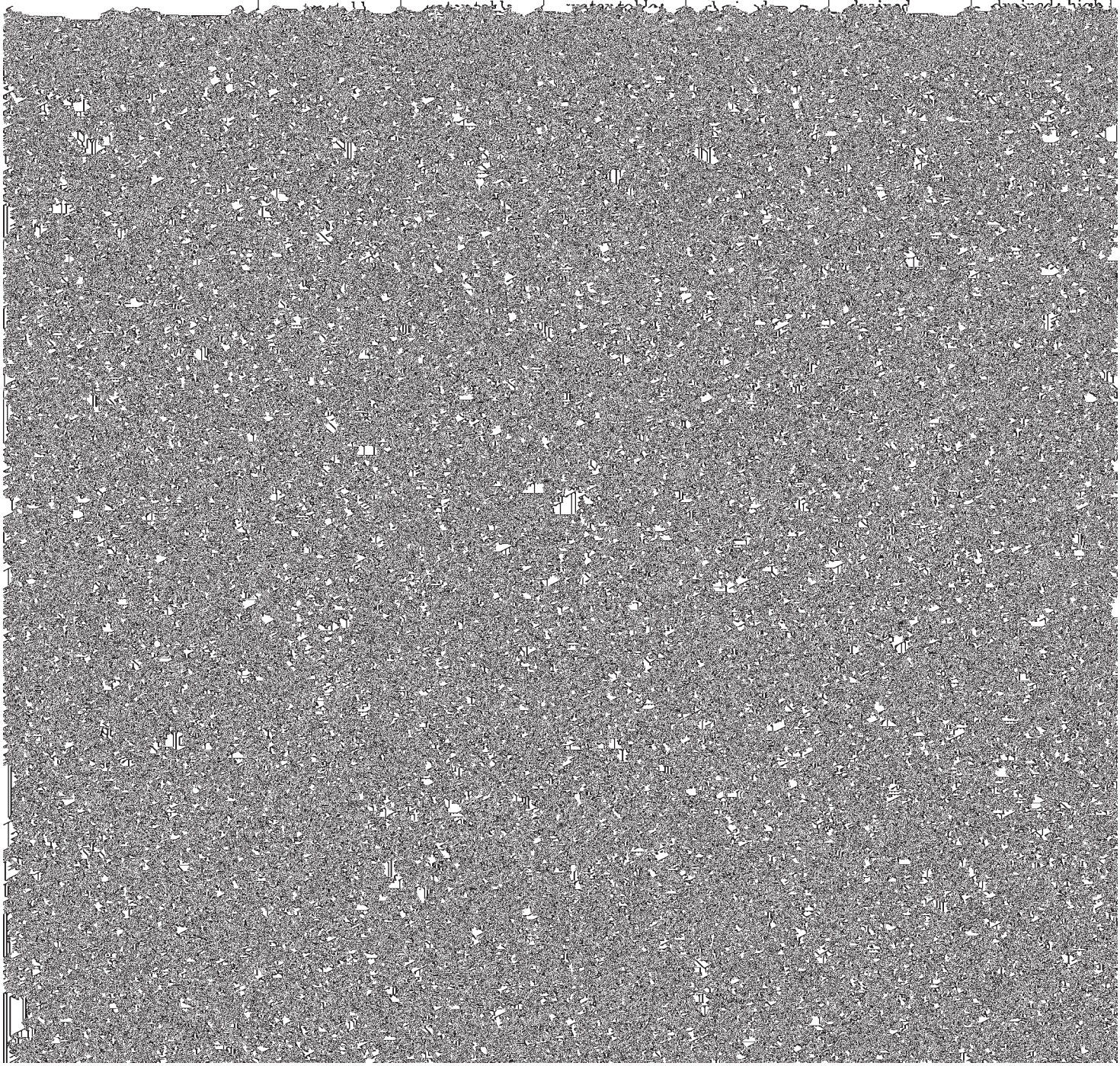
Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank	Sewage	Shallow	Dwellings with	Sanitary	Local roads

engineering properties of the soils—continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Poor: high shrink-swell potential; poorly drained.	Unsuited	Poor: clay texture; poorly drained; moderately saline.	Slow permeability; high seasonal water table.	Fair to poor compaction characteristics; medium to low shear strength; high compressibility.	Slow permeability; poorly drained.	High seasonal water table; slow permeability; high available water capacity; moderately saline.	Clay texture; poor workability; slow permeability.	Not needed.
Poor: high shrink-swell potential; poorly drained.	Unsuited	Poor: clay texture; poorly drained.	Slow permeability; high seasonal water table.	Fair to poor compaction characteristics; medium to low shear strength; high compressibility.	Slow permeability; poorly drained.	High seasonal water table; slow permeability; high available water capacity.	Clay texture; poor workability; slow permeability.	Not needed.
Poor: poorly drained; high shrink-swell potential; high potential frost action.	Unsuited	Poor: poorly drained.	Moderate permeability; high seasonal water table.	Fair to good compaction characteristics; medium to low shear strength; medium compressibility.	Moderate permeability; high seasonal water table; subject to flooding.	Moderate permeability; high seasonal water table; subject to flooding.	Not needed.	Not needed.
Fair: moderate potential frost action; moderate shrink-swell potential.	Unsuited	Good	Moderately slow permeability in substratum.	Fair to good compaction characteristics.	Poor outlets	Moderately slow permeability in substratum; high available water capacity.	Not needed.	Features generally favorable.
Fair: moderate shrink-swell potential; moderate potential frost action.	Unsuited	Fair: clay texture.	Moderate permeability.	Susceptible to piping; medium to low shear strength; medium compressibility.	Not needed	High available water capacity; moderate permeability.	Not needed.	Not needed.
Good if fines	Poor:	Good if tex-	Rapid perme-	Susceptibility	Not needed	Rapid perme-	Suscepti	Susceptible

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
McDonaldsville: Mf ------	Severe: high seasonal	Severe: high seasonal	Severe: high seasonal	Severe: poorly	Severe: poorly	Severe: poorly

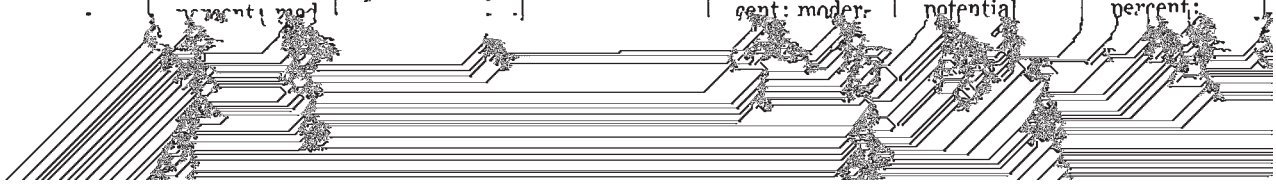


engineering properties of the soils—continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Poor: high shrink-swell potential in upper 30 inches.	Unsuited	Poor: poorly drained; silty clay and clay texture.	Rapid permeability below 30 inches.	Susceptible to piping.	Poor outlets	Poorly drained; high available water capacity; high seasonal water table.	Not needed.	Not needed
Severe: high shrink-swell potential.	Unsuited	Poor: high sodium content.	Features favorable.	Medium to low shear strength; fair to poor compaction characteristics.	Somewhat poorly drained; poor outlets.	Somewhat poorly drained; high sodium content; very slow permeability.	Not needed.	Not needed.
Poor: high potential frost action.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability.	Low shear strength; fair to poor compaction characteristics.	Subject to flooding.	Moderately slow permeability; somewhat poorly drained; high available water capacity.	Subject to flooding.	Subject to flooding.
Poor: poorly drained; high potential frost action.	Unsuited	Poor: highly saline; poorly drained.	High seasonal water table.	Medium to low shear strength; fair to poor compaction characteristics.	Poorly drained; highly saline.	Poorly drained; highly saline.	Not needed.	Highly saline.
Poor: high shrink-swell potential.	Unsuited	Fair: 10 inches of silty clay loam.	Features generally favorable.	Medium shear strength; fair to poor compaction characteristics.	Not needed	Slow permeability; slope is 3 to 25 percent.	Slow permeability; slope is 3 to 25 percent.	Slope is 3 to 25 percent.
Poor: high potential frost action.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability; high available water capacity; slope is 1 to 3 percent.	Features favorable.	Features favorable.
Poor: very poorly drained.	Unsuited	Poor: very poorly drained.	Very poorly drained; organic deposits.	Unstable fill; organic deposits.	Very poorly drained; poor outlets.	Very poorly drained.	Not needed.	Not needed.
Poor: poorly drained; high potential frost action.	Unsuited	Poor: poorly drained.	High seasonal water table; moderately slow permeability; frequently ponded.	Medium to low shear strength; medium to high compressibility.	Moderately slow permeability; frequently ponded; high seasonal water table.	Moderately slow permeability; high available water capacity; poorly drained.	Not needed.	Not needed.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Poppleton: PyA	Moderate: high seasonal water table.	Severe: high seasonal water table; rapid permeability.	Severe: high seasonal water table; somewhat poorly drained.	Moderate: high seasonal water table; somewhat poorly drained.	Severe: high seasonal water table.	Moderate: somewhat poorly drained.
Rauville: Ra	Severe: subject to flooding; high seasonal water table.	Severe: subject to flooding; high seasonal water table.	Severe: very poorly drained.	Severe: subject to flooding; high seasonal water table; very poorly drained.	Severe: high seasonal water table; subject to flooding; very poorly drained.	Severe: very poorly drained; high potential frost action.
Renshaw: RbA, RfB [3]	Slight: potential pollution hazard.	Severe: very rapid permeability in substratum.	Moderate: gravelly substratum.	Slight	Severe: very rapid permeability in substratum; potential pollution hazard.	Slight
Rolette: RoA	Severe: moderately slow permeability.	Slight	Severe: silty clay below a depth of 18 inches.	Severe: high shrink-swell potential.	Severe: silty clay below a depth of 18 inches.	Severe: high shrink-swell potential.
Rough broken land: Rp. Too variable for valid interpretations.						
*Ryan: Rr For Fargo part, see Fargo series.	Severe: very slow permeability.	Slight	Severe: silty clay texture; poor workability.	Severe: poorly drained.	Severe: poorly drained; poor workability.	Severe: poorly drained; high shrink-swell potential.
Serden: SnD	Slight if slope is 6 to 8 percent; mod-	Severe: rapid permeability.	Severe: sand texture.	Slight if slope is 6 to 8 percent; moder-	Severe: rapid permeability; potential	Slight if slope is 6 to 8 percent;



engineering properties of the soils—continued

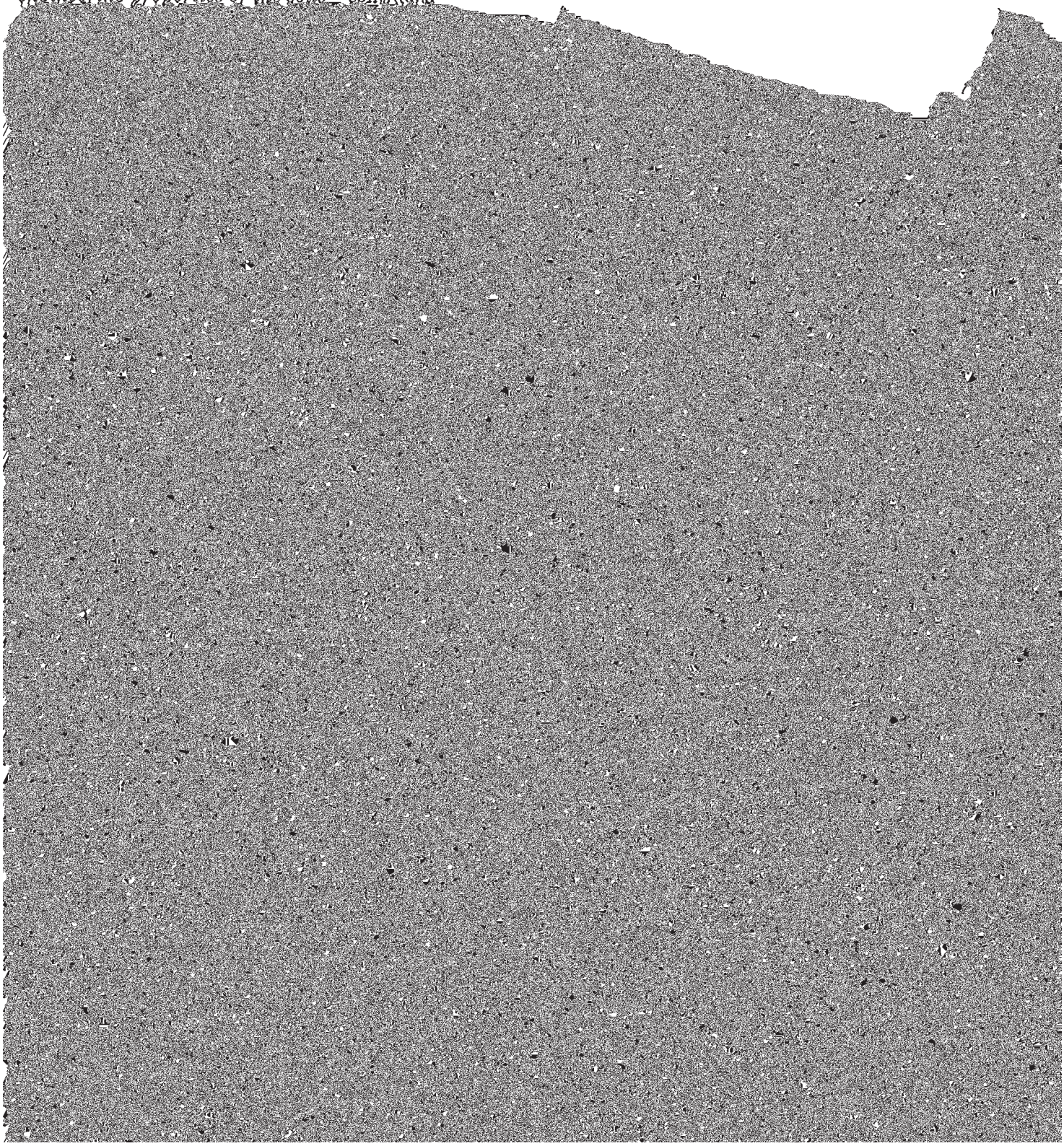


TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets

engineering properties of the soils—continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Fair: moderate potential frost action.	Unsuited ____	Good _____	Moderately slow permeability in substratum; high seepage potential in upper part.	Fair stability and compaction characteristics; low to medium shear strength in substratum; medium to	Not needed __	Moderately slow permeability in substratum; moderate available water capacity	Slope is 1 to 3 percent; susceptible to soil blowing.	Not needed.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
Wheatville: Wv	Severe: high seasonal water table.	Severe: high seasonal water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained; high seasonal water table.	Severe: high seasonal water table.	Severe: high potential frost action; high shrink-swell potential in underlying material.
*Zell: ZgC, ZgD For Gardena parts, see Gardena series.	Moderate: slope is 6 to 15 percent.	Moderate if slope is 6 to 7 percent; severe if more than 7.	Slight if slope is 6 to 8 percent; moderate if more than 8.	Moderate: low shear strength.	Slight	Severe: high potential frost action.

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

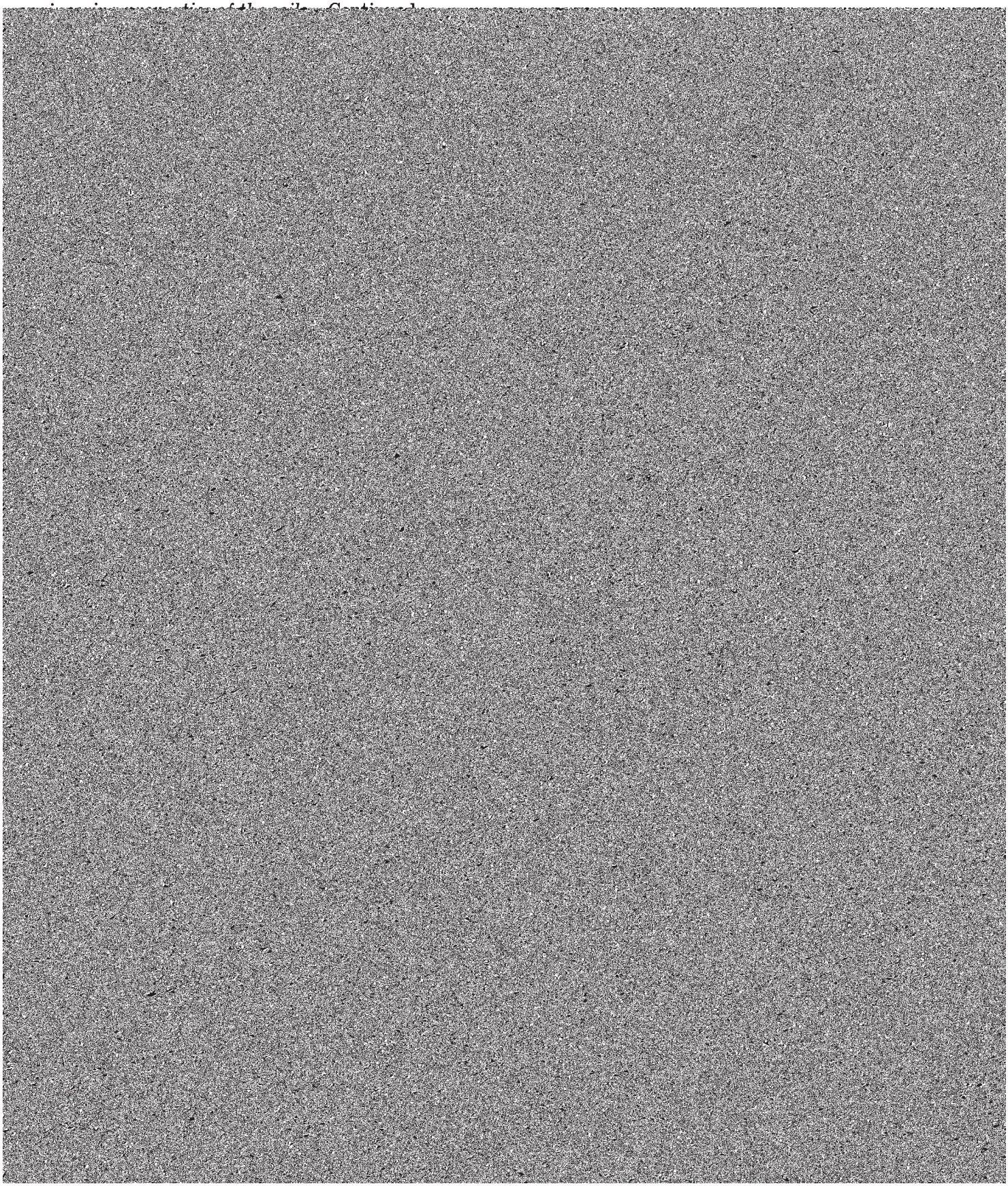
material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 5 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and its shrink-swell potential indicate 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

fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture and content of stone fragments are characteristics that affect suitability of the soil material, but also considered in the ratings is damage that will result to the soil in the area from which the topsoil is taken.

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

Dikes, levees, and other embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength



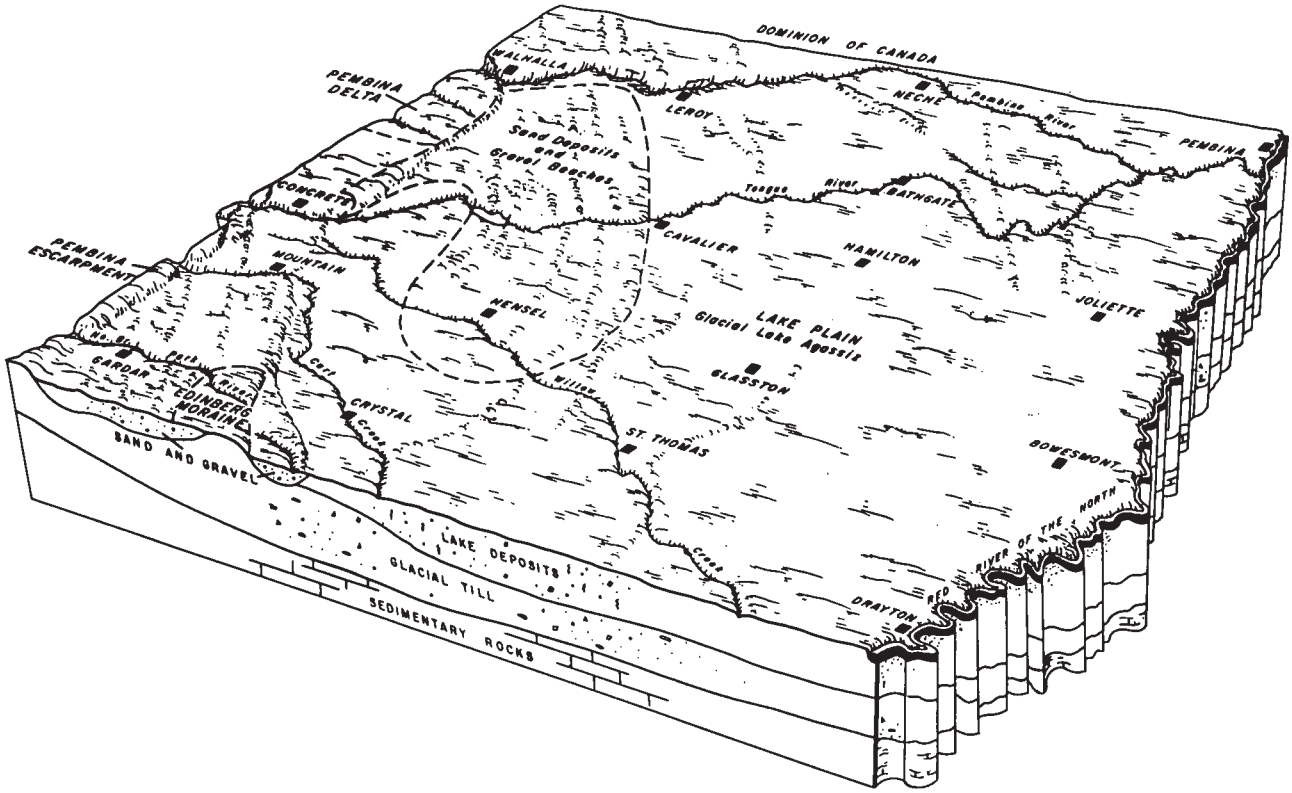


Figure 15.—**Physiographic features of Pembina County.**

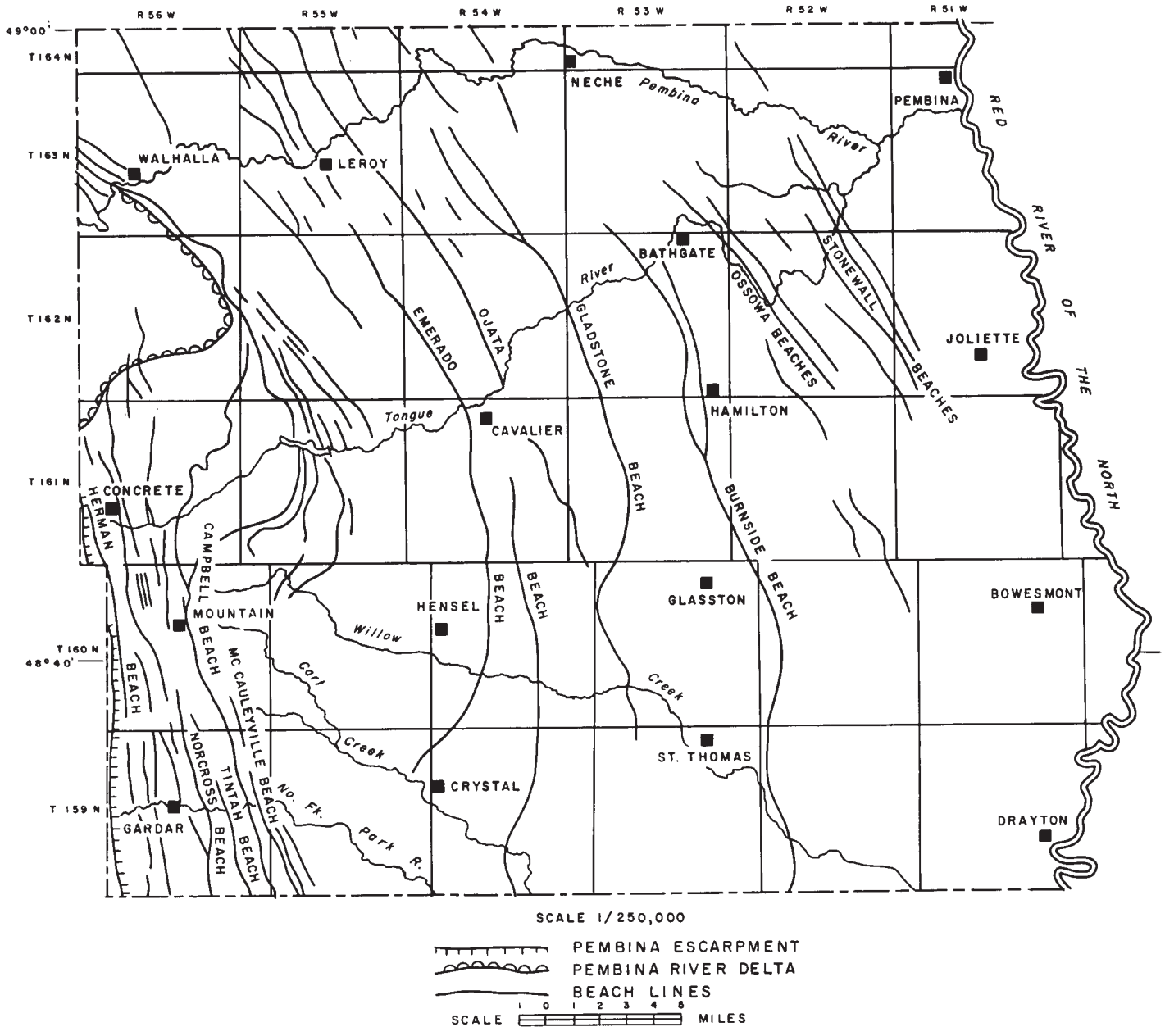


Figure 16. Purchase formed in Pembina County as Glacial Lake Agassiz changed elevation

tall grasses, reeds, rivergrass, slough sedge, American mannagrass, northern reedgrass, and prairie cordgrass.

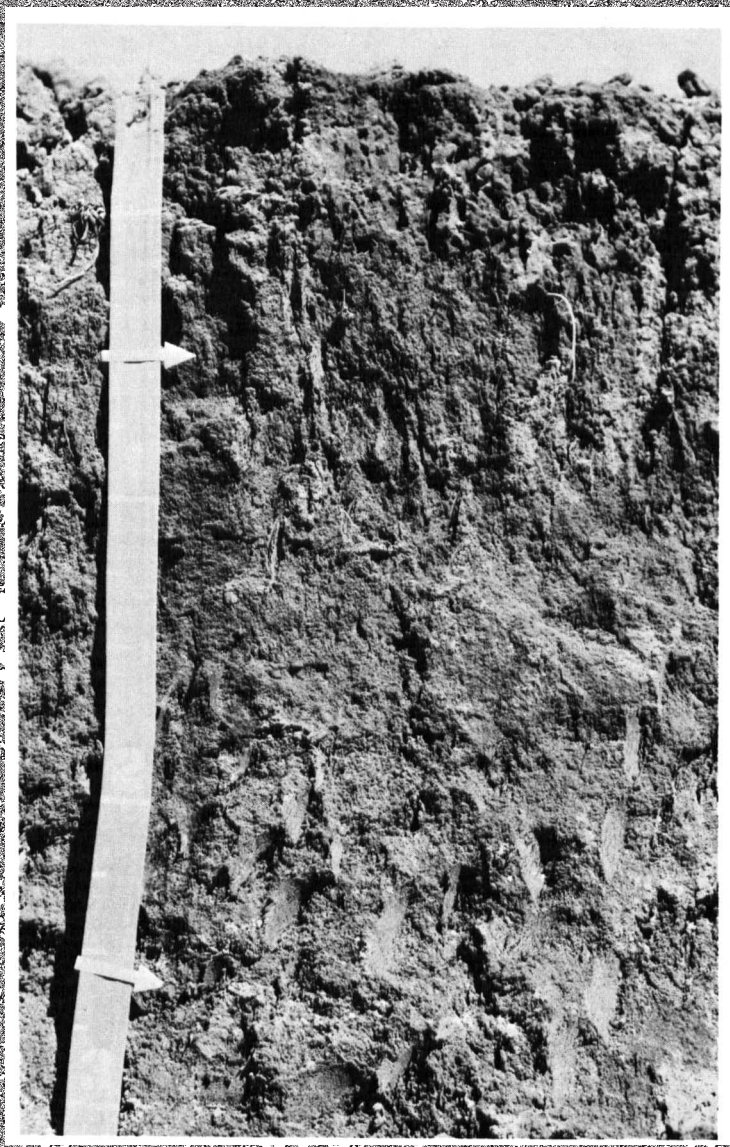
The principal effects of plant and animal life on soil formation are in the accumulation of organic matter and in the translocation of plant nutrients from the lower layers to the upper layers. The native grass has contributed large amounts of organic matter to the soils. The roots penetrate into the lower horizons, take up calcium, phosphorus, potassium, and other nutrients, then leave these elements near the surface when the plants die and decay. The presence of calcium and the high content of organic matter in the surface layer have favored the development of soils that have granular structure.

Bacteria and fungi play an important role in the development of soil by breaking down undecomposed amounts of runoff from higher areas have poor to very poor natural drainage. Most of the soils in these positions are characterized by a black, thick A horizon and mottled black or very dark gray subsoil and subsurface layers. Examples of such soils are those of the Dovray and Perella series.

Time

Time is necessary for the factors of soil formation to act on parent material. The length of time for a particular soil to develop depends on the kind of parent material and many other factors.

The soils of Pembina County range from mature soils that have well-developed profile characteristics to young soils that have little or no horizon differentiation, or profile development (fig. 17). Such well-drained soils



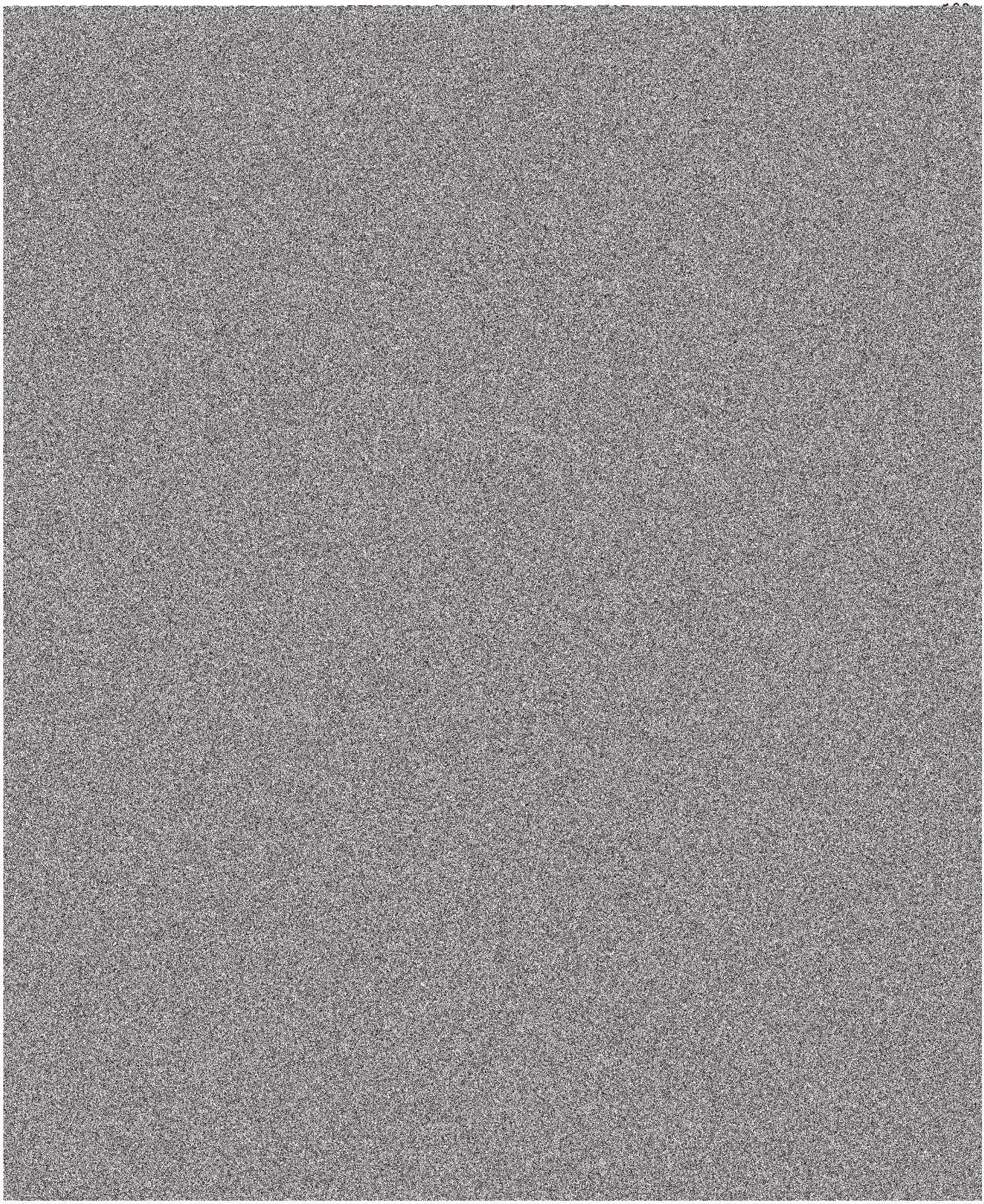


TABLE 8.—*Soil series classified according to the current system*

[Placement of series in December 1971 at the Midwest Regional Technical Center, Lincoln, Nebraska, United States Department of Agriculture, Soil Conservation Service]

Series	Family	Subgroup	Order
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Bearden	Fine-silty, frigid	Aeric Calciaquolls	Mollisols.
Binford	Sandy, mixed	Udic Haploborolls	Mollisols.
Borup	Coarse-silty, frigid	Typic Calciaquolls	Mollisols.
Brantford	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Cashel	Fine, montmorillonitic, frigid	Mollic Udifluvents	Entisols.
Claire	Mixed, frigid	Typic Udipsamments	Entisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Cormant	Mixed, frigid	Typic Psammaquents	Entisols.
Divide	Fine-loamy over sandy or sandy-skeletal, frigid	Aeric Calciaquolls	Mollisols.
Dovray	Fine, montmorillonitic, frigid	Cumulic Haplaquolls	Mollisols.
Egeland	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Fairdale	Fine-loamy, mixed, frigid	Mollic Udifluvents	Entisols.
Fargo	Fine, montmorillonitic, noncalcareous, frigid	Vertic Haplaquolls	Mollisols.
Gardena	Coarse-silty, mixed, frigid	Pachic Haploborolls	Mollisols.
Gilby	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Glyndon	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Grano	Fine, montmorillonitic (calcareous), frigid	Vertic Haplaquolls	Mollisols.
Hamar	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Hecla	Sandy, mixed	Udic Haploborolls	Mollisols.
Hegne	Fine, frigid	Typic Calciaquolls	Mollisols.
Lamoure	Fine-silty, mixed, (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
Lankin	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
La Prairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Maddock variant	Sandy, mixed, frigid	Alfic Udipsamments	Entisols.
McDonaldsville	Clayey over sandy or sandy-skeletal, montmorillonitic, frigid.	Typic Haplaquolls	Mollisols.
Nahon	Fine, montmorillonitic	Udic Natriborolls	Mollisols.
Neche	Fine-silty, mixed	Fluvaquentic Haploborolls	Mollisols.
Ojata	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Olga	Fine, montmorillonitic	Boralfic Argiborolls	Mollisols.
Overly	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Peat	Elastic, eutic	Typic Borosaprists	Histosols.
Perella	Fine-silty, mixed, frigid	Typic Haplaquolls	Mollisols.
Poppleton	Mixed, frigid	Aquic Udipsamments	Entisols.
Rauville	Fine-silty, mixed, (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
Renshaw	Fine-loamy over sandy, or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Rolette	Fine, montmorillonitic	Boralfic Udic Argiborolls	Mollisols.
Ryan	Fine, montmorillonitic, frigid	Typic Natraquolls	Mollisols.
Serden	Mixed, frigid	Typic Udipsamments	Entisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Vang	Fine-loamy over sandy, or sandy-skeletal, mixed	Pachic Udic Haploborolls	Mollisols.
Vang variant	Fine-loamy over sandy or sandy-skeletal	Typic Haplaquolls	Mollisols.
Wahpeton	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Walsh	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Waukon	Fine-loamy, mixed	Mollic Eutroboralfs	Alfisols.
Wheatville	Coarse-silty over clayey, frigid	Aeric Calciaquolls	Mollisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

concerns. The Claire, Hecla, and Maddock soils are deep and sandy. Control of soil blowing and very low or low available water capacity are the main management concerns. The Lankin, Olga, Rolette,

Climate [6]

Pembina County has a continental climate. Summers are pleasantly warm, and although winters are long

temperatures move above freezing. About 85 percent of the precipitation falls during the warm-season period, April through October. Climatic data are

11.54 inches to 28.19 inches. Normally 0.10 inch or more of precipitation is received on about 45 days per year and 0.50 inch or more on about 10 days. The prob-

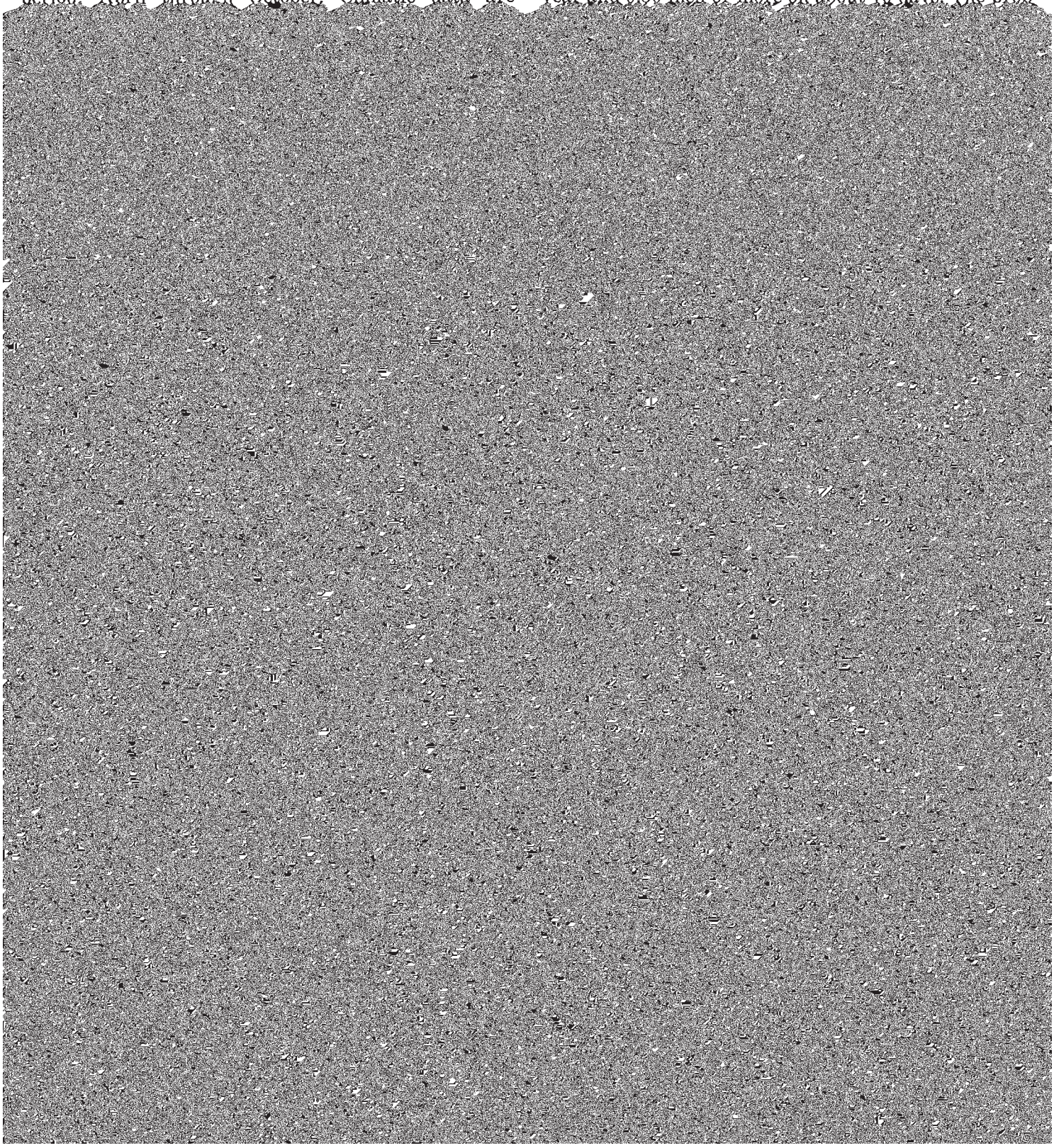


TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data recorded at Cavalier]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					

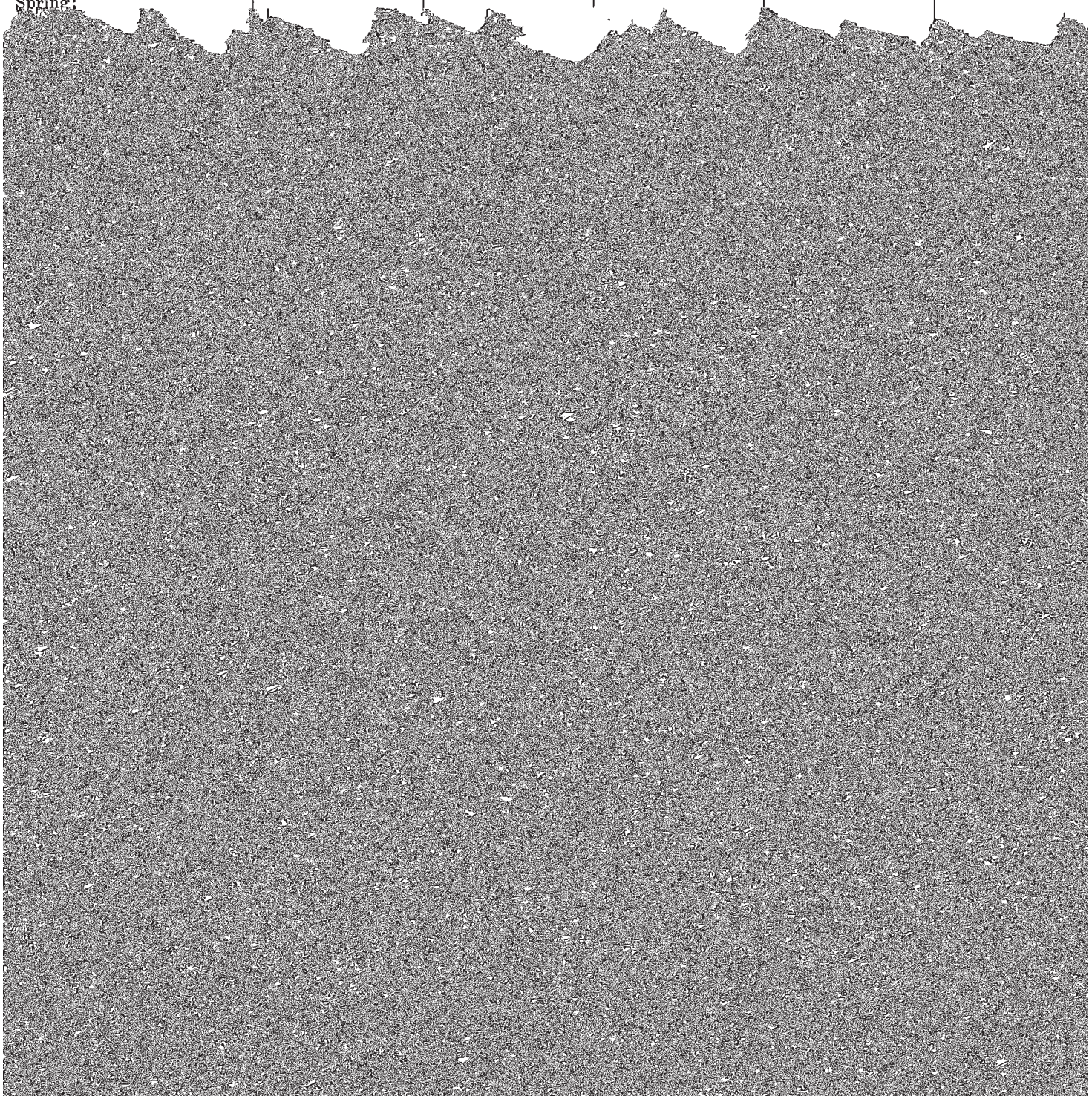


TABLE 11.—*Probabilities of receiving specified amounts of precipitation during the growing season*

[Data from Langden]

Period	Probability, in percent, of receiving—					
	Less than	At least—				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

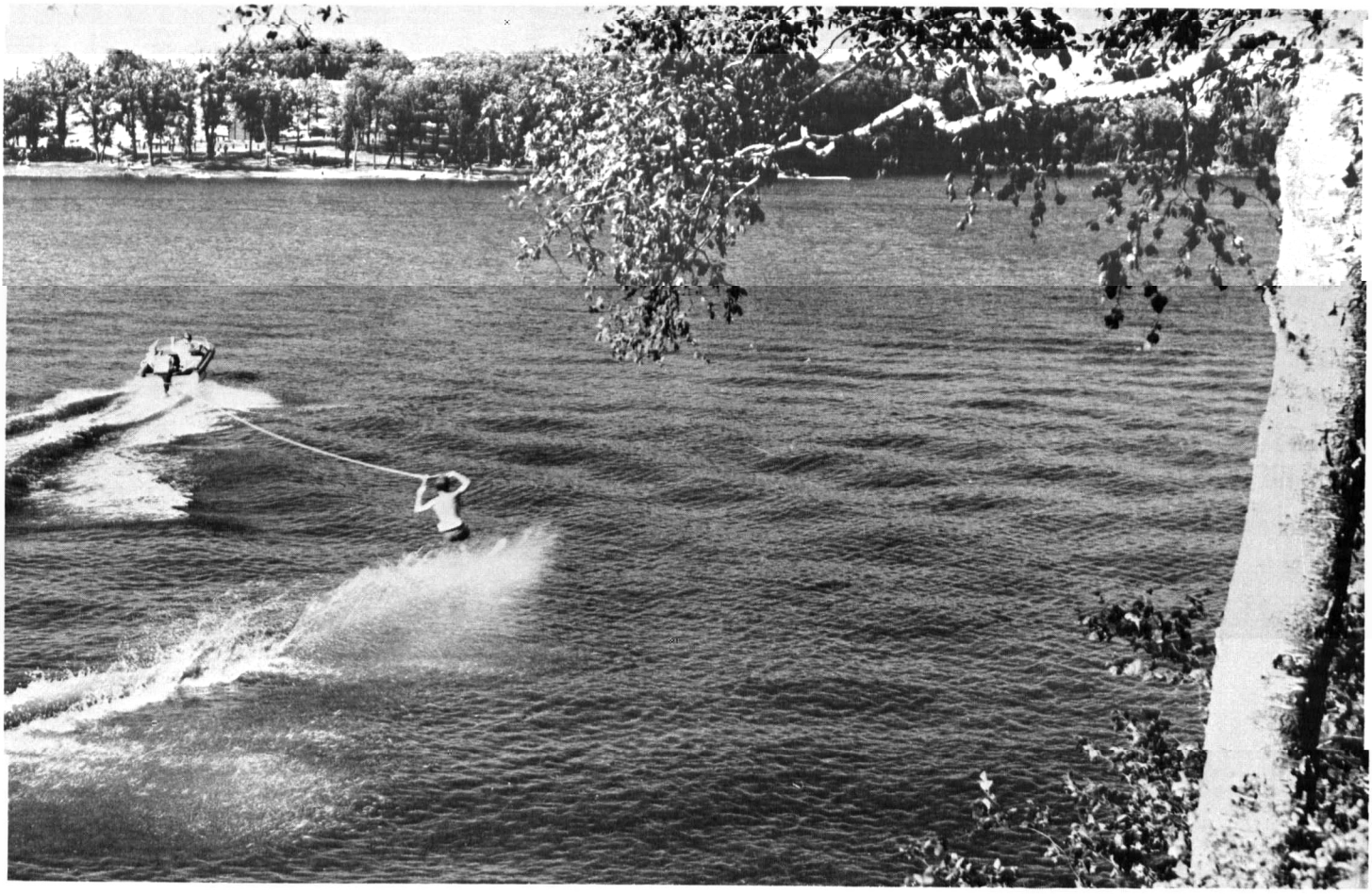


Figure 18.—**The waters behind the Renwick Dam provide an excellent site for water sports, fishing, and camping. Icelandic State Park is on the shores of the Renwick Reservoir.**

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Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Buffer strips. Narrow strips of a few rows of plants such as flax, corn, or sunflowers seeded late in the growing season on summer fallow or after the harvest of low-residue crops such as potatoes or sugar beets. These strips are seeded to protect exposed soil from soil blowing and hold snow on fields over winter.

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

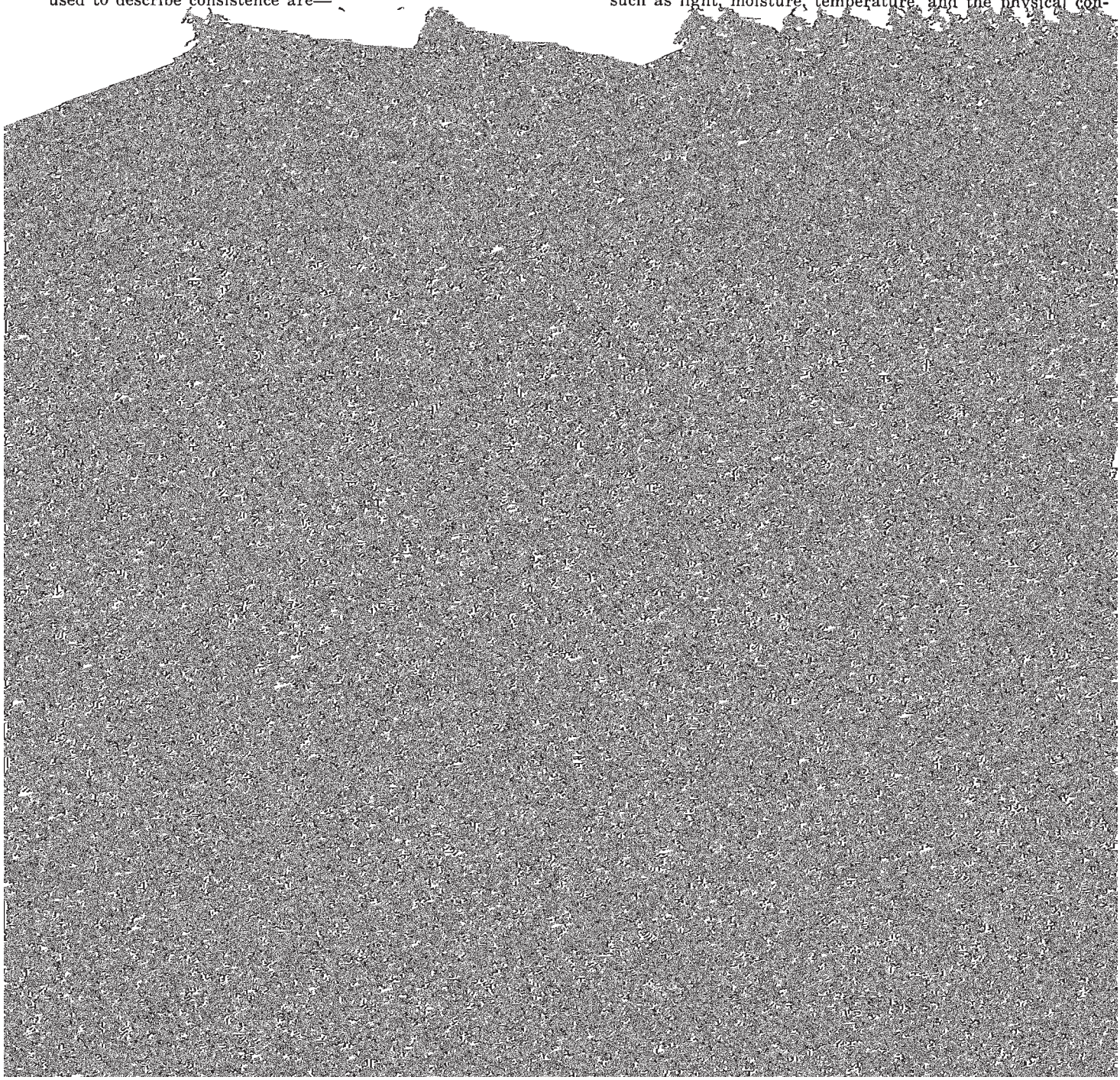
Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Emergency tillage. Cultivation by listing, ridging, duckfooting, chiseling, pitting basin listing, or other means to roughen the soil surface for temporary control of wind erosion.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Fallow. Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. Summer fallow is a common stage before cereal grain in regions of limited rainfall. The soil is tilled for at least one growing season to control weeds, to aid decomposition of plant residues and to encourage the storage of moisture for the succeeding grain crop.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical con-



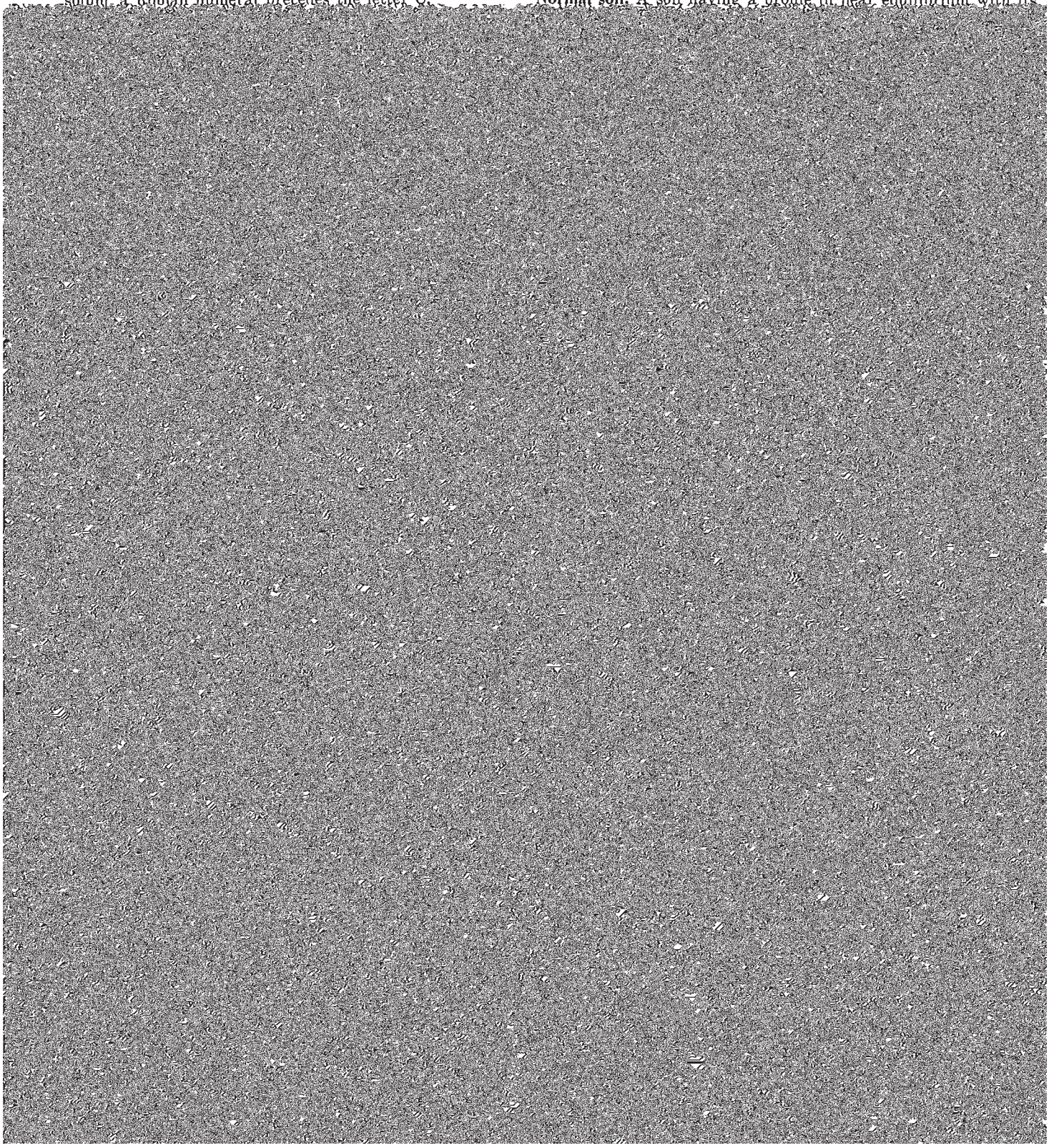
called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Normal soil. A soil having a profile in near equilibrium with its



acts with a base. Salts commonly found in soils break up into cations (sodium, calcium, and so on) and anions (chloride, sulfate, and so on) when dissolved in water.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods

wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

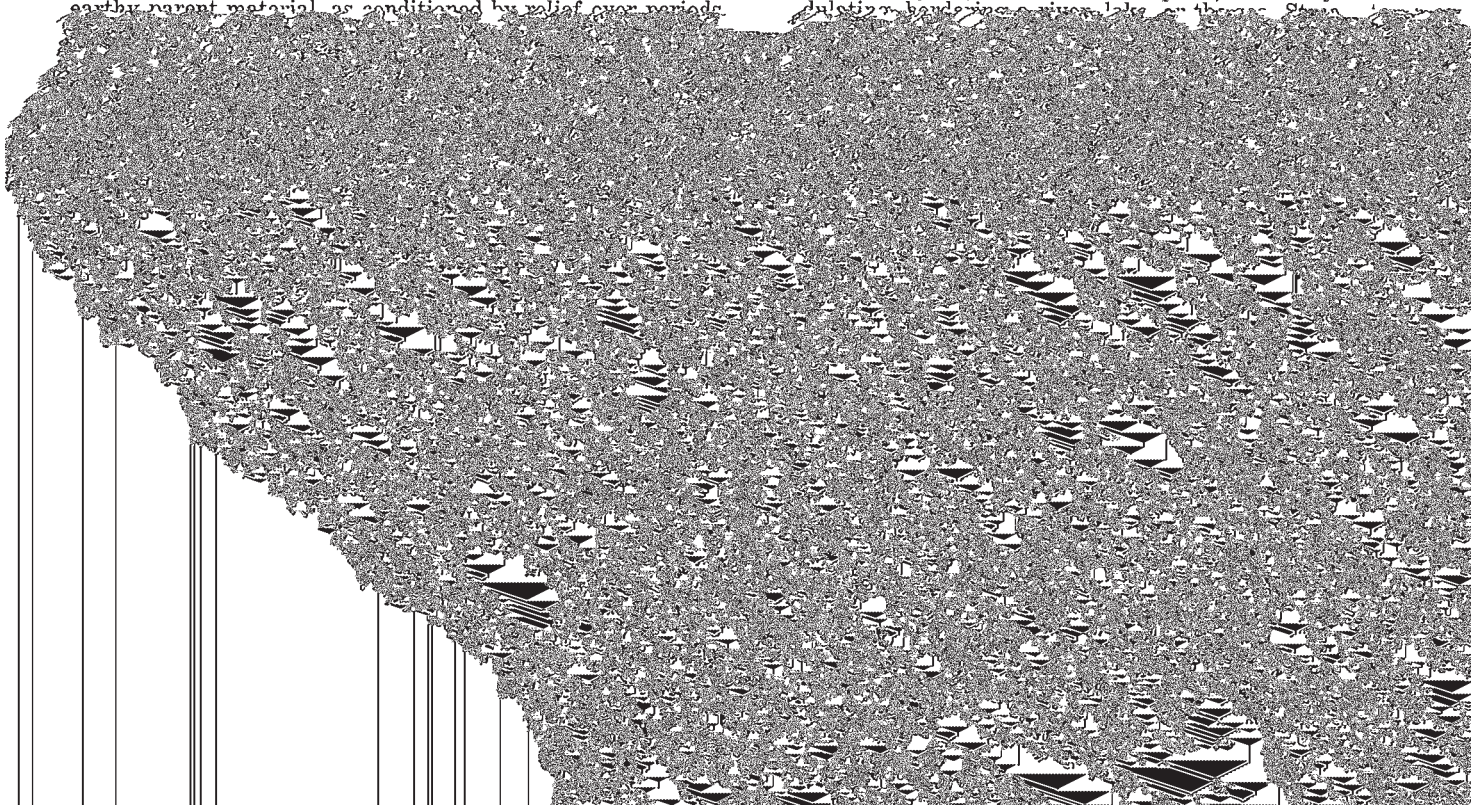
Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or un-



GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of its series.

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ar	Arveson sandy loam	10	IIIw-3	58	2	68
Av	Arveson loam	10	IIIw-5	59	2	68
Aw	Arveson soils, very wet	12	IVw-5	61	2	68
BaD	Barnes loam, 9 to 20 percent slopes	12	VIe-6	63	10	70
BnA	Bearden silty clay loam, 1 to 3 percent slopes	13	IIe-4L	55	1	68
BnB	Bearden silty clay loam, 3 to 6 percent slopes	13	IIe-4L	55	1	68
BrA	Bearden silty clay loam, saline, 1 to 3 percent slopes	13	IIIws-4L	59	10	70
Bs	Bearden-Colvin silty clay loams	13	IIIw-4L	59	1	68
BvA	Bearden and Glyndon silt loams, 1 to 3 percent slopes	13	IIe-4L	55	1	68
BwA	Binford sandy loam, 1 to 3 percent slopes	14	IIIes-3	58	6	69
BwB	Binford sandy loam, 3 to 6 percent slopes	14	IIIes-3	58	6	69
Bx	Borup silt loam	15	IIw-4L	56	2	68
ByA	Brantford loam, 1 to 3 percent slopes	15	IIIs-5	60	6	69
ByB	Brantford loam, 3 to 6 percent slopes	15	IIIe-5	57	6	69
ByC	Brantford loam, 6 to 9 percent slopes	15	IIIe-5	57	6	69
ByD	Brantford loam, 9 to 25 percent slopes	16	VIs-5	64	10	70
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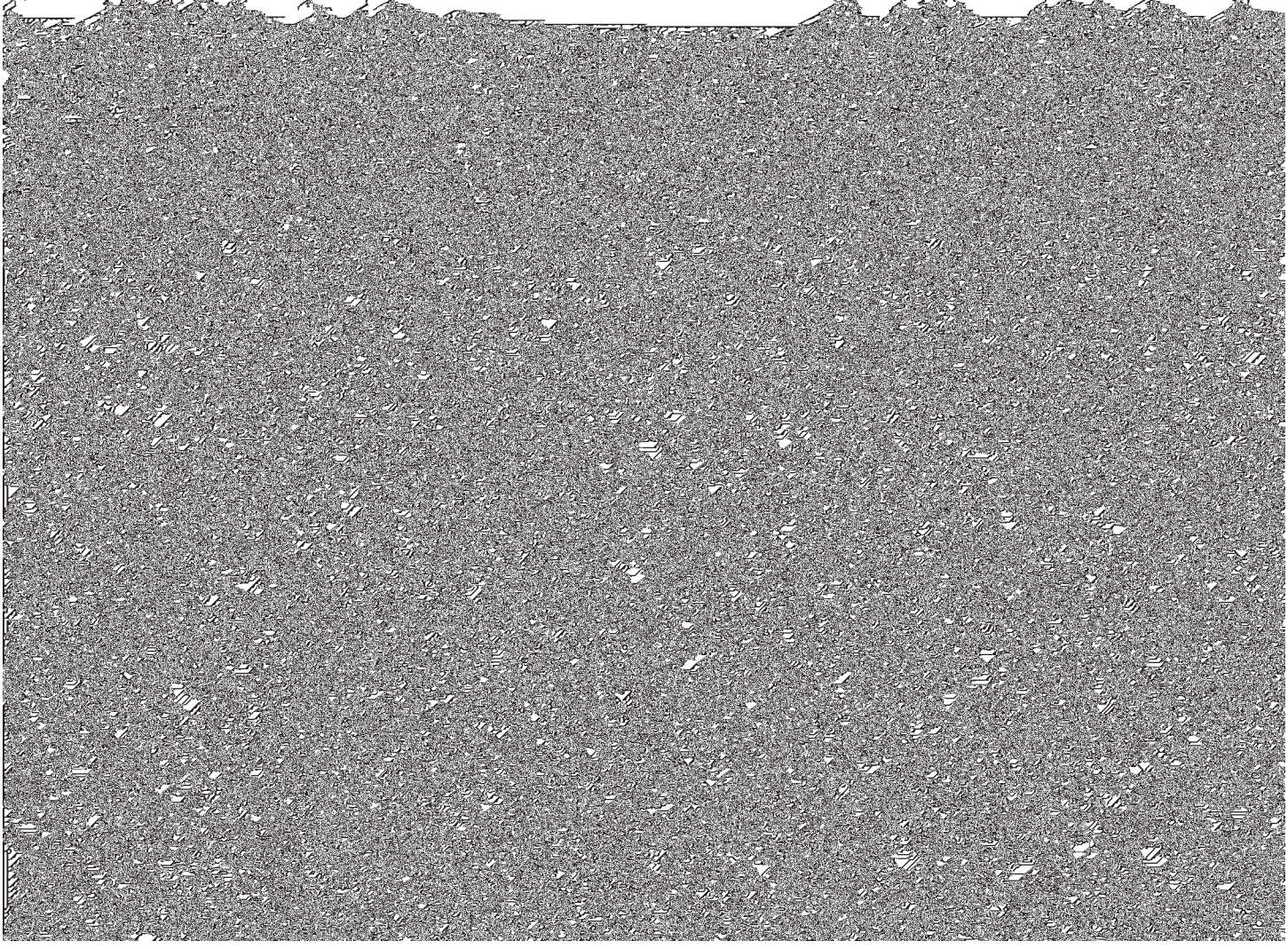
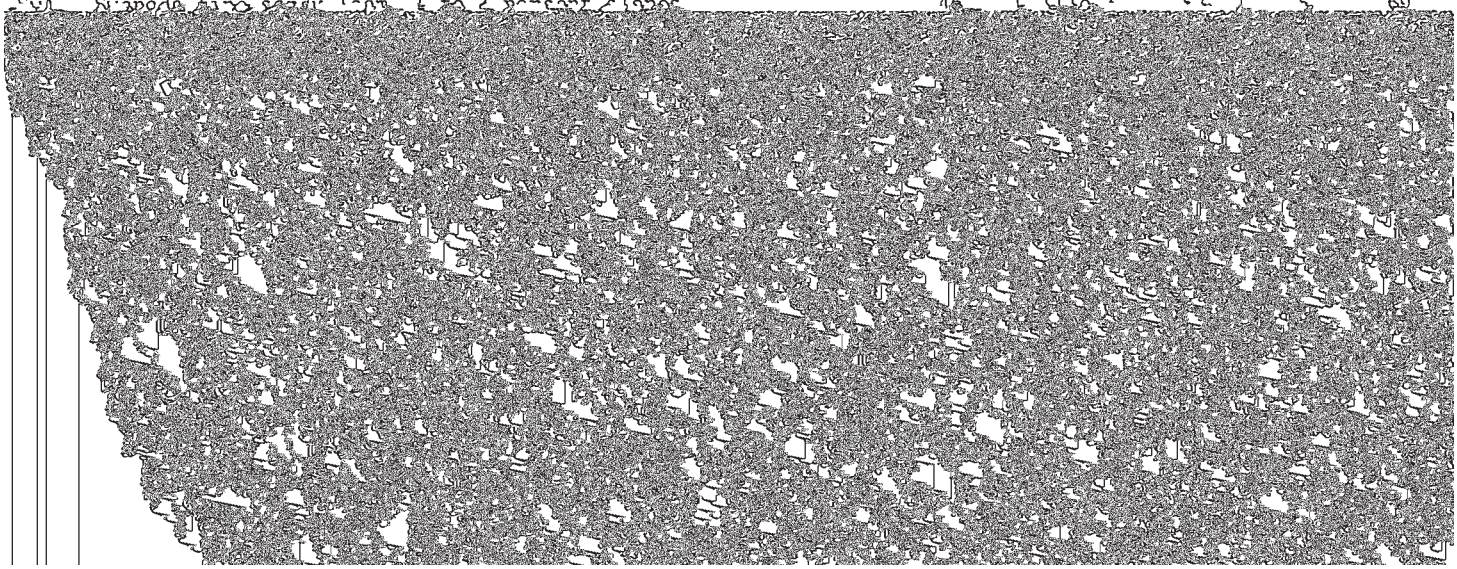


Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
LrB	La Prairie silty clay loam, 3 to 6 percent slopes	34	IIe-7	55	1	68
LvD	La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes	34	VIe-6	63	10	70
MaA	Maddock loamy sand, 1 to 3 percent slopes	34	IVe-2	60	5	69
MaB	Maddock loamy sand, 3 to 6 percent slopes	35	IVe-2	60	5	69
MbA	Maddock sandy loam, 1 to 3 percent slopes	35	IIIe-3	57	5	69
MbB	Maddock sandy loam, 3 to 6 percent slopes	35	IIIe-3	57	5	69
McB	Maddock loamy sand, thin surface variant, 1 to 6 percent slopes	36	IVe-2	60	5	69
Mf	McDonaldsville silty clay	36	IIw-4	56	2	68
Na	Nahon silt loam	37	IVs-4	62	9	70
Ng	Neche silty clay loam	38	IIc-6	57	1	68
Nh	Neche silty clay	38	IIe-4	54	1	68
Oa	Ojata silt loam	38	VIs-4	63	10	70
OgB	Olga silty clay loam, 3 to 6 percent slopes	39	IIIe-4	57	4	69
OgE	Olga silty clay loam, 9 to 25 percent slopes	39	VIe-4	63	10	70
OvA	Overly silty clay loam, 1 to 3 percent slopes	40	IIc-7	57	1	68
Pa	Peat	40	Vw-7	63	10	70
Pu	Perella silty clay loam	41	IIw-7	56	2	68
PyA	Poppleton loamy sand, 1 to 3 percent slopes	41	IVs-2	61	1	68
Ra	Rauville silt loam	42	Vw-8	63	10	70
RbA	Renshaw loam, 1 to 3 percent slopes	42	IIIs-6	60	6	69
RfB	Renshaw very stony loam, 1 to 6 percent slopes	42	VIIs-6	64	10	70
RoA	Rolette silty clay loam, 1 to 3 percent slopes	43	IIe-4	54	4	69
Rp	Rough broken land	43	VIIe-3	64	10	70
Rr	Ryan-Fargo silty clays	45	IVs-4	62	9	70
SnD	Serden sand, 6 to 15 percent slopes	45	VIe-1	63	10	70
SvA	Svea fine sandy loam, 1 to 3 percent slopes	46	IIIe-7	57	5	69



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