SOIL SURVEY OF
Norman County, Minnesota

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

Issued March 1974

Major fieldwork for this soil survey was done in the period 1957–68. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service and the Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the East Agassiz Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

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

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

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

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

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

Newcomers in Norman County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the additional information about the county given in the section "General Nature of the County."

Cover: Small grain harvest. Wheat and barley are the most common cash crops grown on Norman County farms.

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SOIL SURVEY OF NORMAN COUNTY, MINNESOTA

BY MALVERN N. JACOBSON, SOIL CONSERVATION SERVICE

FIELDWORK BY WARD J. AAS, DONALD D. BARRON, MALVERN N. JACOBSON, CLARION J. NESETH, JR., ALDEAN G. RHYNER, AND FRANCIS M. SCILLEY

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH MINNESOTA AGRICULTURAL EXPERIMENT STATION [1]

NORMAN COUNTY is in northwestern Minnesota on the North Dakota border (fig. 1). Ada, the county

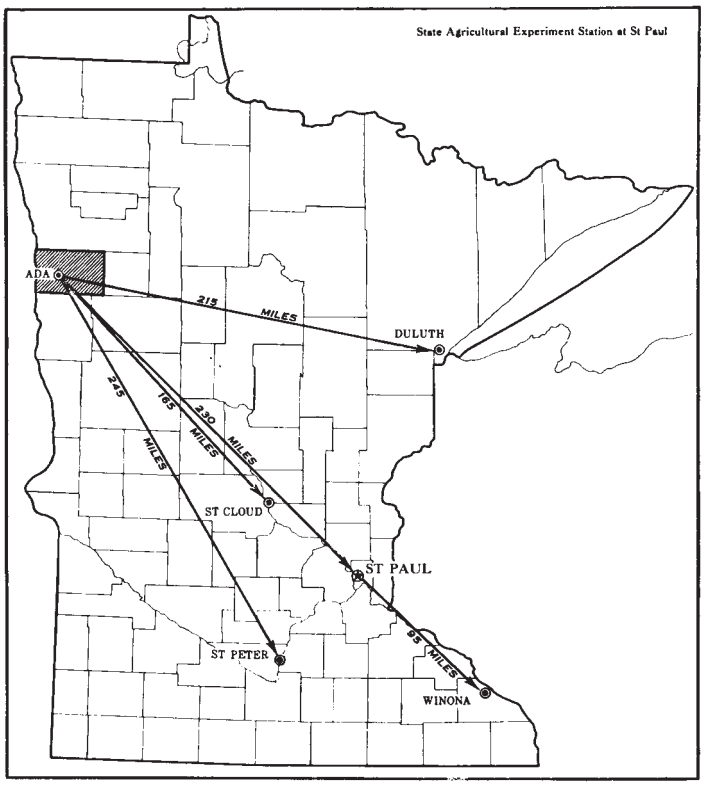

Figure 1.—**Location of Norman County in Minnesota.**

seat, is about 230 air miles northwest of St. Paul, the State capital. The total area of the county is approximately 885 square miles. Open-water areas in semipermanent pools and perennial streams account for slightly more than one square mile of the county. The county is mainly rural; about 522,367 acres of its 566,400 acres is in farms. Wheat, barley, oats, sugar beets, sunflowers, and some hay and pasture crops and corn for feeding livestock are the sources of most farm income.

Norman County has a variety of soil material and topography. In the western two-thirds the soils formed in lacustrine materials and are generally level. These materials range from clay in the western part to sand and gravel in the eastern part. In the eastern third of the county the soils formed in till and outwash materials and are nearly level to very steep. The original vegetation in Norman County was largely tall prairie grasses and wetland reeds and sedges. Trees grew in the eastern part of the county and a few soils in this part have properties that show the influence of forest vegetation.

How This Survey Was Made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures (*6*).[2] The soil series and the soil phase are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Barnes and

[1] Other organizations that supplied information or assisted in preparing this soil survey are the Minnesota Highway Department, Norman County Agricultural Extension Service, and the East Agassiz Soil and Water Conservation District.

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

Fargo, for example, are the names of two series. All the soils in the United States that have the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Barnes loam, 2 to 6 percent slopes, is one of several phases within the Barnes series.

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

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

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

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

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

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

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

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

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

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

The soil associations in Norman County are discussed in the following pages.

1. *Fargo association*

Poorly drained, fine textured and moderately fine textured soils formed in lacustrine clays

This association is nearly level or slightly concave and has some shallow microrelief. The ridges and narrow swales of the microrelief run from northwest to southeast and have a 4- to 12-inch difference in elevation. Deeper, circular or slightly oblong depressions are spotted along the swales. Narrow areas of gently sloping soils are near rivers and other streams. The natural surface runoff is slow, and there are few adequate natural drainageways.

This association is drained by the Red River of the North and its tributaries, the Marsh and Wild Rice Rivers. These rivers have a relatively deep main channel and a strong meander pattern. The Red River of the North flows northward and drains the glacial Lake Agassiz basin. The direction of flow and strong meandering of these rivers increase the number and thickness of ice jams that form during spring breakup. These ice jams have caused serious flooding. Ice blocks and snow blocks in ditches and culverts also cause local flooding.

This association makes up about 12 percent of the county. Soils of the Fargo series make up about 83 percent of the association. Most areas of Fargo soils are nearly level and occupy depressions or a landscape that has shallow microrelief. A small acreage is gently sloping and occurs along rivers and natural drainageways. The Fargo series typically has a surface layer of black silty clay or silty clay loam. The subsoil is very dark gray silty clay, and the underlying material is calcareous, olive-gray silty clay.

Minor soils make up the remaining 17 percent of this association. The most important of these are soils of the Hegne, Colvin, and Bearden series. These soils are more calcareous in or near the surface layer than Fargo soils. Other minor soils are of the Wahpeton and Cashel series.

Nearly all of this association is used for crops. Most farms are more than 640 acres in size. Small grains, sugar beets, sunflowers, soybeans, and legumes are the main crops grown. A small acreage is in grassland or woodland. Most woodland is adjacent to the Wild Rice River, the Marsh River, and the Red River of the North. Wetness is the main limitation. Soil blowing on summer-fallow fields and maintenance of soil structure and fertility also influence use and management.

2. *Hegne-Fargo association*

Poorly drained, fine textured and moderately fine textured soils formed in calcareous lacustrine clays

Most of this association is characterized by ridges, knobs, and swales. The microrelief has a 6- to 18-inch difference in elevation. The swales are elongated and generally joined. The ridges and swales are oriented in a northwest-southeast direction. Some deeper, circular or slightly oblong depressions are common along the swales. These depressions often hold ponded water. The natural surface runoff on this association is slow, and there are few adequate natural drainageways. The large legal ditches that have been constructed to drain these areas are often blocked by snow and ice during spring breakup. This blocking of spring runoff causes local flooding.

This association makes up about 11 percent of the county. Soils of the Hegne series makes up about 65 percent of the association, and soils of the Fargo series make up about 30 percent. These two series commonly occur in intricately mixed patterns.

The Hegne soils occupy ridges or knobs of a microrelief pattern. They typically have a thin surface layer of black or dark-gray, calcareous silty clay. The next main layer is gray to olive-gray, very strongly calcareous clay.

The Fargo soils have a thicker surface layer than Hegne soils, and calcareous material is at a greater depth. Their surface layer is black silty clay or silty clay loam, and their subsoil is very dark gray silty clay. These soils commonly occupy swales and depressions.

Minor soils make up the remaining 5 percent of this association. The most important of these are soils of the Bearden and Colvin series. These soils are more silty than Hegne and Fargo soils and also occur in intricately mixed patterns in the same relief pattern.

Nearly all of this association is used for crops. Most farms are more than 640 acres in size. Small grains, sugar beets, and sunflowers are the most common crops. A small acreage is used for forage crops, pasture, and legumes for green-manure fallow. Wetness is the main limitation. Soil blowing on summer-fallow fields and the need to maintain and improve soil structure and fertility also influence use and management.

3. *Bearden-Colvin association*

Somewhat poorly drained and poorly drained, moderately fine textured soils formed in calcareous lacustrine silts and clays

Much of this association is nearly level. It has slightly convex slopes and a few small, narrow, gently sloping to sloping areas. About half of the association occurs in an intricately mixed pattern that is associated with a microrelief of ridges, knobs, and swales. This microrelief has a 4- to 18-inch difference in elevation. The swales are elongated and generally joined. Some deeper, circular or slightly oblong depressions occur along the swales. Ponded water stands in these depressions at times. The ridges and swales are oriented in a northwest-southeast direction. The natural surface runoff is medium to slow.

The rivers, natural drainageways, and numerous large legal ditches drain excess water from the soils of this association. The Wild Rice and Marsh Rivers have a relatively deep main channel and are strongly meandered. Some parts of the Wild Rice River have been deepened and straightened. The drainageways and ditches are often blocked by snow or ice jams during spring breakup. This blocking of spring runoff causes local flooding.

This association makes up about 18 percent of the county. About 50 percent of the association consists of soils of the Bearden series. These soils are nearly level and occupy slightly convex areas and ridges and knobs on the landscape. A small acreage of Bearden soils also is gently sloping and sloping. These areas are adjacent to rivers and streams. Soils in the Bearden series have a surface layer of black or very dark gray, calcareous silty clay loam. The next main layer is very strongly calcareous, light brownish-gray and light olive-brown silt loam. The underlying material is light olive-brown silt loam that grades to layered silt loam and silty clay.

About 12 percent of this association consists of soils of the Colvin series. These soils occupy flat and concave positions on the landscape. They typically have a surface layer of black, calcareous silty clay loam. The next main layer is grayish-brown, very strongly calcareous silt loam. The underlying material is mainly gray, calcareous silty clay loam or layered silt loam and silty clay.

The remaining 38 percent of the association consists of minor soils. The most important of these are the finer textured Fargo and Hegne soils and the coarser textured Augsburg and Glyndon soils.

Nearly all of this association is used for crops. Most farms are more than 640 acres in size. Small grains, sugar beets, sunflowers, and soybeans are the main crops. A smaller acreage is in grasses and legumes that are used for pasture or returned to the soil as a green-manure crop. A very small acreage, principally along the rivers and streams, is wooded and is idle. Susceptibility to soil blowing, wetness, and a fertility imbalance in the calcareous soils are limitations. The need to control soil blowing, increase or maintain fertility, and improve drainage

influences the use and management of the soils of this association.

4. Hegne-Viking association

Poorly drained, fine textured and moderately fine textured soils formed in calcareous, lake-modified clay till and lacustrine clays

This association is characterized by microrelief of ridges, knobs, and swales. The microrelief has an 8- to 30-inch difference in elevation. The ridges and swales are oriented in a northwest-southeast direction. The swales are elongated and generally joined. Some deeper, circular or slightly oblong depressions occur along the swales. These depressions commonly hold ponded water. Stones, cobblestones, and gravel are scattered on the surface of much of this association, mainly on the ridges and knobs. The natural surface runoff is slow.

This association has a few well-entrenched natural drainageways. Large legal ditches have been constructed to drain the soils of this association. These ditches are blocked by snow and ice, which hold back water during spring breakup. This blocking of spring runoff often causes local flooding. Extended periods of heavy rainfall also cause ditches to overflow.

This association makes up about 5 percent of the county. About 60 percent of the association consists of soils of the Hegne series, which commonly occupy knobs and ridges. Their surface layer is strongly calcareous, black silty clay. The next main layer is very strongly calcareous, gray silty clay. The underlying material is olive-gray silty clay and clay. In this association Hegne soils appear as dark-gray areas if the surface is dry. Gravel, cobblestones, and a few stones are commonly scattered on the surface.

About 30 percent of the association consists of soils of the Viking series, which occupy swales and depressions. Viking soils lack the accumulation of carbonates immediately below the surface layer that is common in Hegne soils. These soils formed in clay till. They have some stones, cobblestones, and gravel scattered on the surface and through the profile. The Hegne and Viking soils commonly occur in an intricately mixed pattern.

Minor soils make up the remaining 10 percent of this association. The most important of these are the siltier Bearden and Colvin soils and the Fargo soils.

Nearly all of this association is used for crops. Most farms are more than 640 acres in size and produce small grains, sugar beets, and sunflowers. A smaller acreage is used for hay and pasture crops and legumes for green manure. Some small areas are idle and support a scattered growth of quaking aspen. Wetness is the main limitation. Soil blowing on summer-fallow fields, the need to maintain and improve soil structure and fertility, and the presence of gravel, cobblestones, and stones also influence use and management of the soils of this association.

5. Glyndon-Wheatville-Borup association

Moderately well drained to poorly drained, medium-textured soils formed in calcareous, lacustrine silts and very fine sands

Most of this association is nearly level. The wetter areas are commonly slightly concave. A small acreage is gently sloping. The natural surface runoff is medium to slow. Some natural draws drain into the Wild Rice River and Spring Creek. A few draws have been straightened and deepened or ditches have been dug to speed the removal of excess water and carry it westward. Streams, ditches, and culverts are often blocked by ice and snow, which hold back water during spring runoff and causes flooding. Excessive rainfall also causes some streams and ditches to overflow.

This association makes up about 12 percent of the county. Soils of the Glyndon series make up about 44 percent of the association. These soils are at slightly higher elevations than the other major soils. They are nearly level and slightly convex. Glyndon soils have a surface layer of very dark gray or black, strongly calcareous loam. The next main layer is light yellowish-brown, very strongly calcareous loam. The underlying material is light brownish-gray, calcareous loamy very fine sand.

Soils of the Wheatville series make up about 26 percent of this association. These soils occupy positions similar to those of the Glyndon soils, but they differ in having contrasting fine-textured underlying material within a depth of 40 inches.

About 14 percent of this association consists of soils of the Borup series. These soils are nearly level and mainly occupy slightly concave positions. They have a surface layer of black, strongly calcareous loam. The next main layer is dark-gray, very strongly calcareous very fine sandy loam. The underlying material is light olive-gray, calcareous loamy very fine sand.

The remaining 16 percent of the association consists of minor soils. The most important of these are Augsburg soils that are similar to Borup soils except for their fine-textured underlying material, the coarser textured Grimstad and Ulen soils, and the finer textured Bearden soils.

Nearly all of this association is used for crops. Most farms are more than 480 acres in size. Small grains, sunflowers, and sugar beets are the most common crops. Some soybeans, corn, and potatoes are also grown on soils of this association. A small acreage is used for pasture or hay or is idle. Most of the idle areas are along rivers and streams and are wooded. Susceptibility to soil blowing, a fertility imbalance caused by the calcareous condition, and wetness on the poorly drained soils are the main limitations. The need to control soil blowing, increase or maintain soil fertility, and improve drainage influences the use and management of the soils of this association.

6. Grimstad-Rockwell association

Moderately well drained to poorly drained, moderately coarse textured soils formed in calcareous, lacustrine fine sands; finer textured loamy material within 40 inches of the surface

Much of this association is nearly level. The wetter soils occupy lower lying, flat or slightly depressed areas. The natural surface runoff is medium to slow. The depth to the water table is fluctuating or shallow. Some natural draws drain into Spring Creek, Mashaug Creek, and the Wild Rice River. These draws are often shallow or narrow, and at times they overflow. Rapid movement of water cuts new channels in the coarser textured sand cap, erodes the channel of established drainageways, and

washes out culverts and road crossings. In some areas of this association the movement of water is slowed or blocked by coarse-textured and medium-textured material on adjoining higher ridges.

This association makes up about 6 percent of the county. Soils of the Grimstad series make up about 42 percent of the association. These soils are nearly level and occupy the higher, slightly convex positions on the landscape. They have a surface layer of black, strongly calcareous fine sandy loam that grades to grayish-brown, very strongly calcareous loamy fine sand. The next main layer is light olive-brown, calcareous fine sand. The underlying material is light brownish-gray fine sandy loam and loam.

About 40 percent of this association consists of soils of the Rockwell series. These soils are nearly level and occupy slightly concave and depressional positions on the landscape. They have a surface layer of black, strongly calcareous fine sandy loam that grades to gray, very strongly calcareous loam. The next main layer is mottled, light olive-gray, calcareous fine sand. The underlying material is mottled, light olive-gray, calcareous loam and silt loam.

The remaining 18 percent of the association consists of minor soils. The most important of these are the less calcareous Kratka, Swenoda, and Towner soils and the Ulen and Arveson soils that formed in deeper sand deposits.

Most farms in this association are less than 640 acres in size. These farms produce small grains and are partly in grass that is used for pasture and hay. A smaller acreage of row crops, such as corn, sunflowers, soybeans, and potatoes, is also grown. A few areas are idle and support a growth of trees, principally quaking aspen. The undrained depressions are commonly vegetated with reeds, sedges, and cattails. Susceptibility to soil blowing, water erosion, and wetness are the most serious limitations to the use of soils of this association. The need to control soil blowing and water erosion, increase soil fertility, and improve drainage influences the use and management of soils of this association.

7. *Ulen-Arveson association*

Moderately well drained to poorly drained, moderately coarse textured and medium-textured soils formed in calcareous, lacustrine fine sands

Much of this association is nearly level. The wetter areas are generally slightly depressional. The natural surface runoff is medium to slow. Some natural draws drain excess water into the Wild Rice River, Mashaug Creek, and Spring Creek. These natural draws are often shallow or narrow and overflow at times, causing water to go over land. Rapid movement of water cuts new channels, erodes the channel of established drainageways, and washes out culverts and road crossings. In some areas movement of water is slowed or blocked by adjoining higher ridges of coarse-textured and medium-textured material.

This association makes up about 8 percent of the county. Soils of the Ulen series make up about 40 percent of the association. These soils are nearly level and occupy the higher, slightly convex positions. Ulen soils have a surface layer of black, calcareous fine sandy loam. The next main layer is dark grayish-brown, very strongly calcareous loamy fine sand. The underlying material is light yellowish-brown to olive-yellow, calcareous loamy fine sand and fine sand.

About 38 percent of the association consists of soils of the Arveson series. These soils are nearly level and occupy slightly concave and depressed positions. They have a surface layer of black, strongly calcareous loam. The next main layer is dark-gray and dark grayish-brown, very strongly calcareous fine sandy loam and sandy loam. The underlying material is mottled, light-gray to grayish-brown fine sand.

The remaining 22 percent of the association consists of minor soils. The most important of these are the less calcareous Hamar and Flaming soils and the Grimstad and Rockwell soils that have finer textured underlying material.

Most farms in this association are less than 640 acres in size. These farms mainly produce small grains, often in rotation with hay or pasture. A smaller acreage is used for row crops, such as potatoes, sunflowers, corn, and soybeans. Some acreage of Kentucky bluegrass, redtop, quackgrass, reeds, and sedges is used for permanent pasture or hay. A few areas are idle and support a growth of quaking aspen. Some undrained depressions support a growth of reeds, sedges, and cattails.

Soil blowing and water erosion, medium to low inherent fertility, and wetness are the most serious limitations to use of this association. A low available water capacity is also a limitation. The need to control soil blowing and water erosion, increase soil fertility, and improve drainage on poorly drained areas influences the use and management of soils of this association.

8. *Kittson-Roliss-Viking association*

Moderately well drained to poorly drained, moderately fine textured and fine textured soils formed in calcareous, lake-modified till

This association is nearly level to sloping. In many places the nearly level, wetter soils occupy areas between beach ridges. The higher, better drained soils are commonly associated with a slightly convex landscape. The gently sloping and sloping areas are adjacent to natural drainageways and on till ridges in the eastern and east-central part of the glacial Lake Agassiz basin. The natural surface runoff ranges from medium to moderately rapid on convex, gently sloping, and sloping areas to slow on nearly level, wet areas. In many places ridges of coarse and finer textured material block or slow water movement from these wetter soils.

This association makes up about 2 percent of the county. Soils of the Kittson series make up about 35 percent of the association. These are nearly level soils on slightly convex landscapes and gently sloping and sloping soils on ridges and in areas adjacent to natural drainageways. The Kittson soils have a surface layer of black, friable loam. Their subsoil is olive-brown loam. The underlying material is calcareous, light olive-brown to light brownish-gray loam.

Soils of the Roliss series make up about 20 percent of the association. These are nearly level soils in slightly concave, depressed positions. They are similar to Kittson soils, except that their subsoil and underlying material

are more grayish in color and are more distinctly mottled.

Soils of the Viking series make up about 15 percent of the association. These soils occupy a landscape similar to that of Roliss soils, but they formed in clay till and are finer textured.

Minor soils make up the remaining 30 percent of this association. The most important of these are the more calcareous Hamerly and Vallers soils and the coarser textured Mavie, Foxhome, Swenoda, and Rockwell soils.

Most farms in this association are less than 640 acres in size. Much of this association is cropland. Small grains are the most important crop. Some areas are used for pasture and hay. A small acreage is used for row crops, such as corn and sunflowers. A few areas are idle. These are mainly depressions that have wetland vegetation or are wooded areas where quaking aspen is the most common tree.

Wetness is a serious limitation on the Roliss, Vallers, and Viking soils. Climate influences choice of crops on the level and nearly level Kittson soils. Water erosion is a hazard on the Kittson and Hamerly soils in areas where slopes are more than 2 percent. Reduced inherent fertility is a limitation on the more calcareous Hamerly and Vallers soils. The main management needs are to improve drainage, control water erosion and soil blowing, and maintain and improve soil structure and fertility. Stones, cobblestones, and gravel are further limitations.

9. *Sioux-Syrene-Sverdrup association*

Excessively drained, somewhat excessively drained, and poorly drained, coarse textured and moderately coarse textured soils formed in outwash areas and on beach ridges

This association is nearly level to sloping. In a few areas, the coarse-textured outwash has a stronger and more complex relief pattern and moderately steep and steep slopes. The natural surface runoff is rapid on these areas, and relatively deep drainageways lead into the Wild Rice and Sand Hill Rivers. The nearly level to sloping soils generally formed in gravelly deposits on beach ridges. These ridges vary considerably in width. They may be nearly level on top and gently sloping or sloping along the edges. The natural surface runoff is rapid on the slightly convex, coarse-textured soils on ridges. Lower lying, nearly level or concave, coarse-textured soils on beach ridges are poorly drained and are affected by seep and a high water table.

This association makes up about 4 percent of the county. Soils of the Sioux series make up about 60 percent of the association. These soils are nearly level to sloping and occupy convex ridges or irregular outwash areas. They have a varying thickness of black sandy loam or gravelly sandy loam in the surface layer. The next main layer is very dark grayish-brown gravelly loamy sand. The underlying material is brown and pale-brown gravelly coarse sand.

Soils of the Syrene series make up about 22 percent of the association. These soils are nearly level and occupy low, nearly flat to slightly concave positions. They have a surface layer of black, strongly calcareous sandy loam. The next main layer is very strongly calcareous, dark-gray and gray sandy loam. The underlying material is calcareous sand and gravel.

Soils of the Sverdrup series make up about 5 percent of the association. These soils are nearly level to sloping and generally occupy outwash areas on the till plain. They have a surface layer of black fine sandy loam. The subsoil is brown to dark yellowish-brown sandy loam and loamy sand. The underlying material is light olive-brown fine sand.

Minor soils make up the remaining 13 percent of the association. The most important of these are Hangaard and Maddock soils. Hangaard soils are similar to Syrene soils except that they are less calcareous; and Maddock soils are similar to Sverdrup soils except that they are coarser textured in the upper layers. Other minor soils are Foxhome, Mavie, Arveson, and Markey soils.

Most farms in this association are less than 640 acres in size, and many of the cultivated areas are several miles apart. About half of this association is cropland. The main crops are small grains, principally rye and oats, and rotation grasses and legumes grown for hay and pasture. Some corn and soybeans are grown on the less steeply sloping soils. The remainder of the acreage is in permanent hay, pasture, or idle land. Introduced grasses, such as Kentucky bluegrass, redtop, quackgrass, and some native grasses, grow in these areas. Some areas are wooded, and patches of quaking aspen and some bur oak are on the higher, better drained soils. Many of the very wet seep areas have water ponded on them and support a growth of reeds, sedges, cattails, and willows. A low available water capacity, low to medium inherent fertility, and susceptibility to soil blowing and water erosion are the most serious limitations to use of the higher lying areas in this association. Wetness is the main limitation on the lower, poorly drained areas. Many wet areas affected by seep are difficult to drain and are suited to wildlife habitat. The Sioux, Maddock, and Sverdrup soils are a good source of gravel and sand.

10. *Flaming-Hamar association*

Moderately well drained to poorly drained, coarse-textured soils formed in lacustrine and outwash fine sands

This association occupies rather uneven areas similar to microrelief. The landscape is characterized by slight ridges, knobs, nearly level areas, and lower, slightly concave and depressional areas. Severe soil blowing and alternate periods of soil removal and accumulation have resulted in the uneven relief on much of this association. Many of the very poorly drained depressions are old blowouts that have no natural drainage outlet.

The soils in this association are also characterized by a fluctuating or shallow water table. The natural drainage is slowed or blocked to some extent by bordering higher ridges of coarse-textured and finer textured materials. Spring Creek, Mashaug Creek, and some draws leading into the Wild Rice River drain this area. Where the natural drainageways are not deep, flooding occurs. Rapid movement of water cuts a new channel in the easily eroded sand. Channel erosion is also a problem in older, well-established channels and in ditches dug to improve natural drainage. Road crossings and culverts along these ditches and channels often wash out during seasons of high runoff.

Dune land makes up a small part of the association in northwestern Sundahl Township. Sand in these dunes is a part of the Sand Hill River Delta. These dunes exhibit little soil development and vary from low dunes that have 1 to 6 percent slopes and microrelief topography to steep dunes that are more than 40 feet high and have slopes up to 60 percent.

This association makes up about 7 percent of the county. Soils of the Flaming series make up about 45 percent of the association. These soils commonly occupy a rather uneven landscape that has alternate areas of soil removal and accumulation. They are nearly flat to slightly convex and have short slopes of up to 3 percent. They have a surface layer of black and very dark gray loamy fine sand that is variable in thickness. The subsoil is very dark grayish-brown, brown, and grayish-brown fine sand. The underlying material is mottled, light brownish-gray fine sand.

Soils of the Hamar series make up about 35 percent of the association. These soils are nearly level and occupy lower, concave and depressed positions on the landscape. They are more poorly drained than Flaming soils and have a surface layer of black loamy fine sand. The subsoil is distinctly mottled, dark grayish-brown and grayish-brown sand. The underlying material is grayish-brown fine sand.

Minor soils make up the remaining 20 percent of this association. The most important of these are the more calcareous Arveson and Ulen soils, the lighter colored Poppleton soils, the better drained Maddock soils, and Dune land.

Most farms in this association are less than 640 acres in size and have livestock-oriented operations. Much of the acreage is used for hay and pasture. Introduced grasses, such as redtop, Kentucky bluegrass, and quackgrass, are the most common hay and pasture crops. A considerable acreage is idle. Most areas support a growth of quaking aspen or are wet depressions that contain cattails, reeds, and sedges. The dune land areas in this association are also idle or are used for limited grazing. Native grasses, such as prairie sandreed and indiangrass, stands of prostrate cedar, and scattered trees, principally bur oak and quaking aspen, grow on these dunes. A smaller part of this association is cultivated. Oats, barley, flax, rye, and some corn for silage or fodder are the most common crops.

Susceptibility to soil blowing and water erosion, low to medium inherent fertility, and wetness are the most serious limitations on the soils in this association. A low available water capacity is also a limitation, especially on the better drained soils. The need to control soil blowing and water erosion, increase soil fertility, and improve drainage on poorly drained areas influences the use and management of these soils.

11. Barnes-Kittson-Flom association

Well-drained to poorly drained, moderately fine textured and medium-textured soils formed in calcareous glacial till

This association has rather strong, complex relief. The landscape is characterized by relatively deep natural drainageways, such as the Garden Slough and the Sand Hill and Wild Rice Rivers and drainageways that lead into them. Some of the steepest topography occurs along these drainageways. These natural drainageways remove water rapidly from the higher areas in this association. The natural surface runoff is slow in the lower areas, and the many deep depressions common in this association are difficult to drain. Many areas have ponded water and support a growth of cattails, reeds, and sedges. The nearly level and gently sloping soils at the base of steeper slopes and along draws commonly contain varying thicknesses of colluvium.

This association makes up about 9 percent of the county. Soils of the Barnes series make up about 25 percent of the association. These soils are nearly level to steep and are well drained. The Barnes soils have a surface layer of black, friable loam. The subsoil is dark-brown, brown, and dark yellowish-brown loam. The underlying material is brown and light olive-brown, calcareous loam till.

About 15 percent of the association consists of the Kittson soils on uplands. These soils are nearly level and gently sloping. They differ from Barnes soils in being more poorly drained, exhibiting grayer colors, and having mottles at a shallower depth.

Soils of the Flom series make up about 15 percent of the association. These soils are nearly level and occupy concave and depressional areas. They have a surface layer of black and very dark gray light silty clay loam and clay loam. The subsoil is dark-gray light silty clay loam. The underlying material is calcareous, olive-gray and gray loam till.

Waukon soils make up about 10 percent of the association, and other minor soils make up about 35 percent. Waukon soils differ from Barnes soils in having stronger development in the B horizon. The Langhei soils occupy the landscape in a complex with Barnes soils. Other minor soils include the calcareous Hamerly and Vallers soils; some coarser textured soils of the Sverdrup and Sioux series; organic soils of the Cathro, Seelyeville, and Rondeau series; and areas of Marsh.

Much of this association is used for small grains, pasture, and forage crops. Such row crops as corn and soybeans are also grown. A small acreage is in woodland, principally oak, maple, and popple. These wooded areas occur as woodlots on farmsteads in some of the more steeply sloping areas. These areas, along with some of the wet depressions and drainageways, are idle land (fig. 2). A susceptibility to water erosion, rapid runoff, and occasional droughty conditions are the most serious limitations on gently sloping to steep, well-drained to somewhat excessively drained soils in this association. The lower, poorly drained and very poorly drained soils in this association have a wetness limitation. The need to control water erosion, reduce runoff, and increase or maintain soil fertility and organic-matter content influences the use and management of the better drained gently sloping to steep soils. The principal needs on the lower, poorly drained and very poorly drained soils are to improve drainage and to maintain soil fertility, organic-matter content, and structure. Many of the deeper, very poorly drained soils in depressions are difficult to drain and are suited to wildlife habitat. Some stones and cobblestones are scattered on soils in this association; they occasionally interfere with the operation of farm machines.

Figure 2.—A typical landscape in the Barnes-Kittson-Flom association.

12. Hamerly-Vallers association

Moderately well drained to poorly drained, medium-textured and moderately fine textured soils formed in calcareous, water-modified glacial till

This association has moderately strong and complex relief. Gently sloping, slightly convex soils commonly occupy higher lying, circular knobs and elongated areas parallel to natural drainageways. The lower lying soils are commonly nearly level and slightly concave. This association also includes many deep depressions that are difficult to drain. Many of these depressions have ponded water in them and support a growth of cattails, reeds, and sedges. The natural surface runoff is moderately rapid to slow. Natural drainageways remove water rapidly from the higher areas in this association. The natural surface runoff is slow in the lower areas, and there are many blockages and depressions in the natural drainage pattern. Most of this association drains south into the Wild Rice River or north and west into the Garden Slough and the Sand Hill River.

This association makes up about 6 percent of the county. Soils of the Hamerly series make up about 50 percent of the association. These soils are nearly level to gently sloping and occupy the higher, slightly convex positions. They have a surface layer of black to dark-gray, calcareous silt loam. The next main layer is dark grayish-brown to light brownish-gray, very strongly calcareous loam. The underlying material is mottled, light yellowish-brown, calcareous loam till.

About 43 percent of the association consists of soils of the Vallers series. These soils are nearly level and occupy slightly concave and depressed positions. They have a surface layer of black, calcareous silt loam. The next main layer is grayish-brown, very strongly calcareous loam. The underlying material is light brownish-gray and light olive-gray, strongly calcareous clay loam and loam till. The Hamerly and Vallers series occur in an intricately mixed pattern as a complex in parts of the association. These areas have a strong microrelief, and the Hamerly and Vallers series are in such close association that they cannot be mapped separately.

Minor soils make up the remaining 7 percent of the association. The most important of these are the less calcareous Kittson and Flom soils; organic soils of the Cathro, Seelyeville, and Rondeau series; and areas of Marsh.

Most farms in this association are less than 640 acres in size. Much of the acreage is used for small grains, pasture, and forage crops. Some legumes are grown for hay and pasture or for green manure. Some row crops, such as corn and soybeans, are also grown. A small acreage is in woodland, principally quaking aspen. Many of these wooded areas and some wet depressions are idle.

Some of the depressions are deep and are difficult to drain. Many of these are better suited to wildlife habitat than to other uses.

The use of this association is limited by a susceptibility to water erosion on gently sloping soils and a fertility imbalance caused by the calcareous condition of the somewhat poorly drained to moderately well drained soils. The lower lying poorly drained soils in the association have a wetness limitation. The need to control water erosion and to increase or maintain soil fertility and organic-matter content influences the use and management of the better drained soils. On lower lying, poorly drained soils, the need to improve drainage and maintain fertility and structure influences use and management. In places stones and cobblestones interfere with the operation of farm machines on the Hamerly, Vallers, and Flom soils in this association.

Descriptions of the Soils

In this section the soil series and mapping units in this county are described. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

The soils of each series are first described as a group. Important features common to all the soils of the series are listed, and the position of the soils on the landscape is given. Each series description has a short narrative description of a representative profile and a much more detailed description of the same profile, from which highly technical interpretations can be made. Following the profile is a brief statement of the range of characteristics of the soils in the series as mapped in this county. Comparisons are made with other soils that are nearby

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

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land, occasionally flooded	5, 160	0. 9	Kittson loam, 2 to 8 percent slopes	440	1. 1
Alluvial land, frequently flooded	4, 350	. 8	Kittson loam, uplands, 0 to 1 percent slopes	6, 410	. 1
Arveson loam	21, 160	3. 7	Kittson loam, uplands, 1 to 5 percent slopes	1, 530	. 3
Arveson and Hamar soils, depressional	5, 880	1. 0	Langhei-Barnes loams, 6 to 12 percent slopes, eroded	1, 920	. 3
Augsburg and Wheatville loams	3, 610	. 6	Langhei-Barnes loams, 12 to 18 percent slopes, eroded	980	. 2
Barnes loam, 0 to 2 percent slopes	1, 680	. 3	Langhei-Barnes loams, 18 to 30 percent slopes	270	(1)
Barnes loam, 2 to 6 percent slopes	5, 900	1. 0	Maddock loamy fine sand, 0 to 2 percent slopes	570	. 1
Barnes loam, 2 to 6 percent slopes, eroded	3, 880	. 7	Maddock loamy fine sand, 2 to 8 percent slopes	600	. 1
Barnes loam, 6 to 12 percent slopes, eroded	820	. 1	Markey muck	460	. 1
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	1, 780	. 3	Marsh	910	. 2
Bearden silty clay loam, 0 to 2 percent sopes	40, 200	7. 1	Mavie loam	2, 390	. 4
Bearden silty clay loam, 2 to 6 percent slopes	1, 800	. 3	Poppleton loamy fine sand	1, 490	. 3
Bearden silty clay loam, 2 to 8 percent slopes, eroded	690	. 1	Rockwell fine sandy loam	12, 270	2. 2
Bearden-Fargo silty clay loams	45, 960	8. 1	Rockwell and Kratka soils, depressional	2, 290	. 4
Borup loam, depressional	2, 380	. 4	Roliss loam	900	. 2
Borup and Glyndon loams	9, 580	1. 7	Roliss loam, depressional	1, 180	. 2
Breaks and Alluvial land	6, 000	1. 1	Rondeau muck	230	(1)
Cashel silty clay, 0 to 2 percent slopes	650	. 1	Seelyeville muck	170	(1)
Cashel silty clay, 2 to 8 percent slopes	810	. 1	Sioux sandy loam, 0 to 2 percent slopes	7, 190	1. 3
Cathro muck	2, 000	. 4	Sioux sandy loam, 2 to 6 percent slopes	6, 120	1. 1
Colvin silty clay loam	11, 620	2. 1	Sioux gravelly sandy loam, 0 to 2 percent slopes	370	. 1
Colvin silty clay loam, depressional	510	. 1	Sioux gravelly sandy loam, 2 to 8 percent slopes	600	. 1
Darnen silt loam, 1 to 4 percent slopes	310	. 1	Sioux and Maddock soils, 12 to 36 percent slopes	330	. 1
Dune land	1, 460	. 2	Sverdrup fine sandy loam, 0 to 2 percent slopes	820	. 1
Fargo silty clay loam, 0 to 1 percent slopes	14, 460	2. 5	Sverdrup fine sandy loam, 2 to 8 percent slopes	640	. 1
Fargo silty clay loam, 1 to 6 percent slopes	460	. 1	Swenoda fine sandy loam, 0 to 2 percent slopes	3, 900	. 7
Fargo silty clay, 0 to 1 percent slopes	43, 710	7. 8	Swenoda fine sandy loam, 2 to 8 percent slopes	3, 910	. 7
Fargo silty clay, 1 to 6 percent slopes	460	. 1	Syrene sandy loam	4, 900	. 9
Fargo silty clay, depressional	1, 600	. 3	Towner loamy fine sand	3, 010	. 5
Flaming loamy fine sand, wind eroded	21, 080	3. 7	Ulen fine sandy loam, 0 to 2 percent slopes	21, 450	3. 8
Flaming, Hamar, and Arveson soils	4, 270	. 8	Ulen fine sandy loam, wind eroded	2, 530	. 4
Flom silty clay loam	4, 430	. 8	Vallers silt loam	20, 300	3. 6
Flom and Vallers soils, depressional	3, 420	. 6	Vallers silt loam, depressional	2, 010	. 4
Foxhome loam, 0 to 3 percent slopes	1, 770	. 3	Viking clay loam	1, 470	. 3
Glyndon loam, 0 to 2 percent slopes	22, 980	4. 1	Wahpeton silty clay, 0 to 2 percent slopes	4, 170	. 8
Glyndon loam, 2 to 6 percent slopes	720	. 1	Wahpeton silty clay, 2 to 6 percent slopes	1, 200	. 2
Glyndon loam, wind eroded	2, 520	. 4	Wahpeton silty clay, 6 to 12 percent slopes	600	. 1
Gravel pits	820	. 1	Waukon loam, 0 to 2 percent slopes	670	. 1
Grimstad fine sandy loam	14, 490	2. 6	Waukon loam, 2 to 6 percent slopes	3, 050	. 5
Hamar loamy fine sand	4, 760	. 8	Waukon loam, 2 to 6 percent slopes, eroded	960	. 2
Hamerly silt loam, 0 to 1 percent slopes	20, 240	3. 6	Waukon loam, 6 to 12 percent slopes	330	. 1
Hamerly silt loam, 1 to 5 percent slopes	7, 200	1. 3	Waukon loam, 12 to 18 percent slopes	210	(1)
Hamerly-Vallers silt loams	5, 340	. 9	Wheatville loam	15, 440	2. 7
Hangaard sandy loam	780	. 1	Open water	700	. 1
Hegne-Fargo silty clays	52, 740	9. 3			
Hegne-Viking complex	15, 480	2. 7			
Kittson loam, 0 to 2 percent slopes	2, 590	. 5	Total	566, 400	100. 0

[1] Less than 0.05 percent.

or are generally similar to the soils of the series being described.

Each soil, or mapping unit, in the series is next described. Soils are the areas delineated on the map and identified by soil symbols. Generally, these descriptions tell how the profile of the soil differs from that described as representative of the series. They also tell about the use and suitability of the soil described and something about management needs.

For full information about any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. General information about the broad patterns of soils in the county is given in the section "General Soil Map." Unless otherwise indicated, the color names and color symbols given are for a moist soil.

Alluvial Land

This miscellaneous land type consists of alluvium deposited in old channel bottoms or along the banks of rivers and streams. These alluvial soils lack uniformity of color, texture, and soil reaction. They show little or no soil development.

Alluvial land, occasionally flooded (Ad).—This miscellaneous land type occupies narrow terraces or bottom lands associated with streams and old stream channels. The areas are dissected by draws that carry runoff water into the larger drainageways and streams. Most of these draws are crossable with farm machines, except during wet periods when they carry drainage water.

Alluvial land, occasionally flooded, ranges from nearly level to sloping. The most common textures are stratified silty and clayey materials. Reaction ranges from neutral to moderately alkaline. Inherent fertility is generally high.

Included in mapping were areas of Cashel soils that are more developed and are generally at slightly higher elevations. These soils make up as much as 20 percent of any given area. Also included were areas of Fargo and Colvin depressional soils that are more developed. These inclusions make up as much as 15 percent of any given area.

Many areas of Alluvial land, occasionally flooded, are included in fields that are used for small grains and row crops. Other areas are used for hay or pasture. A smaller acreage is idle and supports a growth of introduced grasses and scattered trees.

Wetness is a limitation to use of this soil. Most areas are subject to some flooding every 2 to 5 years. In addition, wetness in draws and drainageways running through or adjacent to areas of this land type delays or stops farming operations. During these periods of wetness and flooding, some or all crops drown out. (Capability unit IIIw–5; tree and shrub suitability group 7–D)

Alluvial land, frequently flooded (Af).—This miscellaneous land type occupies old stream channels, oxbows, or land along the edges of rivers and streams. The areas are dissected by narrow, winding channels of intermittent streams.

Alluvial land, frequently flooded, is nearly level and gently sloping. It consists of alluvium deposited in the bottoms of old channels or along the edges of rivers and streams. Material is deposited or washed away each time the area is flooded.

Included in mapping were areas of Marsh and intermittent open-water areas. These inclusions make up as much as 15 percent of any given area.

Most areas of Alluvial land, frequently flooded, are idle. Some areas are pastured. Vegetative cover includes grasses, reeds, sedges, cattails, and various lowland trees and brush.

Wetness limits the use of this soil. Areas are flooded one or more times each year. This frequent flooding and inaccessibility also limit the use of this soil. It provides good wildlife habitat. (Capability unit VIw–1; tree and shrub suitability group 7–D)

Arveson Series

The Arveson series consists of nearly level, poorly drained soils. These soils formed in calcareous, lacustrine sediments that are dominantly fine sand. They are commonly slightly concave, and some areas are irregularly shaped, closed depressions. They formed under tall prairie grasses and wetland reeds and sedges.

In a representative profile, the surface layer is strongly calcareous, black loam 12 inches thick. The next layer is dark-gray and dark grayish-brown fine sandy loam and sandy loam. This layer is 8 inches thick and is very strongly calcareous. Below this is calcareous and strongly calcareous, mottled, light-gray, light brownish-gray, and grayish-brown fine sand.

Arveson soils have medium available water capacity. Permeability is moderately rapid. Inherent fertility is medium. The seasonal water table fluctuates between depths of 1 and 5 feet. Many areas are cultivated. The soils are suited to small grains and to corn, sunflowers, and other row crops.

Representative profile of Arveson loam in a meadow 2,380 feet west and 2,500 feet north of the southeast corner of sec. 28, T. 146 N.,R. 45 W.

Ap—0 to 7 inches, black (N 2/0) loam; moderate, medium, subangular blocky structure parting to moderate, fine, granular; very friable; many roots; moderately alkaline; strongly calcareous; clear, smooth boundary.

A1—7 to 12 inches, black (N 2/0) loam; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; many roots; moderately alkaline; strongly calcareous; clear, wavy boundary.

C1cag—12 to 16 inches, dark-gray (2.5Y 4/1) fine sandy loam; few, medium and coarse, faint mottles of olive gray (5Y 5/2) and few, fine, distinct mottles of olive brown (2.5Y 4/4); weak, medium, subangular blocky structure; very friable; few roots; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C2cag—16 to 20 inches, dark grayish-brown (2.5Y 4/2) sandy loam; few, fine, distinct mottles of olive brown (2.5Y 4/4) and dark yellowish brown (10YR 4/4) and few, fine, prominent mottles of dark brown (7.5YR 3/2); weak, medium, subangular blocky structure; very friable; few roots; moderately alkaline; very strongly calcareous; abrupt, smooth boundary.

IIC3g—20 to 24 inches, light-gray (5Y 7/2) fine sand; common, medium faint mottles of light gray (2.5Y 7/2) and few, fine, distinct mottles of yellowish brown (10YR 5/6); single grain; few, black and dark reddish-brown, soft masses; few roots; moderately alkaline; calcareous; clear, wavy boundary.

IIC4g—24 to 33 inches, light brownish-gray (2.5Y 6/2) fine sand; many, coarse, faint mottles of light gray (2.5Y 7/2) and common, fine and medium, distinct mottles of yellowish brown (10YR 5/6); single grain; loose; few, soft, black masses; moderately alkaline; calcareous; gradual, smooth boundary.

IIC5g—33 to 43 inches, light-gray (2.5Y 7/2) fine sand; common, coarse, faint mottles of light brownish gray (2.5Y 6/2); single grain; loose; moderately alkaline; calcareous; gradual, smooth boundary.

IIC6g—43 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; many, coarse, faint, gray (5Y 6/1) mottles; single grain; loose; moderately alkaline; strongly calcareous.

The A horizon is black or very dark gray. The very dark gray is most common in the lower part of the A horizon if it contains more carbonates. The texture of the A horizon is generally fine sandy loam or loam, but in places it is sandy loam and silt loam. The structure is weak to moderate subangular blocky or granular. The thickness of the A horizon ranges from 8 to 16 inches.

The Ccag horizon is dark gray or gray, grayish brown, dark grayish brown, light brownish gray, olive gray, or light olive gray in color. It ranges from loam to sandy loam in texture. This horizon is strongly calcareous or very strongly calcareous. It ranges from 8 to 16 inches in thickness. Distinct or prominent mottles are within 20 inches of the surface in most profiles.

The IICg horizon generally is fine sand, but in places it is sand. It is mildly alkaline or moderately alkaline and is calcareous or strongly calcareous. Thin bands, ½ to 3 inches thick, of material ranging from fine sandy loam to gravel are in the IICg horizon of some profiles. Mottling ranges from few, faint to many, prominent.

Arveson soils are associated with Ulen, Rockwell, Flaming, and Hamar soils and are similar to Borup soils. They are more poorly drained than Flaming and Ulen soils. They lack the loamy IIIC horizon of Rockwell soils. They have a calcareous A horizon, unlike Hamar soils, which have a noncalcareous A horizon. They contain more fine sand and less very fine sand than Borup soils.

Arveson loam (Ar).—This nearly level soil occupies slightly concave areas that normally range from 5 to 80 acres in size. These areas are in shallow swales and some irregularly shaped depressions. Slopes range from 0 to 2 percent. In cultivated areas, the exposed surface layer is black or, in some areas, grayish.The presence of clean, bleached sand grains and the calcareous condition of the surface layer account for these color variations. This soil has the profile described as representative for the series.

Included in mapping were areas of the better drained Ulen soils. These soils make up as much as 15 percent of any given area. Also included were areas of Hamar soils that are sandier at the surface and less calcareous, as well as areas of Rockwell soils that have finer textured underlying material. These inclusions make up as much as 20 percent of any given area. Also included were areas of this Arveson soil that have a convoluted profile in which the soil material has been mixed, resulting in varied and broken horizons.

In cultivated areas, small grains and corn for fodder or silage are the most common crops. In uncultivated areas, this soil commonly supports a growth of introduced grasses, such as redtop, quackgrass, and Kentucky bluegrass. These areas are often pastured or cut for hay. There also are scattered areas of quaking aspen and willow brush on this soil. Many of these areas are idle.

Wetness is a limitation. Susceptibility to soil blowing and water erosion also influence the use and management of this soil. (Capability unit IIIw–4; tree and shrub suitability group 4)

Arveson and Hamar soils, depressional (As).—These soils occupy depressions that generally range from 3 to 15 acres in size. These areas are surrounded by nearly level, better drained, moderately coarse textured and coarse textured soils. Most of the depressions are closed pockets, but a few areas are in the bottoms of natural draws. Many of the depressions that contain these soils are old blowout areas. The percentage of Arveson loam in this unit ranges from 30 to 80, and that of Hamar loamy fine sand ranges from 20 to 70. These depressional soils commonly support wetland vegetation. If drained and cultivated, they have a black surface layer that has blotches of a more grayish color. Clean, bleached sand grains and strongly calcareous material in the surface layer influence this color variation.

Included in mapping were areas of Rockwell and Kratka soils that have finer textured underlying material. These soils make up as much as 20 percent of any given area. Also included were areas of Markey muck that have an organic surface layer overlying sand and areas of Marsh where soil material has not been determined. These inclusions make up as much as 20 percent of any given area.

Most areas of this unit are idle. A few depressions have been drained and are included in cultivated fields. The main crop is small grains. Many of the depressions are farmed along with areas that are being pastured or cut for hay; they commonly support a growth of reeds, sedges, cattails, and willow brush. A few depressions produce reed canarygrass. (Capability unit IVw–2; tree and shrub suitability group 7–B)

Augsburg Series

The Augsburg series consists of nearly level, poorly drained soils that formed in lacustrine sediments consisting mainly of an upper mantle of very fine sand and silt overlying clay. The topography is nearly level and is common slightly concave. These soils formed under tall prairie grasses and sedges.

In a representative profile, the surface layer is 12 inches of black, strongly calcareous loam. The next layer is gray and dark grayish-brown, very strongly calcareous loam and very fine sandy loam about 8 inches thick. Below this is 9 inches of mottled, light brownish-gray loamy very fine sand. The underlying material is grayish-brown and dark grayish-brown silty clay.

Augsburg soils have medium to high available water capacity. Permeability is moderate to the silty clay and slow in the silty clay. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Most areas are cultivated. The soils are suited to all crops commonly grown in the county.

Representative profile of Augsburg loam in an area of Augsburg and Wheatville loams, in a cultivated field 1,920 feet east and 430 feet south of the northwest corner of sec. 26, T. 143 N., R. 46 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, fine, granular structure; very friable; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

A1—8 to 12 inches, black (10YR 2/1) loam; weak, very fine, subangular blocky structure; very friable; moderately alkaline; strongly calcareous; clear, broken boundary.

C1cag—12 to 15 inches, gray (2.5Y 5/1) loam; few, fine, prominent mottles of yellowish brown (10YR 5/8) and few, fine, distinct mottles of light olive brown (2.5Y 5/6); weak, medium, subangular blocky structure; very friable; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C2cag—15 to 20 inches, dark grayish-brown (10YR 4/2) mixed with dark-gray (10YR 4/1) very fine sandy loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, very fine, subangular blocky structure; very friable; moderately alkaline; very strongly calcareous; clear, wavy boundary..

C3g—20 to 29 inches, light brownish-gray (2.5Y 6/2) loamy very fine sand; common, medium, faint mottles of gray (2.5Y 5/1) and few, fine, distinct mottles of yellowish red (5YR 4/6) and yellowish brown (10YR 5/8); few, fine, soft, black masses; massive; very friable; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

IIC4g—29 to 35 inches, grayish-brown (2.5Y 5/2) silty clay; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, very fine, subangular structure; friable; moderately alkaline; strongly calcareous; gradual, smooth boundary.

IIC5g—35 to 60 inches, grayish-brown (2.5Y 5/2) grading to dark grayish-brown (2.5Y 4/2) silty clay; common, medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, medium, platy structure parting to weak, very fine, angular blocky; firm; few, fine, soft, black masses and soft, white lime masses; few lenses of silt loam and very fine sandy loam up to ½ inch thick in lower part; moderately alkaline; strongly calcareous.

The texture of the A horizon generally is loam, but in places it is very fine sandy loam, silt loam, or sandy clay loam. There is an Aca horizon with a very dark gray color in some profiles. The structure is weak granular or subangular blocky. The thickness ranges from 7 to 16 inches.

The C1cag and C2cag horizons have colors of gray, dark gray, grayish brown, dark grayish brown, and olive gray. Mottles commonly are distinct or prominent. These horizons have a texture of very fine sandy loam, loamy very fine sand. loam, silt loam, and sandy clay loam. They are strongly calcareous or very strongly calcareous and range from 6 to 16 inches in thickness.

The colors in the C3g horizon are gray or dark gray, olive gray, olive, pale olive, grayish brown, and light brownish gray. Mottling ranges from faint to distinct. The C3g horizon typically is loamy very fine sand and very fine sandy loam, but in places it is very fine sand, light silt loam, or loam. Reaction ranges from mildly alkaline to moderately alkaline. This horizon is lacking in some profiles.

The depth to the silty clay IIC horizon ranges from 20 to 40 inches. The colors in the IIC horizon are dark grayish brown, grayish brown, light brownish gray, dark gray, gray, olive gray, and light olive gray. Mottling ranges from faint to prominent. The IIC horizon generally is silty clay, but in places it is clay and silty clay loam. There are thin layers or bands of silt loam and very fine sandy loam in this horizon in most profiles. In some profiles this horizon is more than 60 percent clay.

Augsburg soils are associated with Wheatville and Borup soils and are similar to Rockwell soils. They are more poorly drained than Wheatville soils. They have a clayey IIC horizon, which is lacking in Borup soils. They contain more silt and very fine sand in the A horizon and the Cca horizon and more clay in the IIC horizon than Rockwell soils.

Augsburg and Wheatville loams (Aw).—These nearly level soils occupy areas of shallow microrelief and generally range from 5 to 80 acres in size. Slopes are less than 2 percent. The landscape generally has slight rises and gentle swales. Augsburg soils occupy the gentle swales, and Wheatville soils are on the slight rises. In cultivated areas the surface layer has a smooth appearance and variation of black and dark-gray colors. Augsburg soils make up 55 to 70 percent of the area, and Wheatville soils, from 30 to 45 percent. The depth to distinct or prominent mottles and the colors in the underlying material are so variable that separating the two series is not feasible.

Included in mapping were areas of Borup and Glyndon soils that lack the fine-textured underlying material. These soils make up as much as 15 percent of any given area. Also included were areas of finer textured Colvin and Bearden soils. These inclusions also make up as much as 15 percent of any given area. Other areas of this unit also include as much as 10 percent of coarser textured Grimstad and Rockwell soils.

Nearly all of this unit is cultivated. Small grains, sugar beets, and soybeans are the most commonly grown crops. Some legumes are grown for plowdown as green manure. A very small acreage is used for hay and pasture.

Wetness is a limitation to use of these soils. The strongly calcareous condition also influences use and management. (Capability unit IIw–2; tree and shrub suitability group 4)

Barnes Series

The Barnes series consists of nearly level to very steep, well-drained soils that formed in loam till. These soils are on a complex landscape on uplands. The gently undulating to very steep soils occur in complex with Langhei soils. They formed under tall prairie grasses.

In a representative profile, the surface layer is black loam about 9 inches thick. The subsoil is dark-brown and brown loam that grades to dark yellowish-brown and is about 18 inches thick. The underlying material is brown and light olive-brown, strongly calcareous loam till.

Barnes soils have high available water capacity and moderate permeability. Inherent fertility is high. Depth to the seasonal water table is more than 6 feet. Most areas are cultiated. The soils are suited to small grains and to corn, soybeans, sunflowers, and other row crops. Some areas of steeper soils are suited to hay and pasture.

Representative profile of Barnes loam, 2 to 6 percent slopes, in a cultivated field 2,420 feet south and 540 feet west of the northeast corner of sec. 21, T. 143 N., R. 43 W.

A1—0 to 9 inches, black (10YR 2/1) loam; weak, very fine, subangular blocky structure; very friable; about 2 percent coarse fragments; many roots; neutral; abrupt, wavy boundary.

B1—9 to 13 inches, dark-brown (10YR 3/3) loam; weak, very fine and fine, subangular blocky structure; very friable; few thin, black (10YR 2/1) tongues; about 5 percent coarse fragments; many roots; neutral; smooth boundary.

B2—13 to 18 inches, brown (10YR 4/3) loam; weak, very fine and fine, subangular blocky structure; very friable; thin, patchy, dark-brown (10YR 3/3) coatings on peds; about 5 percent coarse fragments; few roots; neutral; clear, smooth boundary.

B3—18 to 27 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) loam; weak, very fine and fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few roots; neutral to mildly alkaline; weakly calcareous; gradual, smooth boundary.

C1—27 to 33 inches, brown (10YR 5/3) loam; weak, very fine, subangular blocky structure; very friable;

about 5 percent coarse fragments; few roots; moderately alkaline; strongly calcareous; clear, smooth boundary.

C2—33 to 50 inches, light olive-brown (2.5Y 5/4) loam; few, fine, faint mottles of light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6) and few, fine, distinct mottles of yellowish brown (10YR 5/8); weak, very fine, subangular blocky structure; very friable; few, small, reddish-brown (5YR 4/3) concretions; about 5 percent coarse fragments; moderately alkaline; strongly calcareous.

The thickness of the A and B horizons ranges from 12 to 30 inches. The colors in the A horizon are black and very dark gray. The texture of the A horizon is generally loam, but in places it is fine sandy loam, silt loam, or clay loam. The colors of the B horizon are brown, dark brown, dark yellowish brown, yellowish brown, dark grayish brown, and grayish brown. The B horizon is generally loam, but in places it is clay loam. There are thin, patchy clay films and organic films on ped faces in the B horizon of some profiles. The thickness of the combined A horizon and upper part of the B horizon in profiles where colors are very dark grayish brown or darker ranges from 7 to 16 inches.

The colors in the C horizon are dark grayish brown, grayish brown, light olive brown, brown, and olive brown. Mottles range from few, faint to many, prominent. The C horizon is generally loam, but in places it is fine sandy loam and light clay loam. Reaction ranges from mildly alkaline to moderately alkaline.

In this county the combined A and B horizons are generally somewhat thicker than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Barnes soils are associated with Langhei, Kittson, and Flom soils and are similar to Waukon soils. They have a thicker dark-colored A horizon than Langhei soils. They are better drained than Kittson and Flom soils. They contain less translocated clay in the B horizon than Waukon soils.

Barnes loam, 0 to 2 percent slopes (BaA).—This soil occupies irregularly shaped, slightly convex areas that commonly are 3 to 35 acres in size. The landscape is rather complex. Slopes are short and uneven and there are abrupt changes in elevation, drainage, and in some areas, texture. The surface layer is black when moist and has a fine cloddy appearance if it has been plowed and tilled. This layer has a slightly grayer cast when dry. Some stones and cobblestones and a larger number of coarse gravel-size fragments are scattered on the surface.

Included in mapping were areas of moderately eroded or gently sloping Barnes soils. These soils make up as much as 15 percent of any given area. Also included were areas of more poorly drained Kittson loams on uplands, Waukon soils that have more B horizon development, and sandier Swenoda soils. These inclusions make up as much as 15 percent of any given area. Areas that have sandy material at a depth of 36 to 70 inches were also included.

Nearly all areas of this Barnes soil are cultivated. Small grains, corn for silage, soybeans, and grasses and legumes in rotation for hay and pasture are the most common crops. A few areas are wooded, and oak, elm, and aspen are the most common trees. Many of these wooded areas are windbreaks for farmsteads and provide protection for buildings and livestock. Climate limits the selection of crops that can be grown economically. (Capability unit IIc–1; tree and shrub suitability group 1)

Barnes loam, 2 to 6 percent slopes (BaB).—This soil occupies nearly circular to elongated areas, commonly 5 to 80 acres in size. The landscape is rather complex, and there are many short uneven slopes and abrupt changes in drainage and, in some areas, in texture. The surface layer is black when moist and has a fine cloddy appearance if it has been plowed and tilled. The surface color has a slightly grayer cast when dry. Some stones and cobblestones and a larger number of coarse gravel-size fragments are scattered on the surface. This soil has the profile described as representative for the series.

Included in mapping were areas of moderately eroded, rolling Barnes soils. These soils make up as much as 15 percent of any given area. Also included were areas of more poorly drained Kittson loam, uplands, Waukon soils that have a more developed B horizon, and sandier Swenoda and Sverdrup soils. These inclusions make up as much as 15 percent of any given area. Areas that have sandy material at a depth of 36 to 70 inches were also included.

Nearly all of this Barnes soil is cultivated. Small grains, corn for silage, soybeans, and grasses and legumes included in rotation for hay and pasture are commonly grown (fig. 3). A few areas are wooded, and oak, elm, and aspen are the most common trees. Many of these areas form windbreaks around farmsteads and provide protection for buildings and livestock.

Water erosion removes soil from unprotected areas and causes crop damage where rills and gullies form. (Capability unit IIe–1; tree and shrub suitability group 1)

Barnes loam, 2 to 6 percent slopes, eroded (BaB2).—This soil occupies areas that vary in shape from nearly circular to elongated. These areas commonly range from 5 to 50 acres in size. The landscape is rather complex and most slopes are short and uneven. Abrupt changes in drainage and texture are common. The surface layer is generally less than 7 inches thick. In tilled areas a part of the browner subsoil is mixed in the plow layer, causing it to have patches of dark brown and very dark brown mixed with black. Some coarse fragments, commonly in the gravel size range, are scattered on the surface. The profile of this soil is similar to that described as representative for the series, except that the surface layer is thinner and has had one-third to two-thirds of it removed by water erosion.

Included in mapping were areas of Langhei soils that have a shallower, calcareous A horizon and areas of more poorly drained Kittson and Hamerly soils. These soils make up as much as 15 percent of any given area. Also included were areas of Waukon soils that have greater subsoil development and areas of sandier Swenoda and Sverdrup soils. These inclusions make up as much as 15 percent of any given area. Gently undulating Barnes soils that are uneroded to slightly eroded make up as much as 20 percent of the areas. Areas that have sandy material underlying the till at a depth of 36 to 70 inches were also included.

All areas of this Barnes soil are or have been cultivated. Small grains, corn for silage, soybeans, and grasses and legumes grown in rotation for hay and pasture are the most common crops. A small acreage is in permanent hay and pasture.

Water erosion has removed a considerable amount of the surface layer. If the soil is unprotected, erosion continues to remove the surface layer and causes crop damage where rills and gullies form. (Capability unit IIe–1; tree and shrub suitability group 1)

Figure 3.—An excellent pasture of grasses and birdsfoot trefoil on Barnes loam, 2 to 6 percent slopes.

Barnes loam, 6 to 12 percent slopes, eroded (BaC2).—This soil occupies nearly circular to elongated areas that are commonly 3 to 35 acres in size. The landscape is rather complex, and most slopes are short and uneven. Abrupt changes in drainage and texture are common. The surface layer is generally less than 7 inches thick. In tilled areas, a part of the brown subsoil has been mixed in the plow layer, causing it to have patches of dark brown and very dark brown mixed with black. Some coarse fragments, commonly in the gravel size range, are scattered on the surface. The profile of this soil is similar to that described as representative for the series, except that the surface layer is thinner and has had one-third to two-thirds of it removed by water erosion.

Included in mapping were areas of Langhei soils that have a thinner, more calcareous surface layer and areas of rolling Barnes soils that have no to slight erosion. These soils make up as much as 20 percent of any given area. Also included were areas of Waukon soils that have great subsoil development and areas of sandier Swenoda and Sverdrup soils. These inclusions make up as much as 15 percent of any given area. Areas that have sandy material at a depth of 40 to 70 inches were also included.

Most areas of this Barnes soil are or have been cultivated. Small grains and grasses and legumes for hay and pasture are the main crops. A small acreage is used for corn for silage, soybeans, and other row crops. A few areas are wooded, and oak and elm are the most common trees.

Water erosion has removed a considerable amount of the surface layer. If the soil is unprotected, the soil continues to erode and crops are damaged where rills and gullies form. (Capability unit IIIe–1; tree and shrub suitability group 1)

Barnes-Langhei loams, 2 to 6 percent slopes, eroded (BbB2).—The soils in this complex occupy areas that generally range from 5 to 60 acres in size. The landscape is characterized by short, uneven slopes and abrupt changes in drainage. The eroded soils in this complex are of the Langhei series. The Langhei soils occupy circular to slightly oblong areas and have a thinner surface layer than the Barnes soils. The surface layer is grayish brown near the center of these areas. It becomes thicker and grades to darker brown and then black where it adjoins the Barnes soils. Barnes soils make up from 50 to 65 percent of this complex, and Langhei soils, from 20 to 45 percent (fig. 4).

Included in mapping were areas of Darnen soils that have a thicker surface layer and areas of coarser textured Sverdrup and Swenoda soils. These soils make up as much as 15 percent of any given area. Also included

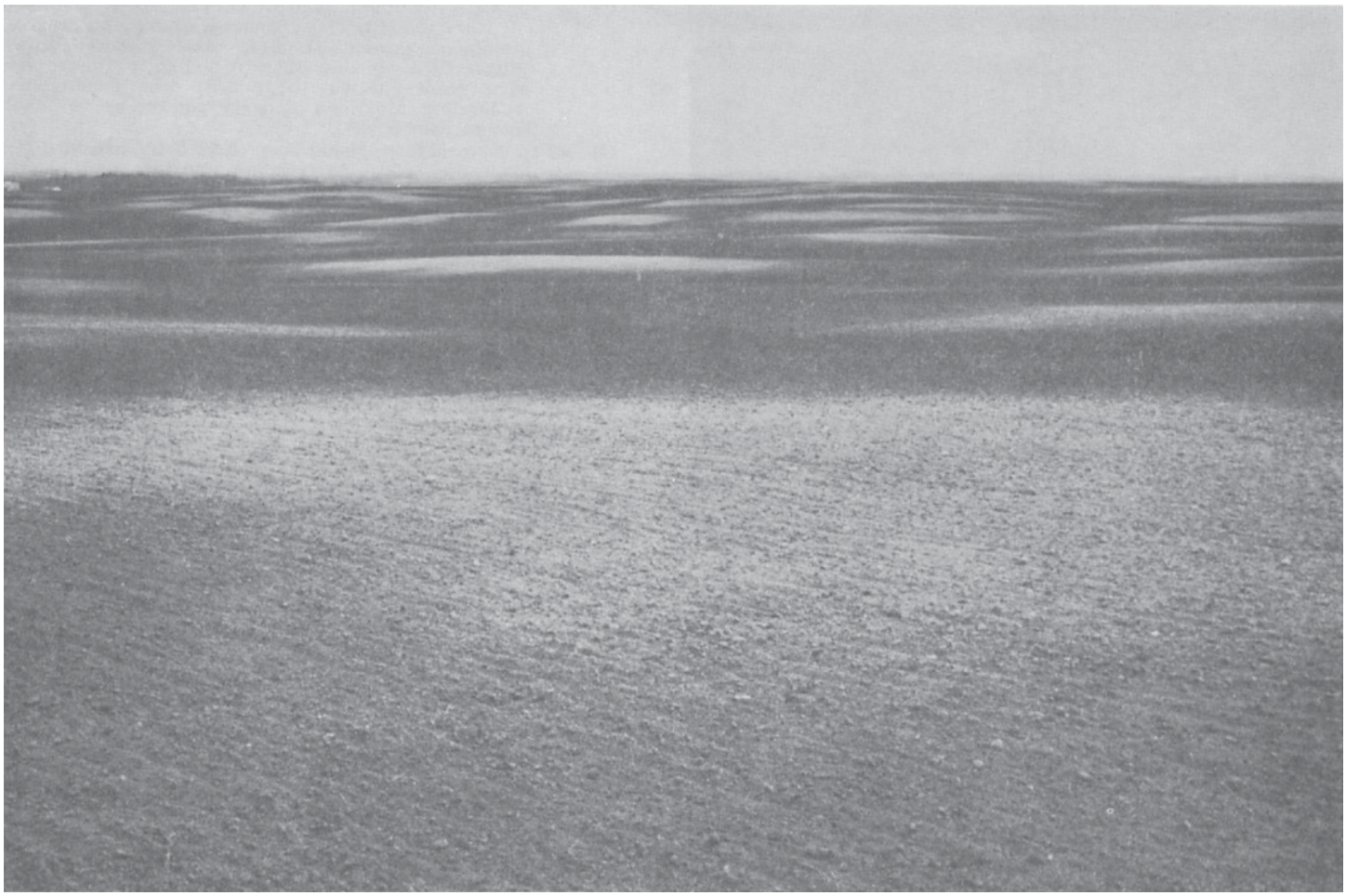

Figure 4.—**A typical landscape of gently undulating Barnes-Langhei complex. The circular to slightly oblong, lighter colored knobs are Langhei soil; the slightly lower, darker areas are Barnes and associated soils.**

were areas of Waukon soils that have a more developed subsoil. These inclusions make up as much as 20 percent of any given area. Areas that have a slightly thicker and darker surface layer than those common to the series were also included.

Nearly all areas of this complex are cultivated. Small grains and grasses and legumes grown in rotation for hay and pasture are the main crops. A small acreage is used for row crops, such as corn for silage and soybeans.

Water erosion has removed topsoil from areas of this complex. This is most evident on the lighter colored Langhei soils. Additional topsoil is removed if soils are unprotected, and rills and shallow gullies form where runoff is rapid. (Capability unit IIe–1; tree and shrub suitability group 2)

Bearden Series

The Bearden series consists of nearly level to sloping, somewhat poorly drained soils that formed in calcareous, lacustrine sediments. These soils are on a glacial lake plain, and the sloping soils commonly are adjacent to natural draws and streams. These soils formed under tall prairie grasses.

In a representative profile, the surface layer is black, strongly calcareous silty clay loam that grades to very dark gray, very strongly calcareous silt loam. It is about 16 inches thick. The next layer is light brownish-gray grading to light olive-brown silt loam. It is very strongly calcareous and 11 inches thick. Below this is light olive-brown gradient to grayish-brown, strongly calcareous and calcareous silt loam that is stratified with silty clay at a depth below 33 inches (fig. 5).

Bearden soils have high to very high available water capacity. Permeability is moderately slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 2 feet and more than 6 feet. Most areas are cultivated. The soils are suited to all crops commonly grown in the county.

Representative profile of Bearden silty clay loam, 0 to 2 percent slopes, in a cultivated field 1,520 feet east and 264 feet north of the southwest corner of sec. 4, T. 143 N., R. 46 W.

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

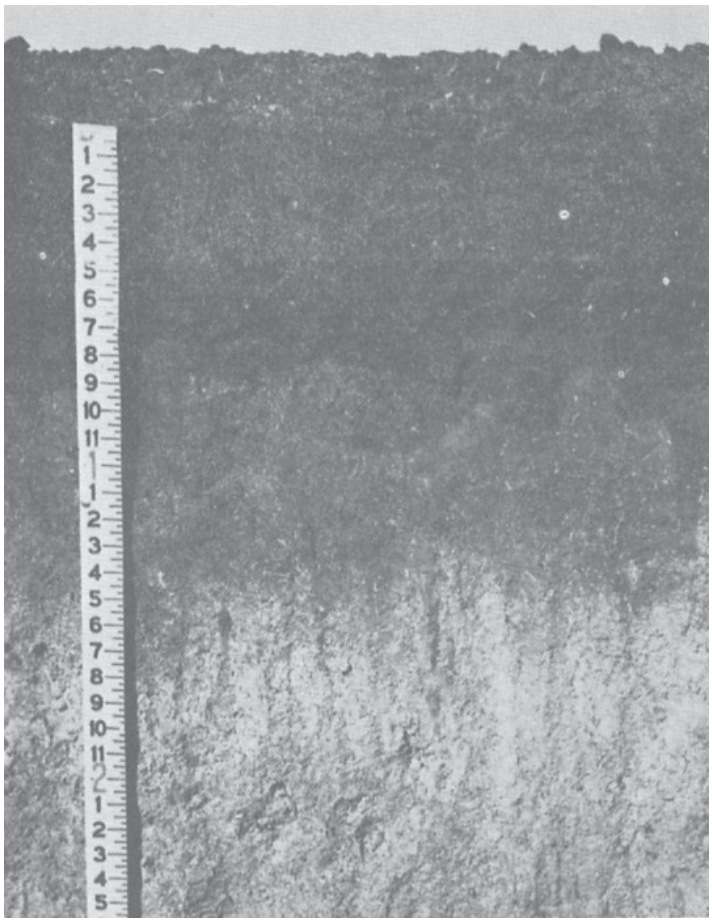

Figure 5.—**A representative profile of Bearden silty clay loam, 0 to 2 percent slopes. The black surface layer is about 9 inches thick. A light-gray, very strongly calcareous layer begins at a depth of about 17 inches.**

All—7 to 9 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; very friable; moderately alkaline; strongly calcareous; clear, wavy boundary.

A12ca—9 to 16 inches, very dark gray (10YR 3/1) silt loam; weak, very fine, subangular blocky structure; very friable; many grayish masses of calcium carbonate and gypsum; moderately alkaline; very strongly calcareous; clear, wavy boundary.

C1ca—16 to 21 inches, light brownish-gray (10YR 6/2) silt loam; weak, very fine, subangular blocky structure; very friable; common very dark gray (10YR 3/1) fillings in old root channels; many light-gray (10YR 7/1) masses of gypsum; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C2ca—21 to 27 inches, light olive-brown (2.5Y 5/4) silt loam; common, fine, faint, light brownish-gray (2.5Y 6/2) and grayish-brown (2.5Y 5/2) mottles; weak, very fine, subangular blocky structure; very friable; few yellowish-brown (10YR 5/4) stains along root channels; common, large, light-gray (10YR 7/1) gypsum masses; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C3—27 to 33 inches, light olive-brown (2.5Y5/4) silt loam; common, medium, faint, light brownish-gray (2.5Y 6/2) mottles and common, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, very fine, subangular blocky structure; very friable; few dark reddish-brown (5YR 3/4) concretions; moderately alkaline; strongly calcareous; clear, smooth boundary.

C4—33 to 43 inches, light olive-brown (2.5Y 5/4) stratified silt loam and silty clay; common, medium and coarse, prominent, gray (5Y 5/1) and yellowish-brown (10YR 5/6) mottles; massive; slightly sticky; few dark reddish-brown (5YR 3/3) iron concretions; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C5—43 to 60 inches, grayish-brown (2.5Y 5/2) stratified silt loam and silty clay; many, medium and coarse, prominent, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles and common, medium, faint, light brownish-gray (2.5Y 6/2) mottles; massive; slightly sticky; a few reddish-brown (5YR 5/4) concretions; moderately alkaline; calcareous.

The texture of the A horizon is generally silty clay loam, but silt loam, clay loam, and silty clay are also in the range. The total thickness of the A horizon ranges from 6 to 16 inches. The A12ca horizon is lacking in some profiles. Reaction in the A horizon ranges from mildly alkaline to moderately alkaline. In a few profiles narrow tongues of the A horizon extend into the Cca horizon. Colors in the C1ca and C2ca horizons are dark grayish brown, grayish brown, light brownish gray, olive brown, light olive brown, light yellowish brown, pale brown, or brown. These horizons have a combined thickness of 8 to 30 inches. Mottles range from faint to prominent, but no distinct or prominent mottles occur at a depth of less than 20 inches. The texture of the C horizon ranges from silt loam to silty clay loam. Gypsum is not present in all profiles.

Bearden soils in this county generally have more clay in the C horizon below a depth of 30 inches than the defined range for the series, but this difference does not alter appreciably their usefulness and behavior.

Bearden soils are associated with Fargo, Colvin, and Glyndon soils and are similar to Hamerly soils. They contain more silt and less clay than Fargo soils. They also have a calcareous A horizon, whereas Fargo soils have a noncalcareous A horizon. They are better drained than Colvin soils. They contain more clay and less silt than Glyndon soils. They contain less sand and more silt than Hamerly soils.

Bearden silty clay loam, 0 to 2 percent slopes (BcA).—This soil occupies slightly convex areas that generally range from 10 to 500 acres in size. The landscape is nearly level to slightly convex. These soils are on a lake plain that has a slight microrelief of alternate ridges and shallow swales. These are oriented in a northwesterly direction. There are some blotches of lighter gray in areas where the surface layer is shallow and tillage operations have mixed the underlying material with the surface layer. The surface layer is commonly mellow, and cultivated fields have a smooth appearance. This soil has the profile described as representative for the series.

Included in mapping were areas of more poorly drained Colvin soils or of Glyndon and Wheatville soils that contain very fine sand. These soils make up as much as 15 percent of any given area. Also included were areas of finer textured and more poorly drained Fargo soils and Hegne soils. These inclusions make up as much as 15 percent of any given area.

Nearly all areas of this Bearden soil are cultivated. Small grains, sugar beets, soybeans, and sunflowers are the most important crops. Grasses and legumes are grown in rotation as green-manure crops. A few areas are used for hay and pasture before being plowed and used for cultivated crops.

Soil blowing is a hazard on this soil. A nutrient imbalance resulting from the strongly calcareous condition of this soil also influences use and management. (Capability unit IIe–2; tree and shrub suitability group 2)

Bearden silty clay loam, 2 to 6 percent slopes (BcB).—This soil occupies long, narrow areas that are more than 3 and commonly less than 40 acres in size. Slopes are mostly 50 to 150 feet long. Most of this soil is adjacent to natural draws and streams, and this accounts for more variation in depth of the surface layer than on nearly level Bearden soils. Except that more areas have a grayish surface layer, the profile of this soil is similar to that described as representative for the series.

Included in mapping were areas of finer textured, gently sloping Fargo soils and Wahpeton soils. These soils make up as much as 15 percent of any given area. Also included were areas of Bearden soils that have a thinner surface layer as a result of water erosion. These inclusions make up as much as 15 percent of any given area. Also included were small areas where slopes are more than 6 percent.

Nearly all areas of this soil are cultivated. Small grains are the main crops, but some fields are farmed along with soils used for sugar beets, soybeans, and sunflowers. Some grasses and legumes are seeded for hay and pasture or for plowdown as green-manure crops.

Water erosion is a hazard on this soil. A nutrient imbalance resulting from the strongly calcareous condition of this soil also influences use and management. (Capability unit IIe–2; tree and shrub suitability group 2)

Bearden silty clay loam, 2 to 8 percent slopes, eroded (BcC2).—This soil occupies areas that are more than 3 and commonly less than 20 acres in size. Most areas of this soil are long and narrow and adjacent to natural draws and streams. Most slopes are 50 to 150 feet long. Water erosion has removed ⅓ to ⅔ of the original surface layer from much of this soil. This results in a more grayish surface color. Except that it is eroded, the profile of this soil is similar to that described as representative for the series.

Included in mapping were areas of finer textured, gently sloping Fargo and Wahpeton soils. These soils make up as much as 10 percent of any given area. Also included were areas of a Bearden soil that is slightly eroded or uneroded. This inclusion makes up as much as 20 percent of any given area. Also included were small areas that slope as much as 12 percent.

Nearly all areas of this soil are cultivated. Small grains are the main crop, but some fields are farmed along with soils used for sugar beets, soybeans, and sunflowers. Some grasses and legumes are seeded for hay and pasture or for plowdown as green-manure crops.

Water erosion is a hazard on this soil. A nutrient imbalance resulting from the strongly calcareous condition of this soil also influences use and management. (Capability unit IIe–2; tree and shrub suitability group 2)

Bearden-Fargo silty clay loams (Bf).—The soils in this complex occupy a landscape that has microrelief commonly covering areas of more than 500 acres in size. In this microrelief alternate ridges and draws and some high knobs and deeper depressions have a difference in elevation of 4 to 20 inches. Slopes are short and range up to 3 percent. The ridges and draws are oriented in a northwesterly direction. The draws generally are joined and contain some deeper depressions. Bearden soils occupy the ridges and knobs. Here a concentration of carbonates is near the surface, where tillage operations mix very strongly calcareous material with the original surface layer. This mixing is most common on the highest part of the ridges and knobs, where a grayer surface color is common. Fargo soils occupy the draws and depressions. They have a thicker, darker colored surface layer than the typical Fargo soils.

The percentage of Bearden soils in this complex ranges from 50 to 70, and the percentage of Fargo soils, from 30 to 50. The soils in this complex have profiles similar to those described as representative for the Bearden and Fargo series, except that there is more variation in the thickness of surface layer and in the texture of the underlying material.

Included in mapping were areas of Hegne and Colvin soils that are more poorly drained than Bearden soils and more calcareous than Fargo soils. These soils make up as much as 15 percent of any given area. Coarse fragments are common on the surface of Bearden soils in places.

Nearly all soils of this complex are cultivated. Small grains, sugar beets, and sunflowers are the main crops. Grasses and legumes are grown in rotation as a green-manure crop. A few areas are harvested for hay or pasture before being plowed and used for cultivated crops.

Wetness is a limitation. The microrelief makes the soils of this complex more difficult to drain. Soil blowing is a hazard if cultivated areas are smooth and have no protective cover. (Capability unit IIw–2; tree and shrub suitability group 4)

Borup Series

The Borup series consists of nearly level, poorly drained soils. These soils formed in deep lacustrine deposits consisting mostly of very fine sands. Topography is commonly slightly concave, and there are some small pocket depressions and natural draws. These soils formed under tall prairie grasses and sedges.

In a representative profile, the surface layer is black, calcareous loam in the upper part and very dark gray, strongly calcareous loam in the lower part. This layer is about 14 inches thick. The next 12 inches is dark gray in the upper part, grading to olive gray. It is very strongly calcareous very fine sandy loam. Below this is mottled, light olive-gray loamy very fine sand.

Borup soils have high available water capacity. Permeability is moderately rapid. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 and 5 feet. Most areas are cultivated. The soils are suited to all crops commonly grown in the county.

Representative profile of Borup loam in an area of Borup and Glyndon loams, in a cultivated field 720 feet north and 210 feet west of the southeast corner of sec. 2, T. 145 N., R. 46 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; clods parting to moderate, fine, granular structure; very friable; many roots; mildly alkaline; calcareous; abrupt, smooth boundary.

A1ca—9 to 14 inches, very dark gray (10YR 3/1) loam; weak, fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; clear, wavy boundary.

C1cag—14 to 21 inches, dark-gray (5Y 4/1) very fine sandy loam; weak, very fine, granular structure; very friable; few roots; moderately alkaline; very strongly calcareous; abrupt, wavy boundary.

C2ca—21 to 26 inches, olive-gray (5Y 4/2) very fine sandy loam; massive; very friable; moderately alkaline; very strongly calcareous; gradual, wavy boundary.

C3—26 to 60 inches, light olive-gray (5Y 6/2) mixed with light-gray (5Y 7/2) loamy very fine sand; common, medium, prominent, olive-yellow (2.5Y 6/6) and yellowish-brown (10YR 5/8) mottles; single grain; loose; moderately alkaline; calcareous.

Colors in the A horizon are black or very dark gray. The texture of the A horizon is generally loam, but in places it is very fine sandy loam and silt loam. A very dark gray and dark gray Aca horizon is in some profiles. The structure of the A horizon is weak or moderate, granular or subangular blocky. The thickness of the A horizon ranges from 7 to 16 inches.

The C1cag and C2ca horizons range from gray, dark gray, grayish brown, dark grayish brown, or olive gray to light olive gray. Some profiles have mottles that range from faint to distinct or prominent. The Cca horizon is very fine sandy loam, loamy very fine sand, loam, or silt loam. It is strongly calcareous or very strongly calcareous and has a more than 15 percent calcium carbonate equivalent and at least 5 percent more than the C horizon. The Cca horizon ranges from 6 to 20 inches in thickness.

Colors in the C3 horizon are gray or light gray, grayish brown or light grayish brown, and olive gray or light olive gray. Mottles range from faint to prominent. The C3 horizon generally is loamy very fine sand or very fine sandy loam, but in places it is very fine sand or silt loam. Reaction ranges from mildly alkaline to moderately alkaline. Masses of gypsum crystals are in the C horizon in many profiles.

Borup soils are associated with Glyndon and Augsburg soils and are similar to Arveson soils. They are more poorly drained than Glyndon soils. They lack the clayey IIC horizon of Augsburg soils. They contain more very fine sand and silt than Arveson soils.

Borup loam, depressional (Bo).—This soil occupies closed depressions and the bottoms of natural drainageways. These depressional areas generally range from 3 to 15 acres in size. The depressed landscape positions occupied by this soil are commonly surrounded by higher areas of associated better drained soils. In cultivated areas, the surface layer of this soil is black. In uncultivated areas, these depressions commonly support a growth of various grasses or wetland reeds and sedges. This soil has a profile similar to that described as representative for the series, except that the dark-colored surface layer is thicker in some profiles and some profiles are underlain by fine sand rather than by very fine sand.

Included in mapping were areas of finer textured Colvin silty clay loam, depressional, and areas that have finer textured underlying material. These inclusions make up as much as 15 percent of any given area. Also included were soils that have a highly organic, mucklike surface layer. These soils make up less than 15 percent of any given area.

Some areas of this soil have been drained and are farmed along with adjacent cultivated fields. These fields produce small grains and various row crops. A few areas are managed along with soils used for hay or pasture. If this soil is not drained, water is ponded in depressions during parts of most growing seasons. Many of these undrained areas are idle and support a growth of wetland vegetation, such as reeds and sedges.

Wetness is a limitation to use of this soil. (Capability unit IIIw–4; tree and shrub suitability group 7–B)

Borup and Glyndon loams (Bp).—These nearly level soils are characterized by shallow microrelief. These areas normally range from 5 to 80 acres in size. The landscape generally has slight rises and gentle swales and slopes of less than 2 percent. Borup soils occupy the gentle swales, and Glyndon soils are on the light rises. In cultivated areas, the surface layer has a smooth appearance and variations of black and dark-gray colors.

This unit consists of 55 to 70 percent Borup soils and 30 to 45 percent Glyndon soils.

Included in mapping were areas of Augsburg and Wheatville soils that differ in having fine-textured underlying material. Also included were areas of sandier Rockwell and Grimstad soils. These inclusions make up as much as 15 percent of any given area. Also included were a few areas that have a loam or silt loam surface layer overlying fine sand.

Nearly all of this unit is cultivated. Small grains, sugar beets, sunflowers, and soybeans are the main crops. Legumes are grown as a green-manure crop on a small acreage. Some areas are used for hay and pasture or are idle.

Wetness is a limitation to use of these soils. Their strongly calcareous condition also influences their use and management. (Capability unit IIw–2; tree and shrub suitability group 4)

Breaks and Alluvial Land

Breaks and Alluvial land (Br) is a moderately steep and steep miscellaneous land type that occupies areas along the rivers and streams that drain the Lake Agassiz Basin. Slopes are short, commonly ranging from 50 to 200 feet, and they are often dissected by drainageways that lead into the larger rivers and streams. Soil materials are normally moderately fine textured or fine textured and dark colored to moderately dark colored. Other soil materials are within the range of the Fargo, Wahpeton, Bearden, and Cashel series. Breaks and Alluvial land lacks uniformity, however, and is mixed with many varied and stratified materials.

Included in mapping were areas of Alluvial land, occasionally flooded, and Alluvial land, frequently flooded, that have less slope. These inclusions make up as much as 20 percent of any given area. Also included were areas of gently sloping and sloping Cashel, Fargo, Bearden, and Wahpeton soils. These soils make up as much as 15 percent of any given area.

Breaks and Alluvial land is seldom cultivated. The most common vegetative cover is such hardwood trees as basswood, elm, ash, and cottonwood. Some areas of Breaks and Alluvial land are pastured.

Susceptibility to water erosion is a limitation on this unit. Most areas are idle because they are so dissected and inaccessible. (Capability unit VIe–1; tree and shrub suitability group 1)

Cashel Series

The Cashel series consists of nearly level to sloping, somewhat poorly drained soils. These soils formed in fine-textured alluvial material. They are on low, narrow terraces adjacent to major stream channels or in partly filled meanders and oxbows. Areas of Cashel soils are flooded by water from adjacent streams. Many of these soils support a growth of grasses or trees, principally bottomland hardwoods. This vegetation has little influ-

ence on soil development, because floodwaters deposit additional alluvium before the influence of vegetation is evident.

In a representative profile, the surface layer is 10 inches of black, weakly calcareous silty clay mixed with dark grayish-brown and grayish-brown silty clay. The next 14 inches is black, very dark gray, and dark grayish-brown silty clay in bands ½ inch to 2 inches thick. It has moderate, fine and medium, angular blocky structure and is weakly calcareous. Below this is clay that is banded in dark gray, very dark gray, and black colors.

Cashel soils have medium available water capacity. Permeability is moderately slow to slow. Inherent fertility is high. If not subjected to prolonged flooding, these soils are suited to crops commonly grown in the county.

Representative profile of Cashel silty clay, 0 to 2 percent slopes, in a cultivated field 3,130 feet west and 2,510 feet north of the southeast corner of sec. 1, T. 144 N., R. 49 W.

A1—0 to 10 inches, 70 percent black (10YR 2/1) and very dark grayish-brown (10YR 3/2) silty clay and 30 percent dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) silty clay; weak to moderate, very fine, subangular blocky structure; sticky; mildly alkaline; weakly calcareous; clear, wavy boundary.

C1—10 to 24 inches, bands ½ inch to 2 inches thick of black (10YR 2/1), very dark gray (10YR 3/1), and dark grayish-brown (10YR 4/2) silty clay; few, fine, distinct, olive-yellow (2.5Y 6/6) and brownish-yellow (10YR 6/8) mottles; moderate, fine and medium, angular blocky structure; sticky; mildly alkaline; weakly calcareous; clear, wavy boundary.

C2—24 to 60 inches, thin bands of dark gray (5Y 4/1), very dark gray (5Y 3/1) and (10YR 3/1), and black (10YR 2/1), clay; common, medium, distinct, yellowish-brown (10YR 5/6 and 5/8) mottles; weak, very fine, subangular blocky structure; very sticky; few fragments of snail shells; mildly alkaline; calcareous.

The texture in all horizons ranges from silty clay to clay. The structure of the A horizon is angular and subangular blocky or granular. Some profiles have thin strata or blotches of grayer colors in the A horizon. Colors in the C horizon are black, very dark gray, dark gray, very dark brown, very dark grayish brown, dark grayish brown, dark olive gray, olive gray, and olive. The C horizon has one or more dark-colored layers that range from ⅛ inch to 5 inches in thickness. All horizons range from neutral to mildly alkaline and are weakly calcareous to moderately calcareous. Lime threads, concretions, and fragments of snail shells are in many profiles.

Cashel soils in this county have darker colors in the A1 and C1 horizons than the defined range for the series, but this difference does not alter their usefulness and behavior.

Cashel soils are associated with Fargo and Wahpeton soils. They lack the B horizon that is characteristic of Fargo soils. Cashel soils are more subject to flooding than Wahpeton soils, are more poorly drained, and have a thinner A horizon.

Cashel silty clay, 0 to 2 percent slopes (CaA).—This soil occupies areas on low terraces or partly filled bottoms of old meanders or oxbows. These areas commonly range from 3 to 15 acres in size. They are characteristically uneven, narrow, or irregularly shaped and are cut up by drainageways leading into the streams. In cultivated areas, the surface layer has a smooth appearance. If cultivated when wet, the surface layer has a rough, cloddy appearance. This soil has the profile described as representative for the series.

Included in mapping were areas of Alluvial land, occasionally flooded, less uniform in texture. This inclusion makes up as much as 20 percent of any given area. Also included were areas of Fargo silty clay, depressional, that has more uniform horizonation and less banding or layering than Cashel soils. This soil makes up as much as 20 percent of any given area.

Many areas of this Cashel soil are used for pasture or are idle. Uncultivated areas support a growth of native and introduced grasses and trees, principally bottomland hardwoods. Some areas are cultivated, commonly for the production of small grains and some row crops.

Flooding and wetness are limitations to use of this soil. If flooding and wetness persist for several years, yields are lower than those predicted in the yield table. (Capability unit IIIw–5; tree and shrub suitability group 7–D)

Cashel silty clay, 2 to 8 percent slopes (CaC).—This soil occupies low terraces and edges of old oxbows and stream meanders. The areas commonly range from 3 to 10 acres in size. They are characteristically uneven, narrow, or irregularly shaped and are cut up by drainageways leading into the streams. In cultivated areas, the surface layer is very dark gray and dark gray in color and has a smooth appearance. When the surface is dry, it commonly has a gray color.

Included in mapping were areas of gently sloping Fargo silty clay that lacks the banding and has more uniform horizontation than this Cashel soil. This soil makes up as much as 20 percent of any given area. Also included were areas of gently sloping and sloping Wahpeton soils that are better drained and more developed. This soil makes up as much as 15 percent of any given area.

Most areas of this Cashel soil are idle or are used for pasture. These areas support a growth of native and introduced grasses mixed with trees, principally bottomland hardwoods. Some areas are cultivated, commonly for the production of small grains.

Flooding is the main limitation. Limited accessibility to some areas also influences use and management. (Capability unit IIIw–5; tree and shrub suitability group 7–D)

Cathro Series

The Cathro series consists of highly decomposed, organic soils about 16 to 50 inches thick over loamy mineral materials. These soils formed in depressions or in the bottoms of old stream channels and small drainageways, and in most areas are on uplands. They formed under cattails, reeds, and sedges. During the time when the organic materials accumulated, conditions were too wet for complete decomposition.

In a representative profile, the surface layer is about 23 inches of black muck. Below this is loam that grades with depth from black to dark gray and light brownish gray.

Cathro soils have high to very high available water capacity. Permeability is moderate. Inherent fertility is low. The seasonal water table generally fluctuates between the surface and a depth of 4 feet, and it is deeper in drained and cultivated areas. A few areas have been cultivated. Small grains and hay or pasture are the main crops. Many areas are idle. These soils are suited to grasses used for hay and pasture.

Representative profile of Cathro muck in an idle area 240 feet south and 1,250 feet west of the northeast corner of sec. 11, T. 146 N., R. 43 W.

Oa1—0 to 15 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 15 percent fiber content, about 10 percent rubbed; weak, very fine and fine, granular structure; very friable; about 15 percent mineral matter; common roots; herbaceous fibers; mildly alkaline; weakly calcareous; clear, smooth boundary.

Oa2—15 to 23 inches, black (10YR 2/1, broken face and rubbed) sapric material; about 5 percent fiber content; weak, medium and coarse, subangular blocky structure; slightly sticky; about 30 percent mineral matter; herbaceous fibers; neutral; clear, smooth boundary.

IIA1b—23 to 29 inches, black (N 2/0) loam; massive; slightly sticky; neutral; clear, smooth boundary.

IIC1g—29 to 38 inches, dark-gray (2.5Y 4/1) loam; massive; slightly sticky; neutral; gradual, smooth boundary.

IIC2g—38 to 52 inches, light brownish-gray (2.5Y 6/2) loam; few, fine, distinct, olive-brown (2.5Y 4/4) mottles and few, coarse, faint, gray (5Y 6/1) mottles; massive; slightly sticky; moderately alkaline; strongly calcareous.

The combined thickness of the organic soil materials ranges from 16 to 50 inches. The most common thickness is 18 to 36 inches. The organic soil material is black, very dark gray, very dark grayish brown, very dark brown, and dark brown. The fiber content of the unrubbed organic soil material commonly ranges from 50 percent to less than 10 percent, and the rubbed fiber content is less than 15 percent. There are thin layers of less decomposed material in a few profiles. Reaction of the organic soil material ranges from neutral to mildly alkaline. The IIC horizon is dark grayish brown, grayish brown, light brownish gray, dark gray, or gray. The texture is loam, sandy loam, silt loam, clay loam, or silty clay loam. Reaction ranges from neutral to moderately alkaline, and the soil is calcareous to strongly calcareous.

Cathro soils are associated with Rondeau, Seelyeville, Flom, Vallers, and Roliss soils. They lack the layer of marl which is characteristic of Rondeau soils. They contain mineral soil material at a shallower depth than Seelyeville soils. Cathro soils contain more organic matter than Flom, Vallers, and Roliss soils.

Cathro muck (Cb).—This soil is in depressions and in the bottoms of natural draws. Areas generally range from 3 to 30 acres in size.

Included in mapping were soils that have less than 16 inches of organic surface material. These soils make up as much as 20 percent of any given area. Also included were soils that have more than 10 inches of organic material and a higher fiber content. These inclusions make up as much as 15 percent of any given area. Also included were areas of Flom, Vallers, and Roliss soils in depressions that have no organic layer. These soils make up as much as 15 percent of any given area.

A few areas of this soil have been drained and are farmed along with soils used for small grains. A more common use is for hay and pasture. The most common grass is reed canarygrass. Some areas are used for reeds and sedges, and some better drained areas are used for various introduced grasses for forage. Many areas are idle and contain reeds, sedges, various weeds, and forbs and scattered areas of more marshy vegetation. In a few areas the organic material is harvested for potting material and mulches.

Wetness is a limitation to use of this soil. The low inherent fertility also influences use and management. (Capability unit IVw-2; tree and shrub suitability group 7-A)

Colvin Series

The Colvin series consists of nearly level, poorly drained soils. These soils formed mostly in lacustrine silty material on an old glacial lake plain that has depressions. They formed under tall prairie grasses and reeds and sedges.

In a representative profile, the surface layer is black silty clay loam in the upper 10 inches and very strongly calcareous, very dark gray silt loam in the lower 6 inches. The next 9 inches is grayish-brown, very strongly calcareous silt loam. Below this is strongly calcareous, grayish-brown and gray silty clay loam. Gray, layered silt loam and silty clay are at a depth below 38 inches.

Colvin soils have high to very high available water capacity. Permeability is moderately slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 and 5 feet. Nearly all areas are cultivated. The soils are suited to all crops commonly grown in the county.

Representative profile of Colvin silty clay loam in a cultivated field 1,400 feet east and 500 feet south of the northwest corner of sec. 24, T. 145 N., R. 46 W.

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

A11—8 to 10 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable; mildly alkaline; calcareous; abrupt, wavy boundary.

12ca—10 to 16 inches, very dark gray (10YR 3/1) silt loam; weak, very fine, subangular blocky structure; very friable; common inclusions of black (10YR 2/1); moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C1cag—16 to 25 inches, grayish-brown (2.5Y 5/2) silt loam; common, fine, distinct, light olive-brown (2.5Y 5/6) and yellowish-brown (10YR 5/8) mottles; weak, very fine, subangular blocky structure; very friable; many fine masses of light-gray (2.5Y 7/2) gypsum crystals; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C2g—25 to 30 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; very friable; few large masses of light brownish-gray (2.5Y 6/2) and light-gray (2.5Y 7/2) gypsum crystals; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C3g—30 to 38 inches, gray (5Y 5/1) silty clay loam; common, medium, faint, gray (5Y 6/1) mottles and many, medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; some primary platy structure; slightly sticky; few small masses of light brownish-gray (2.5Y 6/2) and light-gray (2.5Y 7/2) gypsum crystals; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C4g—38 to 60 inches, gray (5Y 5/1) layered silt loam and silty clay; common, medium, prominent, brown (7.5YR 4/4) mottles and many, medium and coarse, prominent, yellowish-brown (10YR 5/8) mottles; weak, thick, platy structure parting to weak, very fine, subangular blocky; slightly sticky; few, thin, gray (5Y 6/1), silty coatings on faces of plates; few fine masses of light-gray (2.5Y 7/2) gypsum crystals; moderately alkaline; strongly calcareous.

The texture of the A horizon ranges from silt loam to silty clay loam. The thickness ranges from 10 to 16 inches. The C1cag horizon is dark gray, gray, light brownish gray, grayish brown, or olive gray. Mottles in this horizon range from faint to prominent. This horizon is 8 to 20 inches thick. Colors in the matrix of the remainder of the C horizon range

from gray or olive gray to light olive gray or grayish brown, and mottles range from faint to prominent. The texture of the C1cag, C2g, and C3g horizons ranges from silt loam to silty clay loam. The C4g horizon generally is silty clay or stratified silt loam and silty clay, but in some profiles it is silt loam or silty clay loam. Between depths of 10 and 40 inches there is an average of 18 to 35 percent clay, and less than 15 percent of the material is coarser than very fine sand. The C horizon is mildly alkaline to moderately alkaline and is calcareous to strongly calcareous.

The content of clay at a depth below 30 inches commonly is greater than the defined range for the series, but this difference does not appreciably alter the usefulness and behavior of these soils.

Colvin soils are associated with Bearden soils and are similar to Hegne and Vallers soils. Colvin soils are more poorly drained than Bearden soils. They contain more silt and less clay than Hegne soils. They contain more silt and less sand than Vallers soils, which formed in glacial till.

Colvin silty clay loam (Cn).—This nearly level soil occupies slightly concave areas that generally range in size from 3 to 80 acres. The landscape is a lake plain that has 0 to 2 percent slopes. Many areas have a microrelief of low ridges or small knobs and shallow swales. This microrelief is oriented in a northwest-southeast direction. Colvin soils occupy the shallow swales, and some knobs and ridges are occupied by Bearden soils. This soil has the profile described as representative for the series.

Included in mapping were areas of better drained Bearden soils, noncalcareous Fargo soils, and finer textured Hegne soils. These soils make up as much as 20 percent of any given area. Also included were areas of coarser textured Borup and Augsburg soils that make up less than 15 percent of any given area.

Nearly all areas of this soil are cultivated. Small grains, sugar beets, soybeans, and sunflowers are the most important crops. Grasses and legumes are included in some rotations for green manure. A few areas are used for hay and pasture before being plowed and used for crops.

Wetness is a limitation to use of this soil. Soil blowing erodes fields that are smooth and have no vegetative cover. A nutrient imbalance results from the strongly calcareous nature of this soil. Cultivating this soil when it is wet results in compaction and structural damage. (Capability unit IIw–2; tree and shrub suitability group 4)

Colvin silty clay loam, depressional (Co).—This soil occupies nearly round or oblong, pocket depressions. These depressions are commonly more than 3 acres and less than 10 acres in size. The landscape is characterized by closed depressions that are bordered by higher areas of Colvin and Bearden soils. The surface layer of this soil commonly has a rough, cloddy appearance when plowed. Water is ponded in these depressions for varying lengths of time and is most common during spring runoff or after heavy rain. Cultivation is often delayed because of wetness, and extended ponding drowns crops that have already been planted. When this soil dries, a crusted, cracked surface condition is common. This soil has a profile similar to that described as representative for the series, except that more variation in the thickness of the surface layer and in the depth to and thickness of carbonate concentration is common.

Included in mapping were areas of finer textured and less calcareous Fargo silty clay, depressional, and coarser textured Borup loam, depressional. These soils make up as much as 20 percent of any given area.

Wetness is a limitation to use of this soil. Ponding often occurs during periods of heavy precipitation and spring runoff, although open field ditches have been constructed. Some drowning of crops occurs on this soil. Cultivating this soil when it is wet results in compaction and structural damage. (Capability unit IIIw–2; tree and shrub suitability group 7–B)

Darnen Series

The Darnen series consists of nearly level and gently sloping, moderately well drained soils. These soils formed in material washed from the adjoining higher and more sloping soils. They are on an upland landscape that has complex topography. They formed under tall prairie grasses.

In a representative profile, the surface layer is black silt loam about 21 inches thick. The upper part of the subsoil, about 6 inches thick, is very dark grayish-brown loam. The lower part of the subsoil, about 4 inches thick, is mottled, brown, strongly calcareous loam. The underlying material is strongly calcareous, distinctly mottled, yellowish-brown loam.

Darnen soils have high to very high available water capacity. Permeability is moderate. Inherent fertility is high. The seasonal water table fluctuates between depths of 3 feet and more than 6 feet. The soils are suited to most crops grown in the county. Their location on the landscape sometimes limits the use of these soils.

Representative profile of Darnen silt loam, 1 to 4 percent slopes, in a cultivated field 1,610 feet west and 50 feet north of the southeast corner of sec. 16, T. 146 N., R. 43 W.

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

A1—8 to 21 inches, black (10YR 2/1) silt loam; weak, very fine, subangular blocky structure; very friable; neutral; clear, smooth boundary.

B2—21 to 27 inches, very dark grayish-brown (10 YR 3/2) loam; weak, very fine. subangular blocky structure; very friable; neutral; clear, smooth boundary.

B3ca—27 to 31 inches, brown (10YR 5/3) loam; few, fine, distinct, gray (10YR 6/1) and yellowish-brown (10YR 5/6) mottles; massive; very friable; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C—31 to 60 inches, yellowish-brown (10YR 5/4) loam; common, medium, distinct, yellowish-brown (10YR 5/6), olive-yellow (2.5Y 6/6), and light brownish-gray (2.5Y 6/2) mottles; massive; very friable; moderately alkaline; strongly calcareous.

The A horizon is generally black, but it grades to very dark gray in the lower part of some profiles. The texture of the A horizon is generally silt loam or loam, but in places it is fine sandy loam or sandy loam. The thickness of the A horizon ranges from 18 to 28 inches.

The B horizon is very dark grayish brown, brown, yellowish brown, or dark grayish brown. It ranges from 2 to 17 inches in thickness and is loam or clay loam. This horizon is neutral to moderately alkaline and is calcareous to strongly calcareous.

The C horizon is dark grayish brown, grayish brown, light brownish gray, light yellowish brown, yellowish brown, light olive brown, or olive brown. Texture is loam or clay loam. Mottles at a depth below 36 inches range from few, faint to many, prominent.

Darnen soils are associated with Langhei, Barnes, and Flom soils and are similar to Kittson soils. They have an A horizon that is much thicker than that of Langhei soils and is noncalcareous, and they are not so well drained as those soils. They are not so well drained as Barnes soils and have a thicker A horizon. They are better drained than Flom soils and have a thicker A horizon than Kittson soils.

Darnen silt loam, 1 to 4 percent slopes (DaB).—This soil occupies slightly convex areas at the base of slopes and the upper or outer edges of swales and draws on uplands. These areas generally range from 3 to 15 acres in size. They are commonly elongated and narrow, paralleling the more sloping soils that were the source of the colluvium in which they formed. The surface layer is black and has a smooth, mellow appearance.

Included in mapping were areas of Barnes soils and Kittson loam, uplands, that have a thinner surface layer and areas of Flom soils that are more poorly drained. Also included were areas of soils that have coarser textured colluvium and soils that are calcareous at or near the surface. Inclusions make up as much as 15 percent of any given area.

Some areas of Darnen soil are cultivated. Small grains are the most common crop. Many areas are seeded to grasses and legumes for use as hay or pasture. A few small areas are not easily accessible or occupy a position in the landscape that restricts operation of farm machines. Some of these areas are idle. Climate restricts the selection of crops that can be grown economically.

New deposits of colluvium sometimes cover young plants during periods of high runoff. (Capability unit IIc-1; tree and shrub suitability group 1)

Dune Land

Dune land (Du) consists of areas where sand has blown about, causing blowouts and dunes that form microrelief. Differences in elevation are abrupt, and most slopes range from 1 to 6 percent. A few small areas of steeper and higher dunes are included in this miscellaneous land type. These areas have slopes that range from 6 to 60 percent, and some reach a height of more than 40 feet. These higher, steeper dunes are indicated on the soil map by a spot symbol. Each symbol indicates an area of about 5 acres in size.

The sand in these areas is fine and medium. The areas exhibit little evidence of soil development. They commonly have a 1- to 2-inch layer of organic debris and staining. A few small areas show evidence of having been cultivated and have a dark grayish-brown plow layer. The fine and medium sand in Dune land is brown in color. A few, fine, faint, yellowish mottles occur throughout the sand, and some distinct mottles are at a depth below 30 inches.

Included in mapping were areas of Flaming, Hamar, and Arveson soils that have a deeper, darker colored sur-

Figure 6.—An area of Dune land that shows the varied vegetation on the higher, steeper dunes.

face layer and are more poorly drained. These soils make up as much as 20 percent of any given area.

Dune land generally has a vegetative cover of mixed introduced and native grasses and scattered areas of trees. The most common introduced grasses are quackgrass, bluegrass, and redtop. The native grasses include prairie sandreed, little bluestem, and indiangrass. Bur oak and poplar are the most common trees. There are various shrubs, mosslike or lichenlike growths, and growths of prostrate cedar on areas of Dune land (fig. 6).

Dune land is cultivated only if small areas of it are included as part of a field of another soil. A few areas are pastured, but most are idle. Some areas of Dune land and associated sandy soils have plantings of conifers. Low available water capacity and low inherent fertility are limitations. Dune land is also very susceptible to soil blowing. Care must be taken to prevent overgrazing of pastures that reduces vegetative cover and results in these areas becoming active moving sand dunes again. (Capability unit VIs–1; tree and shrub suitability group 6)

Fargo Series

The Fargo series consists of nearly level and gently sloping, poorly drained soils. These soils formed in lacustrine clay on a glacial lake plain, and many areas have a slight microrelief of alternative ridges, draws, and depressions. Stronger microrelief is common where Fargo soils occur in complexes with Hegne or Bearden soils. Areas of gently sloping soils commonly are adjacent to rivers and other natural drainageways. Fargo soils formed under tall prairie grasses and some reeds and sedges.

In a representative profile, the surface layer is black silty clay 10 inches thick with tongues that extend to a depth of about 30 inches. The subsoil is very dark gray, weakly calcareous silty clay 10 inches thick. The underlying material is olive-gray silty clay and is calcareous and strongly calcareous (fig. 7).

Fargo soils have medium available water capacity. Permeability is slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet.

Nearly all areas of Fargo soils are cultivated. They are suited to all crops commonly grown in the county.

Representative profile of Fargo silty clay, 0 to 1 percent slopes, in a cultivated field, 415 feet south and 255 feet east of the northwest corner of sec. 28, T. 143 N., R. 48 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay; clods breaking to weak, very fine, subangular blocky structure; sticky; many roots; neutral; abrupt, smooth boundary.

A1—6 to 10 inches. black (10YR 2/1) silty clay; weak, very fine, angular blocky structure; sticky; many roots; neutral; clear, irregular boundary.

B2g—10 to 20 inches, very dark gray (2.5Y 3/1) silty clay; moderate, very fine, angular blocky structure; very sticky; shiny pressure faces on peds; common, black (10YR 2/1), narrow tongues of A horizon material; many roots; neutral to mildly alkaline in lower part of horizon; weakly calcareous in lower part of horizon; clear, wavy boundary.

Figure 7.—**A representative profile of Fargo silty clay showing the dark-colored tongues that extend to a depth of 30 inches or more. The blocky structure is evident in this profile.**

C1cag—20 to 27 inches, olive-gray (5Y 5/2) silty clay; weak, very fine, subangular blocky structure; very sticky; few, black (10 YR 2/1), narrow tongues of A horizon material; few fine roots; mildly to moderately alkaline; calcareous; gradual, smooth boundary.

C2cag—27 to 40 inches, olive-gray (5Y 5/2) silty clay; common, fine, distinct, light olive-brown (2.5Y 5/6), yellowish-brown (10YR 5/6 and 5/8), and brownish-yellow (10YR 6/8) mottles; weak, very fine, subangular blocky structure; sticky; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C3g—40 to 60 inches, olive-gray (5Y 5/2) silty clay; common, medium, prominent, yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure and some platy structure in the lower part; sticky; few dark reddish-brown (5YR 3/4) concretions; mildly alkaline; calcareous.

The thickness of the solum ranges from 16 to 26 inches. The texture of the A horizon ranges from silty clay loam to clay. Tongues of black or very dark gray A horizon material extend to a depth of 40 inches in some profiles. The B2g horizon ranges from very dark grayish brown to very dark gray in color and from 6 to 16 inches in thickness. The A horizon has moderately or strongly developed angular or subangular blocky structure in some profiles. In many profiles, the

primary structure is weak, coarse, or very coarse, prismatic in the B horizon and the upper part of the C horizon. In some profiles, both the C2cag and C3g horizons have platy primary structure. The colors in the C horizon are gray or olive gray. Mottles range from none in the upper part to many, distinct or prominent at greater depths. The content of clay in the B and C horizons ranges from 45 to 60 percent.

Fargo silty clay loam soils have silty clay loam in the A horizon and silty clay loam or silty clay in the B horizon. They contain less clay than the defined range for the series, but this difference does not appreciably alter the usefulness and behavior of these soils.

Fargo soils are associated with Cashel, Hegne, and Wahpeton soils and are similar to Colvin and Viking soils. They contain more clay and less silt than Bearden soils. Fargo soils have an A horizon that lacks carbonates and is thicker than that of Hegne soils. They are wetter and less permeable than Wahpeton soils. They have a B horizon, whereas Cashel soils lack a B horizon. They contain less clay below the surface layer than Viking soils and lack the coarse fragments that are characteristic of those soils.

Fargo silty clay loam, 0 to 1 percent slopes (FgA).—This soil occupies a smooth lake plain that has some slightly convex areas commonly in the shape of an oblong, low ridge. These areas normally are more than 10 acres and less than 500 acres in size. Some areas have slight microrelief, consisting of alternate ridges and shallow swales oriented in a northwest-southeast direction. If plowed, the surface of this soil has a rough, cloddy appearance. In cultivated areas, the surface is smooth and has much finer clods. This soil has a profile similar to that described as representative for the series, except that the surface layer is silty clay loam and in some places part of the subsoil is silty clay loam.

Included in mapping were areas of better drained and more permeable Wahpeton soils, Fargo silty clay, and Hegne soils. These soils make up as much as 20 percent of any given area. Also included were areas of Colvin soils that are more calcareous and contain less clay than Fargo soil. This inclusion makes up as much as 15 percent of any given area. Areas of this soil that have a wetter surface are indicated on the soil map by the wet spot symbol. Each symbol represents a wet area of 10 acres.

Nearly all areas of this Fargo soil are cultivated. Small grains, sugar beets, soybeans, and sunflowers are the most common crops. Grasses and legumes are grown in a rotation for green manure. A few areas are used for hay and pasture before being plowed and used for crops.

Wetness is a limitation to use of this soil. Structural damage and compaction result if this soil is cultivated when wet. Soil blowing is a hazard where cultivated areas are smooth and have no protective cover. (Capability unit IIw–1; tree and shrub suitability group 3)

Fargo silty clay loam, 1 to 6 percent slopes (FgB).—Most areas of this soil occupy the upper slopes along natural drainageways and streams. These gentle slopes commonly parallel the natural watercourses and are short, generally ranging from 50 to 200 feet in length. The nearness of this soil to waterways and streams accounts for more variation in depths of the dark-colored surface layer than is common in gently sloping soils. Buried, dark-colored horizons and varving also occur. Except for these characteristics and the silty clay loam surface layer, this soil has a profile similar to that described as representative for the series.

Included in mapping were areas of slightly better drained, more permeable Wahpeton soils. These soils make up as much as 25 percent of any given area. Also included were small, eroded areas of soils that have a thinner calcareous surface layer and resemble Hegne soils; Cashel soils that are alluvial and show less development than this Fargo soil; and Bearden soils that are less clayey and more calcareous. These inclusions make up as much as 15 percent of any given area.

Nearly all areas of this Fargo soil are cultivated. Small grains are the most common crop. Some areas are farmed along with other soils and used for sugar beets, sunflowers, and soybeans. Grasses and legumes are included in the rotation as green-manure crops. Some areas are used for hay and pasture before being plowed and used for other crops. An occasional small area is wooded, and elm and poplar are the main trees.

Wetness is a limitation to use of this soil. Structural damage and compaction result if this soil is cultivated when wet. Soil blowing and water erosion are hazards in cultivated areas that have no protective cover. (Capability unit IIw–1; tree and shrub suitability group 3)

Fargo silty clay, 0 to 1 percent slopes (FcA).—This soil occupies uniform areas that are commonly more than 10 acres and less than 1,000 acres in size. The landscape is characterized by a smooth plain or weak microrelief. Alternate small ridges and shallow swales are oriented in a northwest-southeast direction. The surface layer is rough and cloddy when plowed. In cultivated areas, the surface is smoother and has fine clods. This soil has the profile described as representative for the series.

Included in mapping were areas of more calcareous Hegne soils and Fargo silty clay, depressional. These soils make up as much as 20 percent of any given area. Also included were areas of better drained and more permeable Wahpeton soils and more calcareous and less clayey Colvin soils. These inclusions make up as much as 15 percent of any given area. In a few places a few pebbles and stones are scattered on the surface and throughout the profile. These areas look like Viking soils, but they lack the high percentage of clay (more than 60 percent) and exhibit more tonguing than is associated with the Viking soils. Areas of this soil that have a wetter surface layer are indicated on the soil map by the wet spot symbol. Each symbol indicates a wet area of about 10 acres.

Nearly all areas of this Fargo soil are cultivated. Small grains, sugar beets, soybeans, and sunflowers are the most common crops (fig. 8). Grasses and legumes are grown in rotation as green-manure crops. A few areas are used for hay or pasture before being plowed and used for other crops.

Wetness is a limitation to use of this soil. Structural damage and compaction result if this soil is cultivated when wet. Soil blowing is also a hazard where cultivated areas are smooth and have no protective cover. (Capability unit IIw–1; tree and shrub suitability group 3)

Fargo silty clay, 1 to 6 percent slopes (FcB).—This soil occupies the upper slopes along well-entrenched drainageways and streams. These gentle slopes commonly parallel the natural watercourses and are short, generally ranging from 50 to 200 feet in length. The nearness of this soil to waterways and streams accounts for more variation in the depth of the dark-colored surface layer than is common in gently sloping soils. Buried dark-colored horizons and more varving also occur. Except for

Figure 8.—**Sugar beets on a nearly level area of Fargo silty clay. Some Hegne-Fargo silty clays and Fargo silty clay loam are on the far side of this field.**

these characteristics, this soil has a profile similar to that described as representative for the series.

Included in mapping were areas of slightly better drained and more permeable Wahpeton soils and small eroded areas of soils that have a thinner and more calcareous surface layer and resemble Hegne soils. These soils make up as much as 20 percent of any given area. Additional inclusions are Cashel soils that show less development than Fargo soils and Bearden soils that are less clayey and more calcareous. These inclusions make up as much as 15 percent of any given area.

Nearly all areas of this Fargo soil are cultivated. Small grains are the most common crop. Some areas are farmed along with adjacent soils used for sugar beets, sunflowers, and soybeans. Grasses and legumes are included in the rotation as green-manure crops. Some of these areas are used for hay and pasture before being plowed and used for other crops. An occasional small area is wooded, and elm and poplar are the most common trees.

Wetness is a limitation to farming this soil. Structural damage and compaction result if this soil is cultivated when wet. High water in adjacent natural drainageways occasionally floods this soil. Soil blowing and water erosion also are hazards in cultivated areas that have no protective cover. (Capability unit IIw–1; tree and shrub suitability group 3)

Fargo silty clay, depressional (Fd).—This soil occupies nearly round to oblong, pocket depressions. These depressions are more than three acres and commonly less than 40 acres in size. The landscape is characterized by well-defined depressions bordered by higher areas of nearly level Fargo soils. The surface layer commonly is rough and cloddy when plowed. Water is ponded in many places. When this soil dries, the surface layer has a cracked, crusty apperance. This soil has a profile simi-

lar to that described as representative for the series, except that there is more variation in the thickness of the surface layer and the extent and depth of tonguing.

Included in mapping were areas of Cashel soils that formed in fine-textured alluvium and exhibit less development than Fargo soils. These soils make up as much as 10 percent of any given area. Also included were areas of Colvin depressional soils that are calcareous and are less clayey than Fargo soils.

Most areas of this Fargo soil have been cultivated and are farmed along with soils used for small grains, sugar beets, sunflowers, and soybeans. Grasses and legumes are included in rotation as green-manure crops. Open ditches have been constructed in most cultivated fields to remove excess surface water.

Wetness is a limitation to use of this soil. Ponding occurs during periods of heavy rain and spring runoff, even though field ditches have been constructed. Cultivation and seedbed preparation often are delayed by wetness. Structural damage resulting from cultivating this soil when wet often makes seedbed preparation difficult. Some drowning of crops occurs. (Capability unit IIIw-1; tree and shrub suitability group 7-B)

Flaming Series

The Flaming series consists of nearly level, somewhat poorly drained and moderately well drained soils. These soils formed in deep deposits of lacustrine fine sand on an uneven glacial lake plain that has alternate high and low areas of microrelief. They formed under tall prairie grasses.

In a representative profile, the surface layer is black loamy fine sand in the upper part and very dark gray fine sand in the lower part. It is about 12 inches thick. The subsoil is 21 inches of very dark grayish-brown, brown, and grayish-brown fine sand. The underlying material is mottled, light brownish-gray fine sand (fig. 9).

Flaming soils have low available water capacity. Permeability is rapid. Inherent fertility is medium to low. The seasonal water table fluctuates between depths of 2 and 7 feet. Some areas are cultivated. If properly managed they are suited to such crops as oats, rye, and corn. They are suited to grasses used for hay and pasture.

Representative profile of Flaming loamy fine sand, wind eroded, in a meadow 1,630 feet east and 200 feet south of the northwest section corner of sec. 21, T. 146 N., R. 44 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand; weak, fine and medium, subangular blocky structure; slightly hard. very friable; common bleached sand grains; slightly acid; abrupt, smooth boundary.

A3—8 to 12 inches, very dark gray (10YR 3/1) fine sand; weak, medium, subangular blocky structure; slightly hard, very friable; slightly acid to neutral; clear, wavy boundary.

B1—12 to 17 inches, very dark grayish-brown (10YR 3/2) fine sand; common inclusions of pale brown (10YR 6/3) and brown (10YR 4/3); massive; soft, very friable; slightly acid; clear, wavy boundary.

B2—17 to 27 inches, brown (10YR 4/3) fine sand; massive; soft, very friable; slightly acid; gradual, wavy boundary.

B3—27 to 33 inches, grayish-brown (10YR 5/2) fine sand; few, fine, faint, light brownish-gray (2.5Y 6/2) mottles; massive; soft, loose; neutral; clear, wavy boundary.

C—33 to 60 inches, light brownish-gray (2.5Y 6/2) fine sand; many, medium, distinct, yellowish-brown (10YR 5/6) mottles and few, fine, prominent, yellowish-red (5YR 4/8) mottles; single grain; loose; neutral grading to mildly alkaline in the lower part; weakly calcareous in the lower part.

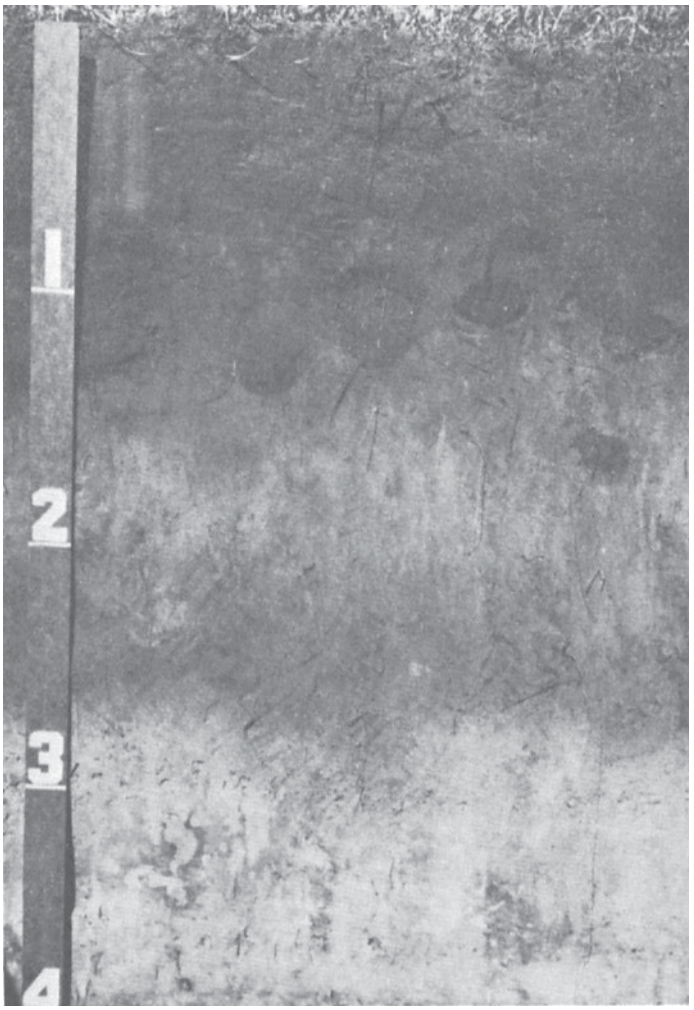

Figure 9.—**Profile of Flaming loamy fine sand, wind eroded. The darker colored krotovinas are a result of rodent activities.**

The thickness of the solum ranges from 20 to 40 inches. The colors of the A horizon are black, very dark gray, very dark brown, or very dark grayish brown. The texture of the A horizon generally is loamy fine sand, but in places it is fine sand. The thickness of the A horizon ranges from 10 to 16 inches. Its structure is weak, granular or subangular blocky.

The matrix of the B1 horizon ranges from very dark grayish brown to dark grayish brown or dark brown in color. The B2 horizon ranges from dark brown to brown or dark yellowish brown in color. The B3 horizon is grayish brown or brown in color. Grayish mottles are in the B2 horizon in some profiles. The B horizon generally is fine sand, but in places it is loamy fine sand. The content of organic matter in the B horizon at a depth below 16 inches is less than 1 percent. Reaction in the A and B horizons ranges from slightly acid to neutral. Reaction varies depending on time of sampling and moisture conditions.

The C horizon is gray, light gray, grayish brown, light brownish gray, olive gray, light olive gray, olive, or pale

olive in color. Mottles range from few to many and faint to prominent. The C horizon generally is fine sand, but in places it is sand. Reaction ranges from slightly acid to mildly alkaline.

Flaming soils are associated with Arveson, Hamar. and Ulen soils and are similar to Poppleton soils. They are better drained than Hamar and Arveson soils. They have a noncalcareous A horizon, whereas Ulen soils have a calcareous A horizon. They have a thicker, darker colored A horizon than Poppleton soils.

Flaming loamy fine sand, wind eroded (Ff).—This nearly level soil occupies an uneven landscape that has a combination of slightly concave and convex topography. Slopes range from 1 to 3 percent. Soil blowing is largely responsible for this topography. Areas of this soil generally range from 10 to 100 acres in size. Areas of soil accumulation are common along wooded areas, fence lines, and field boundaries. In cultivated areas, this soil has a varied pattern of black and brownish colors in the surface layer. This soil has the profile described as representative for the series.

Included in mapping were soils that have a surface layer more than 16 inches thick. These soils make up as much as 30 percent of any given area. They are areas of accumulation and commonly alternate with soils similar to those of the Poppleton series that have a surface layer less than 10 inches thick. These soils make up less than 15 percent of any given area. Areas of more poorly drained Hamar soils make up as much as 20 percent of any given area. Also included were areas of the calcareous Ulen soils and calcareous and poorly drained Arveson soils that make up as much as 15 percent of any given area.

Some areas of this Flaming soil are cultivated. Small grains and corn grown for silage and fodder are the most common crops. A larger acreage is used for quackgrass, bluegrass, and redtop grown for hay and pasture. There is some volunteer sweetclover and various weeds and forbs. Scattered trees, principally quaking aspen and some willow brush, also grow on this soil. Some areas are idle.

Soil blowing is a hazard. Low available water capacity and medium to low inherent fertility also influence the use and management of this soil. (Capability unit IVe–2; tree and shrub suitability group 5)

Flaming, Hamar, and Arveson soils (Fh).—These soils occupy an uneven landscape that has microrelief. Relief is a combination of convex, concave, and depressed areas in which slopes commonly range from 1 to 3 percent. Soil blowing is responsible for this relief. Flaming loamy fine sand commonly occupies convex positions; Hamar loamy fine sand, concave positions; and Arveson loam and Hamar loamy fine sand occupy the depressions. The texture of the surface layer of Flaming soils ranges from fine sand to loamy fine sand. Hamar soils have a loamy sand to fine sandy loam texture. Arveson soils have a surface layer that ranges from sandy loam to light silt loam. Areas of these soils normally range from 5 to 60 acres in size. The percentage of each of these soils in any given area is variable and cannot be accurately predicted. Areas of accumulation are common along wooded areas, fence lines, and field boundaries. In cultivated areas, these soils have a mottled appearing surface and a varied pattern of black and brownish colors in the surface layer. Soils in this unit have profiles similar to those described as representative for the Flaming, Hamar, and Arveson series, except that there is generally more variation in the thickness of the A horizon.

Included in mapping were areas of Poppleton soils that have a thinner, lighter colored surface layer. These soils make up as much as 20 percent of any given area. Also included were areas of more calcareous Ulen soils and Towner and Kratka soils that have finer textured underlying material. These inclusions make up as much as 15 percent of any given area. Areas of Dune land that slope as much as 6 percent were also included and make up as much as 10 percent of any given area.

Some areas of this complex are cultivated. Small grains and corn for silage and fodder are the most common crops. A larger acreage is used for hay and pasture, with such introduced grasses as quackgrass, bluegrass, and redtop. A few areas of this unit have been planted in conifers. There also are scattered areas of quaking aspen and some willow brush on these soils. Some of the depressions have a growth of reeds, sedges, and cattails. Most of the wooded areas and depressions are idle.

Wetness is a limitation on these soils. The microrelief increases the difficulty of drainage. Soil blowing and water erosion also are limitations. Medium to low available water capacity and medium to low inherent fertility influence the use and management of these soils. (Capability unit IVw–2; tree and shrub suitability group 3)

Flom Series

The Flom series consists of nearly level, poorly drained and somewhat poorly drained soils. These soils formed in loam till. They are on upland till plains commonly associated with undulating and rolling soils. Slopes are smooth, slightly concave, and depressional. These soils formed under tall prairie grasses and reeds and sedges.

In a representative profile, the surface layer is mainly about 12 inches of black silty clay loam. The subsoil is 4 inches of prominently mottled, dark-gray silty clay loam. The underlying material is calcareous, olive-gray and gray loam.

Flom soils have high available water capacity. Permeability is moderately slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Many areas of Flom soils are cultivated. The soils are suited to small grains and to corn, soybeans, sunflowers, and other row crops.

Representative profile of Flom silty clay loam in a cultivated field 1,780 feet north and 210 feet west of the southeast corner of sec. 6, T. 146 N., R. 43 W.

Ap—0 to 5 inches, black (10YR 2/1) silty clay loam; clods parting to weak, very fine and fine, subangular blocky structure; friable; many roots; neutral; abrupt, smooth boundary.

A1—5 to 10 inches, black (10YR 2/1) silty clay loam; weak, very fine and fine, subangular blocky structure; friable; many roots; neutral; clear, smooth boundary.

A3—10 to 12 inches, very dark gray (10YR 3/1) clay loam; few, fine, distinct. yellowish-brown (10YR 5/6) mottles; weak to moderate, fine and very fine, subangular blocky structure; friable; about 2 percent coarse fragments; many roots; neutral; gradual, smooth boundary.

B2g—12 to 16 inches, dark-gray (10YR 4/1) silty clay loam; few inclusions of very dark gray (10YR 3/1); common, medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; about 2 percent coarse fragments; few roots; neutral; clear, smooth boundary.

C1g—16 to 21 inches, olive-gray (5Y 5/2) loam; common, medium. prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few roots; mildly alkaline; calcareous; gradual, smooth boundary.

C2g—21 to 28 inches, olive-gray (5Y 5/2) loam; few, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few roots; mildly alkaline; calcareous; gradual, smooth boundary.

C3g—28 to 60 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) loam; many, medium, prominent, olive-yellow (2.5Y 6/8) and yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; moderately alkaline; strongly calcareous.

The thickness of the solum and depth to free carbonates range from 14 to 30 inches. The texture of the A horizon typically is clay loam or silty clay loam, with loam and silt loam textures also in the range. The thickness of the A horizon ranges from 10 to 20 inches.

The colors in the B2g horizon are dark grayish brown, grayish brown, dark gray, gray, and olive gray. Mottles range from none to many, prominent. The B2g horizon typically is silty clay loam or clay loam, but in places it is loam. Weak or moderate, fine or very fine, angular or subangular blocky are the most common structures in the B2g horizon. The B2g horizon ranges from 3 to 12 inches in thickness. Its reaction ranges from neutral to mildly alkaline, and it is calcareous in places.

The colors in the C horizon are gray, light gray, light olive gray, olive gray, olive, pale olive, grayish brown, and light brownish gray. Mottles range from faint to prominent. The C horizon generally is loam, but in places it is clay loam. It ranges from mildly alkaline to moderately alkaline, and it is calcareous to strongly calcareous.

Flom soils are associated with Barnes, Vallers, and Kittson soils and are similar to Roliss soils. They lack the calcareous A horizon and the Cca horizon, which are characteristic of Vallers soils. They are more poorly drained than Darnen and Kittson soils. They are leached of free carbonates to a greater depth than Roliss soils.

Flom silty clay loam (Fm).—This nearly level soil occupies slightly concave swales and natural draws on the upland till plain and is associated with more sloping soils. Areas generally range from 3 to 35 acres in size. Slopes commonly range from 1 to 3 percent. The surface layer has a cloddy appearance, especially if cultivated when wet. Gravel and cobblestones are scattered on the surface in many areas. This soil has the profile described as representative for the series.

Included in mapping were areas of more calcareous Vallers soils that make up as much as 20 percent of any given area. Also included were better drained Kittson loam, uplands, and soils that have deposits of colluvium and surface layers more than 20 inches thick. These inclusions make up as much as 15 percent of any given area. Also included were areas with profiles that contain less sand and more silt than is typical for the Flom series.

Many areas of this Flom soil are cultivated. Small grains are the most common crop, but some row crops, such as corn, soybeans, and sunflowers are also grown. Some areas are used for hay and pasture. These areas generally are seeded to legumes or a grass-legume mixture. Trees and lowland brush also grow on some areas.

Wetness is a limitation. (Capability unit IIw–1; tree and shrub suitability group 3)

Flom and Vallers soils, depressional (Fv).—These soils occupy closed depressions and the bottoms of natural draws that commonly are 3 to 20 acres in size. These depressions and draws are bordered by higher areas of Hamerly, Flom, Vallers, and Kittson uplands soils. A few stones, cobblestones, or gravels are scattered on the surface of these depressions and draws. Profiles in these low areas are similar to those described as representative for the Flom and Vallers series, except that the thickness of the surface layer varies more than is common. Approximately 65 percent of the acreage is Flom soils and 35 percent is Vallers soils, but any individual area can be mostly one soil.

Included in mapping were areas of Cathro muck that have an organic surface layer underlain by loamy material. Also included were areas of Marsh where soil material has not been determined. These inclusions make up as much as 15 percent of any given soil area.

A few areas of this unit have been drained and are included in fields of adjacent soils used for small grains and such row crops as corn and soybeans. Reeds and sedges grow in many of these depressions and are sometimes utilized for livestock feed. Many areas are idle and support a growth of reeds, sedges, cattails, and willow brush.

Wetness is a limitation to use of these soils. Water is commonly ponded in depressional areas. The occurrence of stones and cobblestones also influences use and management. (Capability unit IIIw–1; tree and shrub suitability group 7–B)

Foxhome Series

The Foxhome series consists of nearly level, moderately well drained soils that formed in coarse-textured outwash deposited over loamy material. These soils are commonly associated with an interbeach landscape where soil materials are mixed and relief is variable. They formed under tall prairie grasses.

In a representative profile, the surface layer is mainly black loam about 11 inches thick. The next layer is very dark grayish-brown and dark-brown loamy sand about 3 inches thick. The next 10 inches is dark grayish-brown and brown gravelly coarse sand distinctly mottled in the lower part. The underlying material is strongly calcareous, mottled, grayish-brown and light brownish-gray loam.

Foxhome soils have medium to high available water capacity, but the coarse-textured layers restrict root growth. Permeability is rapid in the coarse material and moderate in the underlying finer material. Inherent fertility is medium. The seasonal water table fluctuates between depths of 2½ feet and more than 6 feet. Some areas are cultivated. The soils are suited to small grains and to corn, sunflowers, and other row crops.

Representative profile of Foxhome loam, 0 to 3 percent slopes, in a pasture 98 feet north and 790 feet west of the southeast corner of sec. 10, T. 143 N., R. 45 W.

A1—0 to 9 inches, black (10YR 2/1) loam; weak, very fine, subangular blocky structure; very friable; neutral; clear. smooth boundary.

A3—9 to 11 inches. very dark brown (10YR 2/2) sandy loam; weak, very fine, subangular blocky structure; very friable; neutral; clear, smooth boundary.

B2—11 to 14 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) loamy sand; weak, fine, subangular blocky structure; very friable; a few fine pebbles; neutral; clear, smooth boundary.

IIB3—14 to 19 inches, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) gravelly coarse sand; single grain; loose; 2 percent of material consists of fragments larger than 3 inches in diameter; mildly alkaline; weakly calcareous; clear, smooth boundary.

IIC1—19 to 24 inches, dark grayish-brown (10YR 4/2) gravelly coarse sand; common, fine, distinct, olive-yellow (2.5Y 6/6 and 6/8) mottles; single grain; loose; about 40 percent gravel; mildly alkaline; weakly calcareous; abrupt, smooth boundary.

IIIC2—24 to 60 inches, grayish-brown (2.5Y 5/2) and light brownish-gray (2.5Y 6/2) loam; many, fine and medium, distinct, olive-yellow (2.5Y 6/8), yellowish-brown (10YR 5/8), and brownish-yellow (10YR 6/8) mottles; weak, very fine, subangular blocky structure; friable; about 5 percent coarse fragments; moderately alkaline; strongly calcareous.

The thickness of the solum ranges from 14 to 30 inches. The depth to the IIIC2 horizon ranges from 20 to 40 inches. The colors in the A horizon are black, very dark gray, very dark brown, or very dark grayish brown. The texture of the A horizon is generally loam or sandy loam, but in places it is silt loam. The structure is weak or moderate and granular or subangular blocky. The thickness of the combined A and B2 horizons ranges from 10 to 16 inches.

The colors in the B2 horizon are very dark grayish brown, dark grayish brown, dark brown, or brown. The B2 horizon is generally sandy loam or loamy sand, but it is loam in some profiles. The thickness ranges from 2 to 10 inches.

The colors in the IIC1 horizon are variable, but they are commonly dark grayish brown, grayish brown, light brownish gray, brown, pale brown, yellowish brown, light yellowish brown, olive brown, and light olive brown. This horizon is generally gravelly coarse sand, but in some profiles it is layered sand and gravel that contains some material the size of cobblestones. The thickness of the combined IIB3 and IIC1 horizons ranges from 6 to 20 inches. Reaction ranges from mildly alkaline to moderately alkaline, but is commonly mildly alkaline. The soil material is weakly calcareous or calcareous.

The colors in the IIIC2 horizon commonly are light olive brown, light yellowish brown, olive yellow, olive, grayish brown, light brownish gray, and pale olive. Mottles range from few to many and from faint to prominent. In most places the IIIC2 horizon is loam or clay loam, but in a few places it is silt loam and silty clay loam. Reaction ranges from mildly to moderately alkaline, and the soil material is calcareous to strongly calcareous.

Foxhome soils are associated with Kittson and Sioux soils and are similar to Mavie soils. They have a coarse-textured IIC1 horizon, which is lacking in the Kittson soils. They have a loamy IIIC2 horizon, which is lacking in Sioux soils. They are better drained and less calcareous in the upper layers than Mavie soils.

Foxhome loam, 0 to 3 percent slopes (FxA).—This soil occupies slightly convex areas that normally range from 5 to 25 acres in size. In most places these areas are associated with the interbeach areas where relief is variable and slopes are short and very gentle. In most places the soil materials are mixed, and there are scattered cobblestones and stones on the surface.

Included in mapping were areas of Kittson and Roliss soils that have less than 6 inches of gravelly sand in the profile. These soils make up as much as 20 percent of any given area. Also included were areas of Mavie soils that are wetter and more calcareous, as well as areas of Sioux or Hangaard soils that have thicker layers of gravelly sand but lack the finer textured underlying material. These inclusions make up as much as 15 percent of any given area.

Some areas of Foxhome soil are cultivated mainly for the production of small grains. Many areas are used for hay and pasture. A few of these areas are seeded to alfalfa or a grass-legume mixture. The use of introduced grasses, such as quackgrass, bluegrass, and redtop, is more common on this soil. Scattered stands of trees, principally quaking aspen, also grow on this soil.

Low available water capacity in the coarse-textured layers and medium fertility are limitations on this soil. Cobblestones and stones scattered on the surface and buried in the soil make operation of farm machinery more difficult. (Capability unit IIIs–1; tree and shrub suitability group 1)

Glyndon Series

The Glyndon series consists of nearly level and gently sloping, somewhat poorly drained and moderately well drained soils. These soils formed in deep deposits of very fine lacustrine sand on a glacial lake plain. Areas of gently sloping soils commonly are small and parallel natural drainageways. These soils formed under tall prairies grasses.

In a representative profile, the surface layer is mixed black and very dark gray loam 11 inches thick. This grades to 5 inches of dark-gray, strongly calcareous loam. The next layer, about 17 inches thick, is dark-gray, strongly calcareous loam in the upper part and light yellowish-brown, very strongly calcareous loam in the lower part. Below this is mottled, light yellowish-brown loamy very fine sand that grades with depth to light brownish gray (fig. 10).

Glyndon soils have high available water capacity. Permeability is moderately rapid. Inherent fertility is high. The seasonal water table fluctuates between depths of 2 and 6 feet. Nearly all areas of Glyndon soils are cultivated. They are suited to all crops commonly grown in the county.

Representative profile of Glyndon loam, 0 to 2 percent slopes, in a cultivated field 665 feet east and 210 feet south of the northwest corner of sec. 25, T. 145 N., R. 46 W.

Ap—0 to 8 inches, black (10YR 2/1) and very dark gray (10YR 3/1) loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

A1—8 to 11 inches, black (10YR 2/1) mixed with very dark gray (10YR 3/1) loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; gradual, wavy boundary.

C1ca—11 to 16 inches, dark-gray (10YR 4/1) loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; gradual, wavy boundary.

C2ca—16 to 28 inches, light yellowish-brown (2.5Y 6/3) loam; few, fine, faint, light yellowish-brown (2.5Y 6/4) mottles; weak, very fine, subangular blocky structure; very friable; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C3—28 to 36 inches, light yellowish-brown (2.5Y 6/4) loamy very fine sand; common, fine, distinct, light olive-brown (2.5Y 5/6) and olive-yellow (2.5Y 6/6) mottles; weak, very fine, subangular blocky structure breaking easily to single grain; very friable; moder-

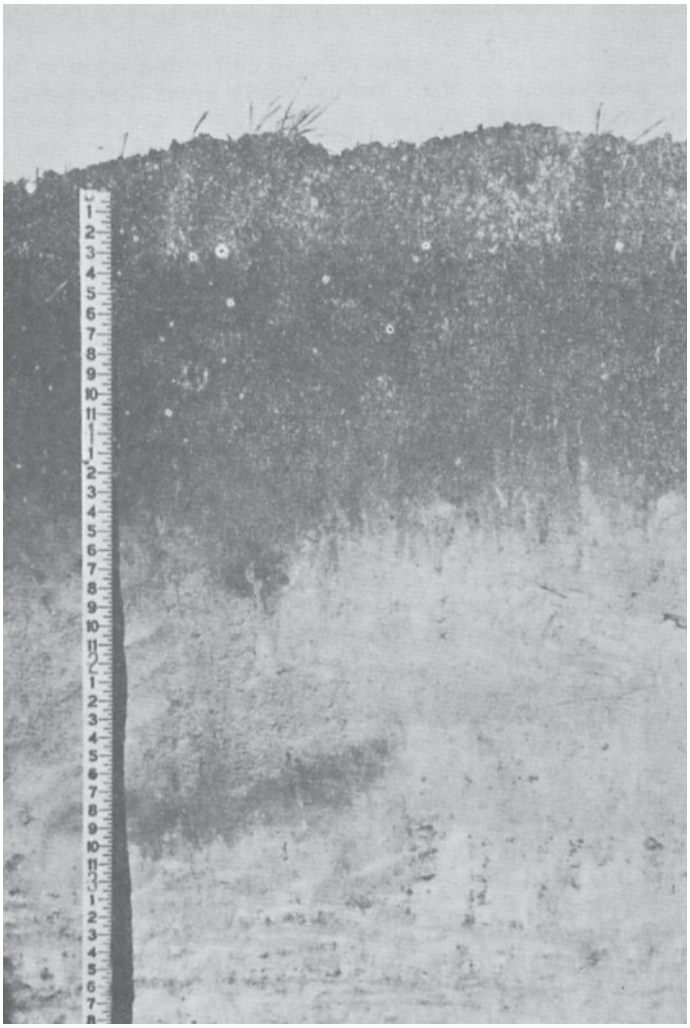

Figure 10.—**Profile of Glyndon loam, 0 to 2 percent slopes. The lighter color between depths of 16 and 28 inches is the zone of maximum carbonate accumulation.**

ately alkaline; strongly calcareous; gradual, smooth boundary.

C4—36 to 50 inches, light brownish-gray (2.5Y 6/2) loamy very fine sand; many, medium, prominent, olive-yellow (2.5Y 6/8), brownish-yellow (10YR 6/8), and yellowish-brown (10YR 5/8) mottles; partly massive and some weak platy structure; very friable; moderately alkaline; strongly calcareous.

The colors in the A horizon are black, very dark gray, very dark brown, and very dark grayish brown. There is a very dark gray Aca horizon in some profiles. The texture of the A horizon generally is loam, but in places it is very fine sandy loam and silt loam. The thickness of the A horizon ranges from 7 to 16 inches. It has fine or very fine, granular or subangular blocky structure.

The Cca horizon ranges from dark gray to light yellowish brown. The Cca horizon has textures of loam, very fine sandy loam, silt loam, and loamy very fine sand. There are faint mottles, in the Cca horizon of some profiles, but no distinct mottles are within 20 inches of the surface. The Cca horizon is strongly calcareous or very strongly calcereous; the calcium carbonate equivalent is more than 15 percent and at least 5 percent more than in the underlying C horizon. The Cca horizon is 6 to 22 inches thick. The remainder of the C horizon generally is loamy very fine sand or very fine sandy loam, but in places it is very fine sand, loam, or silt loam.

Glyndon soils are associated with Wheatville, Borup, Augsburg, and Bearden soils and are similar to Ulen soils. They lack the clayey IIC horizon that is characteristic of Augsburg and Wheatville soils. Glyndon soils are better drained than Augsburg and Borup soils, and they contain less clay and more silt and sand than Bearden soils. They contain more silt and very fine sand than Ulen soils.

Glyndon loam, 0 to 2 percent slopes (GlA).—This soil occupies slightly convex areas that generally range from 10 to 100 acres in size. The surface layer is black and very dark gray and has a smooth appearance when cultivated. This soil has the profile described as representative for the series.

Included in mapping were areas of more poorly drained Borup soils that make up as much as 20 percent of any given area. Also included were areas of Wheatville and Augsburg soils that have contrasting fine-textured underlying material and areas of Bearden soils that have finer textured materials throughout. These inclusions make up as much as 15 percent of any given area. A few saline spots were also included. These spots can best be recognized during the growing season by reduced or very stunted crop growth They are commonly less than three acres in size and occur mostly in an area 2 to 5 miles southeast of Ada.

Nearly all areas of this Glyndon soil are cultivated. Small grains, sugar beets, sunflowers, and soybeans are the main crops. Some legumes are grown for plowdown as green manure. A small acreage is used for hay and pasture.

Soil blowing is a hazard, and the strongly calcareous condition of this soil also influences use and management. (Capability unit IIe–1; tree and shrub suitability group 2)

Glyndon loam, 2 to 6 percent slopes (GlB).—This gently sloping soil occupies areas that commonly parallel natural drainageways. These areas are small, generally ranging in size from 3 to 15 acres. Slopes are short, mostly 50 to 150 feet in length. In cultivated areas, the surface layer has a smooth appearance and a mottled color pattern of black, very dark gray, and dark gray. This soil has a profile similar to that described as representative for the series, except that there is more variation in thickness and color of the surface layer.

Included in mapping were finer textured Bearden soils and areas of Alluvial land, occasionally flooded, that are less uniform and more subject to flooding. These inclusions make up as much as 15 percent of any given area.

Most of this soil is farmed along with fields used for small grains. Some acreage is used for hay and pasture.

Water erosion and soil blowing are hazards on this soil. The strongly calcareous condition also influences use and management. (Capability unit IIe-2; tree and shrub suitability group 2)

Glyndon loam, wind eroded (Gn).—This nearly level soil occupies slightly convex areas that generally range from 10 to 70 acres in size. Slopes are less than 2 percent. In cultivated areas, the surface layer has a smooth appearance and is very dark gray and dark gray in color. Fence-row drifts or other evidences of soil blowing occur in areas of this soil. This soil has a profile similar to that described as representative for the series, except that the surface colors commonly are grayer. The surface layer also is more strongly calcareous and shallower,

with about 7 inches of surface layer or plow layer directly over the Cca horizon.

Included in mapping were areas of Glyndon soils that have a thicker or thinner dark-colored surface layer. These soils make up as much as 30 percent of any given area. Also included were areas of Borup soils that are poorly drained and Wheatville and Augsburg soils that have contrasting fine-textured underlying material. These inclusions make up as much as 15 percent of any given area.

Nearly all of this wind-eroded Glyndon soil is cultivated. Small grains are the most common crops. Some sunflowers, corn, sugar beets, and soybeans also are grown on this soil. A small acreage is seeded to legumes for green manure or is included with a grass mixture and used for hay or pasture.

Soil blowing, the shallow surface layer, and the strongly calcareous condition are limitations on this soil. (Capability unit IIIe–2; tree and shrub suitability group 7–C)

Gravel Pits

Gravel pits (Gp) are areas where gravelly material has been excavated. These pits are generally associated with areas of Sioux soils that occupy beach ridges or areas of coarse-textured outwash. The surface layer has been stripped from these soils and deposited around the edges of the gravel pits. The coarser gravelly material has been removed, leaving an open pit. The size and shape of these pits are influenced largely by the quantity and quality of gravel at each site. Many pits are no longer worked because the supply of quality gravel has been exhausted. Many gravel pits, especially the deeper abandoned ones, have water ponded in them.

Various introduced and native grasses grow on the strippings and nonexcavated areas surrounding gravel pits. A few scattered trees also grow on these areas. The strippings, spoil, and area around gravel pits supply limited grazing, while the deeper pits provide a water supply for livestock. The gravel removed from these pits is used for road surfacing, as concrete aggregates, and in other industrial and construction applications. (Not in a capability unit or tree and shrub suitability group)

Grimstad Series

The Grimstad series consists of nearly level, somewhat poorly drained and moderately well drained soils. These soils formed in fine sand deposited over loamy material on glacial lake plains. They are on an interbeach landscape where soil materials are very mixed and relief is variable. They formed under tall prairie grasses.

In a representative profile, the surface layer is 10 inches of black, strongly calcareous fine sandy loam. The next layer is 12 inches of very strongly calcareous, dark grayish-brown and grayish-brown loamy fine sand. Below this is 6 inches of mottled, light olive-brown, strongly calcareous loamy fine sand. Between depths of 28 and 60 inches is mottled, light brownish-gray fine sandy loam and loam.

Grimstad soils have medium to high available water capacity. Permeability is rapid in the sandy material and moderate in the underlying loamy material. Inherent fertility is medium to high. The seasonal water table fluctuates between depths of 2 feet and more than 6 feet. Most areas of Grimstad soils are cultivated. They are suited to small grains and to corn, soybeans, sunflowers, and other row crops.

Representative profile of Grimstad fine sandy loam in a cultivated field 1,425 feet west and 285 feet south of the northeast corner of sec. 2, T. 145 N., R. 45 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam; common worm casts and root channel fillings of very dark brown (10YR 2/2); clods parting to weak, very fine, angular blocky structure; very friable; common roots; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

C1ca—10 to 14 inches, dark grayish-brown (10YR 4/2) loamy fine sand; about 30 percent tongues and inclusions of very dark grayish brown (10YR 3/2); weak, very fine, granular structure; very friable; common roots; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C2ca—14 to 22 inches, mixed dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y 5/2) loamy fine sand; weak, very fine, granular structure; very friable; few coatings of dark brown (10YR 4/3) on sand grains in lower part; common roots; moderately alkaline; very strongly calcareous; clear, wavy boundary.

C3—22 to 28 inches, light olive-brown (2.5Y 5/4) loamy fine sand; common. fine, faint, light yellowish-brown (2.5Y 6/4) mottles and common, fine, distinct, olive-yellow (2.5Y 6/6) mottles; massive; loose; a few 5- to 10-millimeter blotches of dark brown (10YR 4/3); moderately alkaline; strongly calcareous; clear, smooth boundary.

IIC4—28 to 32 inches, light brownish-gray (2.5Y 6/2) fine sandy loam; common, fine, distinct, light olive-brown (2.5Y 5/4) and light yellowish-brown (2.5Y 6/3) mottles and many, medium, prominent, brownish-yellow (10YR 6/6) mottles; weak, very fine, subangular blocky structure; very friable; moderately alkaline; strongly calcareous; clear, smooth boundary.

IIC5—32 to 60 inches. light brownish-gray (2.5Y 6/2) loam; common, fine, faint, light-gray (2.5Y 7/2) mottles and many, fine, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles; platy structure parting to weak, very fine, subangular blocky; friable; few, fine and medium, prominent, dark reddish-brown (5YR 3/4) concretions; moderately alkaline; strongly calcareous.

The colors in the A horizon are black, very dark gray, very dark brown, and very dark grayish brown. The texture of the A horizon generally is fine sandy loam, but in places it is sandy loam, loamy fine sand, loamy sand, or loam. An Aca horizon is in some profiles. The thickness of the A horizon ranges from 7 to 16 inches. Its structure is weak or moderate, granular, angular or subangular blocky.

The Cca horizon has colors of dark gray, gray, dark grayish brown, grayish brown, and light brownish gray. Mottles are in the Cca horizon of most profiles, but no distinct or prominent mottles occur within a depth of 20 inches. This horizon has textures of fine sandy loam, sandy loam, loamy sand, and loamy fine sand. The Cca horizon is strongly calcareous or very strongly calcareous and ranges from 6 to 16 inches in thickness.

The C3 horizon is brown, pale brown, light yellowish brown, yellowish brown, or light olive brown. Mottles range from few, faint to common, prominent. The texture generally is fine sand, but in places it is sand, loamy sand, or loamy fine sand.

Depth to the IIC horizon ranges from 20 to 40 inches. The IIC horizon has colors of grayish brown, light brownish gray, and light olive gray. Mottles range from few to many and are distinct or prominent. This horizon generally is loam or fine sandy loam, but in places it is silt loam, silty clay loam, or clay loam. It is mildly alkaline or moderately alkaline, and it is calcareous or strongly calcareous.

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Grimstad soils are associated with Rockwell, Ulen, and Swenoda soils and are similar to Wheatville soils. They are better drained than Rockwell soils and have a IIC horizon that is lacking in Ulen soils. They have a calcareous A horizon, whereas Swenoda soils have a noncalcareous A horizon. They contain more fine sand in the A and Cca horizons and less clay in the IIC horizon than Wheatville soils.

Grimstad fine sandy loam (Gr).—This nearly level soil occupies slightly convex areas that generally range from 10 to 50 acres in size. Slopes are less than 3 percent. The landscape is commonly complex, and soil materials are mixed. In cultivated areas, the surface has a smooth appearance and colors are variations of black, very dark brown, and very dark grayish brown.

Included in mapping were areas of more poorly drained Rockwell soils, less calcareous Swenoda soils, Ulen soils that have deeper sands, and finer textured Wheatville soils. These soils make up as much as 15 percent of any given area. Also included were soils that have variations in carbonate content and no well-defined zone of carbonate accumulation.

Many areas of Grimstad soil are cultivated. Small grains are the most common crop, but some row crops, such as corn, soybeans, and sunflowers, are also grown. Some areas are used for hay and pasture. These are seeded to a grass-legume mixture or to quackgrass, Kentucky bluegrass, or redtop. A few scattered trees, principally quaking aspen, also grow on this soil.

Soil blowing is a hazard on this soil. The strongly calcareous condition of the soil also influences use and management. (Capability unit IIIe-2; tree and shrub suitability group 2)

Hamar Series

The Hamar series consists of nearly level, poorly drained and somewhat poorly drained soils. These soils formed in deep deposits of lacustrine fine sand on glacial lake plains that have alternate high and low areas of microrelief. They formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is 12 inches of black loamy fine sand. The subsoil is distinctly mottled, dark grayish-brown and grayish-brown fine sand about 3 inches thick. The underlying material is mainly grayish-brown fine sand that has prominent mottles.

Hamar soils have low available water capacity. Permeability is rapid. Inherent fertility is medium to low. The seasonal water table fluctuates between depths of 1 and 5 feet. Some areas are cultivated. With proper management, these soils are suited to small grains. They are suited to grasses used for hay and pasture.

Representative profile of Hamar loamy fine sand in an area of grass and brush, 90 feet south and 1,980 feet east of the northwest corner of sec. 20, T. 146 N., R. 44 W.

A1—0 to 12 inches, black (10YR 2/1) loamy fine sand; weak, very fine, granular structure; very friable; many roots; common bleached sand grains; mildly alkaline; clear, irregular boundary.

B1g—12 to 15 inches, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) fine sand; common, fine, distinct, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/8) mottles; massive; very friable; many roots; neutral; clear, wavy boundary.

C1g—15 to 23 inches, grayish-brown (2.5Y 5/2) fine sand; common, fine and medium. prominent, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/6) mottles; single grain; loose; few roots; neutral; gradual, smooth boundary.

C2g—23 to 31 inches, grayish-brown (2.5Y 5/2) fine sand; many, medium and large, prominent, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/6) mottles; single grain; loose; mildly alkaline; clear, smooth boundary.

C3g—31 to 37 inches, grayish-brown (2.5Y 5/2) fine sand; common, large, prominent, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6 and 5/8) mottles; single grain; loose; mildly alkaline; weakly calcareous; clear, smooth boundary.

C4g—37 to 39 inches, olive-gray (5Y 4/2) mixed with dark olive-gray (5Y 3/2) fine sand; few, fine and medium, prominent, brown (7.5YR 4/4) and yellowish-brown (10YR 5/8) mottles; single grain; loose; neutral; clear, smooth boundary.

C5g—39 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; common, medium and large, prominent, yellowish-brown (10YR 5/6) and brownish-yellow (10 YR 6/8) mottles; single grain; loose; mildly alkaline; weakly calcareous.

The colors of the A horizon are black, very dark gray, very dark grayish brown, and very dark brown. Distinct or prominent mottles are in the lower part of the A horizon in some profiles. The texture of the A horizon typically is loamy fine sand or loamy sand, but in places it is sandy loam and fine sandy loam. The thickness of the A horizon ranges from 10 to 24 inches. Its reaction ranges from neutral to mildly alkaline. Structure of the A horizon is weak; very fine, fine, or medium; granular or subangular blocky.

The B2g horizon is lacking in some profiles.

Colors in the C horizon are gray or dark gray, grayish brown or dark grayish brown, or olive gray. Mottles in the C horizon range from few to many and from faint to prominent. The C horizon commonly is fine sand, but in places it is loamy sand and loamy fine sand. Hamar soils commonly are noncalcareous to a depth of more than 30 inches, but some profiles contain free carbonates at a depth below 22 inches.

Hamar soils are associated with Flaming, Arveson, and Poppleton soils and are similar to Kratka soils. They are more poorly drained than Flaming soils. They have a noncalcareous A horizon, whereas Arveson soils have a calcareous A horizon. They have a thicker dark-colored A horizon and are more poorly drained than Poppleton soils. They lack the finer textured IIC horizon of Kratka soils.

Hamar loamy fine sand (Ha).—This nearly level soil is on a lake plain. Slopes range from 0 to 2 percent, and there are alternate higher and lower areas of microrelief. Soil blowing is responsible for much of this relief. Some areas of accumulation along fence lines and field boundaries also are associated with this soil. In cultivated areas, this soil has black surface colors modified by a varying content of clean, bleached sand grains.

Included in mapping were areas of soils that have a dark-colored surface layer less than 10 inches thick. These soils make up as much as 20 percent of any given area. Also included were areas of calcareous Arveson soils, better drained Flaming soils, Kratka soils that have finer textured underlying material, and better drained, more calcareous Ulen soils. These inclusions make up as much as 15 percent of any given area.

Some areas of this Hamar soil are cultivated. Small grains are the main crop, but a small acreage is also used for corn and flax. A more common use is for hay and pasture. Introduced grasses, such as quackgrass, Kentucky bluegrass, and redtop, commonly are used for this purpose. Some areas are idle. The idle and pastured areas commonly have scattered growths of trees, princi-

pally quaking aspen and willow brush, mixed with grassed openings.

Wetness is a limitation to the use of this soil. Soil blowing, low available water capacity, and medium to low inherent fertility also influence the use and management of this soil. Capability unit IVw-2; tree and shrub suitability group 3)

Hamerly Series

The Hamerly series consists of nearly level to gently sloping, somewhat poorly drained and moderately well drained soils. These soils formed in water-worked loam and clay loam material in the upland till plains. Hamerly soils are commonly in slightly convex positions, and slopes are as much as 5 percent. They normally are associated with soils in a rolling upland landscape that has numerous draws and depressions. They formed under tall prairie grasses.

In a representative profile, the surface layer is 14 inches of black, very dark gray, and dark-gray, strongly calcareous silt loam. The next layer is 7 inches of dark grayish-brown, very strongly calcareous loam that grades to light brownish gray. Below this is mottled, light yellowish-brown, calcareous loam.

Hamerly soils have high available water capacity. Permeability is moderate. Inherent fertility is medium to high. The seasonal water table fluctuates between depths of 2½ feet and more than 6 feet. Most areas are cultivated. The soils are suited to small grains and to corn, soybeans, sunflowers, and other row crops.

Representative profile of Hamerly silt loam, 0 to 1 percent slopes, in a cultivated field 2,588 feet north and 1,584 feet east of the southwest corner of sec. 14, T. 146 N., R. 44 W.

Ap—0 to 9 inches, black (10YR 2/1) silt loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

A1ca—9 to 14 inches, very dark gray (10YR 3/1) mixed with dark-gray (10YR 4/1) silt loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; clear, irregular boundary.

C1ca—14 to 16 inches, dark grayish-brown (10YR 4/2) loam; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; many roots; moderately alkaline; very strongly calcareous; clear, irregular boundary.

C2ca—16 to 21 inches, light brownish-gray (10YR 6/2) loam; few, fine, faint, light yellowish-brown (10YR 6/2) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few roots; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C3—21 to 36 inches, light yellowish-brown (2.5Y 6/3) loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles and common, fine, faint, olive-yellow (2.5Y 6/6) and light yellowish-brown (10YR 6/4) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; moderately alkaline; calcareous; gradual, smooth boundary.

C4—36 to 60 inches, light yellowish-brown (2.5Y 6/3) loam; many, medium, prominent, yellowish-brown (10YR 5/8), brownish-yellow (10YR 6/8), olive-yellow (2.5Y 6/8), and light-gray (2.5Y 7/2) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; moderately alkaline; calcareous.

The colors in the A horizon are black, very dark gray, and very dark grayish brown. The texture of the A horizon generally is silt loam or loam, but in places it is silty clay loam or clay loam. The A1ca horizon is lacking in some profiles. Structure of the A horizon is weak, very fine and fine, subangular blocky or granular. Combined thickness of the A horizon ranges from 7 to 16 inches.

The colors in the Cca horizons are dark gray, gray, dark grayish brown, grayish brown, light brownish gray, brown, pale brown, light olive brown, and light yellowish brown. Mottles range from none to common and from faint to distinct. No distinct mottles are within a depth of 20 inches. The Cca horizon is loam or clay loam. The colors in the C3 and C4 horizons generally are grayish brown, light grayish brown, light olive brown, or light yellowish brown. Mottles range from few, faint to many, prominent. Texture is loam or clay loam. Reaction ranges from mildly alkaline to moderately alkaline, and the C3 and C4 horizons are calcareous or strongly calcareous.

Some of the Hamerly soils in this county are silt loam or silty clay loam in the Cca horizon. Such soils are outside the defined range for the series, but this difference does not alter their usefulness and behavior.

Hamerly soils are associated with Vallers, Kittson, and Flom soils and are similar to Langhei soils. They are better drained than Vallers soils. They have a calcareous A horizon, whereas Kittson and Flom soils have a noncalcareous A horizon. They are better drained than Flom soils. They are more poorly drained and have a thicker, darker colored A horizon than Langhei soils.

Hamerly silt loam, 0 to 1 percent slopes (HeA).—This nearly level soil occupies very slightly convex areas that generally range from 5 to 40 acres in size. This soil commonly is associated with more rolling soils in numerous draws and depressions on uplands. In most areas the landscape is influenced by water action and the sorting of soil materials on the surface. The surface layer has a black color commonly mixed with patches of very dark gray. These patches are dark gray or gray when dry. Coarse fragments, mostly in the gravel size range, are scattered on the surface in some areas. The surface layer has a smooth appearance when cultivated. This soil has the profile described as representative for the series.

Included in mapping were areas of soils that have more than 24 inches of sorted materials over the underlying tills. These soils make up as much as 20 percent of any given area. Also included were areas of more poorly drained Vallers soils, less calcareous Kittson soils, and soils that have a dark-colored surface layer less than 7 inches thick. These inclusions make up as much as 15 percent of any given area.

Most areas of this Hamerly soil are cultivated. Small grains are the most common crop, but some row crops, such as corn, soybeans, and sunflowers, are also grown. Some areas are used for hay and pasture. These areas are usually seeded to a legume or grass-legume mixture. A few trees also grow on this soil.

Soil blowing on unprotected areas and the strongly calcareous condition are limitations on this soil. (Capability unit IIe-2; tree and shrub suitability group 2)

Hamerly silt loam, 1 to 5 percent slopes (HeB).—This soil occupies areas that normally range from 5 to 60 acres in size. This soil is associated with more rolling upland soils and numerous draws and depressions. In most areas the landscape is influenced by water action and the sorting of soil materials on the surface. The surface layer has a black color, and most areas have patches of very dark gray and very dark brown. These areas are dark gray or gray when dry. Coarse fragments, mostly

in the gravel size range, are scattered on the surface in some areas. The surface layer has a smooth appearance when cultivated.

Included in mapping were areas of soils that have more than 24 inches of sorted materials over the underlying till. Also included were soils that have a dark-colored surface layer less than 7 inches thick and areas of less calcareous Kittson soils. These inclusions make up as much as 15 percent of any given area. Also included were areas of more poorly drained Vallers soils and better drained Langhei soils that make up as much as 10 percent of any given area.

Most areas of this Hamerly soil are cultivated. Small grains are the most common crops, but corn, soybeans, sunflowers, and some other row crops also are grown. Some areas are used for hay and pasture. These areas commonly are seeded to a legume or grass-legume mixture. A few scattered trees also grow on this soil.

Water erosion limits the use of this soil. The strongly calcareous condition also is a limitation. (Capability unit IIe-2; tree and shrub suitability group 2)

Hamerly-Vallers silt loams (Hm).—These soils occupy a landscape that has complex, nearly level to gently undulating topography. The relief is ridges, knobs, swales, and depressions. Differences in elevation range from 1 foot to 4 feet or more. Slopes generally are short and range up to 4 percent. There is no well-defined pattern to the relief in this landscape, but the swales and depressions generally drain to the west. Hamerly soils occupy the ridges, knobs, or higher areas, while Vallers soils commonly are in the swales. Carbonates are nearest the surface on the higher areas and on the rims of depressions. In these areas tillage mixes part of the concentrated carbonates with the surface layer, commonly resulting in a grayer surface color. The lower areas generally have a thicker, darker colored surface layer. Pebbles and some cobblestones commonly are scattered on the surface of both the soils of this complex.

Hamerly soils make up 50 to 70 percent of this complex, and Vallers soils make up 30 to 50 percent.

Included in mapping were areas of less calcareous Kittson loam, uplands, and Flom soils. Also included were areas of sandier and less calcareous Swenoda soils and better drained Barnes and Langhei soils. These inclusions make up as much as 15 percent of any given area.

Most areas of these soils are cultivated. Small grains and grasses and legumes are the most common crops. A smaller acreage is used for soybeans, corn, and sunflowers. A few areas, especially the depressions, are idle and support a growth of cattails, sedges, and other wetland vegetation.

Wetness limits the use of the these soils. The relief pattern makes these areas more difficult to drain. The strongly calcareous condition and the occurrence of coarse fragments also influence use and management. (Capability unit IIw-2; tree and shrub suitability group 4)

Hangaard Series

The Hangaard series consists of nearly level, poorly drained and somewhat poorly drained soils. These soils formed in deep gravelly and sandy deposits commonly associated with beach ridges. The topography varies from slightly concave to slightly convex slopes. These soils formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is about 16 inches thick. The upper 12 inches is black sandy loam, and the lower 4 inches is very dark brown loamy sand. The subsoil is distinctly mottled, very dark grayish-brown sand about 3 inches thick. The underlying material is mottled, calcareous and strongly calcareous, grayish-brown, light brownish-gray, and light olive-gray gravelly sand and gravelly coarse sand.

Hangaard soils have low available water capacity. Permeability is rapid. Inherent fertility is medium. The seasonal water table fluctuates between depths of 1 foot and 6 feet. Some areas of these soils are cultivated. With proper management they are suited to small grains or to corn, soybeans, and some other row crops. They are suited to grasses used for hay and pasture.

Representative profile of Hangaard sandy loam, in a pasture 450 feet north of fence on county line and 0.1 mile east of the southwest corner of sec. 34, T. 143 N., R. 45 W.

A1—0 to 12 inches, black (N 2/0) sandy loam high in content of organic matter; weak, very fine, granular structure; very friable; few bleached sand grains; neutral; gradual, smooth boundary.

A3—12 to 16 inches, very dark brown (10YR 2/2) loamy sand; common very dark grayish-brown (10YR 3/2) inclusions; weak, very fine, granular structure; very friable; neutral; gradual, smooth boundary.

IIB2—16 to 19 inches, very dark grayish-brown (10YR 3/2) sand; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; mildly alkaline; weakly calcareous; clear, smooth boundary.

IIC1g—19 to 27 inches, grayish-brown (2.5Y 5/2) gravelly coarse sand; few, medium, faint, light brownish-gray (2.5Y 6/2) mottles and common, medium, prominent, yellowish-brown (10YR 5/8) and brownish-yellow (10YR 6/8) mottles; single grain; loose; mildly alkaline; calcareous; clear, smooth boundary.

IIC2g—27 to 31 inches, light brownish-gray (2.5Y 6/2) gravelly sand; few, large, prominent, dark reddish-brown (5YR 3/4) and reddish-brown (5YR 4/4) mottles and many, medium, prominent, yellowish-brown (10YR 5/8) and brownish-yellow (10YR 6/8) mottles; single grain; loose; moderately alkaline; calcareous; clear, smooth boundary.

IIC3g—31 to 39 inches, light olive-gray (5Y 6/2) gravelly coarse sand; common, medium, faint, light-gray (2.5Y 7/2) mottles; single grain; loose; moderately alkaline; calcareous; clear, smooth boundary.

IIC4g—39 to 60 inches, light olive-gray (5Y 6/2) gravelly coarse sand; few, medium, prominent, olive-yellow (2.5Y 6/6) mottles; single grain; loose; moderately alkaline; strongly calcareous.

The thickness of the solum ranges from 10 to 20 inches. The texture of the A horizon generally is sandy loam or loamy fine sand, but in places it is loamy sand, fine sandy loam, or loam. The A3 horizon is very dark gray or very dark brown. The B horizon, 2 to 8 inches thick, is dark grayish brown, very dark grayish brown, dark gray, or very dark gray and has distinct or prominent mottles. Texture of the A3 and B horizons is gravelly sand, sand, loamy sand, or coarse sandy loam.

The colors in the IIC horizon range from grayish brown to light olive gray. Mottles are distinct or prominent in the upper part of the IIC horizon and faint to prominent in the lower part.

The A and B horizons are neutral or mildly alkaline, and the depth to free carbonates is more than 10 inches. Below the A horizon reaction ranges from mildly alkaline to moderately alkaline and the profile is calcareous to strongly calcareous.

Hangaard soils are associated with Sioux and Syrene soils and are similar to Hamar soils. They are wetter than Sioux soils. They lack the Cca horizon that is characteristic of Syrene soils, and they have a noncalcareous A horizon. They contain more gravel and more medium and coarse sand than Hamar soils.

Hangaard sandy loam (Hn).—This nearly level soil occupies slightly concave or slightly convex areas that generally range from 4 to 20 acres in size. Slopes range from 0 to less than 2 percent. This soil commonly occupies scattered, elongated or irregularly shaped areas. In some areas cobblestones and stones are scattered on the surface.

Included in mapping were areas of some calcareous Syrene soils, Hamar soils that contain less gravelly material, Arveson soils that are less gravelly and more calcareous, Mavie soils that are more calcareous and have finer textured underlying material, or better drained Sioux soils. These inclusions make up as much as 15 percent of any given area.

Some areas are cultivated and are used mainly for small grains. Many areas are used for hay and pasture. Quackgrass, bluegrass, redtop, and other introduced grasses commonly grow on these areas. Scattered trees, principally quaking aspen and some willow brush, also grow on this soil.

Wetness limits the use of this soil. The low available water capacity and medium inherent fertility also influence use and management. (Capability unit IVw-1; tree and shrub suitability group 3)

Hegne Series

The Hegne series consists of nearly level, poorly drained soils that formed in calcareous lacustrine clay. These soils occupy ridges and knobs in areas of microrelief. The Hegne series is mapped in complexes with Fargo and Viking soils in swales and depressions. They formed under prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is black silty clay that is strongly calcareous and 8 inches thick. The next layer is gray silty clay about 10 inches thick that is very strongly calcareous. Below this is olive-gray, calcareous clay and silty clay.

Hegne soils have medium available water capacity. Permeability is slow. Inherent fertility is medium to high. The shrink-swell potential is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Nearly all areas of Hegne soils are cultivated. They are suited to all crops commonly grown in the county.

Representative profile of Hegne silty clay from an area of Hegne-Fargo silty clays in a cultivated field 285 feet south and 195 feet west of the northeast corner of sec. 23, T. 146 N., R. 47 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) when dry; weak, very fine, subangular blocky structure; sticky; many roots; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

C1cag—8 to 10 inches, gray (2.5Y 6/1) silty clay; weak, very fine, subangular blocky structure; slightly sticky; many roots; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C2cag—10 to 19 inches, gray (5Y 5/1) silty clay; weak, very fine, subangular blocky structure; sticky; few roots; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C3g—19 to 29 inches. olive-gray (5Y 5/2) silty clay; common, fine, faint, light olive-gray and gray (5Y 6/2) and 6/1) mottles and few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; sticky; moderately alkaline; calcareous; gradual, smooth boundary.

C4g—29 to 34 inches, olive-gray (5Y 5/2) clay; common, medium, faint, light olive-gray and gray (5Y 6/2 and 6/1) mottles and common, medium, prominent. yellowish-brown (10YR 5/8) and dark reddish-brown (5YR 3/4) mottles and concretions; weak, very fine, subangular blocky structure; sticky; moderately alkaline; calcareous; gradual, smooth boundary.

C5g—34 to 42 inches, olive-gray (5Y 5/2) silty clay; common, fine, faint, gray (5Y 6/1) mottles and common, medium, prominent, yellowish-brown (10YR 5/8) and dark reddish-brown (5YR 3/4) mottles and concretions; weak, very fine, angular blocky structure; sticky; moderately alkaline; calcareous; gradual, smooth boundary.

C6g—42 to 60 inches, olive-gray (5Y 5/2) laminated clay and silty clay; common, medium, faint, gray (5Y 6/1) mottles and many large, prominent, yellowish-brown (10YR 5/8) and dark reddish-brown (5YR 3/4) mottles and concretions; weak, very fine, angular blocky structure; slightly sticky to sticky; moderately alkaline; calcareous.

Hegne soils that are in complex with Fargo soils have an A horizon that is black or very dark gray in color. The texture ranges from silty clay loam to silty clay and, in a few profiles, clay. The A horizon ranges from 7 to 12 inches in thickness. In some profiles narrow tongues of the A horizon extend to depths of as much as 30 inches. Structure in the A horizon is weak to moderate, very fine and fine, granular or subangular blocky. There is an Aca horizon in some profiles. The Cca horizon is dark gray, gray, olive gray, and, in a few profiles, grayish brown and light brownish gray. The Cca horizon has an accumulation of carbonates, is strongly calcareous to very strongly calcareous, and ranges from 8 to 20 inches in thickness. The C horizon below the Cca horizon is grayish brown to olive gray in color. It ranges from mildly alkaline to moderately alkaline in reaction. Platy structure, which reflects depositional layers, and a range in texture from silty clay loam to clay occur at a depth below 36 inches in some profiles (fig. 11).

The Hegne soils mapped in the Hegne-Viking complex have stones, cobblestones, and gravel scattered on the surface and in the profile. They also have profiles that are more than 60 percent clay in the solum and C horizon and lack platy structure in the C horizon. The A horizon is variable in texture, ranging from clay loam or silty clay loam to clay. Other properties of these Hegne soils are similar to those described in the foregoing paragraph. These Hegne soils are outside the defined range of the series because of these features, but this does not alter the usefulness and behavior of these soils.

Hegne soils are associated with Fargo and Viking soils and are similar to Colvin soils. They are more strongly calcareous in the A horizon and upper part of the C horizon than Fargo and Viking soils. Hegne soils contain more clay and less silt in the solum and upper part of the C horizon than Colvin soils.

Hegne-Fargo silty clays (Ho).—The soils in this complex occupy a landscape that has microrelief covering large areas, commonly more than 500 acres in size. This microrelief has alternate ridges and draws and some higher knobs and deeper pockets. Differences in elevation range from 6 to 18 inches. The short slopes of this complex range up to 2 percent. The ridges and draws are oriented in a northwesterly direction. The draws are elongated and generally are joined. Hegne silty clay occupies the ridges and knobs. The concentration of carbonates is so near the surface in Hegne soils, that in many places tillage mixes part of the very strongly cal-

Figure 11.—**Profile of Hegne-Fargo silty clays. The Hegne soil at the left grades to the darker Fargo soil, which shows tonguing.**

careous layer with the original surface layer. This occurs most often on the highest parts of the ridges and knobs, where a grayer surface color is common. This grayness is most evident when the surface is dry. Fargo soils occupy the draws and pockets and have a deeper and, commonly, a darker colored, less calcareous surface layer (fig. 12).

Hegne silty clay commonly makes up 55 to 75 percent of this complex, and Fargo silty clay, 25 to 45 percent. The soils in this complex have the profiles described as representative for their respective series.

Included in mapping were areas of Hegne-Viking complex with a higher clay content and more coarse fragments and areas of Bearden and Colvin soils that are more silty than Hegne and Fargo soils. These inclusions make up as much as 15 percent of any given area.

Nearly all of this complex is cultivated. Small grains, sugar beets, and sunflowers are the most common crops. Grasses and legumes are included in the rotation as green-manure crops. A few areas are harvested for hay or pasture before being plowed and used for cultivated crops.

Wetness limits the use of these soils. The microrelief makes drainage more difficult. Structural damage and compaction result if soils of this complex are cultivated when wet. Soil blowing is a hazard if cultivated areas are smooth and have no protective cover. (Capability unit IIw-2; tree and shrub suitability group 4)

Hegne-Viking complex (Hv).—The soils in this complex occupy a landscape characterized by microrelief of alternate ridges and draws and some higher knobs and deeper pockets. Differences in elevation range from 8 to 30 inches. The short slopes range up to 3 percent. The draws are elongated and generally are joined. The relief pattern is generally oriented in a northwesterly direction. Hegne silty clay occupies the ridges and knobs, where the concentration of carbonates is so near the surface that tillage often mixes a part of this very strongly calcareous layer with the original surface layer. This is most common near the center of the ridges and knobs where the surface is grayer. This condition is most evident when the surface is dry. Pebbles, cobblestones, and stones are also scattered on the surface of these knobs and ridges. Viking silty clay is in the draws and pockets and has a darker, less calcareous surface layer and fewer coarse fragments scattered on the surface (fig. 13).

Hegne silty clay commonly makes up 55 to 75 percent of this complex, and Viking silty clay makes up 25 to 45 percent. The soils in this complex have profiles similar to those described as representative for their series, except that the Hegne silty clay has coarse fragments scattered on the surface and throughout the profile. Some Hegne soils in this complex also are more than 55 percent clay. The Viking soils commonly have fewer coarse fragments and a finer textured surface layer than is typical for the series.

Included in mapping were areas of Hegne-Fargo silty clays that contain fewer coarse fragments and a lower percentage of clay. Also included were areas of the more silty Bearden and Colvin soils. These inclusions make up as much as 15 percent of any given area.

Nearly all of this complex is cultivated. Small grains are the most common crop. Some row crops, such as sunflowers and sugar beets, also are grown. Grasses and legumes are grown in the rotation as green-manure crops. A few areas are harvested for hay or pasture before being plowed and used for cultivated crops. There also are a few wooded areas.

Wetness is a limitation to use of these soils. The strong microrelief makes these areas more difficult to drain. Structural damage and compaction result if soils of this complex are cultivated when wet. Soil blowing is a hazard if cultivated areas are smooth and have no protective cover. Stones and cobblestones sometimes interfere with the operation of farm machines. (Capability unit IIIw–3; tree and shrub suitability group 4)

Kittson Series

The Kittson series consists of somewhat poorly drained to moderately well drained, medium-textured soils that formed in water-worked loam and clay loam till. These nearly level to sloping soils are on uplands and interbeach landscapes. Slopes are slightly convex and up to 8 percent. These soils formed under tall prairie grasses.

In a representative profile, the surface layer is black loam that is neutral and 10 inches thick. The subsoil is weakly calcareous, faintly mottled, dark grayish-brown loam about 6 inches thick. The underlying material is

Figure 12.—**A typical landscape of Hegne-Fargo silty clays. The grayer Hegne soils are on the ridges and knobs, and the darker colored Fargo soils are in narrow draws and pockets.**

calcareous, mottled, grayish-brown and light brownish-gray loam.

Kittson soils have high available water capacity. Permeability is moderate. Inherent fertility is high. The seasonal water table fluctuates between depths of 2½ feet and more than 6 feet. Most areas are cultivated. The soils are suited to small grains and to corn, soybeans, sunflowers, and other row crops.

Representative profile of Kittson loam, uplands, 0 to 1 percent slopes, in a cultivated field 2,590 feet south and 640 feet west of the northeast corner of sec. 30, T. 146 N., R. 43 W.

A1—0 to 10 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B2—10 to 16 inches, dark grayish-brown (2.5Y 4/3) loam; few, fine, faint, light olive-brown (2.5Y 5/4) mottles; weak, very fine, subangular blocky structure; friable; mildly alkaline; weakly calcareous; clear, smooth boundary.

C1—16 to 29 inches, grayish-brown (2.5Y 5/3) loam; common, fine, distinct, olive-yellow (2.5Y 6/6) mottles; weak, very fine, subangular blocky structure; very friable; few inclusions of coarse sandy loam that is about 5 percent gravel in the lower part; moderately alkaline; calcareous; gradual, smooth boundary.

C2—29 to 38 inches, light brownish-gray (2.5Y 6/2) loam; common, medium, distinct, olive-yellow (2.5Y 6/6) and yellowish-brown (10YR 5/7) mottles; weak, fine and medium, platy structure parting to weak, very fine, subangular blocky; very friable; about 5 percent coarse fragments; few, large, light-gray (2.5Y 7/2) and white (2.5Y 8/2) masses of lime; moderately alkaline; calcareous; gradual, smooth boundary.

C3—38 to 60 inches, light brownish-gray (2.5Y 6/2) loam; many, medium and large, prominent, light olive-brown (2.5Y 5/6) and yellowish-brown (10YR 5/6 mottles; weak, fine, angular blocky structure parting to weak, very fine, subangular blocky; very friable; few, fine, light-gray (2.5Y 7/2) masses of lime; about 5 percent coarse fragments; moderately alkaline; calcareous.

The thickness of the solum ranges from 14 to 25 inches. The A horizon colors are black or very dark gray. The texture of the A horizon generally is loam, but in places it is fine sandy loam, silt loam, or clay loam. It has weak to moderate and fine to medium granular structure or very fine to fine subangular blocky structure. The thickness of the A horizon ranges from 8 to 16 inches.

Some profiles have a B1 horizon with very dark grayish-brown colors. The B2 horizon has colors of dark grayish brown, grayish brown, dark brown, or brown. The B2 horizon also generally is loam, but in places it is silt loam or clay loam.

The colors in the C horizon range from dark grayish brown to light olive brown. Mottles range from few, faint to many, prominent. The C horizon generally is loam, but in places it is clay loam or fine sandy loam. Reaction ranges from mildly alkaline to moderately alkaline. A sandy loam or

Figure 13.—**Pebbles and cobblestones scattered over a typical landscape of Hegne-Viking complex. The light-gray fringe on the lower areas marks the outer limits of ponding.**

coarser textured B3 or C1 horizon is in some profiles, primarily in Kittson soils on the lake plain.

Kittson soils are associated with Hamerly, Roliss, Flom, Vallers, and Barnes soils. They are similar to Foxhome soils. Kittson soils are better drained than Roliss, Flom, and Vallers soils. They are more poorly drained than well-drained Barnes soils. They lack the calcareous A horizon that is characteristic of Hamerly and Vallers soils. They lack the thick, coarse-textured IIB3 or IIC1 horizon of Foxhome soils.

Kittson loam, 0 to 2 percent slopes (KsA).—This soil occupies slightly convex areas that generally range from 5 to 25 acres in size. It is on a lake plain associated with interbeach areas where water-sorted till material is mixed with varied soil materials that commonly are coarser textured. Coarse fragments are mixed in the profile, and in most areas a few are scattered on the surface. These are commonly in the gravel size range, but some scattered stones and boulders also occur.

Included in mapping were areas of soils that have less than 10 inches of surface layer and a dark-colored subsoil. These soils make up as much as 20 percent of any given area. Also included were areas of more poorly drained Roliss soils, more calcareous Hamerly soils, or coarser textured Foxhome and Swenoda soils. These inclusions make up as much as 15 percent of any given area. Also included were areas of soils that are more than 35 percent clay in the subsoil and underlying material. These soils are most common in a till ridge extending from south to north near the center of Rockwell Township.

Most areas are cultivated. Small grains are the most common crop, but corn, soybeans, sunflowers, and other row crops also are grown. Some areas are used for hay and pasture. Introduced grasses, such as quackgrass, Kentucky bluegrass, and redtop, are commonly used. A few areas are seeded to a legume or grass-legume mixture. A few scattered trees also grow on this soil.

Climate limits the selection of crops that can be grown economically. (Capability unit IIc–1; tree and shrub suitability group 1)

Kittson loam, 2 to 8 percent slopes (KsC).—This soil occupies the higher ridgelike positions or slopes along natural drainageways. Areas generally range from 3 to 15 acres in size. The landscape is lake plain associated with interbeach areas where water-sorted till is mixed with varied soil materials that commonly are coarser textured. Coarse fragments are mixed in the soil, and in most areas a few are scattered on the surface. These are commonly in the gravel size range, but some scattered stones and boulders also occur.

Included in mapping were areas of soils that have a surface layer less than 10 inches thick and a dark-colored subsoil. Also included were areas of soils that are more than 35 percent clay in the subsoil and underlying material. These are most common in a till ridge extending from south to north near the center of Rockwell Township. Also included were areas of more calcareous Hamerly soils or coarser textured Foxhome and Swenoda soils that make up as much as 15 percent of any given area.

Many areas are cultivated. Small grains are the most common crop. Some areas are used for hay and pasture. Introduced grasses, such as quackgrass, Kentucky bluegrass, and redtop, are commonly used. A few of these areas are seeded to a legume or grass-legume mixture. Scattered trees also grow on this soil.

Water erosion limits the use of this soil. (Capability unit IIe–1; tree and shrub suitability group 1)

Kittson loam, uplands, 0 to 1 percent slopes (KtA).—This soil occupies very slightly convex areas on uplands. These areas normally range from 5 to 50 acres in size. In most areas the landscape is influenced by water action, and there is some sorting of soil materials on the surface. Some coarse fragments commonly are mixed in and scattered on the surface layer. Most of these are in the gravel size range, but a few are cobblestones and stones. This soil has the profile described as representative for the series.

Included in mapping were soils that have a surface layer less than 10 inches thick and a dark-colored subsoil. These soils make up as much as 20 percent of any given area. Also included were soils that contain more than 5 percent coarse fragments in the surface layer and upper part of the subsoil and areas of more calcareous Hamerly soils. These inclusions make up as much as 15 percent of any given area. Also included were areas of better drained Barnes soils or coarser textured Swenoda soils that make up as much as 10 percent of a given area.

Most of this soil is cultivated. Small grains are the most common crop, but corn, soybeans, sunflowers, and some other row crops also are grown. Some areas are used for hay and pasture; others are used for quackgrass and Kentucky bluegrass. Many areas are seeded to a grass-legume mixture. Some scattered trees also grow on this soil.

Climate limits the selection of crops that can be grown economically. (Capability unit IIc–1; tree and shrub suitability group 1)

Kittson loam, uplands, 1 to 5 percent slopes (KtB).—This soil occupies convex areas on uplands. These areas normally range from 5 to 40 acres in size. In most areas the landscape is influenced by water action, and there is some sorting of soil materials on the surface. The surface layer has a black color that has blotches of very dark gray in some areas. Coarse fragments commonly are mixed in the surface layer and some are on the surface. Most of these are in the gravel size range, but a few are stones and cobblestones.

Included in mapping were areas of soils that have a surface layer less than 10 inches thick and a dark-colored subsoil. These soils make up as much as 20 percent of any given area. Also included were areas of soils that contain more than 5 percent coarse fragments in the upper layer, areas of more calcareous Hamerly soils, and areas of better drained Barnes soils or coarser textured Swenoda soils. These inclusions make up as much as 15 percent of any given area.

Most areas are cultivated. Small grains are the most common crop, but corn, soybeans, sunflowers, and some other row crops also are grown. Some areas, used for hay and pasture, generally are seeded to a legume or grass-legume mixture. A few scattered trees also grow on this soil.

Water erosion limits the use of this soil. (Capability unit IIe–1; tree and shrub suitability group 1)

Kratka Series

The Kratka series consists of nearly level or depressed, poorly drained soils that formed in sandy deposits over loamy material. These soils are on a glacial lake plain commonly adjacent to areas of higher, better drained soils. They formed under prairie grasses and wetland reeds and sedges. The Kratka soils are mapped as a complex with Rockwell soils.

In a representative profile, the surface layer is black loamy fine sand and very dark gray loamy sand about 14 inches thick. The subsoil is mottled, dark-gray fine sand about 4 inches thick. The underlying material is dark-gray and gray fine sand. Below a depth of 38 inches is gray, calcareous loam.

Kratka soils have medium available water capacity. Permeability is moderately rapid in the sandy layers and moderately slow in the contrasting loamy material. Inherent fertility is medium to low. The seasonal water table fluctuates between depths of 0 and 5 feet. Most areas of these soils are idle and support sedges, cattails, and brush. If drained, these soils are suited to grasses for hay or pasture.

Representative profile of Kratka loamy fine sand, from an area of Rockwell and Kratka soils, depressional, 2,200 feet south and 80 feet east of the northwest corner of sec. 12, T. 145 N., R. 44 W.

A1—0 to 10 inches, black (N 2/0) loamy fine sand; weak, very fine, granular structure; very friable; many roots; some clean bleached sand grains; neutral; clear, smooth boundary.

A3—10 to 14 inches, very dark gray (10YR 3/1) loamy sand grading to fine sand in lower part; fine, granular structure grading to massive; very friable; common roots; few clean sand grains; neutral; clear, smooth boundary.

B2g—14 to 18 inches. dark-gray (2.5Y 4/1) fine sand; few, fine, distinct, light olive-brown (2.5Y 5/4) mottles; massive parting to single grain; very friable; few roots; neutral; gradual, smooth boundary.

C1g—18 to 33 inches, gray (2.5Y 5/1) fine sand; common, fine, distinct, light olive-brown (2.5Y 5/4) and olive-yellow (2.5 6/6) mottles; single grain; loose; neutral; gradual, smooth boundary.

C2g—33 to 38 inches, gray (2.5Y 5/1) fine sand; many, medium and large, prominent yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/8) mottles; single grain; loose; neutral grading to mildly alkaline; calcareous in lower part; clear, smooth boundary.

IIC3g—38 to 60 inches, gray (5Y 5/1) loam; common, medium, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles; massive; about 5 percent coarse fragments; slightly sticky; moderately alkaline; calcareous.

The depth to the IIC3g horizon ranges from 20 to 40 inches. The depth to free carbonates ranges from 15 to 40 inches. The texture of the A horizon generally is loamy fine sand, but in places it is loamy sand, sandy loam, or fine

sandy loam. The thickness of the A horizon ranges from 7 to 18 inches.

The colors in the B2g horizon are dark gray or dark grayish brown. This horizon has distinct or prominent mottles. The B horizon generally is loamy fine sand or fine sand, but in places it is loamy sand or sand.

The C1g horizon and the C2g horizon are gray, light gray, grayish brown, light brownish gray, olive gray, light olive gray, olive, or pale olive. Mottles commonly are distinct or prominent. These horizons generally are fine sand, but in places they are loamy sand or sand. The colors in the IIC3g horizon are gray, light gray, grayish brown, light brownish gray, olive gray, and light olive gray. Mottles commonly are distinct or prominent. The IIC3g horizon generally is loam or clay loam, but in places it is silty clay loam or silt loam.

Kratka soils are associated with Rockwell, Hamar, and Arveson soils and are similar to Towner soils. They have a noncalcareous A1 horizon, whereas Rockwell and Arveson soils have a calcareous A1 horizon. They have a loamy IIC horizon that is lacking in Arveson and Hamar soils. They are more poorly drained than Towner soils.

Langhei Series

The Langhei series consists of gently undulating to very steep, somewhat excessively drained soils on uplands. These soils formed in loam glacial till. They are on a complex landscape characterized by short, uneven slopes, pocket depressions, and natural drainageways and draws. They formed under prairie grasses. This vegetative cover was commonly sparse, influenced by rapid runoff and droughtiness. The Langhei soils are mapped as a complex with the Barnes soils (fig. 14).

In a representative profile, the surface layer is grayish-brown, strongly calcareous loam about 7 inches thick. The next layer is pale-brown and brown, very strongly calcareous loam 21 inches thick. Below this is light olive-brown, strongly calcareous loam.

Langhei soils have high available water capacity. Permeability is moderate. Inherent fertility is medium. The depth to the seasonal water table is more than 6 feet. Nearly all areas of rolling and hilly Langhei soils have been or are now cultivated. They are suited to small grains and a rotation of pasture or hay. The steeper soils are suited to permanent grasses and trees.

Representative profile of Langhei loam, from an area of Langhei-Barnes loams, 12 to 18 percent slopes, eroded, in a cultivated field 1,340 feet south and 1,400 feet east of the northwest corner of sec. 28, T. 146 N., R. 43 W.

Ap—0 to 7 inches, grayish-brown (10YR 5/2) loam; weak, very fine, subangular blocky structure; very friable; about 2 percent coarse fragments; many roots; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

C1ca—7 to 11 inches, pale-brown (10YR 6/3) loam; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few reddish-brown stains along root channels; few roots; moderately al-

Figure 14.—A typical landscape of Langhei-Barnes loams, 12 to 18 percent slopes, eroded. The light-colored Langhei soils occupy the knobs and the slopes along the natural draw. Barnes soils are in the foreground.

kaline; very strongly calcareous; gradual, smooth boundary.

C2ca—11 to 28 inches, brown (10YR 5/3) loam; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; few roots in upper part; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C3—28 to 50 inches, light olive-brown (2.5Y 5/4) loam; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; many light brownish-gray (10YR 6/2) and pale-brown (10YR 6/3) lime threads; few, dark-brown (7.5YR 4/4), soft masses; moderately alkaline; strongly calcareous.

The colors in the Ap horizon are dark gray. gray, grayish brown, or dark grayish brown. The texture of the Ap horizon typically is loam, but in places it is fine sandy loam or clay loam. In undisturbed areas there is a 2- to 4-inch thick A1 horizon with colors of black, very dark gray, very dark grayish brown, and very dark brown. Reaction in the A horizon ranges from mildly alkaline to moderately alkaline. This horizon is calcareous to strongly calcareous, and the Ap horizon is generally strongly calcareous because the A horizon has been mixed with some of the C horizon material..

The C horizon ranges from dark grayish brown to olive brown or light yellowish brown in color. Mottles are in the C3 horizon in some profiles. The calcium carbonate equivalent ranges from 15 to 35 percent in the C horizon, and there are no significant layers of accumulation. The lower part of the C horizon of some profiles is mildly alkaline. Langhei soils commonly contain from 2 to 10 percent gravel and cobblestones that are scattered on the surface and throughout the profile.

Langhei soils are associated with Barnes, Waukon, and Darnen soils and are similar to Hamerly soils. Langhei soils have a lighter colored Ap horizon than the other soils. They lack the B horizon that is characteristic of Barnes, Waukon, and Darnen soils. They are somewhat excessively drained, whereas Hamerly soils are moderately well drained.

Langhei-Barnes loams, 6 to 12 percent slopes, eroded (LbC2).—The rolling soils in this complex occupy areas that commonly range from 5 to 50 acres in size. The landscape is characterized by short, uneven slopes and abrupt changes in drainage. The Langhei soils occupy circular and oblong, grayish-brown, convex knobs that are surrounded by slightly lower, darker colored areas of Barnes and associated soils. Langhei soils make up 40 to 65 percent of this complex and Barnes soils make up 20 to 45 percent.

Included in mapping were areas of Darnen soils that have a thicker surface layer, sandier Sverdrup and Swenoda soils, and Waukon soils that have more development in the subsoil. These inclusions make up as much as 15 percent of any given area. Soils that have a surface layer that is calcareous but darker colored than that of Langhei soils also were included.

Nearly all of this complex is cultivated. Small grains and grasses and legumes grown in a rotation for hay or pasture are the most common crops. Some areas are in permanent hay and pasture.

Water erosion has removed topsoil from the knobs and ridges. This is especially evident on the lighter colored Langhei soils. Water removes additional topsoil if areas of this complex are unprotected. Rills and gullies form where runoff is rapid. (Capbility unit IIIe–1; tree and shrub suitability group 2)

Langhei-Barnes loams, 12 to 18 percent slopes, eroded (LbD2).—The soils in this complex occupy hilly areas that commonly range from 5 to 40 acres in size. The landscape is characterized by short, uneven slopes and abrupt changes in drainage. Langhei soils occupy circular and oblong, grayish-brown, convex knobs surrounding darker colored areas of Barnes and associated soils. Langhei soils make up 40 to 65 percent of this complex, and Barnes soils make up 20 to 45 percent. The Langhei soil in this complex has the profile described as representative for the series.

Included in mapping were areas of Darnen soils that have a thicker surface layer, sandier Sverdrup and Swenoda soils, and Waukon soils that have more development in the subsoil. These inclusions make up as much as 15 percent of any given area. Areas that have a surface layer that is calcareous but darker colored than Langhei soils also were included.

Nearly all of this complex has been cultivated. Many areas are in permanent hay and pasture. If cultivated, these areas are used for small grains in rotation with grasses and legumes.

Water erosion has removed topsoil from the knobs and ridges. This is especially evident on the lighter colored Langhei soils. Water removes additional topsoil if areas of this complex are unprotected. Rills and gullies form where runoff is rapid. (Capability unit IVe–1; tree and shrub suitability group 2)

Langhei-Barnes loams, 18 to 30 percent slopes (LbE).—The soils in this complex are steep and very steep and occupy areas that commonly range from 5 to 25 acres in size. The landscape is characterized by short, uneven slopes. Many areas of these soils parallel well-entrenched natural drainageways. The variations in surface color and thickness seldom are visible because areas of this complex almost always have some vegetative cover. Langhei soils make up 40 to 65 percent of this complex, and Barnes soils make up 20 to 45 percent.

Included in mapping were areas of Darnen soils that have a thicker surface layer, coarse-textured areas of sandy and gravelly Maddock and Sioux soils, and Waukon soils that have more development in the subsoil. These inclusions make up as much as 15 percent of any given area.

Nearly all of this complex is used for permanent hay and pasture or is wooded. Oak and elm are the most common trees.

Water erosion removes topsoil from unprotected areas of the steep and very steep soils of this complex. Rills and gullies form where runoff is rapid. (Capability unit VIe–1; tree and shrub suitability group 2)

Maddock Series

The Maddock series consists of nearly level to sloping, well-drained soils that formed in deposits of sandy outwash. Slopes are convex and range up to 8 percent. These soils are associated with an upland or interbeach landscape where soil materials change within short distances and relief is varied. They formed under tall prairie grasses.

In a representative profile, the surface layer is black loamy fine sand about 11 inches thick. The subsoil is 8 inches of dark-brown loamy sand. The underlying material is yellowish-brown and dark yellowish-brown fine sand that grades to pale-brown and light yellowish-brown fine sand at a depth below 40 inches.

Maddock soils have low available water capacity. Permeability is rapid. Inherent fertility is medium to

low. The seasonal water table is at a depth below 6 feet. Some areas of Maddock soils are cultivated. If properly managed, they are suited to small grains, grasses and legumes grown for hay and pasture, and such row crops as corn and soybeans.

Representative profile of Maddock loamy fine sand, 0 to 2 percent slopes, in a cultivated field 2,180 feet east and 1,460 feet north of the southwest corner of sec. 28, T. 144 N., R. 43 W.

Ap—0 to 7 inches, black (10YR 2/1) loamy fine sand; weak, very fine, granular structure; very friable; abundant roots; common bleached sand grains; neutral; abrupt, smooth boundary.

A1—7 to 11 inches, black (10YR 2/1) loamy fine sand; weak, very fine, granular structure; very friable; abundant roots; few bleached sand grains; neutral; gradual, smooth boundary.

B2—11 to 19 inches, dark-brown (10YR 3/3) loamy sand; weak, very fine, granular structure; very friable; few roots; few bleached sand grains; neutral; gradual, smooth boundary.

C1—19 to 27 inches, yellowish-brown (10YR 5/4) fine sand; single grain; loose; neutral; gradual, smooth boundary.

C2—27 to 40 inches, dark yellowish-brown (10YR 4/4) fine sand; few, fine, faint, yellowish-brown (10YR 5/6) mottles; single grain; loose; about 5 percent gravel; neutral grading to mildly alkaline; weakly calcareous in the lower part; gradual, smooth boundary.

C3—40 to 60 inches, pale-brown (10YR 6/3) and light yellowish-brown (10YR 6/4) fine sand; single grain; loose; mildly alkaline; weakly calcareous.

The depth to carbonates ranges from 24 to 40 inches. The colors in A horizon are black and very dark gray. The texture of the A horizon generally is loamy fine sand, but in places it is fine sandy loam, sandy loam, or loamy sand. The thickness of the A horizon ranges from 10 to 16 inches.

The colors in the B horizon are very dark grayish brown or dark brown and very dark brown. The B horizon generally is loamy sand or loamy fine sand, but in places it is sand or fine sand.

The colors in the C horizon range from dark brown to light yellowish brown. The C horizon generally is fine sand, but in places it is loamy sand, loamy fine sand, or sand.

Maddock soils are associated with Sverdrup and Sioux soils. They contain more sand and less silt and clay in the A and B horizons than Sverdrup soils. They contain more fine sand and less gravel in the A and C horizons than Sioux soils.

Maddock loamy fine sand, 0 to 2 percent slopes (MaA).—This soil occupies slightly convex areas that generally range from 3 to 20 acres in size. This soil commonly is mixed or associated with more sloping till soils and gently sloping sandy soils. Most areas of this nearly level Maddock soil are in pockets of sandy outwash scattered over a rather steep, complex upland landscape. A few areas occupy sand ridges associated with beaches of glacial Lake Agassiz. The surface layer of this soil has a smooth appearance if cultivated. Clean, bleached sand grains in the surface layer modify the color of some areas. This soil has the profile described as representative for the series.

Included in mapping were areas of soils that have a dark-colored surface layer less than 10 inches thick. These soils make up as much as 20 percent of any given area. Also included were areas of Sverdrup soils that have a finer textured surface layer and subsoil and areas of Swenoda soils that have finer textured underlying material. These inclusions make up as much as 15 percent of any given area. Also included were areas of more gravelly Sioux soils that make up as much as 10 percent of any given area.

Some areas are cultivated. Small grains are the most common crops, but corn, soybeans, and some other row crops also are grown. Most areas are used for hay and pasture. Some areas are seeded to a legume or grass-legume mixture. A few scattered trees grow on this soil.

A low available water holding capacity and low to medium inherent fertility are limitations on this soil. Soil blowing also is a hazard. (Capability unit IVs–1; tree and shrub suitability group 5)

Maddock loamy fine sand, 2 to 8 percent slopes (MaC).—This soil mostly occupies pockets of sandy outwash scattered in a rather steep, complex, upland landscape. Areas generally range from 3 to 20 acres in size. These soils commonly are mixed or associated with more sloping till soils and nearly level to steep, coarse-textured soils. The surface layer of this soil has a smooth appearance if cultivated. Clean bleached sand grains modify the color of some areas.

Included in mapping were areas of soils that have a dark-colored surface layer less than 10 inches thick. These soils make up as much as 25 percent of any given area. Also included were areas of Sverdrup soils that have a finer textured surface layer and subsoil, areas of Swenoda soils that have finer textured underlying material, and areas of more gravelly Sioux soils. These inclusions make up as much as 15 percent of any given area.

Some areas are cultivated. Small grains are the most common crops, but corn, soybeans, and some other row crops also are grown. A more common use is for hay and pasture. Many areas are seeded to a legume or grass-legume mixture. A few scattered trees grow on this soil.

A low available water capacity and low to medium inherent fertility limit the use of this soil. Soil blowing and water erosion also are hazards. (Capability unit IVs–1; tree and shrub suitability group 5)

Markey Series

The Markey series consists of highly decomposed, organic soil materials about 16 to 50 inches thick over sandy mineral material. These soils formed in depressions, low seep areas, or bottoms of stream channels and lesser natural drainageways. Most of these soils are associated with beach ridges or areas of outwash in a rather complex landscape. They formed under cattails, reeds, and sedges. During the time the organic material accumulated, conditions were too wet for complete decomposition.

In a representative profile, the surface layer consists of black muck about 22 inches thick. The underlying material is gray fine sand and mottled, grayish-brown sand.

Markey soils have high available water capacity. Permeability is moderately rapid in the muck and rapid in the underlying material. Inherent fertility is low. The seasonal water table fluctuates between depths of 0 and 3 feet and is deeper in drained areas. A few areas of Markey soils have been cultivated. Small grains and hay or pasture are the most common crops. Many areas are idle. These soils are suited to grasses used for hay and pasture.

Representative profile of Markey muck in an idle area 1,815 feet east and 820 feet south of the northwest corner of sec. 4, T. 146 N., R. 44 W.

Oa1—O to 6 inches, black (10YR 2/1, broken face and rubbed) sapric material; about 5 percent fiber; weak, very fine, granular structure; very friable; herbaceous fiber; about 20 percent mineral material; many live roots; mildly alkaline; calcareous; clear, smooth boundary.

Oa2—6 to 13 inches, black (10YR 2/1, broken face and rubbed) with very dark brown (10YR 2/2) sapric material; about 20 percent fiber, about 5 percent rubbed herbaceous fiber; weak, medium, platy structure; very friable; 15 percent mineral material; neutral; clear, smooth boundary.

Oa3—13 to 22 inches, black (N 2/0, broken face and rubbed) sapric material; about 5 percent fiber; weak, coarse, subangular blocky structure; friable; herbaceous fiber; about 30 percent mineral material; neutral; clear, irregular boundary.

IIC1—22 to 32 inches, gray (10YR 5/1) fine sand; massive; loose; common, very dark gray strata of fine sandy loam; neutral; clear, smooth boundary.

IIC2—32 to 60 inches, grayish-brown (2.5Y 5/2) grading with depth to gray (5Y 5/1) sand; common, medium, prominent, strong-brown (7.5Y 5/8) mottles; massive; loose; mildly alkaline; calcareous.

The thickness of the organic soil material ranges from 16 to 50 inches. The most common thickness is 18 to 30 inches. The colors are black, very dark gray, very dark brown, very dark grayish brown, and dark brown. The unrubbed fiber content ranges from 50 percent to less than 10 percent. The rubbed fiber content is less than 10 percent. There are thin horizons of less decomposed organic soil material in some profiles. Reaction in the organic soil material ranges from neutral to mildly alkaline. The IIC horizon is gray, grayish brown, light brownish gray, and light gray. It typically is sand, fine sand, loamy sand, or loamy fine sand, but there are thin, finer textured strata in this horizon in some profiles. Its reaction ranges from neutral to moderately alkaline.

Markey soils are associated with Arveson, Hamar, Rockwell, and Kratka soils in depressions and with Syrene and Hangaard soils. They consist of at least 16 inches of organic soil material, whereas those associated soils lack horizons of organic soil material.

Markey muck (Me).—This soil is in pocket depressions, the bottoms of natural draws, and low seep areas. These areas generally range from 3 to 20 acres in size. This soil is associated with beach ridges, sandy outwashes, and some partly filled areas of old stream channels.

Included in mapping were soils that have less than 16 inches of organic surface material over the sandy mineral material. These soils make up as much as 20 percent of any given area. Also included were soils that have an organic surface layer and less than 1 foot of sandy material underlain by loamy material and areas of Arveson, Hamar, Rockwell, and Kratka soils in depressions. These inclusions make up as much as 15 percent of any given area.

Many areas are idle. Willows, reeds, sedges, and scattered areas of cattails are the most common vegetative cover. A few areas are used for hay and pasture. Reed canarygrass, bluegrass, redtop, and quackgrass are some of the species that grow on these areas.

Wetness limits use of this soil. The low inherent fertility also influences use and management. Ditches constructed to drain this soil are easily eroded. (Capability unit IVw–2; tree and shrub suitability group 7–A)

Marsh

Marsh (Mh) occupies wet depressions that have predominantly marsh vegetation. In most places these depressions are deep and range from 3 to 25 acres. Most are in uplands or are associated with seep areas along beach ridges. These marshy depressions remain wet throughout most years. Small patches of open water occupy some areas. The soil material is not identified or classified in areas of Marsh.

Areas of Marsh are idle. A few are included in areas that are pastured, and some of the wetland vegetation can be grazed in dry spells if forage on higher ground has been grazed out. The most common vegetation in these areas is cattails and reedgrass. Marsh areas provide habitat for various species of wildlife, such as muskrat and waterfowl. (Not in a capability unit or a tree and shrub suitability group)

Mavie Series

The Mavie series consists of nearly level, poorly drained soils that formed in gravelly outwash deposited over loamy material. These soils generally are associated with beach ridges or interbeach areas. They formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is black and very dark grayish-brown loam that is high in organic-matter content. This layer is strongly calcareous and very strongly calcareous and is about 16 inches thick. The next layer is mottled, grayish-brown gravelly sandy loam that is strongly calcareous and about 7 inches thick. Below this is grayish-brown gravelly sand to a depth of 38 inches and light olive-gray, strongly calcareous loam till to a depth of 60 inches.

Mavie soils have medium available water capacity. Permeability is moderate. Inherent fertility is medium. The seasonal water table fluctuates between depths of 1 foot and 6 feet. Many areas are cultivated. The soils are suited to small grains and to some row crops, such as corn and sunflowers.

Representative profile of Mavie loam in a meadow 1,055 feet south and 80 feet west of the northeast corner of sec. 26, T. 143 N., R. 44 W.

A11—0 to 10 inches, black (N 2/0) loam; moderate, medium, subangular blocky structure parting to weak, very fine, subangular blocky; friable; common roots; moderately alkaline; strongly calcareous; gradual, smooth boundary.

A12ca—10 to 16 inches, very dark grayish-brown (2.5Y 3/2) mixed with dark grayish-brown (2.5Y 4/2) loam; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; common roots; moderately alkaline; very strongly calcareous; clear, smooth boundary.

IIC1cag—16 to 23 inches, grayish-brown (2.5Y 5/2) gravelly sandy loam; common, large prominent, yellowish-brown (10YR 5/6) and dark reddish-brown (5YR 3/4) mottles; massive; slightly sticky; moderately alkaline; strongly calcareous; gradual, smooth boundary.

IIC2g—23 to 38 inches, grayish-brown (2.5Y 5/2) gravelly sand; common, medium, prominent, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/6) mottles; single grain; loose; mildly alkaline; calcareous; clear, smooth boundary.

IIIC3g—38 to 60 inches, light olive-gray (5Y 6/2 loam; many, medium, prominent, light olive-brown (2.5Y 5/6) and olive-yellow (2.5Y 6/6) mottles; massive; sticky; about 5 percent coarse fragments; moderately alkaline; strongly calcareous.

The texture of the A horizon generally is loam, but in places it is fine sandy loam, sandy loam, or silt loam. The colors of the A12ca horizon generally are very dark grayish brown, dark grayish brown, or very dark gray. Reaction in the A horizon ranges from mildly alkaline to moderately alkaline, and the horizon is calcareous to very strongly calcareous. The combined thickness of the A horizon ranges from 7 to 18 inches. Its structure is weak or moderate, granular or subangular blocky.

The IIC1cag horizon has colors of dark gray, gray, grayish brown, light grayish brown, olive gray, and light olive gray. It is sandy loam, gravelly loam, gravelly sandy loam, gravelly loamy coarse sand, or gravelly coarse sand. It is strongly calcareous or very strongly calcareous.

The IIC2g horizon has grayish-brown to light olive-gray colors. Mottles are distinct or prominent. This horizon is gravelly sand or gravelly coarse sand. It is more than 6 inches thick and ranges to a maximum of 24 inches thick.

The IIIC3g horizon has gray to light olive-gray colors. Mottles range from few to many and faint to prominent. It generally is loam, but in places it is clay loam, silt loam, or silty clay loam. Reaction generally is moderately alkaline, but in place it is mildly alkaline, and the horizon is calcareous or strongly calcareous.

Mavie soils are associated with Syrene, Vallers, and Rockwell soils and are similar to Foxhome soils. They have a loamy IIIC horizon that is lacking in Syrene soils. They have a gravelly IIC horizon that is lacking in Vallers and Rockwell soils. They are more poorly drained than Foxhome soils, and they have a calcareous A horizon that is lacking in Foxhome soils.

Mavie loam (Mm).—This nearly level soil occupies slightly concave areas that generally range from 4 to 20 acres in size. The landscape is associated with beach ridges and interbeach areas. Slopes range from 0 to 2 percent. Some areas of this soil have cobblestones and stones scattered on the surface.

Included in mapping were areas of Vallers and Roliss soils that have less than 6 inches of gravelly material in the profile. These soils make up as much as 25 percent of any given area. Also included were areas of soils that have a similar textural sequence but lack a strongly calcareous or very strongly calcareous layer. These inclusions make up as much as 20 percent of any given area. Also included were areas of Syrene soils that have deeper gravelly deposits and areas of Rockwell soils that have fine sand rather than gravel over loamy material. These soils make up as much as 15 percent of any given area.

Some areas are cultivated principally for small grains. Many areas are used for hay or pasture. Such introduced grasses as quackgrass, bluegrass, and redtop commonly are used for these purposes. Scattered growths of trees, principally quaking aspen and some willow brush, also grow on this soil.

Wetness limits the use of this soil. A medium available water capacity and medium inherent fertility also influence use and management. Stones and cobblestones scattered on some areas of this soil make operation of farm machines more difficult. (Capability unit IIIw-4; tree and shrub suitability group 4)

Poppleton Series

The Poppleton series consists of nearly level, somewhat poorly drained and moderately well drained soils that formed in deep deposits of fine sand. Most of these deposits are associated with sand deposited in river deltas. The topography commonly is characterized by uneven microrelief. These soils formed under deciduous trees, and quaking aspen is the dominant species. Areas of tall prairie grass were mixed with, and occasionally replaced, the trees.

In a representative profile, the surface layer is very dark grayish-brown loamy fine sand about 6 inches thick. The subsurface layer is grayish-brown fine sand about 3 inches thick. The subsoil, about 40 inches thick, is mottled, grayish-brown, brown, and pale-brown fine sand. The underlying material is mottled, grayish-brown fine sand.

Poppleton soils have low available water capacity. Permeability is rapid. Inherent fertility is medium to low. The seasonal water table fluctuates between depths of 2 and 7 feet. Some areas have been cultivated. If properly managed, these soils are suited to such crops as oats, rye, corn, and soybeans. They are suited to grasses used for hay and pasture.

Representative profile of Poppleton loamy fine sand in a field 2,515 feet west and 120 feet south of the northeast corner of sec. 25, T. 144 N., R. 44 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, very fine, granular structure; loose; common bleached sand grains; neutral; abrupt, smooth boundary.

A2—6 to 9 inches, grayish-brown (10YR 5/2) fine sand; few, fine, distinct, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) mottles; massive; loose; slightly acid; clear, irregular boundary.

B1—9 to 16 inches, grayish-brown (10YR 5/2) fine sand; few, fine, distinct, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) mottles and few, fine, faint, brown (10YR 5/3) and light brownish-gray (10YR 6/2) mottles; massive breaking easily to single grain; loose; neutral; gradual, smooth boundary.

B2—16 to 22 inches, brown (10YR 5/3) fine sand; common, medium, faint, grayish-brown (10YR 5/2) and light brownish-gray (10YR 6/2) mottles and few, fine, distinct, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/6) mottles; single grain; loose; neutral; clear, wavy boundary.

B31—22 to 27 inches, pale-brown (10YR 6/3) fine sand; common, medium, faint, light yellowish-brown (10YR 6/4), brown (10YR 5/3), light brownish-gray (10YR 6/2), and light-gray (10YR 7/2) mottles and few, fine, distinct brownish-yellow (10YR 6/6) mottles; single grain; loose; slightly acid; gradual, wavy boundary.

B32—27 to 40 inches, brown (10YR 5/3) fine sand; many, coarse, prominent, yellowish-brown (10YR 5/8), light-gray (10YR 7/2), light brownish-gray (10YR 6/2), and strong-brown (7.5YR 5/6) mottles; single grain; loose; neutral; gradual, wavy boundary.

B33g—40 to 49 inches, grayish-brown (2.5Y 5/2) fine sand; many, medium, distinct, very dark gray (10YR 3/1), very dark grayish-brown (10YR 3/2), black (10YR 2/1), light-gray (10YR 7/2), and light brownish-gray (10YR 6/2) mottles and few, fine, prominent yellowish-brown (10YR 5/8) and strong-brown (7.5YR 5/8) mottles; single grain; loose; most sand grains are coated; neutral; clear, wavy boundary.

Cg—49 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; many, medium, faint, light brownish-gray (2.5Y 6/2) mottles and common, fine, prominent, yellowish-brown (10YR 5/8), brownish-yellow (10YR 6/8), and

strong-brown (7.5YR 5/8) mottles; single grain; loose; neutral.

The thickness of the solum ranges from 30 to 55 inches. The depth to free carbonates ranges from 30 to 70 inches. The A1 horizon is black, very dark gray, very dark brown, or very dark grayish brown in color. The thickness of the A1 horizon ranges from 4 to 10 inches. The A2 horizon is grayish brown or dark grayish brown in color and commonly is mottled. It ranges from 2 to 6 inches in thickness. In some profiles it has been incorporated into the Ap horizon. The texture of the A horizon generally is loamy fine sand, but in places it is fine sand or loamy sand.

The C horizon has colors of grayish brown, light brownish gray, and light gray. Mottles are most common in the upper part of this horizon. The texture in the B and C horizons generally is fine sand, and less than 5 percent is coarse or very coarse sand. Reaction ranges from slightly acid to neutral in the A and B horizons, and the C horizon is slightly acid to mildly alkaline and calcareous.

Poppleton soils are associated with Hamar, Ulen, and Towner soils and are similar to Flaming soils. They are better drained than Hamar soils. Their A horizon is noncalcareous, whereas the A horizon of Ulen soils is calcareous. They have a thinner dark-colored A horizon that is lower in content of organic matter than Swenoda and Towner soils, and they lack the loamy IIC horizon of those soils. They have a thinner dark-colored A horizon that is lower in content of organic matter than Flaming soils.

Poppleton loamy fine sand (Po).—This nearly level soil occupies an uneven landscape that has a combination of convex and slightly concave areas. Slopes are 0 to 3 percent. Soil blowing is largely responsible for this topography. Some wooded areas are more uniformly level, and sloping areas are along natural draws. Areas of this soil generally range from 10 to 80 acres in size. Areas of accumulation are common along the edges of wooded areas, fence lines, and field boundaries. If cultivated, this soil has a mixed pattern of various brownish colors.

Included in mapping were areas of Flaming soils that have a thicker surface layer that contains more organic matter. These soils make up as much as 15 percent of any given area. Also included were areas of Towner and Swenoda soils that have loamy underlying material, Ulen soils that are darker colored and calcareous, or Hamar soils that are darker colored and more poorly drained. These inclusions make up as much as 10 percent of any given area.

Some areas are cultivated. Small grains, some corn for silage and forage, and such other crops as flax and soybeans are grown in small acreages. A more common use is for hay and pasture. Introduced grasses and some seedings of legumes or grass-legume mixtures are used for this purpose. A considerable acreage of this soil is wooded. Aspen, oak, elm, ash, and basswood are the more common trees. Some of these areas are managed along with soils used for pasture, but many are idle.

Soil blowing is a hazard on this soil. A low available water capacity and medium to low inherent fertility also influence use and management. (Capability unit IVe–2; tree and shrub suitability group 5)

Rockwell Series

The Rockwell series consists of nearly level, poorly drained soils that formed in fine sand deposited over loamy material. These soils are on an interbeach landscape where soil materials are very mixed and relief is variable. They formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is 9 inches of black fine sandy loam. It is underlain by 10 inches of dark-gray and gray, very strongly calcareous loam. Below this layer is mottled, light olive-gray fine sand and loamy very fine sand to a depth of 31 inches. The underlying material is mottled, light olive-gray layered loam and silt loam to a depth of 60 inches.

Rockwell soils have medium to high available water capacity. Permeability is moderately rapid in the upper part and moderate in the lower part. Inherent fertility is medium to high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Many areas have been cultivated. The soils are suited to small grains and to row crops, such as corn and sunflowers.

Representative profile of Rockwell fine sandy loam in a cultivated field 575 feet west and 245 feet north of the southeast corner of sec. 22, T. 146 N., R. 44 W.

A1—0 to 9 inches, black (N 2/0) fine sandy loam; weak, very fine, subangular blocky structure; very friable; many roots; moderately alkaline; strongly calcareous; clear, wavy boundary.

C1ca—9 to 19 inches, mixed dark-gray (5Y 4/1) and gray (5Y 5/1) loam; weak, very fine, granular structure; slightly sticky; few roots; moderately alkaline; very strongly calcareous; discontinuous, very dark gray (10YR 3/1) fine sandy loam layer up to 4 inches thick in lower part; clear, wavy boundary.

IIC2—19 to 27 inches, light olive-gray (5Y 6/2) fine sand; common, medium, faint, pale-olive (5Y 6/3) mottles and common, medium, prominent, yellowish-brown (10YR 5/6), strong brown (7.5YR 5/8), and dark-brown (7.5YR 4/4) mottles; single grain; loose; few thin bands containing about 5 percent gravel; few roots; mildly alkaline; calcareous; clear, smooth boundary.

IIC3—27 to 31 inches, light olive-gray (5Y 6/2) layered very fine sand and loamy very fine sand; many, medium and coarse, prominent, yellowish-brown (10YR 5/8), strong-brown (7.5YR 5/8), and dark-brown (7.5YR 4/4) mottles; weak, very fine, granular structure; very friable; few roots; moderately alkaline; strongly calcareous; clear, smooth boundary.

IIIC4—31 to 60 inches, light olive-gray (5Y 6/2) layered loam and silt loam; many, medium and coarse, prominent, yellowish-brown (10YR 5/6 and 5/8) and reddish-brown (5YR 4/4) mottles; massive; slightly sticky; moderately alkaline to mildly alkaline; calcareous.

The colors in the A horizon are black or very dark gray. Its texture generally is fine sandy loam, but in places it is loam, sandy loam, or sandy clay loam. The structure is weak or moderate, granular or subangular blocky. There is an Aca horizon with very dark gray colors in some profiles. Thin, discontinuous streaks or layers, or both, of the A horizon occur at various depths in the C horizon of many profiles. The thickness of the A horizon ranges from 7 to 16 inches.

The C1ca horizon has colors of dark gray, gray, grayish brown, and olive gray. Mottles range from none to many prominent. This horizon is sandy loam, fine sandy loam, and loam in texture. The Cca horizon is moderately alkaline and very strong calcareous and has a 15- to 30-percent range in calcium carbonate equivalent. Its average thickness is at least 6 inches and ranges up to 16 inches.

The colors in the IIC horizon range from gray and grayish brown to light olive gray. Mottles range from faint to prominent, but distinct and prominent are most common. The IIC horizon generally is fine sand, but in places it ranges from loamy fine sand to sand that has some thin banding of gravelly material. The depth to the IIC3 horizon ranges from 20 to 40 inches.

The colors in the IIIC horizon range from gray and olive gray to light brownish gray. Mottles range from few to many, and some are distinct or prominent. The IIIC horizon generally is loam, but in places it is silt loam, fine sandy

loam, silty clay loam, or clay loam. The content of clay in this horizon is less than 35 percent. This horizon has a weakly developed structure, or it is massive.

Rockwell soils are associated with Arveson, Grimstad, and Kratka soils and are similar to Vallers soils. They have a loamy IIIC horizon that is lacking in Arveson soils. Rockwell soils are more poorly drained than Grimstad soils. They differ from Kratka soils in having a strongly calcareous A horizon. They contain more sand and less silt and clay in the A horizon and the upper part of the C horizon than Vallers soils.

Rockwell fine sandy loam (Rc).—This nearly level soil occupies slightly concave areas on a complex landscape. Areas range from 10 to 50 acres in size. Slopes are less than 2 percent. The surface layer has a rather smooth appearance if cultivated. If this soil is cultivated when wet, a cloddy surface commonly results. This soil has the profile described as representative for the series.

Included in mapping were areas of better drained Grimstad soils, Arveson soils with deeper sand deposits, or Vallers soils with less than 6 inches of sand in the profile. These inclusions make up as much as 15 percent of any given area. Some areas that have a surface layer of loamy fine sand and are less strongly calcareous were also included, as well as small areas in which gravelly pockets replace the sandy layer.

Many areas are cultivated. Small grains are the most common crops, but such row crops as corn and sunflowers are sometimes grown. Many areas also are used for hay and pasture. These are seeded to a grass-legume mixture or to such introduced grasses as quackgrass, Kentucky bluegrass, and redtop. Some scattered trees, principally quaking aspen, also grow on this soil.

Wetness limits use of this soil. Soil blowing and a strongly calcareous condition also influence use and management. (Capability unit IIIw–4; tree and shrub suitability group 4)

Rockwell and Kratka soils, depressional (Rk).—These soils occupy depressions surrounded by areas of nearly level, better drained, moderately coarse textured and coarse textured soils. Areas range from 3 to 15 acres in size. Most of these depressions are closed pockets, but a few occur at the bottoms of natural draws. They commonly have wetland vegetation. If drained and cultivated, the soils in these depressions have a black surface layer that has some grayish spots. Clean bleached sand grains in Kratka soils and strongly calcareous spots in Rockwell soils influence the color of the surface layer. The Kratka soil in this unit has the profile described as representative for the series. This unit is generally made up of 40 to 75 percent Rockwell soils and 25 to 60 percent Kratka soils, but any given depression can be made up of mostly one soil.

Included in mapping were areas of Arveson and Hamar soils that lack finer textured underlying material. These soils make up as much as 20 percent of any given area. Also included were areas of Roliss loam, depressional, that lack a significant sandy layer or areas of Markey muck that have an organic surface layer underlain by sand. These inclusions make up as much as 15 percent of any given area.

Most areas are idle. Some depressions have been drained and are included in cultivated fields. Small grains are the most common crops on these areas. Many of these depressional soils are managed along with soils used for hay and pasture and commonly support reeds, sedges, cattails, and willow brush. Some depressions used for pasture or hay produce reed canarygrass.

Wetness limits the use of this unit. (Capability unit IVw–2; tree and shrub suitability group 7–B)

Roliss Series

The Roliss series consists of nearly level, poorly drained soils that formed in water-worked loam and clay loam till. Slopes commonly are slightly concave, and some areas are closed depressions. These soils generally are associated with an interbeach landscape. They formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is black and very dark gray loam about 13 inches thick. The subsoil is very dark grayish-brown, weakly calcareous loam about 3 inches thick. The underlying material is mottled, grayish-brown loam till. This material is strongly calcareous and has some pockets of gypsum crystals and dark-red concretions.

Roliss soils have high available water capacity. Permeability is moderate. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Many areas are cultivated. The soils are suited to most grain crops and to such row crops as corn and soybeans.

Representative profile of Roliss loam in a meadow 1,080 feet south and 600 feet east of the northwest corner of sec. 32, T. 143 N., R. 44 W.

A1—0 to 7 inches, black (10YR 2/1) loam; weak, very fine, subangular blocky structure; friable; abundant roots; neutral; gradual, smooth boundary.

A3—7 to 13 inches, very dark gray (10YR 3/1) loam; weak, very fine, granular structure; very friable; plentiful roots; mildly alkaline; weakly calcareous; clear, smooth boundary.

B2g—13 to 16 inches, very dark grayish-brown (2.5Y 3/2) loam; few, fine, distinct, olive-brown (2.5Y 4/4) and light olive-brown (2.5Y 5/4) mottles; weak, very fine, subangular blocky structure; very friable; plentiful roots; about 10 percent coarse fragments; mildly alkaline; weakly calcareous; clear, smooth boundary.

C1—16 to 30 inches, grayish-brown (2.5Y 5/2) loam; many, fine, faint, light brownish-gray (2.5Y 6/2) mottles; common, fine, distinct, light olive-brown (2.5Y 5/6) and olive-yellow (2.5Y 6/8) mottles; few, fine, prominent, brownish-yellow (10YR 6/6) mottles; weak, very fine, subangular blocky structure; friable; about 5 percent coarse fragments; few roots; few pebbles and cobblestones; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C2—30 to 60 inches, grayish-brown (2.5Y 5/2) loam; many, fine and medium, prominent, yellowish-brown (10YR 5/6), brownish-yellow (10YR 6/8), and olive-yellow (2.5Y 6/6) mottles; weak to moderate, very fine, subangular blocky structure; friable; about 5 percent coarse fragments; few masses of light-gray (5Y 7/1) gypsum crystals and few dark-red (2.5YR 3/6) concretions; moderately alkaline; strongly calcareous.

The depth to free carbonates ranges from 0 to 10 inches. The A horizon generally is black, but in some profiles it is very dark gray or very dark grayish brown in the lower part. The texture of the A horizon generally is loam or clay loam, but in places it is silty clay loam, silt loam, or sandy loam. Its structure is weak or moderate, granular or subangular blocky. The thickness of the A horizon generally ranges from 9 to 15 inches, but thicknesses of 7 to 18 inches are within the range.

The colors in the B2g horizon are very dark grayish brown, dark grayish brown, and light brownish gray. This horizon has distinct or prominent mottles and is from 2 to 7

inches thick. The B2g horizon has textures similar to those of the A horizon. In some profiles the B2g horizon has a concentration of gravel and cobblestones just above the C horizon. This coarse layer is as much as 5 inches thick in some profiles.

The colors in the C horizon range from dark grayish brown to light olive gray. Mottles range from few, faint to many, prominent. The texture of the C horizon is loam or clay loam. Masses of gypsum crystals and dark-colored concretions are in the C horizon of many profiles. Reaction ranges from mildly alkaline to moderately alkaline.

Roliss soils are associated with Kittson and Vallers soils and are similar to Flom soils. They are more poorly drained than Kittson soils. They lack the Aca horizon or a Cca horizon at a shallow depth that is characteristic of Vallers soils. They are calcareous at a shallower depth than Flom soils.

Roliss loam (Ro).—This nearly level soil generally occupies slightly concave areas that range from 5 to 50 acres in size. This soil commonly is associated with an interbeach landscape where soil materials change within short distances and relief is variable. If plowed, the surface layer has a cloddy appearance. Cobblestones and stones are scattered on the surface and buried in the upper layers of this soil. Their number varies considerably. This soil has the profile described as representative for the series.

Included in mapping were areas of more calcareous Vallers soils. Also included were areas of Rockwell and Mavie soils that have more than 6 inches of sand and gravel in the profile or areas of Viking soils that are finer textured. These inclusions make up as much as 15 percent of any given area. Also included were areas of better drained Kittson soils that make up as much as 10 percent of any given area.

Some areas have been cultivated principally for small grains. Many areas are used for hay and pasture. Such introduced grasses as quackgrass, redtop, and bluegrass are the most common forage. Scattered trees, principally quaking aspen, also grow on this soil.

Wetness limits the use of this soil. Cobblestones and stones on the surface and buried in the upper 2 feet of the soil make operation of farm machines more difficult. (Capability unit IIw–1; tree and shrub suitability group 3)

Roliss loam, depressional (Rs).—This soil occupies closed depressions that vary in shape and commonly range from 3 to 10 acres in size. This soil is bordered by higher lying areas of Roliss or Vallers soils and other associated soils. A few cobblestones and stones are scattered on the surface in most areas. This soil has a profile similar to that described as representative for the series, except that there is more variation in thickness of the dark-colored surface layer.

Included in mapping were areas of depressional Vallers soils that are more strongly calcareous. These soils make up as much as 25 percent of any given area. Also included were areas of depressional Rockwell and Kratka soils that differ in having a sand layer that is more than 6 inches thick. These soils make up as much as 15 percent of any given area. Areas of Cathro muck that have an organic surface layer underlain by loamy material or areas of Marsh where soil material has not been determined were also included and make up as much as 10 percent of any given area.

A few areas of this soil have been included in fields of other soils cultivated for small grains. Other areas are managed along with pasture or hayland, where their reeds and sedges are sometimes used for livestock feed. A large part of this depressional soil is idle and supports reeds, sedges, cattails, and willow brush.

Wetness limits the use of this soil. Water ponded in depressions is not uncommon. Cobblestones and stones on the surface and buried in the soil make operation of farm machines more difficult. (Capability unit IIIw–1; tree and shrub suitability group 7–B)

Rondeau Series

The Rondeau series consists of highly decomposed organic soil material about 16 to 50 inches thick over marl lake seriments. These soils formed in deep depressions formerly occupied by lakes. They are associated with a rather complex upland landscape or with wet areas between beach ridges. They formed in deposits of herbaceous organic materials and lake sediments. The formation of these soils is unique in that the areas were open water during the time the marl and other lake sediments were deposited. As the lake filled with these sediments, water-tolerant plants grew and herbaceous organic materials began to accumulate because they were too wet for complete decomposition. Fluctuating water levels during the time these soils formed resulted in layers of lake sediments being mixed with herbaceous organic materials.

In a representative profile, the surface layer is black and dark grayish-brown muck that has small amounts of snail shells. This layer is 44 inches thick. The next layers are gray marl and black mucky peat. The underlying material is pale-olive marl (mucky silt loam).

Rondeau soils have very high available water capacity. Their permeability is slow. Inherent fertility is low. The seasonal water table fluctuates between depths of 0 and 3 feet. Some areas are used for hay and pasture. Most are idle. The soils are suited to wildlife habitat or can be managed for hay and pasture.

Representative profile of Rondeau muck 640 feet east and 2,310 feet south of the northwest corner of sec. 25, T. 144 N., R. 43 W.

Oa1—0 to 26 inches, black (2.5Y 2/1 broken face and rubbed) sapric material; about 20 percent fiber, about 10 percent rubbed; massive; herbaceous fiber; about 5 percent snail shells; mildly alkaline; calcareous; gradual, smooth boundary.

Oa2—26 to 36 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 25 percent fiber, about 10 percent rubbed; massive; herbaceous fiber; about 2 percent snail shells; mildly alkaline; calcareous; clear, smooth boundary.

Oa3—36 to 44 inches, dark grayish-brown (2.5Y 4/2 broken face and rubbed) sapric material; about 30 percent fiber, but none after rubbing; massive; about 2 percent shell fragments; massive; mildly alkaline; calcareous; clear, smooth boundary.

Lca1—44 to 55 inches, gray (5Y 6/1) marl (mucky silt loam); about 30 percent small fragments of plants; massive; about 70 percent mineral matter; about 2 percent snail shells; moderately alkaline; strongly calcareous; gradual, smooth boundary.

Oe—55 to 68 inches, black (10YR 2/1) broken face and rubbed) hemic material with very dark grayish-brown (10YR 3/2) fibers; about 50 percent fiber, about 30 percent rubbed; massive; about 20 percent mineral matter; mildly alkaline; calcareous; abrupt, smooth boundary.

Lca2—68 to 90 inches, pale-olive (5Y 6/3) marl (mucky silt loam); massive; about 80 percent mineral matter; about 10 percent snail shells; moderately alkaline; very strongly calcareous.

The thickness of the organic material over the marl ranges from 16 to 50 inches. The combined thickness of the organic soil material and the marl generally ranges from 55 to 80 inches. The mineral material underlying those materials is variable in texture. The colors in the organic soil material range from black to very dark gray, very dark grayish brown, dark grayish brown, and very dark brown on broken faces. This material commonly is massive, but in some profiles its structure is weak, fine and medium, granular and subangular blocky. Its reaction ranges from neutral to mildly alkaline. The content of snail shells, which ranges from none to 10 percent, is largely responsible for differences in reaction. Fiber content in the sapric materials generally is less than 25 percent and is 10 percent or less rubbed. The organic soil material is 20 to 45 percent mineral material. The hemic material, or the Oe horizon, is lacking in some profiles. Layers of marl, or the Lca horizon, range from 1 to 3 in number and from 2 inches to several feet in thickness. The colors in this material range from gray and light brownish gray to pale olive. Snail shell and fragments in this material range up to 50 percent of the mass.

Rondeau soils are associated with Seelyeville, Cathro, Flom, and Vallers soils in depressions. They differ from Seelyeville and Cathro soils in having marl layers above a depth of 50 inches. They have layers of organic soil material that are lacking in Flom and Vallers soils.

Rondeau muck (Ru).—This soil occupies depressions that at one time were lakes. Small open-water areas still exist in some of these depressions. Areas of muck generally range from 5 to 60 acres in size. This soil is associated with a rather complex upland landscape or occupies areas between beach ridges. Some areas appear to be raised on floating bogs. Many areas have an extremely rough, hummocky surface.

Included in mapping were areas of soils that have more than 36 inches but less than 51 inches of herbaceous material and lake sediments. These soils make up as much as 25 percent of any given area. Also included were areas of soils that have no lake sediments and areas of Marsh where soil materials have not been determined. These inclusions make up as much as 15 percent of any given area.

Most areas are idle, and reeds, sedges, scattered cattails, and willows are the most common kinds of vegetative cover. A few areas are used for pasture. These areas commonly are very hummocky.

Wetness limits use of this soil. A greater susceptibility to frost damage of growing crops, the possibility of fires causing deep burnouts, and the low inherent fertility of this soil also influence use and management. (Capability unit IVw–3; tree and shrub suitability group 7–A)

Seelyeville Series

The Seelyeville series consists of deep, highly decomposed organic soil material that is more than 50 inches thick. These soils formed in depressions, seep areas, and bottoms of old stream channels. Most areas of these soils are associated with an upland landscape. They formed under cattails, reeds, and sedges. During the time the organic materials accumulated, they were too wet for complete decomposition.

In a representative profile, the upper 24 inches is black muck. The next 24 inches is black muck that has a few more fibers than the layer above, and the next 12 inches is very dark brown muck that is 30 percent fiber.

Seelyeville soils have very high available water capacity. Permeability is moderately rapid. Inherent fertility is low. The seasonal water table fluctuates between depths of 0 and 3 feet but is deeper in drained areas. Some areas are used for hay and pasture, but more areas are idle. The soils are suited to wildlife habitat or can be managed for hay and pasture.

Representative profile of Seelyeville muck 340 feet south and 920 feet west of the northeast corner of sec. 26, T. 144 N., R. 43 W.

Oa1—0 to 24 inches, black (N 2/0 broken face and rubbed) sapric material; about 10 percent fiber, about 5 percent rubbed; weak, very fine, granular structure; very friable; herbaceous fiber; about 40 percent mineral matter; mildly alkaline; calcareous; diffuse boundary.

Oa2—24 to 48 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber, about 5 percent rubbed; weak, very fine, granular structure; sticky; herbaceous fiber; about 50 percent mineral matter; neutral; calcareous; clear, smooth boundary.

Oa3—48 to 60 inches, very dark brown (10YR 2/2 broken face) sapric material, black (10YR 2/1) when rubbed; about 30 percent fiber, about 10 percent rubbed; massive; sticky; about 60 percent mineral material; neutral; calcareous.

The thickness of the organic material is more than 50 inches. The most common thickness ranges from 50 to 65 inches. Underlying the organic material is sandy or loamy mineral material. The sapric material generally has a black color, but very dark gray and very dark grayish brown broken face colors are within the range. The fiber content generally is less than 25 percent undisturbed and less than 10 percent rubbed. Some profiles have less decomposed organic soil material in layers totaling less than 10 inches in thickness. The reaction in the organic layer ranges from slightly acid to mildly alkaline. A few shell fragments scattered throughout the organic material are largely responsible for the mildly alkaline reaction. The content of mineral material in the organic layer ranges from 10 to 60 percent.

Seelyeville soils in this county typically contain more mineral material and more free carbonates in the organic soil material than the defined range of the series. This difference does not appreciably alter the usefulness or behavior of these soils.

Seelyeville soils are associated with Rondeau, Cathro, Flom, and Vallers soils in depressions. They have a thicker continuous layer of organic soil material than Rondeau and Cathro soils. They have a layer of organic soil material that is lacking in Flom and Vallers soils.

Seelyeville muck (Sc).—This soil is in pocketed depressions, parts of old stream channels, and low seep areas between beach ridges. These areas normally range from 5 to 40 acres in size. This soil is most common in the uplands.

Included in mapping were areas of organic soils that have more than 36 inches but less than 50 inches of organic material. The underlying mineral material in these areas ranges from sandy to clayey in texture. These soils make up as much as 20 percent of any given area. Areas of organic accumulations that have a higher undisturbed and rubbed fiber content also were included, since they represent less than 1 percent of the deep organic soils in Norman County. Also included were areas of Marsh where soils materials have not been determined. These inclusions make up as much as 15 percent of any given area.

Many areas are idle. Reeds, sedges, scattered cattails, and willows are the most common vegetative cover. A few wooded areas have various species of bottom-land hardwoods. A few areas are used for hay and pasture. Reed canarygrass is the most important crop on these areas. In some areas organic materials are harvested for use in potting and mulching.

Wetness is a limitation to use of this soil. If this soil is drained, the hazard of fire in the organic materials also is a limitation. The low inherent fertility also influences use and management. (Capability unit IVw–3; tree and shrub suitability group 7–A)

Sioux Series

The Sioux series consists of nearly level to very steep, excessively drained soils. These soils formed in gravelly desposits on beach ridges and in pockets of outwash. The beach ridges represent old shorelines of glacial Lake Agassiz. They extend for miles in length and are quite narrow. The pockets of outwash commonly are associated with more steeply sloping till soils and larger natural drainageways.

In a representative profile, the surface layer is black sandy loam about 9 inches thick. The next layer is 5 inches of very dark grayish-brown gravelly loamy sand. The underlying material is brown and pale-brown gravelly coarse sand (fig. 15).

Sioux soils have low to very low available water capacity. Permeability is rapid. Inherent fertility is low to medium. The depth to the seasonal water table is more than 6 feet. Sioux sandy loam soils sometimes are cultivated. They are suited to small grains and to grasses and legumes. Sioux gravelly loamy sand soils are suited to grasses and legumes for hay or pasture.

Representative profile of Sioux sandy loam, 2 to 6 percent slopes, in a cultivated field 2,030 feet west and 490 feet north of the southeast corner of sec. 4, T. 146 N., R. 45 W.

Ap—0 to 9 inches, black (10YR 2/1) sandy loam; weak, medium, subangular blocky structure parting to weak, very fine, granular; very friable; many, clean, bleached sand grains; neutral grading to mildly alkaline; weakly calcareous in lower part; clear, smooth boundary.

AC—9 to 14 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand; massive; loose; about 10 percent inclusions of irregular masses and streaks, 1 inch thick and 1½ inches in diameter, that have black (10YR 2/1) and very dark gray (10YR 3/1) colors and weak, very fine, granular structure that is very friable; neutral to mildly alkaline; calcareous; clear, smooth boundary.

IIC1—14 to 22 inches, brown (10YR 5/3) gravelly coarse sand; single grain; loose; lighter carbonate coatings on the underside of some pebbles; moderately alkaline; calcareous; gradual, smooth boundary.

IIC2—22 to 33 inches, pale-brown (10YR 6/3) gravelly coarse sand; single grain; loose; mildly alkaline to moderately alkaline; calcareous; gradual, smooth boundary.

IIC3—33 to 60 inches, pale-brown (10YR 6/3) gravelly coarse sand; few, medium, distinct, brownish-yellow (10YR 6/6) and light olive-brown (2.5Y 5/6) mottles; single grain; loose; 1 percent material larger than 3 inches in diameter; moderately alkaline; calcareous.

The colors in the A horizon are black or very dark gray. The texture of the A horizon generally is sandy loam or fine sandy loam, but in places it is loam, loamy sand, gravelly sandy loam, or gravelly loamy sand. The thickness of the A horizon range from 7 to 14 inches. The AC horizon, that is very dark grayish-brown, dark-brown, dark grayish-brown, and brown colors, is lacking in some profiles. The depth to free carbonates ranges from 0 to 8 inches.

The colors in the IIC horizon range from grayish brown to light olive brown and pale yellow. The content of gravel in the IIC horizon generally ranges from 35 to 60 percent, but in places the IIC horizon is less than 35 percent gravel.

Some of the Sioux sandy loam soils in this county contain less gravel and more sand in the A horizon and the upper part of the IIC horizon than the defined range for the series, but this difference does not appreciably alter the usefulness and behavior of these soils.

Sioux soils are associated with Maddock, Syrene, Arveson, and Hangaard soils and are similar to Foxhome soils. They are more gravelly than Maddock soils and are better drained and less calcareous than Syrene soils. Sioux soils are better drained and more gravelly than Arveson soils and are better drained than Hangaard soils. They differ from Foxhome soils in lacking finer textured underlying material.

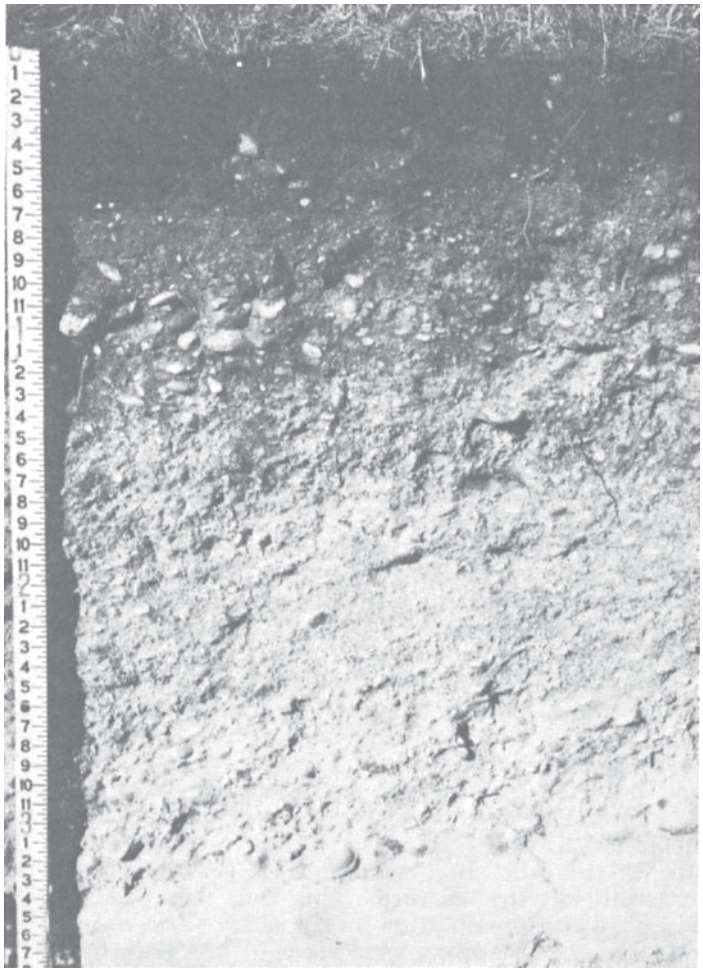

Figure 15.—**Profile of Sioux sandy loam, 2 to 6 percent slopes. There is a greater content of gravel between depths of 7 and 10 inches than in the dark-colored surface layer.**

Sioux sandy loam, 0 to 2 percent slopes (SdA).—This soil occupies slightly convex areas that generally range from 10 to 80 acres in size. Much of the landscape is a raised, convex beach ridge generally oriented in a north-south direction and bordered by low, wet seep areas. Some of this soil occupies outwash areas where gravelly deposits are associated with well-entrenched natural

drainageways or steeper till soils. In places there is a little gravel size material on the surface.

Included in mapping were areas of more poorly drained Hangaard soils and less gravelly Maddock soils. These soils make up as much as 15 percent of any given area. Also included were areas of Foxhome soils that have finer textured underlying material within a depth of 40 inches and make up as much as 10 percent of any given area. Included in outwash areas were soils that have a subsoil of loam. Some soils that have a surface layer more than 14 inches thick also were included.

Some areas of this Sioux soil have been cultivated. Small grains, such as rye or oats, are the most common crops. A few areas are used for corn, and many areas are used for hay and pasture. Such introduced grasses as Kentucky bluegrass, redtop, and quackgrass are common in these areas. There also are some scattered wooded areas. Some areas are idle. This soil is a source of gravel for road construction, concrete aggregates, and fill. Gravel pits are common.

A low to very low available water capacity and medium to low inherent fertility are limitations to use of this soil. Soil blowing also influences use and management. (Capability unit IVs–1; tree and shrub suitability group 5)

Sioux sandy loam, 2 to 6 percent slopes (SdB).—This soil occupies areas that generally range from 5 to 80 acres in size. The landscape is mostly a raised, convex beach ridge generally oriented in a north-south direction and bordered by low, wet seep areas. Some of this soil occupies outwash areas where gravelly deposits are associated with well-entrenched natural drainageways or steeper till soils. In places there is a little gravel-size material on the surface. This soil has the profile described as representative for the series.

Included in mapping were areas of less gravelly Maddock soils and more poorly drained Hangaard soils. These soils make up as much as 15 percent of any given area. Also included were areas of Foxhome soils that have finer textured underlying material within a depth of 40 inches and make up as much as 10 percent of any given area. Included in outwash areas were soils that have a subsoil of loam. Some soils that have a surface layer more than 14 inches thick also were included.

Some areas have been cultivated. Small grains, such as rye or oats, are the most common crops. A few areas are used for corn. Many areas are used for hay and pasture. Such introduced grasses as Kentucky bluegrass, redtop, and quackgrass are common in these areas. There also are a few scattered wooded areas. Some areas are idle. This soil is a source of gravel for road construction, concrete aggregates, and fill. Gravel pits are common.

A low to very low available water capacity and medium to low inherent fertility are limitations to use of this soil. Soil blowing and water erosion also influence use and management. (Capability unit IVs–1; tree and shrub suitability group 5)

Sioux gravelly sandy loam, 0 to 2 percent slopes (SgA).—This soil occupies slightly convex areas that generally range from 5 to 40 acres in size. The landscape is mostly a raised, convex beach ridge generally oriented in a north-south direction and bordered by low, wet seep areas. Some of this soil occupies outwash areas where gravelly deposits are associated with well-entrenched natural drainageways or steeper till soils. This soil has a profile similar to that described as representative for the series, except that it generally has a thinner surface layer and more coarse material. This layer has 17 to 25 percent gravel-size material mixed in it, and some of the gravel is visible on the surface.

Included in mapping were areas of less gravelly Maddock soils and Foxhome soils that have finer textured underlying material within a depth of 40 inches. These soils make up as much as 15 percent of any given area.

Some areas are used for hay and pasture. Such introduced grasses as Kentucky bluegrass, redtop, and quackgrass are common in these areas. A few areas have been cultivated, and rye is the most common crop. Many areas are idle and have some scattered trees. This soil is a source of gravel for road construction, concrete aggregates, and fill. Gravel pits are common.

A low to very low available water capacity and low inherent fertility are limitations to use of this soil. Soil blowing also influences use and management. (Capability unit VIs–1; tree and shrub suitability group 6)

Sioux gravelly sandy loam, 2 to 8 percent slopes (SgC).—This soil occupies areas that generally range from 5 to 30 acres in size. The landscape is mostly a raised, convex beach ridge generally oriented in a north-south direction and bordered by low, wet seep areas. Some of this soil occupies outwash areas where gravelly deposits are associated with well-entrenched natural drainageways and steeper till soils. This soil has a profile similar to that described as representative for the series, except that the surface layer is thinner and has more coarse material. This layer has 17 to 25 percent gravel-size material mixed in it, and some is visible on the surface.

Included in mapping were areas of less gravelly Maddock soils and Foxhome soils that have finer textured underlying material within a depth of 40 inches.

Some areas are used for hay and pasture. Such introduced grasses as Kentucky bluegrass, redtop, and quackgrass are common in these areas. Many areas are idle and have some scattered wooded areas. This soil is a source of gravel for road construction, concrete aggregates, and fill. Gravel pits are common.

A low to very low available water capacity and low inherent fertility are limitations to use of this soil. Soil blowing and water erosion also influence use and management. (Capability unit VIs–1; tree and shrub suitability group 6)

Sioux and Maddock soils, 12 to 36 percent slopes (SmE).—These soils occupy areas of coarse-textured outwash on uplands. The landscape is commonly complex and has many variations in length and steepness of slope. In many places these soils line the outer edges of well-entrenched draws or are located at the base of a higher ridge of till material. The surface layer of the Sioux soils ranges from gravelly loamy sand to loam, and the surface layer of the Maddock soils ranges from loamy sand to fine sandy loam. These soils have profiles similar to those described as representative for their series, except that there is more variation in the thickness of the surface layer. Cobblestones and stones are on the surface of some areas of this unit. This unit consists of 30 to 70 percent Sioux soils and 30 to 70 percent Maddock soils. However, any given area may consist of all one soil.

Included in mapping were areas of Sverdrup soils that have a finer textured surface layer and subsoil and areas of Swenoda soils that have contrasting loamy material in the underlying material. Also included were areas of steep, medium-textured till soils that make up as much as 20 percent of any given area.

These soils seldom are cultivated. A small acreage is seeded to grass or a grass-legume mixture and is harvested for hay. Some areas are pastured. Many areas are idle and support a growth of native and introduced grasses and scattered trees. The most common grasses are bluegrass, quackgrass, redtop, blue grama, and indiangrass.

Droughtiness, low inherent fertility, and erosion are limitations to use of these soils. (Capability unit VIs-1; tree and shrub suitability group 6)

Sverdrup Series

The Sverdrup series consists of nearly level to sloping, somewhat excessively drained soils that formed in deposits of sandy outwash. These soils are on an upland landscape that has convex slopes up to 8 percent. They formed under tall prairie grasses.

In a representative profile, the surface layer is about 13 inches thick. The upper 9 inches is black fine sandy loam, and the lower 4 inches is very dark brown sandy loam. The subsoil is brown sandy loam in the upper part and dark yellowish-brown loamy sand in the lower part. It is 11 inches thick. The underlying material is light olive-brown fine sand.

Sverdrup soils have medium available water capacity. Permeability is moderately rapid in the upper part and rapid in the underlying material. Inherent fertility is medium. The seasonal water table is at a depth below 6 feet. Many areas have been cultivated. The soils are suited to small grains and to such row crops as corn and soybeans.

Representative profile of Sverdrup fine sandy loam, 2 to 8 percent slopes, in a cultivated field 2,540 feet west and 880 feet north of the southeast corner of sec. 28, T. 144 N., R. 43 W.

A1—0 to 9 inches, black (10YR 2/1) fine sandy loam; weak, very fine, granular structure; very friable; neutral; clear, smooth boundary.

A3—9 to 13 inches, very dark brown (10YR 2/2) sandy loam; weak, very fine, granular structure; very friable; neutral; clear, smooth boundary.

B2—13 to 19 inches. brown (10YR 4/3) sandy loam; weak, fine, prismatic structure parting to weak, very fine, subangular blocky; very friable; few, thin, dark grayish-brown coatings on faces of peds; neutral; clear, smooth boundary.

B3—19 to 24 inches, dark yellowish-brown (10YR 4/4) loamy sand; massive; very friable; neutral; gradual, smooth boundary.

C1—24 to 34 inches, light olive-brown (2.5Y 5/4) fine sand; single grain; loose; neutral; gradual, smooth boundary.

C2—34 to 60 inches, light olive-brown (2.5Y 5/4) fine sand; few, fine, faint, light olive-brown (2.5Y 5/6) mottles; single grain; loose; neutral to mildly alkaline; weakly calcareous.

The thickness of the solum generally ranges from 20 to 26 inches, and the extreme range is 16 to 30 inches. The depth to free carbonates generally ranges from 24 to 36 inches, but the extreme range is 15 to 40 inches. The colors in the A horizon are black, very dark gray, and very dark brown. The texture of the A horizon generally is fine sandy loam, but in places it is loam. Its structure ranges from weak to moderate, very fine to medium, and is granular or subangular blocky. The thickness of the A horizon ranges from 10 to 16 inches.

The colors in the B horizon range from dark grayish brown to light olive brown. The B2 horizon generally is sandy loam, but in places it is loam. The B3 horizon is loamy sand, loamy fine sand, fine sandy loam, or sandy loam.

The colors in the C horizon are light brownish gray, pale brown, brown, olive brown, and light olive brown. The C horizon generally is fine sand, but in places it is medium sand.

Sverdrup soils are associated with Maddock and Sioux soils and are similar to Swenoda soils. They are finer textured in the A and B2 horizons than Maddock soils. They are finer textured than Sioux soils, having fine sand rather than gravel in the profile. They differ from Swenoda soils in lacking the loam IIC horizon above a depth of 40 inches.

Sverdrup fine sandy loam, 0 to 2 percent slopes (SnA).—This soil occupies slightly convex areas that generally range from 5 to 30 acres in size. This soil commonly is mixed or associated with more sloping till soils and gently undulating sandy soils. Most areas of this soil are on pockets of sandy outwash scattered in a complex, upland landscape. A few areas also occupy sandy deposits along the outer edges of old, rather broad stream channels. The surface layer of this soil has a smooth appearance if cultivated.

Included in mapping were areas of soils that have a dark-colored surface layer less than 10 inches thick. These soils make up as much as 20 percent of any given area. Also included were areas of coarser textured Maddock soils, areas of Swenoda soils that have finer textured underlying material or areas of Sioux soils that have gravel rather than fine sand in the profile. These inclusions make up as much as 15 percent of any given area.

Many areas have been cultivated. Small grains are the most important crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay and pasture and are seeded to a legume or grass-legume mixture.

Soil blowing and medium available water capacity are limitations to use of this soil. (Capability unit IIIs-1; tree and shrub suitability group 5)

Sverdrup fine sandy loam, 2 to 8 percent slopes (SnC).—This soil occupies areas that generally range from 3 to 20 acres in size. These soils commonly are mixed or associated with more sloping till soils and nearly level to steep, coarse-textured soils. Most areas of this soil occupy pockets of sandy outwash in a complex, upland landscape. A few areas of sandy deposits are along the outer edges of old, rather broad stream channels. The surface layer of this soil has a smooth appearance if cultivated. This soil has the profile described as representative for the series.

Included in mapping were areas of soils that have a dark-colored surface layer less than 10 inches thick. These soils make up as much as 20 percent of any given area. Also included were areas of Maddock soils that have a coarser textured surface layer and subsoil, Swenoda soils that have finer textured underlying material, and more gravelly Sioux soils. These inclusions make up as much as 15 percent of any given area.

Many areas have been cultivated. Small grains are the most important crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay

and pasture and are seeded to a legume or grass-legume mixture.

Soil blowing and water erosion are hazards on this soil. A medium available water capacity is also a limitation. (Capability unit IIIs-1; tree and shrub suitability group 5)

Swenoda Series

The Swenoda series consists of nearly level to sloping, moderately well drained soils. These soils formed in outwash and lacustrine sediments that consist mostly of fine sand deposited over loamy material. They are associated with an interbeach and upland landscape where soil materials are mixed and relief is variable. Slopes are convex and up to 8 percent.

In a representative profile, the surface layer is neutral fine sandy loam about 14 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is 11 inches of very dark grayish-brown and dark grayish-brown loamy fine sand. The underlying material is grayish-brown loamy fine sand to a depth of 32 inches and light brownish-gray and olive-gray layered silt loam and silty clay loam to a depth of 60 inches.

Swenoda soils have medium to high available water capacity. Permeability is rapid in the upper part and moderate in the lower part. The seasonal water table fluctuates between depths of 2½ and more than 6 feet. Many areas have been cultivated. The soils are suited to small grains and to such row crops as corn and soybeans.

Representative profile of Swenoda fine sandy loam, 0 to 2 percent slopes, in a cultivated field 2,485 feet east and 1,980 feet south of the northwest corner of sec. 28, T. 144 N., R. 43 W.

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam; weak, very fine, granular structure; very friable; neutral; abrupt, smooth boundary.

A3—9 to 14 inches, very dark gray (10YR 3/1) fine sandy loam; common inclusions of black (10YR 2/1); weak, very fine, granular structure; very friable; neutral; gradual, smooth boundary.

B1—14 to 21 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, very fine, granular structure; few black and very dark gray fillings in old animal burrows; very friable; neutral; clear, smooth boundary.

B2—21 to 25 inches, dark grayish-brown (10YR 4/2) loamy fine sand; massive; very friable; few black and very dark gray fillings in old animal burrows; neutral; gradual, smooth boundary.

C1—25 to 32 inches, grayish-brown (2.5Y 5/2) loamy fine sand; few, fine, light olive-brown (2.5Y 5/6) mottles; massive; very friable; few black and very dark gray fillings in old animal burrows; neutral; gradual, smooth boundary.

C2—32 to 34 inches, light yellowish-brown (2.5Y 6/4) fine sandy loam; many, fine and medium, prominent, yellowish-brown (10YR 5/8) and strong-brown (7.5YR 5/8) mottles; massive; very friable; mildly alkaline; weakly calcareous; abrupt, wavy boundary.

IIC3—34 to 60 inches, light brownish-gray (2.5Y 6/2) grading to olive-gray (5Y 5/2) layered silt loam and silty clay loam; common, fine and medium, prominent, yellowish-brown (10YR 5/6) and brownish-yellow (10YR 6/6) mottles; common, coarse, prominent, strong-brown (7.5YR 5/8) mottles and common, medium, faint, light-gray (2.5Y 7/2) mottles; weak, thick, platy structure parting to fine subangular blocky; friable; mildly alkaline to moderately alkaline; calcareous.

The depth to the IIC horizon ranges from 24 to 40 inches. The texture of the A horizon generally is fine sandy loam, but in places it is sandy loam or loam. Structure is weak, very fine or fine, subangular blocky or granular. The colors in the B horizon are very dark grayish brown, dark grayish brown, brown, dark brown, dark yellowish brown, and olive brown. The B horizon typically is fine sandy loam or loamy fine sand, but in places it is loamy sand or sandy loam. Also, there is a B3 horizon that is fine sand, sand, loamy sand, or loamy fine sand in some profiles. The thickness of the A horizon and the B1 horizon ranges from 16 to 24 inches. Reaction in the A and B horizons typically is neutral, but in some profiles the part of the B horizon below a depth of 18 inches is mildly alkaline and calcareous.

The colors in the C1 and C2 horizons are grayish brown, light yellowish brown, or light olive brown. Mottles range from few, faint to many, prominent. The textures in C1 and C2 horizons range from sand to fine sandy loam. The reaction ranges from neutral to moderately alkaline and weakly calcareous to calcareous.

The color of the IIC3 horizon ranges from dark grayish brown to pale olive. Mottles range from few, faint to many, prominent. The IIC3 horizon is silt loam or silty clay loam. In some profiles these materials are stratified. The content of clay in this horizon ranges from 20 to 25 percent. The IIC3 horizon ranges from mildly alkaline to moderately alkaline in reaction and from calcareous to strongly calcareous.

Swenoda soils are associated with Grimstad and Towner soils and are similar to Sverdrup soils. They lack the calcareous A horizon that is characteristic of Grimstad soils. They contain more silt and clay in the solum than Towner soils. They have a loamy IIC horizon above a depth of 40 inches that is lacking in Sverdrup soils.

Swenoda fine sandy loam, 0 to 2 percent slopes (SwA).—This soil occupies slightly convex areas that normally range from 5 to 30 acres in size. These soils commonly are on shallow outwash deposits associated with higher and more sloping soils or deeper deposits of sandy outwash. This soil also is associated with interbeach areas where soil materials are very mixed and relief is variable. The surface layer has a smooth appearance if cultivated. This soil has the profile described as representative for the series.

Included in mapping were areas of soils that lack the underlying finer textured material or have a thinner dark-colored surface layer. Also included were areas of more calcareous Grimstad soils or sandier Towner soils and areas of soils in which the underlying material averages more than 35 percent clay. These inclusions make up as much as 15 percent of any given area.

Many areas have been cultivated. Small grains are the most common crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay and pasture, and many of these are seeded to a legume or grass-legume mixture.

Use of this soil is limited by the lower available water capacity in the upper sandier part and a hazard of soil blowing. (Capability unit IIIs-1; tree and shrub suitability group 1)

Swenoda fine sandy loam, 2 to 8 percent slopes (SwC).—This soil occupies areas that generally range from 3 to 20 acres in size. These soils commonly are on shallow, sandy outwash deposits associated with till soils or deeper deposits of sandy outwash, all in a varied relief pattern. A few areas of this soil also are associated with interbeach areas where soil materials are very mixed. The surface layer of this soil has a smooth appearance if cultivated.

Included in mapping were areas of soils that have deeper sandy material and soils that have a dark-colored

surface layer less than 16 inches thick. Also included were areas of more calcareous Grimstad soils or sandier Towner soils and areas of soils in which the underlying material averages more than 35 percent clay. These inclusions make up as much as 15 percent of any given area.

Many areas have been cultivated. Small grains are the most common crop. A small acreage of corn and soybeans also is grown. Some areas are used for hay and pasture, and many of these are seeded to a legume or grass-legume mixture.

The hazards of water erosion and soil blowing are limitations on this soil. A lower available water capacity in the upper sandier part also is a limitation. (Capability unit IIIs-1; tree and shrub suitability group 1)

Syrene Series

The Syrene series consists of nearly level, poorly drained soils that formed in deep gravelly deposits associated with beach ridges. Slopes commonly are slightly concave, and many areas are affected by seep from the higher beach ridges. These soils formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is black sandy loam. This layer is strongly calcareous and is about 10 inches thick. The next layer is 8 inches of very strongly calcareous, dark-gray and gray sandy loam. Below this is grayish-brown, yellowish-brown, and light brownish-gray, strongly calcareous and calcareous gravelly loamy coarse sand and gravelly coarse sand.

Syrene soils have low available water capacity. Permeability is moderately rapid in the upper part and rapid in the lower part. Inherent fertility is medium. The seasonal water table fluctuates between depths of 1 foot and 5 feet. Some areas have been cultivated. With proper management, these soils are suited to most small grains. They are suited to grasses used for hay and pasture.

Representative profile of Syrene sandy loam in an idle meadow 246 feet north and 1,060 feet east of the southwest corner of sec. 24, T. 143 N., R. 45 W.

A1—0 to 10 inches black (N 2/0) sandy loam; moderate, very fine, granular structure; very friable; moderately alkaline; strongly calcareous; clear, irregular boundary.

C1cag—10 to 18 inches, dark-gray (N 4/0) sandy loam grading to gray (N 5/0) with depth; common fine streaks of very dark gray (2.5Y 3/1); weak, very fine, subangular blocky structures; very friable; moderately alkaline; very strongly calcareous; clear, wavy boundary.

IIC2cag—18 to 24 inches, grayish-brown (2.5Y 5/2) gravelly loamy coarse sand; few, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; very friable; about 20 percent gravel; moderately alkaline; strongly calcareous; clear, smooth boundary.

IIC3—24 to 28 inches, yellowish-brown (10YR 5/6) gravelly coarse sand; single grain; loose; mildly alkaline; calcareous; clear, broken boundary.

IIC4g—28 to 55 inches, light brownish-gray (2.5Y 6/2) gravelly coarse sand; single grain; loose; mildly alkaline; calcareous.

The A horizon generally is black, but in some profiles the lower part of the A horizon that contains more carbonates is very dark gray. The texture of the A horizon generally is sandy loam or loam, but in places it is silt loam or fine sandy loam. The thickness of the A horizon ranges from 8 to 16 inches. Reaction ranges from mildly alkaline to moderately alkaline, and it is calcareous to strongly calcareous. The structure is weak or moderate, granular or subangular blocky.

The colors in the C1cag and IIC2cag horizons range from dark gray to light olive gray and light brownish gray. Mottles range from few, faint to many, prominent. The C1cag horizon is sandy loam or loam, and the IIC2cag horizon is gravelly loamy sand or gravelly loamy coarse sand. The combined thickness of these horizons ranges from 7 to 20 inches. The colors in the IIC horizon below the IIC2cag horizon range from gray to light olive gray, and some profiles are mottled. Some profiles have thin or discontinuous layers that have a concentration of iron oxides and colors that are higher in chroma and redder or yellow in hue. The IIC horizon below the IIC2cag horizon is stratified sand and gravel or gravelly sand and gravelly coarse sand. The reaction in these horizons ranges from mildly alkaline to moderately alkaline, and they are calcareous to strongly calcareous.

Syrene soils are associated with Sioux and Hangaard soils and are similar to Mavie soils. They are more calcareous and more poorly drained than Sioux soils. They are more calcareous than Hangaard soils. They differ from Mavie soils in lacking a loamy IIC horizon above a depth of 40 inches.

Syrene sandy loam (Sy).—This nearly level soil occupies slightly concave areas that normally range in size from 5 to 30 acres. The landscape is associated with beach ridges and has slopes up to 2 percent. This soil commonly occupies scattered, elongated or irregularly shaped areas. In some areas cobblestones and stones are scattered on the surface.

Included in mapping were areas of Arveson soils that contain fine sand rather than gravel. Also included were areas of less calcareous Hangaard soils or Mavie soils that have finer textured underlying material. These inclusions make up as much as 15 percent of any given area.

A few areas have been cultivated, mainly for small grains. Many areas are used for hay and pasture. Such introduced grasses as quackgrass, bluegrass, redtop, and a few reeds and sedges commonly grow in these areas. Scattered trees, principally quaking aspen, also grow on this soil (fig. 16).

Wetness limits the use of this soil. A low available water capacity and medium inherent fertility also influ-

Figure 16.—Typical pasture vegetation on an area of Syrene sandy loam.

ence use and managment. (Capability unit IVw-1; tree and shrub suitability group 4)

Towner Series

The Towner series consists of nearly level, moderately well drained soils that formed in deposits of dominantly fine sand over loamy material. Topography commonly is complex, and it is characterized by alternate high and low areas of microrelief. These soils formed under tall prairie grasses.

In a representative profile, the surface layer is very dark gray loamy fine sand in the upper 8 inches and very dark brown fine sand in the lower 4 inches. The subsoil is 5 inches of very dark grayish-brown and dark-brown fine sand. The underlying material is mottled, dark grayish-brown and grayish-brown fine sand to a depth of 26 inches and strongly calcareous, light olive-brown loam to a depth of 60 inches.

Towner soils have a low to medium available water capacity. Permeability is rapid in the sand material and moderate in the finer underlying material. Inherent fertility is medium. The seasonal water table fluctuates between depths of 2½ feet and more than 6 feet. Some areas have been cultivated. With proper management, these soils are suited to such crops as oats, rye, and corn. They are suited to grasses used for hay and pasture.

Representative profile of Towner loamy fine sand in a field 230 feet south and 63 feet west of the northeast corner of sec. 33, T. 146 N., R. 45 W.

A11—0 to 8 inches, very dark gray (10YR 3/1) loamy fine sand; weak, very fine, granular structure; very friable; many, clean, bleached sand grains; neutral; gradual, wavy boundary.

A12—8 to 12 inches, very dark brown (10YR 2/2) fine sand; weak, very fine, granular structure; very friable; neutral; gradual, smooth boundary.

B2—12 to 17 inches, very dark grayish-brown (10YR 3/2) fine sand, grading to dark brown (10YR 3/3) in the lower part; few, fine, faint, brown (10YR 4/3) mottles; single grain; loose; neutral; clear, smooth boundary.

C1—17 to 21 inches, dark grayish-brown (10YR 4/2) fine sand; few, fine, distinct, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) mottles; single grain; loose; neutral; gradual, smooth boundary.

C2—21 to 26 inches, grayish-brown (10YR 5/2) fine sand; many, fine, distinct. yellowish-brown (10YR 5/4) mottles; single grain; loose; thin layer of gravelly fine sand and a few cobblestones at base of horizon; neutral; gradual, smooth boundary.

IIC3—26 to 31 inches, light olive-brown (2.5Y 5/4) loam; many, fine, prominent, light olive-brown (2.5Y 5/6) and olive-yellow (2.5Y 6/8) mottles; weak, medium, subangular blocky structure parting to weak, very fine, subangular blocky; friable; moderately alkaline; strongly calcareous; gradual, smooth boundary.

IIC4—31 to 60 inches, light olive-brown (2.5Y 5/4) loam; many, fine and medium. brownish-yellow (10YR 6/6) and light-gray (2.5Y 6/1) mottles; weak, medium, subangular blocky structure parting to weak, very fine, subangular blocky; friable; moderately alkaline; strongly calcareous.

The colors in the A1 horizon are very dark gray, black, or very dark brown. Some profiles have a very dark gray or very dark grayish-brown A3 horizon. Faint or distinct mottles are in the lower part of the A horizon of some profiles. The texture of the A horizon is generally loamy fine sand or fine sand, but in places it is loamy sand, fine sandy loam, or sandy loam. The total thickness of the A and B horizons ranges from 16 to 24 inches.

The C1 and C2 horizons range from dark grayish brown to light yellowish brown and light olive brown in color. Mottles range from few, faint to many, prominent. The C1 and C2 horizons generally are fine sand or sand, but in places they are loamy sand or loamy fine sand. There is a cobbly and gravelly layer that contains some sand in the lower part of the C2 horizon in many profiles.

The depth to the IIC horizon ranges from 20 to 40 inches. The colors in the IIC horizon range from gray, grayish brown, or dark grayish brown to pale olive. Mottles range from few, faint to many, prominent. The reaction ranges from mildly alkaline to moderately alkaline.

Towner soils are associated with Swenoda, Grimstad, and Kratka soils and are similar to Flaming soils. They contain less silt and clay in the A horizon and the B2 horizon than Swenoda soils. They have a noncalcareous A horizon, whereas Grimstad soils have a calcareous A horizon. They are better drained than Kratka soils. They have a loamy IIC horizon above a depth of 40 inches that is lacking in Flaming soils.

Towner loamy fine sand (To).—This nearly level soil is on a slightly uneven landscape that has some alternate concave and convex areas. Slopes range from 1 to 3 percent. Soil blowing is responsible for much of the uneven topography. Areas of this soil generally range from 5 to 30 acres in size. If cultivated, this soil commonly has a varied pattern of black and brownish surface colors.

Included in mapping were areas of soils that have a dark-colored surface layer less than 16 inches thick. These soils make up as much as 20 percent of any given area. Also included were areas of Flaming soils that have deeper sand, Swenoda soils that are finer textured, or Grimstad soils that are finer textured and more calcareous. These inclusions make up as much as 15 percent of any given area.

Some areas have been cultivated. Small grains are the most common crop, but some corn, soybeans, and flax also are grown. This soil is used for hay and pasture more than for row crops. Legumes or a grass-legume mixture is sometimes seeded for this purpose. A larger acreage is used for such introduced grasses as quackgrass, bluegrass, and redtop that also are used for hay or pasture. Scattered trees, principally quaking aspen, also grow on this soil.

Soil blowing is a hazard on this soil. A low available water capacity in the sandy material and medium inherent fertility also influence use and management. (Capability unit IVe-2; tree and shrub suitability group 5)

Ulen Series

The Ulen series consists of nearly level, somewhat poorly drained and moderately well drained soils that formed in deep deposits of lacustrine fine sand. Most slopes are slightly convex, and there are some alternate high and low areas of microrelief. These soils formed under tall prairie grasses.

In a representative profile, the surface layer is calcareous, black fine sandy loam in the upper 10 inches and strongly calcareous, very dark gray very fine sandy loam in the lower 5 inches. The next layer is dark grayish-brown and yellowish-brown loamy fine sand. This layer is very strongly calcareous and is 11 inches thick. Below this is mottled, light yellowish-brown to olive-yellow, calcareous loamy fine sand and fine sand (fig. 17).

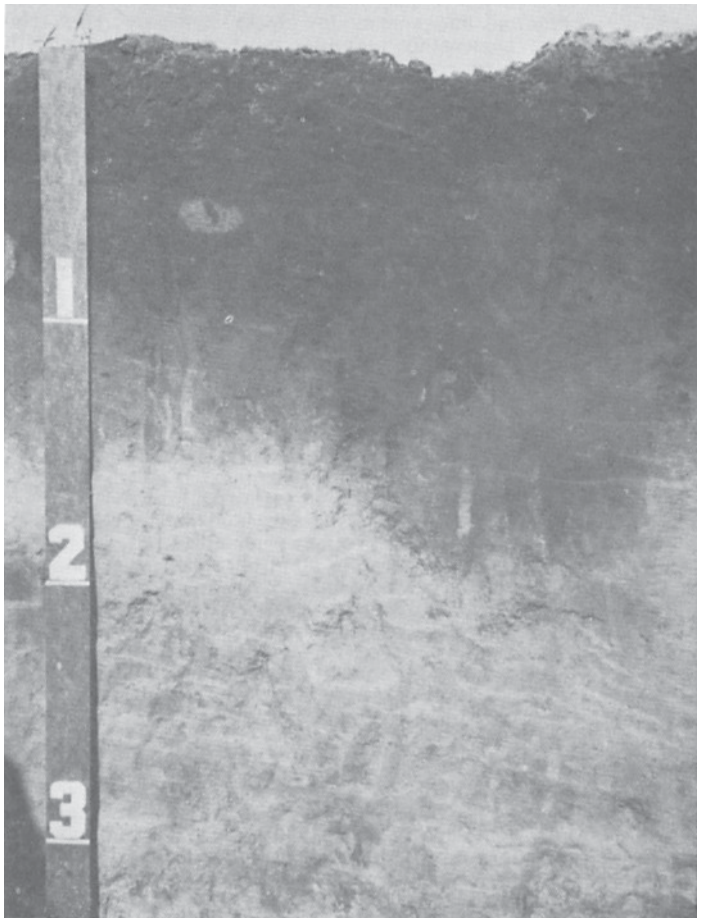

Figure 17.—**Profile of Ulen fine sandy loam, 0 to 2 percent slopes. The dark-colored surface layer grades to a zone of carbonate accumulation at a depth of about 10 inches.**

Ulen soils have medium to low available water capacity. Permeability is moderately rapid. Inherent fertility is medium. The seasonal water table fluctuates between depths of 2 and more than 6 feet. Many areas have been cultivated. The soils are suited to small grains generally grown in the county. They also are suited to soybeans, corn, and sunflowers.

Representative profile of Ulen fine sandy loam, 0 to 2 percent slopes, in a cultivated field 130 feet west and 280 feet north of the southeast corner of sec. 19, T. 144 N., R. 44 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam; weak, medium, angular blocky structure breaking to weak, fine, granular; very friable; common roots; mildly alkaline to moderately alkaline; calcareous; abrupt, smooth boundary.

A1ca—10 to 15 inches, very dark gray (10YR 3/1) very fine sandy loam; weak, fine and medium, subangular blocky structure; very friable; common roots; moderately alkaline; strongly calcareous; clear, wavy boundary.

C1ca—15 to 20 inches, dark grayish-brown (10YR 4/2) loamy fine sand; few, fine, faint, grayish-brown (10YR 5/2) mottles; weak, fine and medium, subangular blocky structure; very friable; few roots; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C2ca—20 to 26 inches, yellowish-brown (10YR 5/4) loamy fine sand; weak, medium, subangular blocky structure; very friable; few roots; about 5 percent root channel fillings of dark grayish brown (2.5Y 4/2); moderately alkaline; very strongly calcareous; clear, smooth boundary.

C3—26 to 32 inches, light yellowish-brown (10YR 6/4) loamy fine sand; weak, medium, subangular blocky structure; very friable; few roots; mildly alkaline; calcareous; clear, smooth boundary.

C4—32 to 39 inches, olive-yellow (2.5Y 6/6) fine sand; common, fine, faint, pale-yellow (2.5Y 7/4) mottles; single grain; loose; mildly alkaline; calcareous; clear, smooth boundary.

C5—39 to 60 inches, brownish-yellow (10YR 6/6) fine sand; common, medium, distinct, light brownish-gray (2.5Y 6/2), light-gray (2.5Y 7/2), and gray (2.5Y 6/1) mottles and few, medium, prominent, dark reddish-brown (5YR 3/4) mottles; single grain; a few, fine, black concretions; mildly alkaline; calcareous.

The colors in the A horizon are black, very dark gray, very dark brown, or very dark grayish brown. The texture of the A horizon generally is fine sandy loam or loamy fine sand, but sandy loam, loamy sand, and very fine sandy loam also are within the range. The structure is weak granular, angular blocky, or subangular blocky. The A1ca horizon is lacking in some profiles. The combined thickness of the A horizon ranges from 10 to 16 inches.

The colors in the Cca horizon are grayish brown, dark grayish brown, yellowish brown, or brown. Some faint mottles occur in this horizon in some profiles, but no distinct mottles occur within 20 inches of the surface. The Cca horizon has textures of loamy fine sand, sandy loam, fine sandy loam, and very fine sandy loam. It is strongly calcareous or very strongly calcareous and ranges from 6 to 16 inches in thickness. The colors in the C horizon below the Cca horizon range from brown to olive yellow. Mottles range from none to common, medium, prominent. This horizon generally is fine sand, but in places it is sand, loamy sand, or loamy fine sand. Reaction ranges from mildly alkaline to moderately alkaline.

Ulen soils are associated with Grimstad, Arveson, and Flaming soils and are similar to Glyndon soils. They lack the loamy IIC horizon above a depth of 40 inches that is characteristic of Grimstad soils. They are better drained than Arveson soils. They have a calcareous A horizon that Flaming soils lack. They contain more fine sand and less very fine sand and silt than Glyndon soils.

Ulen fine sandy loam, 0 to 2 percent slopes (UlA).—This soil occupies slightly convex areas that generally range from 10 to 50 acres in size. The topography is slightly uneven and has alternate high and low areas of microrelief. If this soil is cultivated, the surface layer has a smooth appearance and variations of black, very dark brown, and very dark gray surface colors. Clean, bleached sand grains often are in the surface layer and influence the color. This soil has the profile described as representative for the series.

Included in mapping were areas of more poorly drained Arveson soils, less calcareous Flaming soils, and Grimstad soils that contain loamy material within a depth of 40 inches. These inclusions make up as much as 15 percent of any given area. Some soils that have a high content of very fine sand also were included.

Many areas have been cultivated. Small grains are the most common crop, but corn, soybeans, sunflowers, and some other row crops also are grown. Many areas also are used for hay and pasture and are seeded to a grass-legume mixture or to such introduced grasses as quackgrass, Kentucky bluegrass, and redtop. Some scattered trees, principally quaking aspen, also grow on this soil.

Soil blowing limits the use of this soil. A medium to low available water capacity and a calcareous condition also influence use and management. (Capability unit IIIe-2; tree and shrub suitability group 2)

Ulen fine sandy loam, wind eroded (Un).—This nearly level soil occupies slightly convex areas that normally range from 10 to 35 acres in size. The topography is slightly uneven, with alternate high and low areas and slopes of less than 3 percent. If this soil is cultivated, the surface layer has a smooth appearance and very dark brown, very dark gray, and dark-gray colors. Clean, bleached sand grains are common in the surface layer and influence its color. Accumulation of soil along fencelines or other evidences of soil blowing are associated with areas of this soil. This soil has a profile similar to that described as representative for the series, except that the surface layer is less than 10 inches thick and may have grayer or browner colors.

Included in mapping were areas of less eroded Ulen soils that have a thicker dark-colored surface layer, more poorly drained Arveson soils, and more sandy and less calcareous Flaming and Poppleton soils. These inclusions make up as much as 15 percent of any given area.

Many areas have been cultivated. Small grains are the most common crop. Such row crops as corn, soybeans, and sunflowers also are grown. Some areas also are used for hay and pasture and are seeded to a grass-legume mixture or to such introduced grasses as quackgrass, Kentucky bluegrass, and redtop. Some scattered trees also grow on this soil.

Soil blowing is a limitation. The thin surface layer, calcareous condition, and medium to low available water capacity also influence use and management. (Capability unit IIIe–2; tree and shrub suitability group 7–C)

Vallers Series

The Vallers series consists of nearly level, poorly drained soils that formed in a thin mantle of silty sediments overlying loam and clay loam till. These soils are associated with an interbeach or upland landscape where soil materials are mixed and relief is low but variable. Slopes are slightly concave, and there are some closed depressions. These soils formed under tall prairie grasses, reeds, and sedges.

In a representative profile, the surface layer is about 12 inches thick. It is black, calcareous silt loam in the upper 8 inches and grades to strongly calcareous, very dark gray and dark-gray loam in the lower 4 inches. The next layer is 6 inches of very strongly calcareous, grayish-brown loam. Below this is strongly calcareous, mottled, light brownish-gray and light olive-gray clay loam and loam.

The available water capacity is high. Permeability is moderately slow. The seasonal water table fluctuates between depths of 1 foot and 6 feet or more. Inherent fertility is medium to high. Many areas of Vallers soils are cultivated. They are suited to small grains and to such row crops as corn and sunflowers.

Representative profile of Vallers silt loam 2,110 feet west and 2,130 feet north of the southeast corner of sec. 33, T. 144 N., R. 45 W.

A11—0 to 8 inches, black (10YR 2/1) silt loam; weak, very fine and fine, subangular blocky structure; very friable; moderately alkaline; calcareous; clear, smooth boundary.

A12ca—8 to 12 inches, very dark gray (10YR 3/1) loam, about 10 percent dark gray (10YR 4/1); weak, very fine, subangular blocky structure; very friable; moderately alkaline; strongly calcareous; clear, smooth boundary.

C1cag—12 to 18 inches, grayish-brown (2.5Y 5/2) loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C2g—18 to 25 inches, light brownish-gray (2.5Y 6/2) loam; common, medium, distinct, olive-yellow (2.5Y 6/6) and light olive-brown (2.5Y 5/6) mottles; weak, very fine, subangular blocky structure; very friable; about 5 percent coarse fragments; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C3g—25 to 33 inches, light brownish-gray (2.5Y 6/2) clay loam; common, fine, prominent, brownish-yellow (10YR 6/6 and 6/8) and yellowish-brown (10YR 5/6 and 5/8) mottles; weak, very fine, subangular blocky structure; slightly sticky; about 5 percent coarse fragments; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C4g—33 to 60 inches, light olive-gray (5Y 6/2) loam; many, medium, prominent, yellowish-brown (10YR 5/6) and dark reddish-brown (2.5YR 3/4) mottles; weak, very fine, subangular blocky structure; slightly sticky; about 5 percent coarse fragments; moderately alkaline; strongly calcareous.

The texture of the A horizon is generally silt loam or loam, but it is clay loam of silty clay loam in places. The thickness of the A horizon ranges from 8 to 16 inches. Mottling occurs in the lower part of the A horizon of some profiles. Structure ranges from weak to strong and is subangular blocky or granular. Reaction ranges from mildly alkaline to moderately alkaline. Colors in the C1cag horizon range from dark gray and dark grayish brown to light olive gray. Mottles range from few to common and from faint to prominent. In a few profiles there are no mottles in this horizon. The texture is generally loam, but it is clay loam or silty clay loam in places. This horizon is strongly or very strongly calcareous. Masses of gypsum crystals are in this horizon in some profiles. The colors in the rest of the C horizon range from grayish brown to light olive gray and light gray. Mottles range from few to many and from faint to prominent. The texture is loam or clay loam.

Vallers soils are associated with Roliss, Flom, Hamerly, and Kittson soils and are similar to Colvin soils. They have more lime in their A horizon than Roliss and Flom soils and are more poorly drained than Hamerly soils. They are more poorly drained than Kittson soils, which, in addition, have a noncalcareous A horizon. They have more sand and less silt in the A horizon and the C horizon than Colvin soils.

Vallers silt loam (Va).—This nearly level soil is in slightly concave areas that generally range from 5 to 40 acres in size. The landscape is rolling uplands or mixed, variable interbeach areas. This soil is in the shallow swales, natural draws, and low, nearly level areas. Slopes are less than 2 percent in most areas. Color at the surface is dominantly black, but there are many small areas of dark gray where carbonates are nearer the surface. In most places the surface is smooth, but clods usually form if the soil is cultivated when wet. Some coarse fragments, most of them the size of gravel but a few the size of cobblestones and stones, are scattered on the surface. Coarse fragments are least common in areas where the silt loam surface layer is thicker. This soil has the profile described as representative for the Vallers series.

Included in mapping were areas of soils that have less than 8 inches of surface layer or a very strongly calcar-

eous surface layer. These soils make up as much as 20 percent of any given area. Also included were areas of less calcareous Roliss and Flom soils and better drained Hamerly soils. These inclusions make up as much as 15 percent of any given area. Also included were areas where the surface layer of water-sorted silt loams is 24 inches or more thick.

Many areas are cultivated. Small grains are the most common crop, but some row crops, such as corn, soybeans, and sunflowers, are also grown. Some areas are used for hay and pasture. These areas are usually seeded to a legume or grass-legume mixture. There are also a few areas of trees and lowland brush.

Wetness is a limitation on this soil. Its strongly calcareous condition near the surface and the occurrence of cobblestones and stones also influence use and management. (Capability unit IIw-2; tree and shrub suitability group 4)

Vallers silt loam, depressional (Vd).—This soil is in closed depressions and the bottoms of natural draws. These low areas range from 3 to 15 acres in size. The landscape includes rolling uplands or interbeach areas. Relief is low and varied in places where the depressions are bordered by higher areas of Vallers, Hamerly, Roliss, and Kittson soils. A few stones, cobblestones, or pebbles are scattered on the surface of most of these depressions. The profile of this soil is similar to that of the soil described as representative for the Vallers series, except that more variation in thickness of the dark-colored surface layer is common.

Included in mapping were areas of less calcareous Roliss and Flom soils, which make up as much as 15 percent of any given area. Also included were areas of Cathro muck, which has an organic surface layer over loamy material, or of Marsh. These areas make up as much as 10 percent of any given area. Some depressions have 24 inches or more of water-modified silt loam or dark-colored colluvial material at the surface.

A few areas are cultivated for the production of small grains and corn or other row crops. The reeds and sedges that grow in many of these depressions are sometimes used for livestock feed. Many areas are idle and support a growth of reeds, sedges, cattails and willow brush.

Wetness is a limitation on this soil. It is common for water to be ponded in depressions. The strongly calcareous condition near the surface and the presence of stones and cobblestones also influence use and management. (Capability unit IIIw–2; tree and shrub suitability group 7–B)

Viking Series

The Viking series consists of nearly level, poorly drained soils that formed in water-modified clay till. These soils occur alone or in a complex with Hegne soils. The topography is smooth to slightly concave or, in the Hegne-Viking complex, characterized by strong microrelief. These soils formed under tall prairie grasses and wetland reeds and sedges.

In a representative profile, the surface layer is black clay loam and clay about 11 inches thick. The subsoil is calcareous, olive-gray clay about 22 inches thick. The underlying material is strongly calcareous, mottled olive-gray clay.

Viking soils have medium available water capacity. Permeability is slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet. Most areas have been cultivated for crops and used for hay and pasture. The soils are suited to most small grains and forage crops.

Representative profile of Viking clay loam, in a cultivated field 1,570 feet north and 500 feet east of the southwest corner of sec. 1, T. 146 N., R. 46 W.

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

A1—7 to 11 inches, black (10YR 2/1) clay; some very dark brown (10YR 2/2 coatings; moderate, fine, subangular blocky structure; friable; discontinuous gravelly layer in parts; mildly alkaline; calcareous; clear, smooth boundary.

B2g—11 to 18 inches, olive-gray (5Y 4/2) clay; moderate, medium and coarse, prismatic structure parting to moderate, very fine, subangular blocky; about 3 percent coarse fragments; few spots with colors of higher value and chroma along old root channels; sticky; mildly alkaline; calcareous; gradual, smooth boundary.

B3g—18 to 33 inches, olive-gray (5Y 4/2) clay; few, fine, prominent, yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) mottles; moderate, medium and coarse, prismatic sttucture parting to weak, very fine, subangular blocky; sticky; about 3 percent coarse fragments; few large, light-gray (5Y 7/1) masses of lime; mildly alkaline; calcareous; gradual, smooth boundary.

Cg—33 to 60 inches, olive-gray (5Y 4/2) clay; few, fine, prominent, yellowish-brown (10YR 5/6) and dark yellowish brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; sticky; few slickensides; about 3 percent coarse fragments; moderately alkaline; strongly calcareous.

The texture of the A horizon is sandy clay loam, silty clay loam, clay loam, silty clay, and clay. The thickness ranges from 9 to 18 inches. There is a layer of gravel and cobblestones from 1 to 5 inches thick in the lower part of the A horizon or in the upper part of the B horizon. This band of coarse material is commonly discontinuous.

The B2g horizon ranges from 3 to 10 inches in thickness. This horizon has colors of very dark gray, dark gray, dark olive gray, and olive gray. Mottles range from none to few, distinct. The texture ranges from silty clay loam to clay. There are some very dark gray coatings on faces of blocky peds in some profiles.

The B3g and C horizons have dark-gray, gray, or olive-gray and light olive-gray colors and distinct or prominent mottles. The average content of clay in the B and C horizons ranges from 60 to 78 percent. In most profiles the C horizon becomes massive somewhere below a depth of 5 feet. The reaction in the C horizon ranges from mildly alkaline to moderately alkaline.

Viking soils are associated with Roliss and Hegne soils and are similar to Fargo soils. They contain more clay than Roliss and Vallers soils, and they are less calcareous than Vallers soils. They contain more clay and more coarse fragments in the B and C horizons than Fargo soils.

Viking clay loam (Vk).—This nearly level soil occupies slightly concave areas that generally range from 10 to 60 acres in size. The landscape consists of slight depressions in shallow, microrelief topography. Slopes are 0 to 2 percent. If plowed, the surface layer has a cloddy appearance. Pebbles, cobblestones, and some stones are scattered on the surface. The amount of this coarse material on the surface or buried in the upper 18 inches is variable. This soil has the profile described as representative for the series.

Included in mapping were areas of coarser textured Roliss and Vallers soils. The Vallers soils also are more calcareous than Viking soils. Also included were areas of Rockwell and Mavie soils that differ from Viking soils in containing a sandy or gravelly layer that is more than 6 inches thick.

Many areas have been cultivated. Small grains are the most important crop. Pasture and hay also are important uses for this soil. Most pastures consist of such introduced grasses as quackgrass, redtop, and bluegrass. Areas harvested for hay produce these introduced grasses or a drilled grass-legume mixture, commonly brome and alfalfa. Some scattered trees, such as quaking aspen, cottonwood, and various kinds of brush, occur on areas of this soil.

Wetness limits the use of this soil. Structural damage and compaction result if this soil is cultivated when wet. Cobblestones and stones on the surface and buried in the upper 2 feet interfere with farm machine operation. (Capability unit IIw–1; tree and shrub suitability group 3)

Wahpeton Series

The Wahpeton series consists of nearly level to sloping, somewhat poorly drained soils. These soils formed in clayey alluvium deposited on high levee positions along major streams. The topography is nearly level except for some gentle swales that lead into deeper drainageways and narrow slopes on breaks along streams. These soils formed under trees and tall prairie grasses.

In a representative profile, the surface layer is black silty clay about 15 inches thick. The subsoil is 14 inches of very dark gray, very dark grayish-brown, and black clay. The underlying material is distinctly mottled, dark grayish-brown clay.

Wahpeton soils have medium available water capacity. Permeability is moderately slow. Inherent fertility is high. The seasonal water table fluctuates between depths of 2½ feet and more than 6 feet. Nearly all areas have been cultivated. A small acreage adjacent to streams is wooded. Wahpeton soils are suited to all crops commonly grown in the county.

Representative profile of Wahpeton silty clay, 0 to 2 percent slopes, in a cultivated field 2,320 feet north and 1,415 feet east of the southeast corner of sec. 1, T. 144 N., R. 49 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay; weak, very fine, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

A11—6 to 10 inches, black (10YR 2/1) silty clay; very dark gray (10YR 3/1) inclusions; weak, very fine, subangular blocky structure; friable; many roots; neutral; gradual, wavy boundary.

A12—10 to 15 inches, black (10YR 2/1) silty clay; many inclusions and coatings of very dark gray (10YR 3/1); weak, fine, prismatic structure parting to moderate, very fine, angular blocky; friable; many roots; neutral; clear, wavy boundary.

B2—15 to 25 inches, mixed very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) clay; moderate, medium, prismatic structure parting to moderate, fine, angular blocky; firm; thin black coatings on faces of blocky peds; abundant roots; neutral; gradual, smooth boundary.

B3—25 to 29 inches, very dark gray (10YR 3/1) clay; common layers of black (10YR 2/1); moderate, very fine, angular and subangular blocky structure; firm; many roots; neutral; clear, smooth boundary.

C—29 to 60 inches, dark grayish-brown (10YR 4/2) clay; few, fine, distinct yellowish-brown (10YR 5/8) mottles; weak, very fine, subangular blocky structure; firm; common masses of woody fragments; few roots; neutral to mildly alkaline; calcareous.

The thickness of the solum ranges from 20 to 50 inches or more. The colors in the A horizon range from black to very dark brown. The texture of the A horizon generally is silty clay, but silty clay loam and clay also are in the range.

The colors in the B horizon are very dark gray or very dark grayish brown. The texture in these horizons is clay or silty clay.

The C horizon has colors of dark grayish brown, grayish brown, and olive gray and contains bands or broken layers of black, very dark gray, and dark gray. Mottles range from none to many, distinct or prominent. Evidence of banding or lamination of soil materials is common in this horizon. The reaction in the C horizon ranges from neutral to mildly alkaline and calcareous. The content of clay generally averages 40 to 55 percent, and extreme ranges are 35 to 60 percent.

Wahpeton soils are associated with Cashel and Fargo soils. They differ from Cashel soils in being better drained, having a B horizon, and being less subject to flooding. They are better drained and have a thicker solum than Fargo soils.

Wahpeton silty clay, 0 to 2 percent slopes (WaA).—This soil occupies high levee positions near major streams. This soil has slightly convex slopes and occupies areas that range from 5 to 150 acres in size. If this soil is cultivated when wet, the surface has a cloudy appearance. This soil has the profile described as representative for the series.

Included in mapping were areas of more poorly drained Fargo soils that make up as much as 15 percent of any given area. Also included were areas of Cashel soils that are more subject to flooding and areas of the more calcareous Bearden soils. These inclusions make up as much as 10 percent of any given area.

Most areas have been cultivated. Small grains and sugar beets are the most common crops. Some sunflowers and soybeans also are grown. A small acreage is wooded and is idle or managed along with soil used for pasture.

If water levels are high in the adjoining streams, some areas of this soil flood. If this soil is worked when wet, compaction and damage to structure result. (Capability unit IIw–1; tree and shrub suitability group 1)

Wahpeton silty clay, 2 to 6 percent slopes (WaB).—This soil occupies high levee positions near major stream channels. These areas commonly range from 3 to 20 acres in size. Many of them are long and narrow, paralleling steeper slopes. If this soil is cultivated when wet, the surface has a cloddy appearance.

Included in mapping were areas of Fargo soils that are more poorly drained, Bearden soils that have a more calcareous surface layer, and Cashel soils that are more subject to flooding. These soils make up as much as 15 percent of any given area.

Most areas have been cultivated. Small grains are the most common crop, but sugar beets, soybeans, and some other row crops also are grown. Some areas are wooded and are idle or used for pasture.

High water in the adjoining streams floods some areas of this soil. Working this soil when it is wet causes compaction and structure damage. Water erosion is a slight hazard. (Capability unit IIw–1; tree and shrub suitability group 1)

Wahpeton silty clay, 6 to 12 percent slopes (WaC).—This soil occupies high levee positions near major stream channels. These areas commonly range from 3 to 10 acres in size. They commonly are long and narrow, paralleling steeper slopes, or are adjacent to lower terraces. This soil has a profile similar to the one described as representative for the series, except that there is more variation in thickness of the surface layer and subsoil.

Included in mapping were areas of soils that have thinner dark-colored layers and contain more calcareous and coarser textured material. They are similar to the soils included in the miscellaneous land type Breaks and Alluvial land. These inclusions make up as much as 15 percent of any given area.

A few areas have been cultivated. Small grains are the most common crop. Many areas still are wooded and are idle or are managed along with soils used for pasture.

High water in the adjoining streams floods some areas of this soil. Water erosion is a hazard. (Capability unit IIw–1; tree and shrub suitability group 1)

Waukon Series

The Waukon series consists of nearly level to hilly, well-drained soils that formed in loam till on uplands. These soils are associated with gently rolling to steep soils on a complex landscape. They formed under tall prairie grass and a later encroachment of mixed hardwoods.

In a representative profile, the surface layer is about 9 inches thick and is mainly very dark brown loam. The subsoil is about 17 inches of dark-brown and dark yellowish-brown sandy clay loam. The underlying material is strongly calcareous, light yellowish-brown loam (fig. 18).

Waukon soils have a high available water capacity. Permeability is moderate. Inherent fertility is high. The depth to the seasonal water table is more than 6 feet. Most areas have been cultivated. The soils are suited to small grains and to such row crops as corn and soybeans. Some hilly areas are suited to hay and pasture.

Representative profile of Waukon loam, 0 to 2 percent slopes, in a wooded area, 1,260 feet north and 300 feet east of the southwest corner of sec. 4, T. 146 N., R. 43 W.

A1—0 to 8 inches, very dark brown (10YR 2/2) loam; weak, very fine, subangular blocky structure; very friable; about 2 percent coarse fragments; many roots; neutral; clear, smooth boundary.

A2—8 to 9 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, thin, platy structure; very friable; about 2 percent coarse fragments; many roots; neutral; clear, smooth boundary.

B1t—9 to 18 inches, mixed dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, fine, subangular blocky structure; friable; about 4 percent coarse fragments; many roots; thin, nearly continuous, dark-brown (10YR 3/3) clay films on faces of peds; neutral; clear, smooth boundary.

B2t—18 to 26 inches, dark-brown (10YR 4/3) sandy clay loam; moderate, very fine and fine, subangular blocky structure; firm; many pale-brown (10YR 6/3) sand grains on faces of peds in upper part; very thin, discontinuous, dark-brown (10YR 3/3) clay films on faces of peds; about 4 percent coarse fragments; common roots; neutral; clear, smooth boundary.

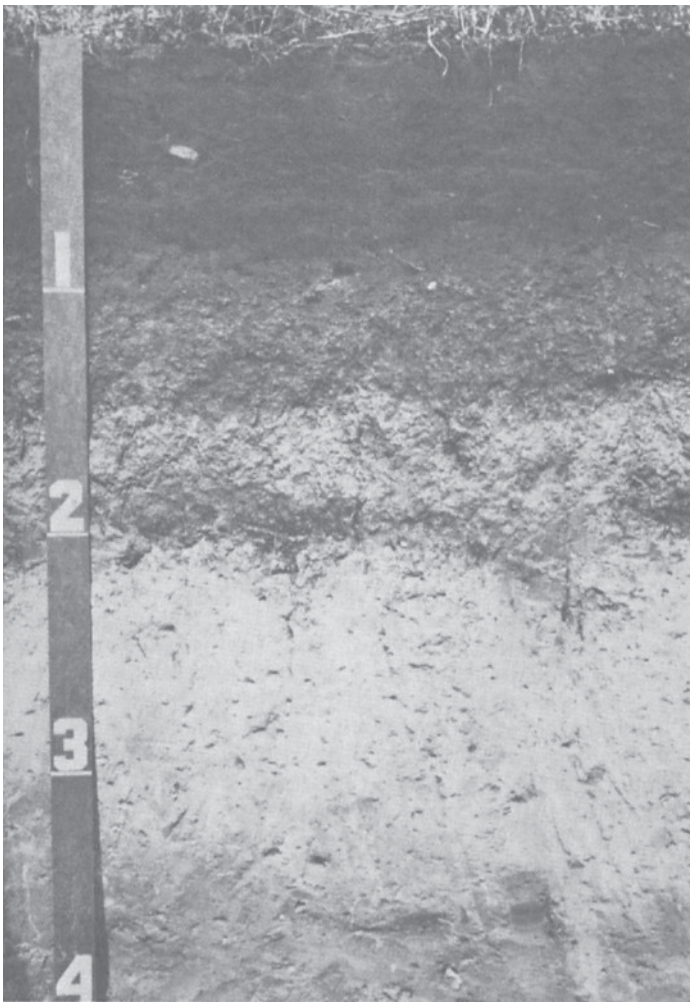

Figure 18.—**Profile of Waukon loam, 0 to 2 percent slopes, in a cultivated area. The lighter colors in the lower part of the subsoil result from sandy coatings on ped faces. The strongly calcareous underlying material begins at a depth of about 26 inches.**

C1ca—26 to 39 inches, light yellowish-brown (10YR 6/4) loam; weak, very fine, subangular blocky structure; friable; few, fine, distinct, white (10YR 8/1) and very pale brown (10YR 8/3) masses of lime; few, fine, prominent, dark-red (2.5YR 3/6) concretions; about 4 percent coarse fragments; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C2—39 to 50 inches, light yellowish-brown (2.5Y 6/3) loam; few, fine, distinct, brownish-yellow (10YR 6/6) mottles; weak, very fine, subangular blocky structure; friable; few, fine, prominent, dark-red (2.5YR 3/6) concretions; about 4 percent coarse fragments; moderately alkaline; strongly calcareous.

The thickness of the solum generally is 20 to 32 inches, and the extreme range is 18 to 40 inches. The Ap and A1 horizons have colors of very dark brown, very dark gray, or very dark grayish brown. The texture of these horizons generally is loam or fine sandy loam, but in places it is silt loam and clay loam. The thickness of the A1 or Ap horizon ranges from 6 to 10 inches. The structure is weak or moderate, granular or subangular blocky. The A2 horizon has colors of very dark gray, dark gray, gray, very dark grayish brown, dark grayish brown, or grayish brown. Its texture is loam, sandy loam, or fine sandy loam. The A2 horizon generally is mixed with the Ap horizon in cultivated areas.

The colors in the B horizon range from brown, dark brown, or yellowish brown to dark yellowish brown. The texture of the B horizon generally is clay loam or sandy clay loam, but in places it is loam and fine sandy loam. The structure in the B horizon generally is moderate or strong subangular blocky, and it is angular blocky in some profiles. There is a B3 horizon that has weaker structure and colors that have a 2.5Y hue in some profiles.

The C horizon has colors of brown, pale brown, light yellowish brown, yellowish brown, or light olive brown. Mottles range from few, faint to many, prominent. The texture generally is loam, but in places it is sandy loam. The reaction ranges from mildly alkaline to moderately alkaline.

Waukon soils are associated with Barnes, Kittson, and Langhei soils. They contain more translocated clay in the B horizon than Barnes soils and have a thinner A1 horizon than those soils. They are better drained than Kittson loam, uplands. They have a thicker solum than Langhei soils and lack the calcareous A horizon that is characteristic of those soils.

Waukon loam, 0 to 2 percent slopes (WkA).—This soil occupies slightly convex areas that normally range from 3 to 15 acres in size. These areas commonly occupy crests of high position on the landscape. Most areas are surrounded by or adjacent to more sloping soils. The landscape commonly is rather complex, with short, uneven slopes and abrupt changes in elevation, drainage, and in some areas, texture. Gravel and cobblestones are scattered on the surface in most areas. This soil has the profile described as representative for the series.

Included in mapping were areas of Barnes soils, more poorly drained Kittson loam, uplands, and sandier Swenoda soils. These soils make up as much as 15 percent of any given area. Also included were areas where there is sandy underlying material at a depth below 40 inches. Areas that have a thicker or darker surface layer also were included.

Most areas have been cultivated. Small grains are the most common crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay and pasture. These commonly are seeded to a legume or a grass-legume mixture. A few small areas are wooded, and oak and elm are the most common trees.

Climate limits the selection of crops that can be grown economically. (Capability unit IIc–1; tree and shrub suitability group 1)

Waukon loam, 2 to 6 percent slopes (WkB).—This soil occupies slightly convex areas that generally range from 3 to 40 acres in size. These areas vary in shape from elongated to nearly circular and commonly have a rather complex pattern of short slopes. The landscape is complex, and there are abrupt changes in elevation, drainage conditions, and, in some areas, soil materials. Gravel and cobblestones are scattered on the surface in most areas.

Included in the mapping were areas of Barnes soils and areas of moderately eroded Waukon soils that have a shallower surface layer and some dark-brown material from the subsoil exposed. These inclusions make up as much as 15 percent of any given area. Also included were areas of Darnen soils that have a thicker surface layer or areas of sandier Swenoda soils. These soils make up as much as 10 percent of any given area. Also included were areas that have sandy underlying material at a depth below 40 inches.

Most areas have been cultivated. Small grains are the most common crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay and pasture. These commonly are seeded to a legume or a grass-legume mixture. A few small areas are wooded, and oak and elm are the most common trees.

Water erosion limits the use of this soil. (Capability unit IIe–1; tree and shrub suitability group 1)

Waukon loam, 2 to 6 percent slopes, eroded (WkB2).—This soil occupies slightly convex areas that normally range from 3 to 20 acres in size. These areas vary in shape and commonly have a rather complex pattern of short slopes. The landscape is complex, and there are abrupt changes in elevation, drainage conditions and, in some areas, soil materials. Gravel and cobblestones are scattered on the surface in most areas. This soil has a profile similar to that described as representative for the series, except that ⅓ to ⅔ of the surface layer has been removed by water erosion. The removal of material from this soil is not uniform, and 50 to 80 percent of the acreage is eroded.

Included in mapping were areas of Barnes soils, sandier Swenoda soils, and more calcareous Langhei soils. These inclusions make up as much as 15 percent of any given area. Also included were areas that have sandy underlying material at a depth below 40 inches.

Most areas have been cultivated. Small grains are the most common crop, but corn, soybeans, and some other row crops also are grown. Some areas are used for hay and pasture. These commonly are seeded to a legume or a grass-legume mixture.

Water erosion limits the use of this soil. (Capability unit IIe–1; tree and shrub suitability group 1)

Waukon loam, 6 to 12 percent slopes (WkC).—This soil occupies areas that normally range from 3 to 15 acres in size. The landscape is complex, slopes are short, and there are abrupt changes in elevation, drainage conditions, and, in some areas, soil materials. Gravel and cobblestones are scattered on the surface in most areas. This soil has a profile similar to that described as representative for the series, except that there are areas that have a thinner surface layer.

Included in mapping were areas of eroded Waukon soils that have one-third to two-thirds of the surface layer removed by water action. These soils make up as much as 20 percent of any given area. Areas that have a thicker surface layer also were included. Also included were areas of Barnes soils, sandier Swenoda soils or more calcareous Langhei soils. These soils make up as much as 20 percent of any given area. Areas that have sandy underlying material at a depth below 40 inches also were included.

Many areas have been cultivated. Small grains are the most common crop. Some areas are used for hay and pasture and commonly are seeded to a legume or a grass-legume mixture. A few acres are used for such row crops as corn and soybeans. A few small areas are wooded, and oak and elm are the most common trees.

The hazard of water erosion limits the use of this soil. (Capability unit IIIe–1; tree and shrub suitability group 1)

Waukon loam, 12 to 18 percent slopes (WkD).—This soil occupies long areas that commonly parallel deep natural drainageways. These areas generally range from 3 to 15 acres in size. The landscape is complex, and has abrupt changes in elevation, drainage conditions, and, in some areas, soil materials. Gravel and cobblestones are

scattered on the surface in most areas. This soil has a profile similar to that described as representative for the series, except that there are areas that have a thinner surface layer.

Included in mapping were areas of Waukon soils that have had one-third to two-thirds of the surface layer removed by water erosion. These soils make up as much as 20 percent of any given area. Also included were areas of Barnes soils, sandier Swenoda soils, or more calcareous Langhei soils. These inclusions make up as much as 15 percent of any given area. Areas that have sandy underlying material at a depth below 40 inches also were included.

Some areas have been cultivated. Small grains are the most common crop. Many areas are seeded to grasses or a grass-legume mixture and are used for hay or pasture. Some areas also are wooded; and oak, elm, and maple are the most common trees.

There is a severe hazard of water erosion. (Capability unit IVe–1; tree and shrub suitability group 1)

Wheatville Series

The Wheatville series consists of nearly level, somewhat poorly drained and moderately well drained soils. These soils formed in loamy material high in content of very fine sand deposited over clay in lake basins. They formed under tall prairie grasses.

In a representative profile, the surface layer is black, strongly calcareous loam in the upper 8 inches and very dark gray sandy clay loam in the lower 3 inches. The next layer is about 10 inches of dark grayish-brown, very strongly calcareous sandy clay loam and very fine sandy loam. Below this is 9 inches of mottled, light yellowish-brown, strongly calcareous very fine sandy loam. The underlying material is mottled, grayish-brown, calcareous clay.

Wheatville soils have a medium to high available water capacity. Permeability is moderate in the loamy material and slow in the underlying clay. Inherent fertility is high. The seasonal water table fluctuates between depths of 2 feet and more than 6 feet. Nearly all areas have been cultivated. They are suited to all crops commonly grown in the county.

Representative profile of Wheatville loam in a field 370 feet south and 2,360 feet west of the northeast corner of sec. 10, T. 145 N., R. 46 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, very fine, granular structure; very friable; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

A1ca—8 to 11 inches, very dark gray (10YR 3/1) sandy clay loam; weak, very fine, subangular blocky structure; very friable; few dark yellowish-brown (10YR 4/4) stains along root channels; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C1ca—11 to 16 inches, dark grayish-brown (10YR 4/2) sandy clay loam; weak, very fine, subangular blocky structure; very friable; few inclusions of very dark grayish brown (10YR 3/2) in the upper part; moderately alkaline; very strongly calcareous; gradual, smooth boundary.

C2ca—16 to 21 inches, dark grayish-brown (10YR 4/2) very fine sandy loam; weak, very fine, subangular blocky structure; very friable; moderately alkaline; very strongly calcareous; clear, smooth boundary.

C3—21 to 30 inches, light yellowish-brown (2.5Y 6/4) very fine sandy loam; common, fine and medium, faint, olive-yellow (2.5Y 6/6) mottles; massive; very friable; few, fine, very dark gray (10YR 3/1) and very dark brown (10YR 2/2) concretions; moderately alkaline; strongly calcareous; clear, wavy boundary.

IIC4—30 to 60 inches, grayish-brown (2.5Y 5/2) clay; many, fine prominent, yellowish-brown (10YR 5/6) mottles and common, fine, faint, light-gray (2.5Y 7/2) mottles; weak, thin, platy structure parting to weak, very fine, subangular blocky; sticky; mildly alkaline; calcareous.

The depth to the IIC4 horizon ranges from 20 to 40 inches. The colors in the A horizon are black or very dark gray. The texture of the A horizon generally is loam, but in places it is very fine sandy loam, silt loam, or sandy clay loam. The structure of the A horizon is weak granualar or subangular blocky.

The colors in the C1ca and C2ca horizons range from dark grayish brown to grayish brown. There are faint mottles in the upper parts of these horizons in most profiles, but there are no distinct mottles within a depth of 20 inches. These horizons have textures of very fine sandy loam, loamy very fine sand, silt loam, loam, and sandy clay loam. They are strongly calcareous or very strongly calcareous and range from 6 to 16 inches in combined thickness.

The colors in the C3 horizon are pale brown or light yellowish brown, brown, yellowish brown, and light olive brown. Mottles range from faint to prominent. The C3 horizon generally is loamy very fine sand or very fine sandy loam, but in places it is loam or silt loam. Reaction ranges from mildly alkaline to moderately alkaline.

Colors in the IIC4 horizon range from dark gray and dark grayish brown to pale olive. Mottles range from faint to prominent. The IIC4 horizon has textures of clay, silty clay, or silty clay loam in a few profiles. Reaction ranges from mildly alkaline to moderately alkaline. Thin, ½- to 2-inch, silty layers are in the horizon in some profiles.

Wheatville soils are associated with Augsburg, Glyndon, and Bearden soils and are similar to Grimstad soils. They are better drained than Augsburg soils. They have a clayey IIC horizon that is lacking in Glyndon soils. They contain more sand and silt in the A and Cca horizons than Bearden soils. They contain more very fine sand and silt in the A and Cca horizons than Grimstad soils.

Wheatville loam (Wm).—This nearly level soil occupies slightly convex areas that generally range from 10 to 100 acres in size. Slopes are less than 3 percent. The surface of this soil has a smooth appearance if cultivated.

Included in mapping were areas of more poorly drained Augsburg soils that make up as much as 20 percent of any given area. Also included were areas of Glyndon and Borup soils that lack the underlying clay material and areas of Bearden soils that are finer textured above the underlying clay. These inclusions make up as much as 15 percent of any given area. A few saline spots were included. They commonly are less than 3 acres in size and can be recognized during the growing season by a very stunted crop growth.

Nearly all of this Wheatville soil is cultivated. Small grains, sugar beets, and soybeans are the most common crops. Some legumes are grown for plowdown as green manure. A very small acreage is used for hay and pasture.

Soil blowing and the very strongly calcareous condition of the soil are limitations to farming. (Capability unit IIe–2; tree and shrub suitability group 2)

Use and Management of the Soils

This section explains the system of capability classification used by the Soil Conservation Service and

describes the management of the soils by capability units. Predicted average acre yields of the principal crops are given. This section also discusses the use and management of the soils for wildlife, as woodland, and for engineering purposes.

Use of the Soils for Crops

Most of the farmland in Norman County is used for wheat, barley, and oats. Some soybeans are grown, with the largest acreage in the southern and eastern parts of the county. Sugar beets are an important crop on the medium-textured to fine-textured soils in the western half of the county. Sunflowers are a relatively new crop that has been gaining in importance. Some corn is grown, and a considerable acreage is seeded to legumes and various grasses. Corn generally is harvested for silage, but legumes and grasses are used for livestock feed or are plowed under as green manure. A relatively small acreage of potatoes also is grown in Norman County.

The gently sloping and more sloping soils are subject to water erosion if they are cultivated and not protected. Most slopes in Norman County are short and uneven and do not adapt well to a terracing plan. Farming on the contour and in strips and managing crop residues aid the control of water erosion. By slowing runoff, these practices also increase the water available to crops. The construction of grassed waterways helps to control erosion in areas where a flow of runoff water is concentrated.

Sandy soils are more subject to soil blowing than other soils. All soils, however, are subject to soil blowing if not protected. Vegetative cover, the return of crop residues, rough tillage, and field windbreaks aid in controlling soil blowing.

Improved drainage is needed on the wet, level and depressed soils. Open field ditches are used to remove excess surface water from these areas.

All crops grown in Norman County respond to applications of fertilizer. The amount and kind of fertilizer needed vary with the soil, the past and present management, and the crop grown. Applications of fertilizer should be based on information received from soil tests and field trials.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of farming. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are farmed, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classificiation is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs. The capability classification of any soil in the county can be learned by referring to the "Guide to Mapping Units."

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. There are no class I soils in Norman County.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

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

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. There are no class V soils in this country.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat. There are no class VII soils in this county.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes. There are no class VIII soils in this 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, although they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike

to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIe–2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Norman County are described and suggestions for the use and management of the soils are given. The soil series represented in each capability unit are named in the description of that unit, but this does not mean that all the soils of a given series are in the unit. To find the names of all the soils in a capability unit, refer to the "Guide to Mapping Units."

The miscellaneous land types Marsh and Gravel pits are not placed in a capability unit. Because the kind of soil in Marsh areas is not determined, proper classification cannot be made. Gravel pits are excavations where coarse materials have been removed for construction purposes. They represent no soil series and are not classified.

CAPABILITY UNIT IIe–1

This unit consists of medium-textured, gently sloping and sloping, somewhat poorly drained to somewhat excessively drained soils of the Barnes, Glyndon, Kittson, Langhei, and Waukon series. The soils of this unit are on till plains in the eastern part of the county. A small acreage of gently sloping Kittson soils occupies areas of lake-modified till in the eastern part of the glacial Lake Agassiz basin.

The surface layer is neutral, except in eroded areas of Barnes and Waukon soils that are mildly alkaline and calcareous in places and in areas of Langhei soils that are moderately alkaline and strongly calcareous. The organic-matter content is moderate to high except in Langhei soils, where it is low to moderate. The inherent fertility is high except in Langhei soils, where it is medium. Available water capacity is medium to high, and permeability is moderate.

The hazard of water erosion is the principal limitation to use of these soils. The strongly calcareous condition of Langhei soils also is a limitation.

Most areas of these gently sloping and sloping soils are used for crops. Wheat, barley, oats, soybeans, and corn grown principally for silage are the common crops. A small acreage is in grasses and legumes that are used for hay and pasture. In wooded areas oak, elm, and popple are the most common trees.

Such practices as rough tillage, stubble mulching, and planting parallel to the slope help to slow runoff and reduce erosion. The addition of barnyard manure, return of crop residues to the soil, and the plowdown of green-manure crops help to maintain organic-matter content and improve soil structure. The strongly calcareous Langhei soils need extra care to maintain fertility.

CAPABILITY UNIT IIe–2

This unit consists of medium-textured and moderately fine textured, somewhat poorly drained to moderately well drained, nearly level to sloping soils of the Bearden, Glyndon, Hamerly, and Wheatville series. The soils of this unit are in the western and central parts of the glacial Lake Agassiz basin. The Hamerly soils are associated with the till plain of the eastern part of the county.

The surface layer is moderately alkaline and is strongly calcareous. The organic-matter content is high, and the inherent fertility is medium to high. Available water capacity is medium to high. Permeability is moderate to moderately rapid except in areas of Wheatville soils, where is it moderate in the upper part and slow in the lower part.

Susceptibility to soil blowing and water erosion and the strongly calcareous surface condition are limitations to farming. Stones and cobblestones sometimes interfere with farming operations on the Hamerly soils.

Most areas of these nearly level to sloping soils are cultivated. Wheat, barley, oats, and sunflowers are the most common crops. Some soybeans, corn, and potatoes also are grown. Sugar beets are grown on all the soils in this unit except Hamerly soils. A small acreage is seeded to grasses and legumes used for hay and pasture or included in the rotation as a green-manure crop.

Such practices as rough tillage, stubble mulching, and the use of cover crops and field shelterbelts help to control erosion. The addition of barnyard manure, return of crop residues, and plowdown of green-manure crops maintain organic-matter content and improve soil structure. These strongly calcareous soils need extra care to maintain fertility. The removal of stones and cobblestones may be necessary to operate farm machinery efficiently on some areas of Hamerly soils.

CAPABILITY UNIT IIw–1

This unit consists of medium-textured to fine-textured; poorly drained and somewhat poorly drained; nearly level, gently sloping, and sloping soils of the Fargo, Flom, Roliss, Viking, and Wahpeton series. The Fargo and Wahpeton soils are in the western part of the glacial Lake Agassiz basin. The gently sloping and sloping soils represent a small acreage and occupy areas adjacent to streams and natural drainageways. The Viking and Roliss soils are on areas of water-modified till in the central and eastern parts of the Lake Agassiz basin. Flom soils are in areas of water-modified till in the uplands of the eastern part of the county.

The surface layer is neutral to mildly alkaline and is calcareous. It has high organic-matter content. The inherent fertility of these soils is high. They have medium to high available water capacity and are slowly to moderately permeable.

Wetness is the principal limitation to use of these soils. Structural damage and compaction result if these soils are cultivated when wet. Soil blowing is a hazard on fields that are smooth and have no vegetative cover. Water sometimes erodes the gently sloping and sloping Fargo and Wahpeton soils. Very high water in adjacent streams floods some areas of the Fargo and Wahpeton soils. Stones and cobblestones sometimes interfere with farming operations on the Viking, Roliss, and Flom soils.

Wheat, barley, oats, and sunflowers are the most commonly grown crops. Sugar beets are a common crop on nearly level Fargo and Wahpeton soils. A small acreage is used for soybeans, corn, and legumes and grasses for hay, pasture, or green manure.

Open field ditches are needed to reduce the wetness limitation on most areas. Growing deep-rooted legumes opens up the underlying material and improves internal drainage. Returning crop residues to the soil, the use of green-manure crops, and the application of barnyard manure maintain organic-matter content and maintain and improve soil structure. Timely tillage also is important, because working these soils when they are wet damages soil structure and makes seedbed preparation difficult. Such practices as rough tillage, stubble mulching, and cover cropping help to control soil blowing and water erosion. The removal of stones and cobblestones from some areas of Viking, Roliss, and Flom soils may be necessary to operate farm machinery efficiently.

CAPABILITY UNIT IIw–2

This unit consists of medium-textured, medium-textured over fine textured, moderately fine textured, and fine textured soils that are poorly drained to moderately well drained and nearly level. These are soils of the Colvin and Vallers series, Augsburg and Wheatville loams, Borup and Glyndon loams, and soils of the Bearden-Fargo, Hamerly-Vallers, and Hegne-Fargo complexes. The soils of this unit are in areas of the glacial Lake Agassiz basin and on the water-modified till plain of the eastern part of the county.

The surface layer of all except the Fargo soils is mildly alkaline to moderately alkaline and is moderately calcareous to strongly calcareous. The Fargo soils have a neutral surface layer. Organic-matter content is high. The inherent fertility is medium to high, and available water capacity is medium to high. Permeability is slow to moderate except in the Augsburg and Wheatville loams, where it is moderate in the upper part and slow in the underlying material.

Wetness is the principal limitation to use of these soils. Soil blowing is a hazard on fields that are smooth and have no vegetative cover. The soil complexes and undifferentiated units commonly occupy microrelief on which numerous draws and pockets are wetter than other areas and interfere with farming operations. Water occasionally erodes areas of these soils that have slopes of more than 1 percent. Stones and cobblestones interfere with farming operations on some areas of Hamerly and Vallers soils.

Wheat, barley, sugar beets, sunflowers, and legumes for green manure are the most common crops on the Bearden-Fargo, Augsburg and Wheatville, Borup and Glyndon, Hegne-Fargo, and Colvin soils. Wheat, barley, oats, some soybeans, corn, and legumes and grasses for hay and pastures are the most common crops on the Hamerly-Vallers complex and on the Vallers soils.

Open field ditches are needed to reduce wetness. Growing deep-rooted legumes aids in opening up the underlying material and improves internal drainage. Return of crop residues, plowdown of green-manure crops, and additions of barnyard manure help maintain organic-matter content, maintain and improve soil structure, and reduce the effect of carbonates on plant nutrient and water availability. Cultivating these soils when they are wet damages soil structure and makes seedbed preparation more difficult. Such practices as rough tillage, stubble mulching, and cover cropping help to control soil blowing and water erosion. The removal of stones and cobblestones from some areas of Hamerly and Vallers soils is necessary to operate farm machinery efficiently.

CAPABILITY UNIT IIc–1

This unit consists of medium-textured, somewhat poorly drained to well-drained, nearly level soils of the Barnes, Darnen, Kittson, and Waukon series. The soils of this unit are on the till plain of the eastern part of the county. A small acreage of Kittson soils is in higher areas on lake-modified till in the eastern part of the glacial Lake Agassiz basin.

The surface layer is neutral and has a moderate to high organic-matter content. The inherent fertility is high. Available water capacity is medium to high, and permeability is moderate.

Climate is the principal limitation to farming. Length of the growing season limits the selection of crops. Some crops do not return an economic yield when averaged over a number of years.

Most of this capability unit is used for crops. Wheat, barley, oats, soybeans, and corn grown mainly for silage are the common crops. Some areas, especially narrow areas of Darnen soils at the base of steeper soils, are used for hay and pasture. A small acreage, mainly on older farmsteads, is wooded. Oak, elm, and aspen are the most common trees.

The addition of barnyard manure, return of crop residues, and plowdown of green-manure crops are practices that help maintain organic-matter content and improve soil structure.

CAPABILITY UNIT IIIe–1

This unit consists of medium-textured, well-drained soils of the Barnes and Waukon series and a well-drained to somewhat excessively drained Langhei-Barnes complex. These soils are sloping and are in the till plain of the eastern part of the county.

The surface layer of Barnes and Waukon soils is neutral. Some mildly alkaline and calcareous spots are present in eroded areas of Barnes soils. Langhei soils are moderately alkaline and are strongly calcareous. The organic-matter content is moderate to high except in Langhei soils, where it is low to moderate. The inherent fertility of Barnes and Waukon soils is high, and that of Langhei soils is medium. Available water capacity is medium to high, and permeability is moderate.

Susceptibility to water erosion is the principal limitation to use of these soils. The strongly calcareous condition of Langhei soils also is a limitation.

Most of these sloping soils are used for crops. Wheat, barley, oats, soybeans, and corn grown mainly for silage are the common crops. Some areas are seeded to grasses or legumes and are used for hay and pasture. A small acreage is wooded, and oak, elm, and aspen are the most common trees.

Such practices as rough tillage, stubble mulching, contour stripping or planting parallel to the slope, and use of grassed waterways slow runoff and reduce erosion. The addition of barnyard manure, return of crop resi-

dues, and plowdown of green-manure crops help maintain organic-matter content and improve soil structure. The strongly calcareous Langhei soils need extra care to maintain fertility.

CAPABILITY UNIT IIIe-2

This unit consists of moderately coarse textured and medium-textured, somewhat poorly drained to moderately well drained, nearly level soils of the Grimstad and Ulen series and wind-eroded phases of Glyndon and Ulen soils. The soils in this unit are in the central and eastern parts of the glacial Lake Agassiz basin.

The surface layer commonly is moderately alkaline and is strongly calcareous. The organic-matter content is moderate to high, and the inherent fertility is medium to high. Available water capacity is medium for Ulen soils and high for Grimstad and Glyndon soils. Permeability is moderate and moderately rapid except in Grimstad soils, where it is moderately rapid in the upper part and moderate in the underlying material.

Susceptibility to soil blowing and the moderately alkaline and strongly calcareous surface condition are limitations to farming these soils.

Most areas in this unit are cultivated. Oats, wheat, barley, and grasses and legumes for hay and pasture are the most common crops. A smaller acreage is used for corn, potatoes, soybeans, sunflowers, and flax. Some scattered areas are wooded, and quaking aspen is the most common tree.

Such practices as stubble mulching and the use of cover crops and field shelterbelts help to control erosion. The addition of barnyard manure, return of crop residues, and plowdown of green-manure crops help maintain organic-matter content and reduce the effect of the strongly calcareous condition on fertility.

CAPABILITY UNIT IIIw-1

This unit consists of medium-textured to fine-textured soils of the Fargo, Flom, Roliss, and Vallers series. The Flom soils are in depressions with calcareous Vallers soils. The soils of this unit are in the glacial Lake Agassiz basin of the western and central parts of the county and the till plain of the eastern part.

The surface layer is neutral to moderately alkaline and is calcareous. It has high organic-matter content. The inherent fertility of these soils is medium to high. They have medium to high available water capacity and are moderately to slowly permeable.

Wetness is the principal limitation to farming. Stones and cobblestones sometimes interfere with farming operations on the Flom, Vallers, and Roliss soils. Unless drainage is provided, intermittent ponding of water in the depressions can be expected. Cultivation of these soils when they are wet damages soil structure and makes seedbed preparation more difficult.

Most areas of Fargo soils in depressions are part of cultivated fields that produce wheat, barley, sugar beets, sunflowers, and legumes and grasses for hay, pasture, or green manure. Many areas of Flom, Vallers, and Roliss soils in depressions are left idle and support reeds, sedges, cattails, and willows. Drained areas that adjoin cultivated fields are used for small grains or forage crops.

Open field ditches are needed to reduce the wetness limitation. During periods of excessive precipitation or spring runoff, these depressions may be flooded by water that backs up through the drainage system or overflows from the surrounding areas. The removal of stones and cobblestones may be necessary to operate farm machinery efficiently on the Flom, Vallers, and Roliss soils. Growing deep-rooted legumes improves internal drainage, and if the crop is plowed down, helps to maintain organic-matter content and soil structure. Timely tillage is important, because working these soils when they are wet damages soil structure.

CAPABILITY UNIT IIIw-2

This unit consists of moderately fine textured and medium-textured soils of the Colvin and Vallers series. The soils of this unit are in depressions in the western and central glacial Lake Agassiz basin and on the till plain of the eastern part of the county.

The surface layer is mildly alkaline to moderately alkaline and is moderately calcareous to strongly calcareous. It has high organic-matter content. The inherent fertility of these soils is medium to high. They have high available water capacity and moderately slow permeability.

Wetness is the principal limitation to farming. Stones and cobblestones sometimes interfere with farming operations on the Vallers soils. Unless drainage is provided, intermittent ponding of water in the depressions can be expected. Cultivating these soils when they are wet damages soil structure and makes seedbed preparation more difficult. The calcareous surface condition also is a limitation.

Most areas of Colvin soils are in the western half of the county and are farmed along with soils used for wheat, barley, sugar beets, sunflowers, and some legumes used mainly for green manure. The Vallers soils are mainly in the eastern one-third of the county in deep, pocket depressions that are difficult to drain. Many of these soils are idle and support a growth of reeds, sedges, cattails, and willows. If drained, areas of this soil are cultivated and produce small grains or forage crops or are included in improved pastures.

Open field ditches are needed to reduce wetness. During periods of excessive precipitation or spring runoff, depressions may be flooded by water that backs up through the drainage system or overflows from the surrounding area. The plowdown of legumes and return of crop residues maintain soil structure and improve internal drainage. These practices also help maintain organic-matter content and reduce fertility.

CAPABILITY UNIT IIIw-3

This unit consists of fine textured and moderately fine textured, poorly drained, nearly level Hegne-Viking complex. This complex is in areas of microrelief in the western part of the glacial Lake Agassiz basin. Soils in this complex are arranged in ridges or knobs and swales and depressions generally are oriented in a northwest-southeast direction. The Hegne soils occur on ridges and knobs, and the Viking soils occupy swales and depressions.

The surface layer of the Hegne soils is moderately alkaline, is strongly calcareous, and has high organic-mat-

ter content. The surface layer of the Viking soils is mildly alkaline, is calcareous, and has high organic-matter content. The inherent fertility of these soils is medium high to high. They have medium available water capacity and are slowly permeable.

Wetness is the principal limitation. The pattern and strength of the microrelief topography increases the difficulty of draining soils of this unit. Cultivating these soils when they are wet damages soil structure and makes seedbed preparation difficult. Soil blowing is a hazard on fields that are smooth and have no vegetative cover. Stones and cobblestones sometimes interfere with farming operations.

Wheat, barley, sunflowers, sugar beets, and legumes for plowdown as green manure are the most common crops. A small acreage is used for hay and pasture or is idle.

Open field ditches are needed to reduce wetness. Because of the strong microrelief, the number and depth of ditches needed are increased. Growing deep-rooted legumes removes water and improves internal drainage. The return of crop residues and the plowdown of green-manure crops help maintain and improve organic-matter content and soil structure and reduce the effect of carbonates on plant nutrient and water availability. Timely tillage is important, because cultivating these soils when they are wet damages soil structure. Such practices as rough tillage, stubble mulching, and cover cropping help to control soil blowing. The removal of stones and cobblestones from some areas is necessary to operate farm machinery efficiently.

CAPABILITY UNIT IIIw–4

This unit consists of medium-textured to moderately coarse textured, poorly drained, nearly level soils of the Arveson, Borup, Mavie, and Rockwell series. The Arveson, Mavie, and Rockwell soils are in the eastern part of the glacial Lake Agassiz basin. The Borup soils are in depressions in the central and eastern parts of this basin.

The surface layer is mildly alkaline to moderately alkaline and calcareous and strongly calcareous. It has high organic-matter content. The inherent fertility of these soils is medium to high. They have low to high available water capacity and are moderately or moderately rapidly permeable.

Wetness is the principal limitation to farming. The strongly calcareous surface condition also is a limitation. Soil blowing is a hazard on fields that have no vegetative cover. Intermittent ponding occurs on Borup soils in depressions.

Wheat, barley, oats, sunflowers, and grasses and legumes grown for hay and pasture are the most common crops. A smaller acreage is used for soybeans and corn. Some areas are idle and support reeds, sedges, some grasses, willows, and quaking aspen.

Open field ditches are needed to reduce wetness. The return of crop residues, plowdown of green-manure crops, and addition of barnyard manure are management practices that help maintain organic-matter content, maintain soil structure, and reduce the effects of carbonates on plant nutrient and water availability. Such practices as rough tillage and stubble mulching and the use of cover crops and field windbreaks help to control soil blowing.

CAPABILITY UNIT IIIw–5

This unit consists of fine-textured, somewhat poorly drained, nearly level to sloping soils of the Cashel series and Alluvial land, occasionally flooded. This unit is in areas of mixed alluvium that commonly are on narrow terraces and high bottom lands associated with streams and old stream channels.

The Cashel soils have little development and commonly are layered, fine-textured, mildly alkaline to moderately alkaline, calcareous and strongly calcareous, alluvial deposits. Alluvial land is variable in texture and drainage. It commonly varies from medium textured to fine textured and from neutral to moderately alkaline and strongly calcareous. Inherent fertility and organic-matter content commonly are high. Available water capacity is medium to high, and permeability is slow to moderate.

Wetness is the principal limitation. High water in adjoining streams and channels floods areas of this unit and sometimes erodes areas or deposits additional materials. Erosion is serious if a gully forms that affects the operation of farm equipment.

Wheat, barley, and oats are the most commonly grown crops. Some areas produce grasses and legumes used for hay and pasture. A considerable acreage is idle and supports trees.

If cultivated, the soils of this unit often require some improvement of adjoining channels or diking to reduce the hazard of flooding. Such practices as stubble mulching, use of cover crops, and grassing of drainageways and waterways help to control erosion.

CAPABILITY UNIT IIIs–1

This unit consists of soils that have a surface layer of medium-textured to moderately coarse textured material overlying sand or sand and gravel that is underlain by medium-textured to moderately fine textured material. The soils of this unit are moderately well drained to somewhat excessively drained, nearly level, gently sloping, and sloping. They are of the Foxhome, Sverdrup, and Swenoda series. They are in the eastern part of the glacial Lake Agassiz basin and the uplands of the eastern part of the county.

The surface layer is neutral in reaction and has moderate to high organic-matter content. The inherent fertility is medium to high. Available water capacity is medium in the Sverdrup soils and medium to high in the Foxhome and Swenoda soils. Permeability is rapid in the sandy and gravelly material, moderate in the finer textured underlying material of the Foxhome and Swenoda soils, and moderately rapid in the Sverdrup soils.

A low to medium available water capacity in the major root zone is the principal limitation. These soils also are susceptible to soil blowing and water erosion.

Many areas are cultivated, and oats, wheat, barley, corn, and soybeans are the most common crops. Some areas are seeded to grasses and legumes or support introduced and native grasses that are used for hay and pasture. There also are scattered wooded areas. Oak and popple are the most common trees.

Such practices as stubble mulching and the use of cover crops and field shelterbelts hold or more evenly distribute snow cover, conserve moisture, and control erosion. The addition of barnyard manure and return of crop residues maintain organic-matter content.

CAPABILITY UNIT IVe–1

This capability unit consists of medium-textured, moderately steep, well-drained to somewhat excessively drained Langhei-Barnes loams, 12 to 18 percent slopes, eroded, and well-drained Waukon loam, 12 to 18 percent slopes. The soils of this unit are on the till plain of the eastern part of the county. The Langhei and Barnes soils occur as a complex on an eroded landscape. The Waukon soils are in areas that have no to slight erosion.

The surface layers range from neutral for the Barnes and Waukon soils to moderately alkaline and strongly calcareous for the Langhei soils. Organic-matter content is low to moderate in the Langhei soils, moderate in the Waukon soils, and high in the Barnes soils. The inherent fertility is medium in Langhei soils and high in Barnes and Waukon soils. Available water capacity is medium to high, and permeability is moderate.

Susceptibility to water erosion is the principal limitation. Rapid runoff, especially from areas of Langhei soils, increases the possibility of erosion and reduces available water. The strongly calcareous condition of the Langhei soils also is a limitation.

Most areas are seeded to grasses and legumes for hay or pasture. A few areas are wooded, and oak and elm are the most common trees. A small acreage is used for wheat, oats, and barley.

Such practices as rough tillage, stubble mulching, and planting on the contour or in strips help to slow runoff and reduce erosion. Properly constructed grassed waterways and erosion control structures are needed in areas of concentrated runoff where gullies may form. The addition of barnyard manure, return of crop residues, and plowdown of green-manure crops increase and maintain organic-matter content and improve or maintain soil structure and fertility. The strongly calcareous Langhei soils need extra care to maintain fertility.

CAPABILITY UNIT IVe–2

This unit consists of coarse-textured, somewhat poorly drained and moderately well drained, nearly level soils of the Flaming, Poppleton, and Towner series. The soils in this unit are in the eastern part of the glacial Lake Agassiz basin.

The surface layer is slightly acid to neutral. Organic-matter content is low for Poppleton soils and moderate for Flaming and Towner soils. The inherent fertility is medium to low. Available water capacity is low or medium. Fluctuations in depth to the water table have a recharging effect on water available to plants. Permeability is rapid except in the underlying finer textured material of Towner soils, where it is moderate.

Susceptibility to soil blowing is the principal limitation to use of these soils. Medium to low inherent fertility also is a limitation.

Most areas are used for hay and pasture. Such introduced grasses as quackgrass, Kentucky bluegrass, and redtop commonly are used. Some areas are cultivated and produce oats, wheat, barley, flax, and corn harvested mainly for silage. These soils also have scattered wooded areas, and quaking aspen is the most common tree. A few plantings of pine, spruce, and cedar have been made.

Such practices as stubble mulching and the use of cover crops and field shelterbelts help to control erosion and conserve moisture. The addition of barnyard manure, return of crop residues, or plowdown of green-manure crops increases organic-matter content and improves fertility.

CAPABILITY UNIT IVw–1

This unit consists of soils that have a moderately coarse textured surface layer over gravelly coarse sand. They are poorly drained and somewhat poorly drained, nearly level soils of the Hangaard and Syrene series. The soils of this unit are in areas commonly associated with beach ridges in the eastern part of the glacial Lake Agassiz basin.

The surface layer of the Hangaard soils is neutral, and that of the Syrene soils is moderately alkaline and strongly calcareous. Both have high organic-matter content. The inherent fertility of these soils is medium. They have a low available water capacity and are moderately rapidly permeable.

Wetness is the principal limitation. The strongly calcareous surface condition of the Syrene soils also is a limitation. Soil blowing is a hazard on fields that are smooth and have no vegetative cover.

Small grains and grasses and legumes grown for hay and pasture are the most common crops. Some areas are left idle and support scattered trees, principally quaking aspen. Open field ditches are needed to reduce the wetness limitation. Cover crops, stubble mulching, and field windbreaks control soil blowing. The return of crop residues, plowdown of green-manure crops, and additions of barnyard manure help maintain organic-matter content and reduce the effect of carbonates on the nutrient availability in Syrene soils.

CAPABILITY UNIT IVw–2

This unit consists of soils that have a medium-textured to coarse-textured surface layer over deep sand, sand underlain by fine-textured material, or an organic surface layer overlying sandy or loamy material. These are soils of the Arveson, Cathro, Flaming, Hamar, Rockwell, Kratka, and Markey series. The soils in this unit are nearly level and are in depressed or low areas commonly located in the eastern part of the glacial Lake Agassiz basin and on uplands in the eastern part of the county. The undifferentiated unit, Flaming, Hamar, and Arveson soils, is on microrelief topography.

The surface layer of the Flaming, Hamar, and Kratka soils is slightly acid or neutral to mildly alkaline and is calcareous. The Cathro and Markey soils have a mildly alkaline surface layer that is calcareous. Arveson and Rockwell soils are moderately alkaline and strongly calcareous in the surface layer. The organic-matter content is moderate in Flaming, Hamar, and Kratka soils; high in Arveson and Rockwell soils; and very high in Cathro and Markey soils. The inherent fertility is low in Cathro and Markey soils and is high to low in other soils of this unit. Available water capacity is high in Cathro and Markey soils; medium in Arveson and Kratka soils; medium to high in Rockwell soils; and low in Hamar

and Flaming soils. Permeability is moderately slow in Kratka soils; moderate in Cathro and Rockwell soils; moderately rapid in Arveson and Markey soils; and rapid in Flaming and Hamar soils. The coarser textured underlying material in Markey soils is rapidly permeable, and the sandy upper layer of the Kratka and Rockwell soils is moderately rapidly permeable.

Wetness is the main limitation to use of these soils. Soil blowing is a hazard in areas where these soils lack vegetative cover. Soils in this unit are difficult to drain. Many occupy deep, pocket depressions. Ditches constructed to drain the sandy soils erode easily and are difficult to maintain.

Many areas are used for hay and pasture. Such introduced grasses as redtop, Kentucky bluegrass, and quackgrass are commonly used. A large acreage is left idle and supports a scattered growth of quaking aspen or willows. Cattails, reeds, and sedges are more common in very wet depressions. A small acreage has been cultivated and is used for oats, barley, flax, rye, and some corn for silage and fodder.

Open field ditches are needed to reduce wetness. Such practices as stubble mulching, cover cropping, and grassing waterways and ditches help to control erosion. Care in construction and maintenance of ditches also reduces the possibility of channel erosion.

CAPABILITY UNIT IVw–3

This unit consists of nearly level or depressed, organic soils of the Rondeau and Seelyeville series. The organic materials are mainly highly decomposed reed and sedge peats. The soils in this unit are in low areas, principally in the eastern one-third of the county.

The surface layer is mildly alkaline to moderately alkaline and is calcareous to strongly calcareous. The inherent fertility is low. These soils have very high available water capacity, Permeability is slow in the Rondeau soils and moderately rapid in the Seelyeville soils.

Wetness is the principal limitation to use of these soils. Their location on the landscape and the length of time they remain frozen (determined by the insulating properties of the organic material) increase the frost hazard. Fires that burn out parts of the organic material and leave the area pocketed also are a limitation.

Most areas are left idle. Reeds, sedges, cattails, and willow brush are the most common vegetation. Some areas are used for pasture or hay. A few drained areas have been cultivated and are used for forage crops, grasses harvested for seed, and occasionally, small grains.

Open field ditches are needed to reduce wetness. Many areas are difficult to drain because of the depth of the cut required or because of inadequate outlets. Extra care needs to be taken to maintain fertility of soils in this unit, especially of the strongly calcareous Seelyeville soils.

CAPABILITY UNIT IVs–1

This unit consists of coarse textured and moderately coarse textured, well-drained and excessively drained, nearly level to sloping soils of the Maddock and Sioux series. The soils of this unit are in the eastern part of the glacial Lake Agassiz basin and on uplands in the eastern part of the county.

The surface layer of these soils is neutral. Their organic-matter content is moderate to high, and the inherent fertility is medium to low. They have low available water capacity and rapid permeability.

The low available water capacity is the principal limitation to farming. The water table is so deep that it has little or no recharging effect on water available to plants. These soils also are susceptible to soil blowing and water erosion.

Most areas support introduced grasses and are used for hay and pasture. If cultivated, soils in this unit commonly produce oats, rye, soybeans, and corn grown mainly for silage. Some areas are wooded, and oak and popple are the most common trees. A few plantings of pine, spruce, and cedar have been made.

The use of stubble mulching, cover crops, and field shelterbelts aids in conserving moisture and controlling erosion in cultivated areas. Additions of barnyard manure and return of crop residues maintain organic-matter content.

CAPABILITY UNIT VIe–1

This unit consists of Langhei-Barnes loams, 18 to 30 percent slopes, and Breaks and Alluvial land. The Langhei-Barnes loams are on the till plain of the eastern part of the county and occur as a complex on this landscape. They are medium textured and well drained to somewhat excessively drained. Breaks and Alluvial land is in areas along rivers and streams. These areas vary in texture but commonly range from medium to fine. They are moderately steep and steep.

The surface layer ranges from neutral in the Barnes soil to moderately alkaline and strongly calcareous in the Langhei soil and neutral to mildly alkaline and calcareous in Breaks and Alluvial land. Organic-matter content is low to moderate in the Langhei soil, high in the Barnes soil, and medium to high in Breaks and Alluvial land. Inherent fertility is medium in the Langhei soil and high in the Barnes soil. Available water capacity is medium to high and permeability is moderate in the Barnes and Langhei soils. Available water capacity and permeability are variable in Breaks and Alluvial land.

Susceptibility to water erosion is the principal limitation. Rapid runoff increases the possibility of erosion and reduces the availability of water. The strongly calcareous surface condition of Langhei soil also is a limitation. Many slopes are short and uneven, making operation of farm machinery difficult.

Many areas of Langhei-Barnes loams are seeded to grasses and legumes and used for hay and pasture. Other areas are wooded, and oak and elm are the most common trees. Most areas of Breaks and Alluvial land are left idle and support a growth of trees, such as elm, popple, and various bottom-land hardwoods. These areas are suited to wildlife habitat.

Soils in this unit are too steep or inaccessible to be cultivated. Rotation of pastures to prevent overgrazing insures enough vegetative cover to slow runoff and reduce erosion. Properly constructed grassed waterways and structures control erosion in areas of concentrated runoff where gullies may form.

CAPABILITY UNIT VIw–1

This unit consists of moderately fine textured to moderately coarse textured Alluvial land, frequently flooded.

This miscellaneous land type is in old stream channels, in oxbows, and on the edges of active stream channels.

The alluvial land in this unit lacks uniformity in color, texture, and reaction. It exhibits little or no soil development, and material is deposited or removed each time the flooding occurs.

Wetness or flooding is the principal limitation. High water and runoff flood areas of this unit one to three times a year.

The wetness, flooding hazard, and inaccessibility of this unit restrict its use and seldom allow cultivation. If not affected by flooding, many areas can be pastured. Most areas, however, are left idle and support a growth of bottom-land hardwoods or wetland vegetation. Land in this unit is well suited to development of improved wildlife habitat.

CAPABILITY UNIT VIs-1

This unit consists of moderately coarse textured to coarse textured, well-drained to excessively drained, nearly level to very steep soils of the Sioux and Maddock series and Dune land. The soils of this unit are in the eastern part of the glacial Lake Aggasiz basin and on uplands in the eastern part of the county.

The surface layer is neutral or slightly acid. Organic-matter content is moderate to low, and the inherent fertility is low to medium. Available water capacity is low and very low, and permeability is rapid.

The principal limitation is low and very low available water capacity and generally low inherent fertility. Soil blowing and water erosion also are limitations.

Most areas are idle. They commonly support native and introduced grasses or scattered trees, principally popple and oak. A few areas are pastured or the grasses are harvested for hay. Some areas also have been planted to pine, spruce, and cedar. These plantings stabilize sand dunes and steep soils that are very subject to erosion. They provide recreational areas and wildlife habitat.

Plantings of trees and grasses should be utilized to provide cover in this unit. Limited grazing helps to control erosion.

Predicted yields

Table 2 lists predicted average acre yields for the principal crops grown in Norman County under two levels of management.

Columns A show yields to be expected under the management commonly used in the county. At this level, some fertilizer is used on grain and row crops, but the applications seldom are based on soil tests and average less than is needed for efficient utilization by the growing crop. Herbicides and pesticides are used, but not always in a timely or consistent manner. Crops are rotated and some green-manure crops are included, but efficient rotations are not followed. Erosion control practices are not used extensively. Some surface drainage is provided, but additional ditches are needed to reduce wetness on poorly drained soils. Pastures seldom are fertilized, but some manure is spread on these areas. Rotation grazing seldom is practiced.

Columns B show yields to be expected under a high level of management. At this level, fertilizer is applied according to soil test and recommendations based on field trials. These applications are made to get the maximum economic return from fertilizer. Herbicides and pesticides approved for use are applied when and where needed. Crop rotations are followed for efficient soil use. Erosion control practices are used where needed. Adequate drainage is provided to reduce wetness on poorly drained soils. Pastures are seeded or renovated, fertilized, and rotated or regulated for maximum grazing.

The predictions of yields were based on information received from several sources. Yields were measured on experimental plots for some soils. Records of yields and of soil management practices were reported by farmers for crops on some of the soils. Information was obtained from a study of the productivity of specific soils conducted jointly by the Soil Conservation Service, the Agricultural Extension Service, and the Department of Soils, University of Minnesota. Observations of crops were made, and farmers were interviewed during the course of the soil survey. The predictions were judged in relation to soil properties that are known to affect growth of crops and were compared with predictions made for similar soils in other counties and checked against average yields that are reported in data from the agricultural census.

The yields given in table 2 are those obtainable using present farming practices and varieties of crops. As agricultural technology advances, increased yields per acre might be obtained. It is also possible that plant diseases and pests might cause average yields to be less than those predicted.

Use of the Soils for Wildlife[3]

The soils of Norman County have the potential to provide excellent habitat for various species of wildlife. Table 3 shows the wildlife habitat potentials of the soils. Different soils have different potentials for wildlife habitat. In addition, there is a distinct interrelationship between the soil, the vegetative cover, and the kinds of wildlife. For example, soils in the Barnes-Kittson-Flom association have a high potential to produce habitat elements that the mallard duck requires. Cultivated areas of Barnes, Kittson, and associated soils produce such food plants as wheat, barley, and oats. Flom and Vallers soils in depressions, organic soils, and marsh areas produce cattails, bulrushes, sedges, and water-tolerant grasses, which provide nesting and brooding cover.

In dry years, resident waterfowl populations are more common in the Barnes-Kittson-Flom and the Hamerly-Vallers associations because they have pocket depressions that continue to provide some open-water areas and wetland vegetation for cover for nesting areas.

Norman County is in the native range of the prairie chicken and sharp-tailed grouse. However, these species are somewhat restricted to the Ulen-Arveson and Flaming-Hamar associations because these areas continue to provide more suitable habitat.

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[3] JOHN W. BEDISH, biologist, Soil Conservation Service, helped prepare this section.

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

[In columns A are yields expected under average management; in columns B are yields expected under improved

Soil	Oats		Wheat		Barley		Soybeans	
	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Alluvial land, occasionally flooded	40	70	20	40	25	50		
Alluvial land, frequently flooded								
Arveson loam	35	65	20	35	25	45	10	18
Arveson and Hamar soils, depressional	25	50	15	20	15	30		
Augsburg and Wheatville loams	50	80	30	45	35	55	15	25
Barnes loam, 0 to 2 percent slopes	55	80	35	45	40	65	18	26
Barnes loam, 2 to 6 percent slopes	55	80	35	45	40	60	17	26
Barnes loam, 2 to 6 percent slopes, eroded	50	75	30	40	35	55	16	25
Barnes loam, 6 to 12 percent slopes, eroded	45	70	25	35	30	50	12	21
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	45	75	25	40	35	55	14	23
Bearden silty clay loam, 0 to 2 percent slopes	50	80	30	45	35	55	15	25
Bearden silty clay loam, 2 to 6 percent slopes	50	80	30	45	35	55	14	24
Bearden silty clay loam, 2 to 8 percent slopes, eroded	45	75	25	40	30	50	12	22
Bearden-Fargo silty clay loams	45	75	25	45	30	55	14	24
Borup loam, depressional	30	60	20	35	20	45	10	18
Borup and Glyndon loams	45	80	30	45	35	55	15	25
Breaks and Alluvial land								
Cashel silty clay, 0 to 2 percent slopes[6]	45	75	30	40	35	55	14	23
Cashel silty clay, 2 to 8 percent slopes[6]	40	75	25	40	30	55	12	22
Cathro muck	30	60	20	30	20	40		
Colvin silty clay loam	45	75	25	45	30	55	15	23
Colvin silty clay loam, depressional	30	60	20	35	20	45	9	18
Darnen silt loam, 1 to 4 percent slopes	50	80	30	45	35	60	17	26
Dune land								
Fargo silty clay loam, 0 to 1 percent slopes	50	75	35	45	40	60	15	25
Fargo silty clay loam, 1 to 6 percent slopes	50	75	35	45	40	60	12	24
Fargo silty clay, 0 to 1 percent slopes	45	75	30	45	35	60	11	24
Fargo silty clay, 1 to 6 percent slopes	45	75	30	45	35	60	10	23
Fargo silty clay, depressional	30	60	20	35	25	45	8	18
Flaming loamy fine sand, wind eroded	25	55	10	20	25	35		
Flaming, Hamar, and Arveson soils	25	50	10	20	20	30		
Flom silty clay loam	55	75	35	45	40	60	15	25
Flom and Vallers soils, depressional	30	60	20	30	25	45	8	17
Foxhome loam, 0 to 3 percent slopes	45	70	25	35	30	50	12	22
Glyndon loam, 0 to 2 percent slopes	50	80	30	45	35	55	15	25
Glyndon loam, 2 to 6 percent slopes	50	80	30	45	35	55	13	23
Glyndon loam, wind eroded	45	75	30	40	35	55	14	24
Gravel pits								
Grimstad fine sandy loam	45	75	30	40	35	55	14	24
Hamar loamy fine sand	25	55	10	25	25	35		
Hamerly silt loam, 0 to 1 percent slopes	50	75	30	40	35	55	15	24
Hamerly silt loam, 1 to 5 percent slopes	50	75	30	40	35	55	14	23
Hamerly-Vallers silt loams	45	75	25	35	30	50	12	22
Hangaard sandy loam	30	55	15	25	25	40	9	15
Hegne-Fargo silty clays	40	70	25	45	35	55	10	22
Hegne-Viking complex	35	65	20	40	30	50	9	19
Kittson loam, 0 to 2 percent slopes	50	80	35	45	40	65	18	26
Kittson loam, 2 to 8 percent slopes	50	80	30	45	40	60	16	25
Kittson loam, uplands, 0 to 1 percent slopes	55	80	35	45	40	65	18	26
Kittson loam, uplands, 1 to 5 percent slopes	55	80	35	45	40	60	17	25
Langhei-Barnes loams, 6 to 12 percent slopes, eroded	40	65	25	35	30	50	11	18
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	30	50	20	30	25	40	8	12
Langhei-Barnes loams, 18 to 30 percent slopes								
Maddock loamy fine sand, 0 to 2 percent slopes	25	50	10	20	20	35	9	13
Maddock loamy fine sand, 2 to 8 percent slopes	25	50	10	20	20	35	8	12
Markey muck	20	50	10	20	20	35		
Marsh								
Mavie loam	40	60	20	30	25	40	10	17
Poppleton loamy fine sand	25	45	10	15	15	30	8	11
Rockwell fine sandy loam	40	70	25	35	30	50	11	21
Rockwell and Kratka soils, depressional	30	50	15	25	20	35		
Roliss loam	45	75	25	40	35	55	12	23
Roliss loam, depressional	30	55	20	30	25	45		
Rondeau muck								
Seelyeville muck								

See footnotes at end of table.

principal crops under two levels of management

management. Absence of a figure indicates the crop is not suited to the soil or ordinarily not grown on it]

Corn for silage		Sugar beets		Sunflowers [1]		Rotation hay and pasture [2]				Permanent pasture [3]	
A	B	A	B	A	B	A		B		A	B
Tons	Tons	Tons	Tons	Lb.	Lb.	Tons	AUD [4]	Tons	AUD [4]	AUD [4]	AUD [4]
						2.5	125	4.0	180	45	85
										25	70
6	11			650	950	1.5	75	3.0	160	35	80
4	7									90	[5]230
7	13	11	17	750	1,050	2.7	135	4.0	180	50	95
9	15			800	1,150	3.2	155	4.5	200	65	105
8	15			800	1,150	3.2	155	4.5	200	65	105
7	14			750	1,100	3.0	150	4.2	190	60	100
6	12			700	1,000	2.5	125	3.5	175	45	90
6	13			700	1,050	3.0	150	4.2	190	60	100
7	13	11	17	750	1,100	2.7	135	4.1	185	60	95
6	13	10	16	700	1,050	2.7	135	4.1	185	60	95
						2.5	125	3.7	175	45	90
5	12	10	16	700	1,050	2.5	130	4.0	180	50	95
4	10	8	13							100	[5] 250
7	13	10	17	750	1,100	2.7	135	4.0	180	50	95
										25	70
7	13	9	15	700	1,050	2.7	135	4.0	180	50	95
6	12	8	14			2.7	135	4.0	180	50	95
										100	[5] 250
6	12	10	17	750	1,050	2.5	125	4.0	180	45	95
4	10	8	13							100	[5] 250
8	15					3.2	135	4.5	200	65	105
										15	30
7	13	11	17	750	1,150	2.7	135	4.1	185	50	95
6	13	9	16	750	1,100	2.7	135	4.1	185	50	95
6	13	10	17	700	1,100	2.5	125	4.0	180	45	95
5	12	9	16	700	1,100	2.5	125	4.0	180	45	95
4	10	7	13	600	950	1.6	85	3.0	160	40	80
4	9					1.5	75	2.5	125	35	80
3	8					1.5	75	2.0	100	30	75
7	14			750	1,050	2.7	135	4.1	185	50	95
4	9									100	[5] 250
6	11			650	950	2.5	125	3.8	180	40	80
8	13	10	16	750	1,100	2.7	135	4.0	180	50	90
7	12	9	15	750	1,100	2.7	135	4.0	180	50	90
7	12	9	16	700	1,050	2.6	135	3.8	175	45	85
8	13			700	1,050	2.6	135	3.8	175	50	90
4	10					1.7	80	2.7	130	40	80
7	12			700	1,100	2.7	135	4.0	180	50	90
6	11			700	1,050	2.7	135	4.0	180	50	90
5	11			650	1,050	2.7	135	3.8	175	45	85
5	11			600	900	1.5	75	2.7	130	40	80
4	11	9	15	650	1,050	2.0	85	3.0	160	45	85
4	10	8	14	600	1,000	1.7	80	2.7	140	40	80
9	15			700	1,100	3.2	155	4.5	200	65	105
8	14			700	1,050	3.2	155	4.5	200	65	105
9	15			700	1,050	3.2	155	4.5	200	65	105
8	15			700	1,050	3.2	155	4.5	200	65	105
5	11			650	1,000	2.4	120	3.4	170	45	90
4	9					2.0	100	3.0	150	35	70
						1.5	70	2.5	120	30	70
4	9			600	900	1.5	75	2.5	120	35	75
3	8			550	850	1.5	75	2.5	120	35	75
										90	[5] 240
6	12			600	950	1.7	85	3.0	155	40	85
3	7			600	900	1.5	75	2.0	100	30	75
6	12			650	1,000	2.0	100	3.2	165	45	90
4	8									95	[5] 245
7	13			650	1,050	2.7	135	3.8	185	50	95
5	8									100	[5] 250
										90	[5] 230
										95	[5] 240

See footnotes at end of table.

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

Soil	Oats		Wheat		Barley		Soybeans	
	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Sioux sandy loam, 0 to 2 percent slopes	25	45	10	20	20	30	8	11
Sioux sandy loam, 2 to 6 percent slopes	25	45	10	20	20	30	7	10
Sioux gravelly sandy loam, 0 to 2 percent slopes								
Sioux gravelly sandy loam, 2 to 8 percent slopes								
Sioux and Maddock soils, 12 to 36 percent slopes								
Sverdrup fine sandy loam, 0 to 2 percent slopes	35	60	20	35	25	45	12	18
Sverdrup fine sandy loam, 2 to 8 percent slopes	35	60	20	30	25	40	10	17
Swenoda fine sandy loam, 0 to 2 percent slopes	45	75	30	40	35	55	15	25
Swenoda fine sandy loam, 2 to 8 percent slopes	40	75	25	40	30	55	13	24
Syrene sandy loam	30	55	15	25	20	35	8	11
Towner loamy fine sand	30	55	15	25	30	40	10	15
Ulen fine sandy loam, 0 to 2 percent slopes	45	70	25	35	30	50	12	22
Ulen fine sandy loam, wind eroded	40	65	20	30	25	45	10	20
Vallers silt loam	40	70	25	40	30	50	12	22
Vallers silt loam, depressional	25	55	15	30	20	40	8	16
Viking clay loam	40	75	25	40	30	55	10	23
Wahpeton silty clay, 0 to 2 percent slopes	55	80	35	45	45	65	17	25
Wahpeton silty clay, 2 to 6 percent slopes	55	80	35	45	45	65	16	24
Wahpeton silty clay, 6 to 12 percent slopes	50	75	30	45	40	60	13	22
Waukon loam, 0 to 2 percent	55	80	35	45	45	65	17	26
Waukon loam, 2 to 6 percent slopes	50	80	35	45	40	65	16	25
Waukon loam, 2 to 6 percent slopes, eroded	50	75	30	40	40	60	15	23
Waukon loam, 6 to 12 percent slopes	45	70	25	35	35	55	12	20
Waukon loam, 12 to 18 percent slopes	40	65	20	30	30	50	10	17
Wheatville loam	50	80	35	45	35	55	15	25

[1] Sunflowers are more recent as an important crop, and less yield information is available. Yields for oil-producing varieties may be higher. New varieties, especially introduced hybrids, could substantially raise yields.

[2] Yields are those expected if a mixture of alfalfa and bromegrass is grown. Expected yields are slightly less for alfalfa alone.

[3] Permanent pasture yields are for such introduced grasses as redtop, quackgrass, Kentucky bluegrass, and timothy.

TABLE 3.—*Wildlife habitat potentials of the soils*

Soil association [1]	Potential habitat for [2]—				
	Upland game			Waterfowl (ducks and geese) and furbearers (mink and muskrat) [3]	Big game (deer)
	Prairie chickens and sharp-tailed grouse	Squirrels	Rabbits		
1. Fargo association	High	Low	Medium to high	High	Low.
2. Hegne-Fargo association	Medium	Low	Medium	High	Low.
3. Bearden-Colvin association	High	Low	Medium to high	High	Low.
4. Hegne-Viking association	Medium	Low	Medium to high	High	Low.
5. Glyndon-Wheatville-Borup association.	High	Low	Medium to high	Medium to high	Low.
6. Grimstad-Rockwell association	Medium to high	Low	Medium to high	High	Low.
7. Ulen-Arveson association	High	Low	Medium	Medium	Low to medium.
8. Kittson-Roliss-Viking association	Medium to high	Low	Medium	Medium	Low to medium.
9. Sioux-Syrene-Sverdrup association	High	Low	Medium	Medium to high	Low to medium.
10. Flaming-Hamar association	High	Low	Medium	Medium	Low to medium.
11. Barnes-Kittson-Flom association	Medium	Medium	Medium	High	Low to medium.
12. Hamerly-Vallers association	Medium	Low	Medium	High	Low.

[1] See General Soil Map for location.

[2] Habitat management is employed as required.

[3] Very poorly drained and poorly drained soils in depressions have a high potential for wetland development.

crops under two levels of management—Continued

Corn for silage		Sugar beets		Sunflowers [1]		Rotation hay and pasture [2]				Permanent pasture [3]	
A	B	A	B	A	B	A	B	A	B	A	B
Tons	*Tons*	*Tons*	*Tons*	*Lb.*	*Lb.*	*Tons*	*AUD* [4]	*Tons*	*AUD* [4]	*AUD* [4]	*AUD* [4]
4	8			600	900	1.4	70	2.4	115	30	70
3	7			600	900	1.4	70	2.4	115	30	70
										20	45
										20	45
										20	40
7	12			650	950	2.0	100	2.7	135	45	80
6	11			600	900	2.0	100	2.7	135	45	80
8	13			700	1,050	2.6	135	3.8	175	50	90
7	12			650	1,000	2.6	135	3.8	175	50	90
4	10			550	850	1.5	75	2.6	125	40	80
5	10			650	900	1.7	85	2.7	140	40	85
7	12			650	1,000	2.0	100	3.0	155	40	80
6	11			600	950	1.8	85	2.5	125	35	75
6	12			700	1,050	2.5	125	3.8	175	45	95
3	8									100	[5] 250
6	12			650	1,050	2.5	125	4.0	180	45	95
8	14	12	18	800	1,150	3.2	155	4.5	200	65	105
7	14	11	17	800	1,150	3.2	155	4.5	200	65	105
6	13					3.0	150	4.2	190	60	100
9	15			800	1,150	3.2	155	4.5	200	65	105
8	14			800	1,150	3.2	155	4.5	200	65	105
7	13			750	1,100	3.0	150	4.2	190	60	100
6	12			700	1,050	2.7	135	3.7	175	55	95
5	10					2.5	125	3.2	155	45	85
8	13	12	17	750	1,100	2.8	130	4.1	185	50	95

[4] AUD: Animal-unit-days is a term used to indicate the carrying capacity of pasture. An animal-unit-day is the number of days during a normal growing season that 1 acre will provide grazing for an animal unit (one cow, horse, or steer; five hogs; or seven sheep) without injury to the pasture.

[5] These yields are for reed canarygrass. Yields of other grasses on these soils are too variable to predict.

[6] If soils are flooded and wet for several years, yields will be lower.

White-tailed deer range throughout the county but are more concentrated along the wooded river bottoms and the eastern half of the county where more cover is available.

Norman County has a small pheasant population. It is on the northern edge of the pheasant range.

Soil features, such as topography, drainage, and texture, as well as existing land use, have influenced the wildlife uses within the county. These features make it possible to separate the county into three areas that have different wildlife uses. These areas can be located by referring to the General Soil Map.

Area I consists of the Fargo, Hegne-Fargo, Bearden-Colvin, Hegne-Viking, and Glyndon-Wheatville-Borup associations. These areas commonly have nearly level topography with some depressions. In wet years, water is ponded in these depressions. Ditches have been constructed to drain excess surface water from soils in most of these associations, so ponding normally is of a temporary nature. Waterfowl nesting is limited by this lack of ponded water and by lack of adequate or permanent cover. Upland game birds, such as the prairie chicken and sharp-tailed grouse, have very limited habitat. Some cover for deer is provided in the wooded areas along streams, channels, and farmstead windbreaks.

Area II consists of the Grimstad-Rockwell, Ulen-Arveson, Kittson-Roliss-Viking, Sioux-Syrene-Sverdrup, and Flaming-Hamar associations. The topography in this area is nearly level, with some gently sloping and sloping soils. Some depressions and low seep areas also occur. Areas suitable for wildlife habitat are available to waterfowl for longer periods of time than those in Area I. Wet seep areas on gravelly beach ridges are less intensively farmed and provide habitat for waterfowl. Wooded areas provide more suitable cover for white-tailed deer. There is also better habitat for upland game birds, such as the sharp-tailed grouse and Hungarian partridge.

Area III consists of the Barnes-Kittson-Flom and Hamerly-Vallers associations. The topography of this area ranges from depressed to very steep. This area has more waterfowl habitat than Areas I and II. Wet depressions with marsh vegetation and intermittent open water are scattered throughout this area. Grassed areas used for pasture provide additional nesting. There is good deer cover in wooded areas on steeper soils and in farm woodlots and farmstead windbreaks.

Woodland and Windbreaks [4]

Except for small wooded areas in the northeastern and east-central parts of the county and a narrow band along the major rivers, nearly all of Norman County was orig-

[4] JOHN HULTGREN, woodland conservationist, Soil Conservation Service, helped prepare this section.

inally prairie. Some trees, principally quaking aspen, encroach upon the original grassland a short distance west of the first major beach ridge, or approximately 16 miles west of the eastern boundary of the county.

In Norman County trees and shrubs are more important for windbreaks and beautification than for use in commercial forest products. Field windbreaks were first planted extensively on coarser textured, drier soils during the soil blowing of the 1930's. Plantings of this type have since been established in all parts of the county for purposes of protection, beautification, wildlife habitat, and recreation (fig. 19). Other plantings, principally pine, were made during the early 1940's to stabilize sand dunes. These plantings are now well established and provide recreation and wildlife habitiat in addition to controlling erosion (fig. 20). Plantings are being expanded to include a larger area of these very erodible sands.

For convenience, the soils in Norman County have been placed into tree and shrub suitability groups as listed in table 4. For soils in a complex or undifferentiated unit, if the individual soil can be identified, it is best to refer to the suitability group for that soil. For example, Langhei-Barnes loams, 6 to 12 percent slopes, eroded, is in suitability group 2, but the Barnes part of the complex is best adapted to suitability group 1.

Each group consists of soils that have similar characteristics that affect the survival and growth of trees and shrubs. Characteristics that affect the placement of soils in these groups are drainage, depth to water table, reaction (pH value), texture, available water capacity, and inherent fertility. Species to plant or to favor in stands, seedling mortality, plant competition, erosion hazard, and equipment limitations are other factors used to group the soils.

Seedling mortality refers to the expected loss of naturally occurring or planted seedlings, as a result of unfavorable soil characteristics. Mortality is slight if the expected loss is less than 25 percent. It is moderate if the expected loss is between 25 and 50 percent. Mortality is severe if the expected loss is more than 50 percent.

Plant competition refers to establishment problems of a desired species because of encroachment of competing vegetation. Competition is slight if competing vegetation does not cause mortality or restrict growth of seedlings. It is moderate if the plant invaders delay, but do not prevent, the establishment of a normal, fully stocked stand of desirable species. Competition is severe if grass, brush, or undesirable trees prevent adequate regeneration. Intensive site preparation and maintenance are needed.

Figure 19.—Aerial view of the village of Halstad in the west-central part of the county. Older plantings in the center of town and along the Red River of the North are in the background. More recent plantings for windbreak and beautification are on the outer edges of the village. The most common soil in this area is Fargo silty clay.

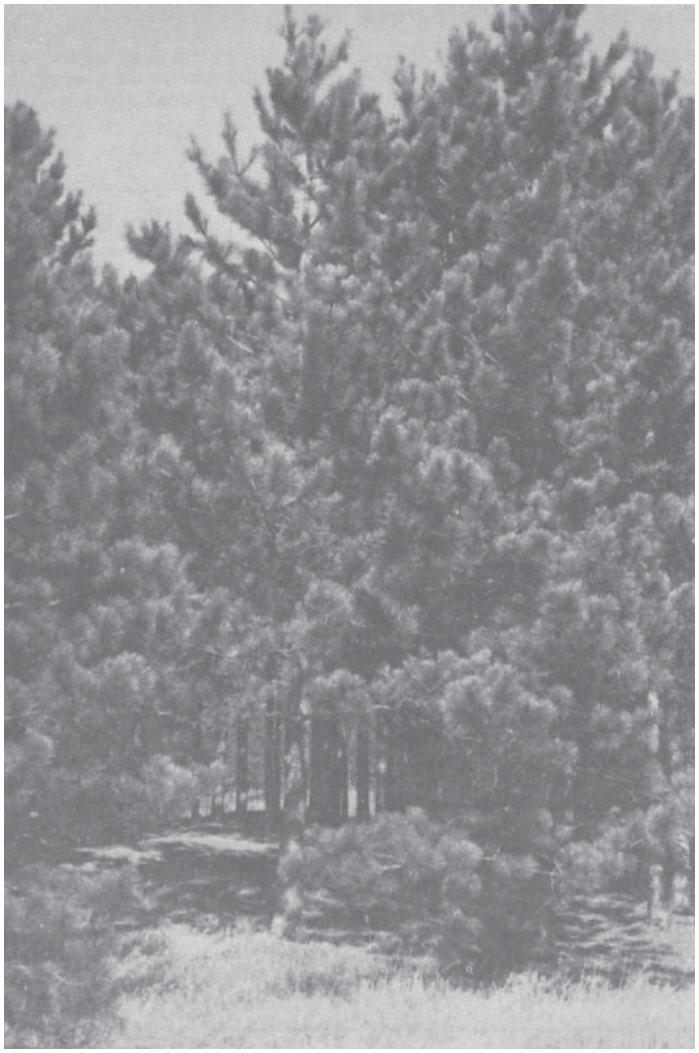

Figure 20.—**Twenty-five year old red pines growing on Dune land near the village of Gary.**

The *equipment limitation* is slight if there are no restrictions on the type of equipment or on the time of year that the equipment can be used. The limitation is moderate if the use of equipment is restricted by slope or by soils that stay wet up to 3 months, or if the use of equipment damages tree roots to some extent. The limitation is severe if the use of normal equipment is restricted or limited more than 3 months in a year.

The *erosion hazard* is the degree of potential loss of soil by blowing or water. Vegetative cover, slope, and soil properties are important factors. The hazard is slight if erosion is no problem. It is moderate if normal measures are needed to prevent unnecessary loss of soil. It is severe if special care and methods are needed to minimize loss and deterioration of the soil.

TREE AND SHRUB SUITABILITY GROUP 1

Soils of the Barnes, Darnen, Foxhome, Kittson, Swenoda, Wahpeton, and Waukon series and Breaks and Alluvial land are in this group. These are somewhat poorly drained to well-drained soils that are level to moderately steep.

Soils in this group formed mostly in loam or clay loam glacial till or in silty clay and clay alluvium. The Swenoda and Foxhome soils have a sandy or gravel layer above the till, and the Darnen soils formed in silt loam and loam washed in from adjacent areas. Slopes range from 0 to 18 percent. The surface layer is neutral. Organic-matter content and inherent fertility are medium to high.

Seedling mortality on soils of this group is slight. Plant competition from herbaceous plants is severe. The erosion hazard and equipment limitations are slight where slopes are 0 to 12 percent and moderate where slopes are more than 12 percent.

TREE AND SHRUB SUITABILITY GROUP 2

Soils of the Bearden, Glyndon, Grimstad, Hamerly, Ulen, and Wheatville series are in this group. These are somewhat poorly drained and moderately well drained soils that are level to sloping (0 to 8 percent slopes). Also in this group are Barnes-Langhei and Langhei-Barnes complexes. These are well-drained and somewhat excessively drained soils that are gently sloping to steep (2 to 30 percent slopes).

Soils in this group formed in till or lacustrine material that ranges from silty clay loam to fine sand in texture. The Ulen soils formed in fine sand and are coarser textured than other soils in this group. The surface layer of all soils in this group except the Barnes soils is mildly alkaline or moderately alkaline and is calcareous or strongly calcareous. The surface layer of the Barnes soils is neutral. The organic-matter content of all the soils except the Langhei soils is moderate to high. Langhei soils have a low to moderate organic-matter content. Inherent fertility is medium to high.

Seedling mortality on soils of this group is slight. Plant competition from herbaceous plants is severe, except on the Langhei soils, where it is moderate. The erosion hazard is slight for all soils, except that it is moderate to severe on the Langhei-Barnes soils where the slope is more than 12 percent. On all the soils, there is a moderate limitation in the use of tree planting and tillage quipment where the slope is more than 12 percent.

TREE AND SHRUB SUITABILITY GROUP 3

Soils of the Arveson, Fargo, Flaming, Flom, Hamar, Hangaard, Roliss, and Viking series are in this group. These are poorly drained to somewhat poorly drained soils that are level to gently sloping (0 to 6 percent slopes).

Texture of these soils ranges from loamy fine sand to silty clay. The surface layer of all soils in this group except the Arveson soils is neutral to mildly alkaline and is calcareous. The surface layer of the Arveson soils is moderately alkaline. The organic-matter content is moderate to high, and the inherent fertility is medium low to high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet.

Seedling mortality on soils of this group is moderate because of the high water table and the occasional ponding or flooding. Plant competition from herbaceous plants is severe. The erosion hazard is slight.

TABLE 4.—*Ratings of trees and shrubs by suitability group*

[*Well suited* species are vigorous, have good survival potential, and are easily managed; *suited* species have good survival potential, but lack one or more of the desired qualities of the well suited species; *unsuited* species will not survive without special treatment. No rating is given for suitability group 7 because it has questionable value for trees and shrubs and onsite determinations are needed]

Species	Tree and shrub suitability groups					
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Conifers:						
Jack pine	Suited	Unsuited	Unsuited	Unsuited	Suited	Well suited.
Ponderosa pine	Well suited	Suited	Suited	Unsuited	Well suited	Well suited.
Redcedar	Well suited	Suited	Suited	Unsuited	Well suited	Well suited.
Red pine	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Well suited.
Spruce	Well suited	Suited	Suited	Unsuited	Well suited	Suited.
White-cedar	Well suited	Suited	Well suited	Suited	Suited	Unsuited.
White pine	Well suited	Unsuited	Suited	Unsuited	Well suited	Unsuited.
Deciduous trees:						
American elm	Suited	Suited	Suited	Suited	Suited	Unsuited.
Bur oak	Suited	Suited	Unsuited	Unsuited	Well suited	Well suited.
Golden willow	Suited	Suited	Suited	Suited	Suited	Unsuited.
Green ash	Well suited	Well suited	Well suited	Well suited	Well suited	Suited.
Hackberry	Well suited	Suited	Well suited	Unsuited	Well suited	Suited.
Laurel-leaf willow	Well suited	Suited	Well suited	Suited	Unsuited	Unsuited.
Poplar	Well suited	Well suited	Well suited	Well suited	Suited	Unsuited.
Siberian elm	Suited	Well suited	Well suited	Well suited	Well suited	Suited.
Soft maple	Well suited	Suited	Well suited	Unsuited	Suited	Unsuited.
Small trees and shrubs:						
Amur maple	Well suited	Unsuited	Well suited	Unsuited	Unsuited	Unsuited.
Buffaloberry	Suited	Well suited	Suited	Unsuited	Well suited	Well suited.
Caragana	Well suited	Suited	Suited	Suited	Well suited	Suited.
Chokecherry	Well suited	Suited	Suited	Unsuited	Well suited	Suited.
Cotoneaster	Suited	Suited	Suited	Unsuited	Well suited	Well suited.
Dogwood	Well suited	Suited	Well suited	Well suited	Suited	Unsuited.
Flowering crab	Well suited	Well suited	Suited	Suited	Well suited	Unsuited.
Honeysuckle	Well suited	Well suited	Well suited	Well suited	Well suited	Suited.
Lilac	Well suited	Well suited	Well suited	Well suited	Well suited	Suited.
Nannyberry	Well suited	Well suited	Well suited	Suited	Unsuited	Unsuited.
Russian-olive	Suited	Well suited	Suited	Well suited	Suited	Suited.
Serviceberry	Well suited	Unsuited	Suited	Unsuited	Well suited	Suited.
Wild plum	Suited	Well suited	Well suited	Suited	Suited	Unsuited.

TREE AND SHRUB SUITABILITY GROUP 4

Soils of the Arveson, Colvin, Mavie, Rockwell, Syrene, and Vallers series are in this group. These are poorly drained soils. Also in this group are Augsburg and Wheatville loams, Borup and Glyndon loams, and the Bearden-Fargo, Hamerly-Vallers, Hegne-Fargo, and Hegne-Viking soil complexes. These are poorly drained to moderately well drained soils. Soils of this group are level to gently sloping.

Soils in this group formed in lacustrine sediment that ranges from silty clay to gravel and in till that ranges from clay to loam. The surface layer is high in organic-matter content. Except for the Fargo and Viking soils, the soils of this group have a surface layer that is mildly alkaline to moderately alkaline and calcareous to strongly calcareous. The surface layer of Fargo and Viking soils is neutral. Inherent fertility is medium to high. The seasonal water table fluctuates between depths of 1 foot and more than 6 feet.

Seedling mortality of soils of this group is moderate to severe because of the high water table, the occasional ponding or flooding, and the strongly calcareous soil. Plant competition from herbaceous vegetation is severe. The erosion hazard is slight, and the equipment limitation is moderate to severe because of wetness.

TREE AND SHRUB SUITABILITY GROUP 5

Soils of the Flaming, Maddock, Poppleton, Sverdrup, and Towner series and Sioux sandy loams are in this group. These are somewhat poorly drained to excessively drained soils that are nearly level to sloping (0 to 8 percent slopes).

Soils in this group formed in lacustrine or outwash sand and gravel. Towner soils are sand underlain by loamy material. The surface layer of soils of this group is slightly acid to neutral. The organic-matter content ranges from high to low, and inherent fertility is medium or low. The depth to the seasonal water table ranges from 2 to more than 6 feet.

Seedling mortality in soils of this group is slight to moderate. Plant competition is moderate. The erosion hazard is slight to moderate.

TREE AND SHRUB SUITABILITY GROUP 6

Soils of the Sioux and Maddock series and Dune land are in this group. These are well-drained to excessively drained, nearly level to very steep soils (0 to 36 percent slopes).

Soils in this group formed in lacustrine or outwash sand and gravel. The surface layer is slightly acid to neutral. The organic-matter content ranges from moder-

ate to low. Inherent fertility is medium to low. The depth to the seasonal water table is more than 6 feet.

Seedling mortality on soils of this group is moderate to severe. Plant competition is slight to moderate. The erosion hazard is moderate to severe for both soil blowing and water erosion.

TREE AND SHRUB SUITABILITY GROUP 7

Soils of this group are unsuitable for trees and shrubs unless special practices are applied. This group includes soils of the Arveson, Borup, Cashel, Cathro, Colvin, Fargo, Flom, Glyndon, Hamar, Kratka, Markey, Rockwell, Roliss, Rondeau, Seeleyeville, Ulen, and Vallers series and Alluvial land.

GROUP 7A. Wet, organic soils of the Cathro, Markey, Rondeau, and Seelyeville series that have a water table at a depth of 0 to 4 feet.

GROUP 7B. Wet, depressional, mineral soils of the Borup, Colvin, Fargo, Roliss, and Vallers series and Arveson, Hamar, Flom, Vallers, Rockwell, and Kratka soils in depressions. Water often is ponded on these depressional soils, and the water table is between depths of 0 and more than 5 feet.

GROUP 7C. Soils that have a thin surface layer that is moderately alkaline and very strongly calcareous. Wind-eroded Glyndon and Ulen soils are in this group.

GROUP 7D. Alluvial land and soils that have a flooding hazard. The Cashel soils and Alluvial land, frequently flooded, and Alluvial land, occasionally flooded, are in this group. They have scattered areas of bottomland hardwoods.

Engineering Uses of the Soils [5]

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. This section deals with those properties of the soils that affect construction and maintenance of roads, airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties most important in engineering are permeability, compaction characteristics, shear strength, shrink-swell potential, water-holding capacity, drainage, grain-size distribution, plasticity, and reaction. Depth to water table and topography also are important.

Information concerning these and related soil properties is furnished in tables 5, 6, and 7. The estimates and interpretations of soil properties in these tables can be used in:

1. Planning and designing agricultural drainage systems, farm ponds and pits, irrigation systems, waterways, and other structures for controlling water and conserving soil.
2. Selecting potential locations for local roads and streets, airports, pipelines, and underground cables.
3. Locating probable sources of sand or gravel suitable for use as construction material.
4. Selecting potential industrial, commercial, residential, and recreational areas.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works, especially works that involve heavy loads or that require excavations deeper than the thickness of layers reported in this survey. It should also be noted that inclusions in mapping units often have different estimates and interpretations. Even in these situations, however, the soil map is useful in planning more detailed field investigations and in indicating the kinds of problems that may be expected.

Some terms used by soil scientists may be unfamiliar to engineers, and some words have different meanings in soil science than they have in engineering. Many of these terms are defined in the Glossary.

Engineering classification of the soils

The two systems most commonly used in classifying soils for engineering (*4*) are the AASHO system adopted by the American Association of State Highway Officials (*2*) and the Unified system used by the Soil Conservation Service, the Department of Defense, and other agencies (*9*).

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, a soil is placed in one of seven basic groups that range 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 road fill; at the other extreme, in group A-7, are clay soils that have low strength when wet. The best soils for road fill are therefore classified as A-1, the next best A-2, and so on to the poorest, which are classified A-7. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are subdivided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7; and A-7-5 and A-7-6. Highly organic soils are classified as A-8. If soil material is near a classification boundary, it is given a symbol showing both classes; for example, A-2 or A-4. Within each group, the relative 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 for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 5; the estimated classification for all soils mapped in the survey area is given in table 6.

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt.

Engineering test data

Table 5 contains the results of engineering tests performed on several important soils in Norman County. The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

[5] RICHARD D. WENBERG, assistant State conservation engineer, assisted with this section.

TABLE 5.—*Engineering*

[Tests performed by the Minnesota Department of Highways, in cooperation with the U.S. Department of Commerce, Bureau

Soil name and location	Parent material	Minnesota report No. SS—	Depth	Moisture-density data [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb./cu. ft.*	*Percent*
Bearden silty clay loam: SW¼SE¼SW¼ sec. 4, T. 143 N., R. 46 W. (Modal)	Lacustrine silt.	6611	0–7	82	32
		6612	21–27	105	20
		6613	33–43	101	22
Fargo silty clay: NW¼NW¼ sec. 28, T. 143 N., R. 48 W. (Modal)	Lacustrine clay.	6654	0–10	83	31
		6655	10–20	85	23
		6656	27–40	90	30
Flaming loamy fine sand: NW¼NE¼ sec. 17, T. 145 N., R. 44 W. (Modal)	Lacustrine sand.	6632	0–11	109	12
		6633	11–17	108	13
		6634	17–32	104	14
Glyndon loam: NW¼NE¼NW¼ sec. 25, T.145 N., R. 46 W. (Modal)	Lacustrine silt and very fine sand.	6645	0–8	98	22
		6646	17–28	109	17
		6647	28–36	106	15
Hegne silty clay: NE¼NE¼NE¼ sec. 23, T. 146 N., R. 47 W. (Modal)	Lacustrine clay.	6614	0–6	83	33
		6615	10–19	104	21
		6616	34–42	98	24
Sioux sandy loam: NE¼NW¼ sec. 28, T. 146 N., R. 45 W. (Modal)	Coarse lacustrine sediments.	6617	0–9	92	22
		6618	9–14	111	13
		6619	19–38	134	9
Sioux gravelly sandy loam: NW¼NW¼ sec. 15, T. 146 N,, R. 45 W. (Modal for gravelly phases)	Coarse lacustrine sediments.	6620	0–6	121	13
		6621	6–13	111	14
		6622	27–50	129	10
Ulen fine sandy loam: NW¼SW¼ sec. 33, T. 144 N., R. 44 W. (Modal)	Lacustrine sand.	6605	0–9	107	14
		6606	12–21	110	12
		6607	21–36	104	15
Waukon loam: NW¼SW¼ sec. 4, T. 146 N., R. 43 W. (Modal)	Glacial till.	6629	0–10	112	14
		6630	10–18	112	15
		6631	26–39	122	11

[1] Based on AASHO Designation: T 99–57, Method C (*1*).

[2] Mechanical analyses according to the AASHO Designation: T 88–57. Results by this procedure frequently differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser

test data

of Public Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—							
¾ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO	Unified [3]
									Percent			
100	100	100	99	95	87	49	23	18	49	13	A–7–5	OL
100	100	100	92	88	84	53	22	12	35	11	A–6	ML or CL
100	100	100	100	99	98	69	32	26	39	15	A–6	ML or CL
100	100	100	98	96	95	79	47	34	60	23	A–7–5	OH
100	100	100	99	97	97	90	61	48	68	40	A–7–6	OH–CH
100	100	100	100	99	98	93	69	54	66	39	A–7–6	CH
100	100	100	98	10	9	7	3	1	(4)	(4)	A–2–4	SP–SM
100	100	100	98	6	5	5	3	1	(4)	(4)	A–3	SP–SM
100	100	100	98	4	3	3	3	3	(4)	(4)	A–3	SP
100	100	100	99	88	72	27	16	11	35	5	A–4	OL
100	100	100	100	94	64	37	27	23	28	8	A–4	CL
100	100	100	100	88	53	10	8	5	(4)	(4)	A–4	ML
100	100	100	96	91	85	65	42	32	59	27	A–7–5	OH
100	100	100	100	98	91	86	59	46	51	30	A–7–6	CH
100	100	100	100	99	99	91	62	47	54	35	A–7–6	CH
100	100	99	94	36	18	10	1	1	(4)	(4)	A–2–4	SM
100	98	96	86	19	9	8	3	2	(4)	(4)	A–1–a	SP
91	57	41	8	4	1	1	1	1	(4)	(4)	A–1–b	SP
99	91	72	40	13	11	7	2	1	(4)	(4)	A–1–b	SM
100	98	84	13	2	2	1	1	1	(4)	(4)	A–1–b	SP
90	65	39	12	1	1	1	1	1	(4)	(4)	A–1–a	SP
100	100	100	99	16	13	11	9	5	(4)	(4)	A–2–4	SM
100	100	100	99	21	16	14	9	7	(4)	(4)	A–2–4	SM
100	100	100	99	12	8	8	6	5	(4)	(4)	A–2–4	SM
100	100	99	90	52	45	30	15	12	24	4	A–4	OL
100	100	99	91	53	46	35	24	20	25	9	A–4	CL
99	98	96	88	54	48	33	19	14	21	5	A–4	ML or CL

than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification; for example, ML–CL.

[4] Nonplastic.

TABLE 6.—*Estimated*

[Alluvial land (Ad and Af), Breaks and Alluvial land (Br), Gravel pits (Gp), and Marsh (Mh) are not listed, because their properties are kinds of soil. Because these soils may have different properties and limitations, it is necessary to follow carefully the instructions for

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
*Arveson: Ar, As	1–5	0–12	Loam	OL	A–4
For properties of Hamar soils in mapping unit As, refer to Hamar series.		12–20	Fine sandy loam	SM	A–2
		20–60	Fine sand	SM	A–2
*Augsburg: Aw	1–6	0–15	Loam	OL	A–4
For properties of Wheatville soils in mapping unit Aw, refer to Wheatville series.		15–20	Very fine sandy loam	ML	A–4
		20–29	Loamy very fine sand	SM	A–4
		29–60	Silty clay	CH	A–7
*Barnes: BaA, BaB, BaB2, BaC2, BbB2	>6	0–9	Loam	OL	A–6
For properties of Langhei soils in mapping unit BbB2, refer to Langhei series.		9–27	Loam	ML or CL	A–6
		27–50	Loam	ML or CL	A–6
*Bearden: BcA, BcB, BcC2, Bf	2–6	0–16	Silty clay loam	OL	A–7
For properties of Fargo soils in mapping unit Bf, refer to Fargo series.		16–33	Silt loam	ML or CL	A–6
		33–60	Silty clay loam	CL	A–7
*Borup: Bo, Bp	1–5	0–14	Loam	OL	A–4
For properties of Glyndon soils in mapping unit Bp, refer to Glyndon series.		14–26	Very fine sandy loam	ML	A–4
		26–60	Loamy very fine sand	SM	A–4
Cashel: CaA, CaC	1–6	0–10	Silty clay	OH	A–7
		10–24	Silty clay	CH	A–7
		24–60	Clay	CH	A–7
Cathro: Cb	0–4	0–23	Muck (Sapric)	Pt	A–8
		23–52	Loam	CL	A–6
Colvin: Cn, Co	1–5	0–10	Silty clay loam	OH	A–7
		10–25	Silt loam	ML or CL	A–6
		25–60	Silty clay loam and silt loam	CL	A–7
Darnen: DaB	3–6	0–21	Silt loam	OL	A–6
		21–27	Loam	ML or CL	A–6
		27–60	Loam	ML or CL	A–6
Dune land: Du	>6	0–2	Fine sand	SP–SM	A–3
		2–60	Fine and medium sand	SP–SM	A–3
Fargo: FaA, FaB, FcA, FcB, Fd	1–6	0–10	Silty clay	OH	A–7
		10–20	Silty clay	OH–CH	A–7
		20–60	Silty clay	CH	A–7
*Flaming: Ff, Fh	2–7	0–8	Loamy fine sand	SM	A–2
For properties of Hamar and Arveson soils in mapping unit Fh, refer to Arveson and Hamar series.		8–60	Fine sand	SP–SM	A–3
*Flom: Fm, Fv	1–6	0–12	Silty clay loam	OL	A–6
For properties of Vallers soils in mapping unit Fv, refer to the Vallers series.		12–16	Silty clay loam	CL–CH	A–7
		16–60	Loam	CL	A–6
Foxhome: FxA	2½–6	0–11	Loam	SM	A–4
		11–14	Loamy sand	SM	A–2
		14–24	Gravelly coarse sand	SP–SM	A–1
		24–60	Loam	CL	A–6
Glyndon: GlA, GlB, Gn	2–6	0–11	Loam	OL	A–4
		11–28	Loam	CL	A–4
		28–50	Loamy very fine sand	ML	A–4
Grimstad: Gr	2–6	0–10	Fine sandy loam	SM	A–2
		10–28	Loamy fine sand	SM	A–2
		28–60	Loam	CL	A–6

properties of the soil

too variable to estimate. An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more referring to other series that appear in the first column. The symbol > means greater than; the symbol < means less than]

Estimated percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH*	
100	100	70–85	50–65	2. 0–6. 0	0. 19–0. 21	7. 9–8. 4	Low.
100	100	50–75	12–35	2. 0–6. 0	0. 14–0. 16	7. 9–8. 4	Low.
100	100	50–75	12–35	>6. 0	0. 05–0. 07	7. 4–8. 4	Low.
100	100	90–100	85–95	0. 6–2. 0	0. 20–0. 22	7. 9–8. 4	Low to moderate.
100	100	90–95	50–65	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	Low to moderate.
100	100	90–95	35–50	2. 0–6. 0	0. 12–0. 15	7. 4–8. 4	Low.
100	100	95–100	95–100	0. 06–0. 20	0. 10–0. 12	7. 9–8. 4	High.
100	90–100	85–95	50–70	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low to moderate.
100	90–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Low to moderate.
100	90–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Low to moderate.
100	95–100	90–100	80–100	0. 20–0. 6	0. 20–0. 22	7. 4–8. 4	Moderate.
100	95–100	95–100	80–100	0. 20–2. 0	0. 19–0. 21	7. 9–8. 4	Moderate.
100	95–100	95–100	80–100	0. 20–2. 0	0. 15–0. 19	7. 9–8. 4	Moderate to high.
100	100	90–100	85–95	0. 6–2. 0	0. 20–0. 22	7. 4–8. 4	Low to moderate.
100	100	90–100	50–65	2. 0–6. 0	0. 17–0. 19	7. 9–8. 4	Low to moderate.
100	100	90–100	35–50	2. 0–6. 0	0. 12–0. 15	7. 4–8. 4	Low.
100	100	95–100	90–100	0. 2–0. 6	0. 12–0. 14	6. 6–8. 4	High.
100	100	95–100	90–100	0. 2–0. 6	0. 12–0. 14	6. 6–8. 4	High.
100	100	95–100	90–100	0. 06–0. 2	0. 09–0. 11	6. 6–8. 4	High.
				0. 6–2. 0	0. 30–0. 45	6. 6–7. 8	High.
100	90–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	6. 6–8. 4	Moderate.
100	95–100	90–100	80–95	0. 20–0. 6	0. 20–0. 22	7. 4–7. 8	High.
100	95–100	90–100	80–95	0. 20–0. 6	0. 19–0. 21	7. 9–8. 4	Moderate to high.
100	95–100	90–100	80–95	0. 20–0. 6	0. 18–0. 20	7. 4–8. 4	High.
100	95–100	90–100	80–95	0. 6–2. 0	0. 21–0. 23	6. 6–7. 3	Moderate.
100	90–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	6. 6–7. 8	Low to moderate.
100	90–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	Low to moderate.
95–100	90–100	50–75	5–10	>6. 0	0. 07–0. 09	6. 1–7. 3	Low.
95–100	90–100	50–75	5–10	>6. 0	0. 05–0. 07	6. 1–7. 3	Low.
100	100	95–100	95–100	0. 06–0. 20	0. 17–0. 19	6. 6–7. 3	Very high.
100	100	95–100	95–100	0. 06–0. 20	0. 12–0. 14	6. 6–7. 8	Very high.
100	100	95–100	95–100	0. 06–0. 20	0. 10–0. 12	7. 4–8. 4	Very high.
100	95–100	65–85	12–35	>6. 0	0. 10–0. 12	6. 1–7. 3	Low.
100	95–100	50–75	5–10	>6. 0	0. 06–0. 08	6. 1–7. 8	Low.
100	95–100	90–100	80–95	0. 2–0. 6	0. 21–0. 23	6. 6–7. 3	Moderate to high.
100	95–100	90–100	80–95	0. 2–0. 6	0. 18–0. 20	6. 6–7. 3	Moderate to high.
100	95–100	90–100	70–85	0. 2–0. 6	0. 17–0. 19	7. 4–8. 4	Moderate.
100	95–100	85–95	35–50	>6. 0	0. 19–0. 21	6. 6–7. 3	Low.
100	95–100	85–95	12–35	>6. 0	0. 09–0. 11	6. 6–7. 3	Low.
40–60	50–75	30–50	5–12	>6. 0	0. 03–0. 05	7. 4–7. 8	Low.
100	95–100	85–95	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
100	100	90–100	80–95	0. 6–2. 0	0. 20–0. 22	7. 9–8. 4	Low to moderate.
100	100	90–100	80–95	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	Low to moderate.
100	100	90–100	50–85	2. 0–6. 0	0. 13–0. 15	7. 9 8. 4	Low.
100	95–100	90–100	12–35	2. 0–6. 0	0. 16–0. 18	7. 9–8. 4	Low.
100	95–100	90–100	12–35	>6. 0	0. 08–0. 10	7. 9–8. 4	Low.
100	95–100	90–100	50–75	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.

TABLE 6.—*Estimated*

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Hamar: Ha	1–5	0–12	Loamy fine sand	SM	A–2
		12–23	Fine sand	SP–SM	A–3
		23–60	Fine sand	SP–SM	A–3
*Hamerly: HeA, HeB, Hm	2–6	0–14	Silt loam	OL	A–6
		14–60	Loam	CL	A–6
For properties of Vallers soils in mapping unit Hm, refer to the Vallers series.					
Hangaard: Hn	1–6	0–16	Sandy loam	SM	A–2
		16–60	Gravelly coarse sand	SP–SM	A–1
*Hegne: Ho, Hv	1–6	0–8	Silty clay	OH	A–7
		8–29	Silty clay	CH	A–7
		29–60	Silty clay	CH	A–7
For properties of Fargo soils in mapping unit Ho, refer to Fargo series. For properties of Viking soils in mapping unit Hv, refer to Viking series.					
Kittson: KsA, KsC, KtA, KtB	2½–6	0–10	Loam	OL	A–6
		10–16	Loam	ML or CL	A–6
		16–60	Loam	ML or CL	A–6
Kratka	0–5	0–12	Loamy fine sand	SM	A–4
		12–38	Fine sand	SM	A–2
		38–60	Clay loam	CL	A–6
*Langhei: LbC2, LbD2, LbE	>6	0–7	Loam	CL	A–4
		7–28	Loam	CL	A–4
		28–50	Loam	ML or CL	A–4
For properties of Barnes soils in mapping units LbC2, LbD2, and LbE, refer to the Barnes series.					
Maddock: MaA, MaC	>6	0–11	Loamy fine sand	SM	A–2
		11–19	Loamy sand	SP–SM	A–3
		19–60	Fine sand	SP–SM	A–3
Markey: Me	0–3	0–22	Muck (Sapric)	Pt	A–8
		22–60	Sand	SP–SM	A–3
Mavie: Mm	1–6	0–16	Loam	OL	A–4
		16–38	Gravelly sand	SP–SM	A–1
		38–60	Loam	CL	A–6
Poppleton: Po	2–7	0–6	Loamy fine sand	SM	A–2
		6–60	Fine sand	SP–SM	A–3
*Rockwell: Rc, Rk	1–6	0–19	Fine sandy loam	OL	A–4
		19–31	Fine sand	SM	A–2
		31–60	Loam	ML or CL	A–6
For properties of Kratka soils in mapping unit Rk, refer to the Kratka series.					
Roliss: Ro, Rs	1–6	0–7	Loam	OL	A–6
		7–16	Loam	ML or CL	A–6
		16–60	Loam	CL	A–6
Rondeau: Ru	0–3	0–90	Muck (Sapric)	Pt	A–8
Seelyeville: Sc	0–3	0–60	Muck and mucky peat (Sapric and hemic).	Pt	A–8
*Sioux: SdA, SdB, SgA, SgC, SmE	>6	0–9	Fine sandy loam	SM	A–2
		9–14	Gravelly loamy sand	SP–SM	A–1
		14–60	Gravelly coarse sand	SP	A–1
For properties of Maddock soils in mapping unit SmE, refer to the Maddock series.					
Sverdrup: SnA, SnC	>6	0–19	Sandy loam	SM	A–4
		19–24	Loamy sand	SM	A–2
		24–60	Fine sand	SP–SM	A–3

properties of the soil—Continued

Estimated percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH*	
100	95–100	85–95	12–35	>6. 0	0. 11–0. 13	6. 6–7. 8	Low.
100	95–100	85–95	5–10	>6. 0	0. 07–0. 09	6. 6–7. 3	Low.
100	95–100	85–95	5–10	>6. 0	0. 06–0. 08	7. 4–7. 8	Low.
100	95–100	90–100	80–95	0. 6–2. 0	0. 20–0. 22	7. 9–8. 4	Moderate.
100	90–100	85–95	80–95	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Low to moderate.
95–100	90–100	50–70	12–35	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
50–60	30–50	25–50	5–12	>6. 0	0. 03–0. 05	7. 4–8. 4	Low.
100	100	95–100	95–100	0. 2–0. 6	0. 15–0. 17	7. 9–8. 4	High.
100	100	95–100	95–100	0. 06–0. 20	0. 12–0. 13	7. 9–8. 4	High.
100	100	95–100	95–100	0. 06–0. 20	0. 10–0. 12	7. 4–8. 4	High.
100	95–100	90–100	50–70	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
100	95–100	90–100	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate
100	95–100	90–100	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
100	95–100	85–95	35–50	2. 0–6. 0	0. 11–0. 13	6. 6–7. 3	Low.
100	95–100	85–95	12–35	>6. 0	0. 06–0. 08	6. 6–7. 8	Low.
100	100	90–100	70–95	0. 6–2. 0	0. 15–0. 17	7. 9–8. 4	Moderate.
95–100	95–100	90–100	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Low to moderate.
95–100	95–100	90–100	50–80	0. 6–2. 0	0. 16–0. 18	7. 9–8. 4	Low to moderate.
90–100	90–100	90–100	50–70	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Low to moderate.
100	95–100	60–80	12–35	>6. 0	0. 11–0. 13	6. 6–7. 3	Low.
100	95–100	50–75	5–10	>6. 0	0. 09–0. 11	6. 6–7. 3	Low.
100	95–100	50–70	5–10	>6. 0	0. 06–0. 08	6. 6–7. 8	Low.
				2. 0–6. 0	0. 30–0. 45	6. 6–7. 8	High.
95–100	90–100	50–75	5–10	>6. 0	0. 05–0. 07	6. 6–8. 4	Low.
100	90–100	85–95	50–65	2. 0–6. 0	0. 19–0. 21	7. 9–8. 4	Moderate to low.
50–60	30–50	10–50	5–12	>6. 0	0. 03–0. 05	7. 4–8. 4	Low.
95–100	85–100	75–95	70–85	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
100	95–100	50–75	12–35	>6. 0	0. 10–0. 12	6. 1–7. 3	Low.
100	95–100	50–75	5–10	>6. 0	0. 06–0. 08	6. 1–7. 8	Low.
100	100	90–100	50–65	2. 0–6. 0	0. 16–0. 18	7. 9–8. 4	Moderate to low.
100	100	50–75	12–35	>6. 0	0. 07–0. 09	7. 4–8. 4	Low.
100	90–100	85–95	50–85	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
100	90–100	85–95	50–70	0. 2–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
100	90–100	85–95	50–70	0. 2–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
100	90–100	85–95	50–70	0. 2–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
				<. 06–0. 2	0. 30–0. 45	6. 6–8. 4	High.
				2. 0–6. 0	0. 30–0. 45	6. 1–7. 8	High.
95–100	95–100	50–75	12–35	>6. 0	0. 12–0. 14	6. 6–7. 8	Low.
70–95	65–90	30–50	5–12	>6. 0	0. 03–0. 05	6. 6–7. 8	Low.
50–95	50–75	20–50	1–5	>6. 0	0. 02–0. 04	7. 4–8. 4	Low.
100	95–100	65–85	35–50	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
100	95–100	50–75	12–35	>6. 0	0. 09–0. 11	6. 6–7. 3	Low.
100	95–100	50–70	5–10	>6. 0	0. 06–0. 08	6. 6–7. 8	Low.

TABLE 6.—*Estimated*

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Swenoda: SwA, SwC	2½–6	0–14	Fine sandy loam	SM	A–4
		14–25	Loamy fine sand	SM	A–2
		25–34	Sandy loam and loamy sand	SM	A–4 or A–2
		34–60	Silty clay loam	ML or CL	A–6
Syrene: Sy	1–5	0–10	Sandy loam	SM	A–4
		10–18	Sandy loam	SM	A–2
		18–55	Gravelly coarse sand	SP–SM	A–1
Towner: To	2–6	0–8	Loamy fine sand	SM	A–2
		8–26	Fine sand	SP–SM	A–3
		26–60	Loam	CL	A–6
Ulen: UlA, Un	2–6	0–15	Fine sandy loam	SM	A–4
		15–36	Loamy fine sand	SM	A–2
		36–60	Fine sand	SM	A–2
Vallers: Va, Vd	1–6	0–8	Silt loam	OL	A–6
		8–25	Loam	ML or CL	A–6
		25–60	Clay loam	CL	A–6
Viking: Vk	1–6	0–7	Clay loam	OH	A–7
		7–33	Clay	CH	A–7
		33–60	Clay	CH	A–7
Wahpeton: WaA, WaB, WaC	2½–6	0–15	Silty clay	OH	A–7
		15–60	Clay	CH	A–7
Waukon: WkA, WkB, WkB2, WkC, WkD	>6	0–9	Loam	OL	A–4
		9–26	Sandy clay loam	CL	A–4
		26–50	Loam	ML or CL	A–4
Wheatville: Wm	2–6	0–8	Loam	OL	A–4
		8–16	Sandy clay loam	ML	A–4
		16–30	Very fine sandy loam	ML	A–4
		30–60	Clay	CH	A–7

properties of the soil—Continued

Estimated percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH*	
100	95–100	65–85	35–50	2. 0–6. 0	0. 16–0. 18	6. 6–7. 3	Low.
100	95–100	50–75	12–35	>6. 0	0. 09–0. 11	6. 6–7. 8	Low.
100	95–100	55–85	25–50	2. 0–6. 0	0. 11–0. 13	6. 6–7. 8	Low.
100	95–100	85–95	70–95	0. 6–2. 0	0. 18–0. 20	7. 4–8. 4	Moderate.
95–100	90–100	65–85	35–50	2. 0–6. 0	0. 13–0. 15	7. 9–8. 4	Low.
95–100	85–95	65–85	12–35	>6. 0	0. 11–0. 13	7. 9–8. 4	Low.
90–95	65–80	20–50	5–12	>6. 0	0. 03–0. 05	7. 4–8. 4	Low.
100	95–100	65–85	12–35	>6. 0	0. 10–0. 12	6. 6–7. 3	Low.
100	95–100	50–75	5–10	>6. 0	0. 06–0. 08	6. 6–7. 3	Low.
100	95–100	85–95	50–90	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	Moderate.
100	95–100	90–100	35–50	2. 0–6. 0	0. 16–0. 18	7. 4–8. 4	Low.
100	95–100	90–100	12–35	>6. 0	0. 10–0. 12	7. 4–8. 4	Low.
100	95–100	90–100	12–35	>6. 0	0. 06–0. 08	7. 4–8. 4	Low.
100	90–100	85–95	50–70	0. 6–2. 0	0. 20–0. 22	7. 4–8. 4	Moderate to high.
100	90–100	85–95	50–70	0. 2–0. 6	0. 17–0. 19	7. 9–8. 4	Moderate to high.
100	90–100	85–95	50–70	0. 2–0. 6	0. 15–0. 19	7. 4–8. 4	Moderate to high.
100	100	95–100	65–95	0. 06–0. 2	0. 15–0. 19	6. 6–7. 8	High.
100	100	95–100	80–95	0. 06–0. 2	0. 10–0. 12	7. 4–7. 8	Very high.
100	100	95–100	90–100	0. 06–0. 2	0. 09–0. 11	7. 4–8. 4	Very high.
100	100	95–100	95–100	0. 2–0. 6	0. 17–0. 19	6. 6–7. 3	High.
100	100	95–100	95–100	0. 2–0. 6	0. 11–0. 13	6. 6–7. 8	Very high.
95–100	90–100	85–95	50–75	0. 6–2. 0	0. 19–0. 22	6. 6–7. 3	Low to moderate.
95–100	90–100	85–95	50–75	0. 6–2. 0	0. 16–0. 18	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–75	0. 6–2. 0	0. 15–0. 19	7. 4–8. 4	Low to moderate.
100	95–100	90–100	50–80	0. 6–2. 0	0. 20–0. 22	7. 9–8. 4	Low to moderate.
100	95–100	90–100	50–80	0. 6–2. 0	0. 16–0. 18	7. 9–8. 4	Low to moderate.
100	95–100	90–100	50–80	2. 0–6. 0	0. 13–0. 16	7. 4–8. 4	Low to moderate.
100	100	95–100	80–95	0. 06–0. 2	0. 10–0. 12	7. 4–8. 4	High.

TABLE 7.—*Interpretations of engineering*

[Alluvial land (Ad and Af), Breaks and Alluvial land (Br), Gravel pits (Gp), and Marsh (Mh) are not listed because their properties are kinds of soil. Because these soils may have different properties and limitations, it is necessary to

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
*Arveson: Ar	Good to fair: strongly calcareous in many places.	Fair for fine sand.	Fair: high seasonal water table; fair stability.	Poorly drained; high seasonal water table; moderate potential for frost heaving.	Poor resistance to piping; high seasonal water table; fair stability; moderate compacted permeability.
As. For interpretations of Hamar soils in As, refer to Hamar series.	Poor: strongly calcareous in many places; frequently ponded.	Fair for fine sand.	Poor: high seasonal water table; fair stability; frequently ponded.	Poorly drained; high seasonal water table; moderate potential for frost heaving; frequently ponded.	Poor resistance to piping; high seasonal water table; fair stability; moderate permeability when compacted; frequently ponded.
*Augsburg: Aw. For interpretations of Wheatville soils in Aw, refer to Wheatville series.	Good to fair: strongly calcareous in many places.	Poor: has a layer of loamy very fine sand.	Poor: high seasonal water table; poor shear strength; fair to poor stability; fair to poor compaction characteristics, finer textured underlying material has high shrink-swell potential and poor workability.	Poorly drained; high seasonal water table; fair to poor stability; underlying finer textured material has high compressibility; high shrink-swell potential; high potential for frost heaving.	High seasonal water table; fair to poor stability; poor shear strength; upper 2 to 3 feet has medium permeability when compacted; finer textured underlying material has high shrink-swell potential.
*Barnes: BaA, BaB, BaB2, BaC2, BbB2. For interpretations of Langhei soils in BbB2, refer to Langhei series.	Good: some coarse fragments in places.	Not suitable	Fair: fair shear strength and stability.	Medium compressibility; moderate potential for frost heaving.	Fair shear strength, stability, and resistance to piping; some stones and cobblestones.
*Bearden: BcA, BcB, BcC2, Bf. For interpretations of Fargo soils in Bf, refer to Fargo series.	Good to fair: strongly calcareous in places.	Not suitable	Fair: fair to poor shear strength; moderate to high shrink-swell potential; fair workability; medium to high compressibility; fair stability; moderately high seasonal water table.	Medium to high compressibility; moderately high seasonal water table; poor to fair shear strength; moderate to high shrink-swell potential; fair stability; high potential for frost heaving.	Poor to fair shear strength; moderate to high shrink-swell potential; fair resistance to piping; fair stability.
*Borup: Bo	Poor: frequently ponded; strongly calcareous in places.	Poor: very fine sand mixed with some silt and clay.	Poor: high seasonal water table; frequently ponded; poor shear strength; poor stability; poor compaction characteristics.	Poorly drained: high seasonal water table; frequently ponded; poor stability; medium compressibility; high potential for frost heaving; high erodibility.	High seasonal water table; frequently ponded; poor shear strength; poor stability; poor resistance to piping; medium permeability when compacted; frequently ponded.

See footnotes at end of table.

properties of the soils

too variable to interpret. An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more follow carefully the instructions for referring to other series that appear in the first column]

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundations for low buildings	Septic tank absorption fields	Sewage lagoons
Moderately rapid permeability; poor resistance to piping.	High seasonal water table; shallow to highly erodible sandy material.	Poorly drained; shallow to sandy material; highly erodible.	Fair shear strength; high seasonal water table.	Severe: high seasonal water table may pollute local water supplies.	Severe: rapid permeability; poor resistance to piping; poor reservoir site material.
Moderately rapid permeability; poor resistance to piping.	High seasonal water table; shallow to highly erodible sandy material; frequently ponded.	Poorly drained; shallow to sandy material; highly erodible; frequently ponded.	Fair shear strength; high seasonal water table; frequently ponded.	Severe: poorly drained; high seasonal water table may pollute local water supplies.	Severe: rapid permeability; poor reservoir site material.
Moderate permeability; poor resistance to piping in upper 2 to 3 feet; all features favorable in finer textured underlying material.	High seasonal water table; upper very fine sand layer is highly erodible.	Poor natural drainage; moderate to very fine sand; highly erodible in upper 2 to 3 feet.	High seasonal water table; poor shear strength; high compressibility and shrink-swell potential in finer textured underlying material.	Severe: poorly drained; high seasonal water table; slow permeability in finer textured underlying material.	Moderate to severe: moderate permeability in upper 2 to 3 feet; all features favorable in finer textured underlying material.
Moderate permeability.	Not needed	Soil features favorable; slopes up to 12 percent.	Fair shear strength; low to moderate shrink-swell potential; medium to high compressibility.	Slight: moderate where slopes are 6 to 12 percent.	Severe where slopes are more than 6 percent; moderate where slopes are 2 to 6 percent; moderate permeability.
Moderately slow permeability.	Generally not needed.	Moderately erodible; slopes are 2 to 8 percent.	Poor to fair shear strength; moderate to high shrink-swell potential; medium to high compressibility; moderately high seasonal water table.	Moderate: moderately slow permeability; somewhat poorly drained; moderately high seasonal water table.	Slight to moderate; moderately slow permeability; fair reservoir site material; moderate where slopes are 2 to 8 percent.
Moderate permeability; poor resistance to piping.	Moderately shallow to loamy very fine sand; highly erodible; high seasonal water table; frequently ponded.	Moderately shallow to very fine sand; poorly drained; highly erodible; frequently ponded.	High seasonal water table; frequently ponded; poor shear strength and stability.	Severe: high seasonal water table; poor natural drainage; frequently ponded.	Moderate: moderately rapid permeability; fair reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
*Borup—Continued					
Bp. For interpretations of Glyndon soils in Bp, refer to Glyndon series.	Good to fair: strongly calcareous in places.	Poor: very fine sand mixed with some silt and clay.	Poor: high seasonal water table; poor shear strength; poor stability; poor compaction characteristics.	Poorly drained; high seasonal water table; poor stability; medium compressibility; high potential for frost heaving; high erodibility.	Poor resistance to piping; poor shear strength and stability; moderate permeability when compacted; poor compaction characteristics.
Cashel: CaA, CaC	Poor: high clay content.	Not suitable	Poor: fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; high shrink-swell potential; fair to poor stability; poor workability; subject to flooding.	Somewhat poorly drained; high seasonal water table; fair to poor stability; high compressibility; high shrink-swell potential; moderate to high potential for frost heaving; subject to flooding.	Fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; high shrink-swell potential; fair to poor stability; poor workability.
Cathro: Cb	Good to mix with mineral soils.	Not suitable	Poor: organic layer must be stripped off; high seasonal water table; underlying material has fair shear strength; fair compaction characteristics; medium to high compressibility; moderate shrink-swell potential; frequently ponded.	Organic layer must be stripped off; high seasonal water table; moderate shrink-swell potential; fair shear strength; frequently ponded; high potential for frost heaving.	Organic layer must be stripped off; high seasonal water table; frequently ponded; underlying material has moderate shrink-swell potential; fair shear strength; medium to high compressibility.
Colvin					
Cn	Good to fair: strongly calcareous in places.	Not suitable	Poor: fair to poor compaction characteristics: high seasonal water table; poor shear strength; poor to fair stability; fair workability.	Poorly drained; high seasonal water table; poor to fair stability; high shrink-swell potential; high potential for frost heaving.	Fair to poor compaction characteristics; high seasonal water table; poor shear strength; high shrink-swell potential; fair stability; fair workability; high compressibility.
Co	Poor: frequently ponded; strongly calcareous in places.	Not suitable	Poor: fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; poor to fair stability; fair workability.	Poorly drained; high seasonal water table; poor to fair stability; high shrink-swell potential; high potential for frost heaving; frequently ponded.	Fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; high shrink-swell potential; fair stability; fair workability; frequently ponded.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Moderate permeability; poor resistance to piping.	Moderate depth to loamy very fine sand; high seasonal water table.	Poorly drained; highly erodible; shallow depth to very fine sand.	High seasonal water table; medium compressibility; poor shear strength.	Severe: high seasonal water table; poorly drained.	Moderate: moderately rapid permeability; fair reservoir site material.
Features generally favorable, except subject to flooding.	High seasonal water table; moderate to slow permeability; fine textured; subject to flooding.	Somewhat poorly drained; poor workability.	Poor shear strength; high shrink-swell potential; high compressibility; high seasonal water table; subject to flooding.	Severe: moderate to slow permeability; high seasonal water table; somewhat poorly drained; subject to flooding.	Moderate: subject to flooding; high organic-matter content; slopes up to 8 percent.
Organic layer has moderate permeability and very high organic-matter content; underlying material has favorable features.	Very poorly drained; high seasonal water table; very high organic-matter content.	Very poorly drained; frequently ponded; very high organic-matter content.	High seasonal water table; very poorly drained; frequently ponded; very high organic-matter content.	Severe: high seasonal water table; very poorly drained; frequently ponded.	Severe: organic layer has moderate permeability; very high organic-matter content.
All features favorable.	High seasonal water table; moderately slow permeablity.	Poorly drained; fair workability.	Poor shear strength; high shrink-swell potential; high compressibility; high seasonal water table.	Severe: moderately slow permeability; high seasonal water table; poorly drained.	Moderate: most features favorable, but high organic-matter content.
All features favorable.	High seasonal water table; moderately slow permeability; fine-textured underlying material; frequently ponded.	Poorly drained; poor workability; frequently ponded.	High seasonal water table; poor shear strength; high shrink-swell potential; high compressibility; frequently ponded.	Severe: high seasonal water table; moderately slow permeability; poorly drained; frequently ponded.	Moderate: most features favorable, but high organic-matter content.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
Darnen: DaB	Good	Not suitable	Fair: medium to high compressibility; fair shear strength; fair stability.	Medium to high compressibility; moderate potential for frost heaving.	Medium to high compressibility; fair shear strength; fair stability; upper 2 feet should be stripped off.
Dune land: Du	Poor: sandy and shallow surface layer.	Good for sand	Fair: poor stability.	Poor stability; moderate where slopes are 12 to 25 percent; severe where slopes are more than 25 percent.	Poor resistance to piping; rapid permeability when compacted; poor stability.
Fargo: FaA, FaB, FcA, FcB	Poor to fair; high clay content.	Not suitable	Poor: fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; very high shrink-swell potential; fair stability; poor workability.	Poorly drained; high seasonal water table; fair stability; high compressibility; very high shrink-swell potential; moderate to high potential for frost heaving.	Fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; very high shrink-swell potential; fair stability; poor workability.
Fd	Poor: high clay content; frequently ponded.	Not suitable	Poor: fair to poor compaction characteristics; high compressibility; high seasonal water table; frequently ponded; poor shear strength; very high shrink-swell potential; fair stability; poor workability.	Poorly drained; high seasonal water table; fair to poor stability; high compressibility; very high shrink-swell potential; moderate to high potential for frost heaving; frequently ponded.	Fair to poor compaction characteristics; high compressibility; high seasonal water table; poor shear strength; very high shrink-swell potential; fair stability; poor workability; frequently ponded.
*Flaming: Ff, Fh. For interpretations of the Hamar and Arveson soils in Fh, refer to Hamar series and Arveson series respectively.	Fair to poor: organic-matter content is moderate; medium to low inherent fertility.	Good for fine sand.	Fair: fair workability; fair to poor stability; moderately high seasonal water table.	Moderately high seasonal water table; poor to fair stability.	High compacted permeability; poor resistance to piping; fair to poor stability.
*Flom: Fm	Fair: silty clay loam surface layer may have some coarse fragments.	Not suitable	Fair: fair compaction characteristics; medium to high compressibility; high seasonal water table; fair shear strength; moderate to high shrink-swell potential.	Poorly to somewhat poorly drained; high seasonal water table; medium to high compressibility; moderate to high shrink-swell potential; high potential for frost heaving.	Medium to high compressibility; high seasonal water table; moderate to high shrink-swell potential; fair shear strength.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Moderate permeability.	Not needed	Most soil features favorable but moderately erodible in upper 2 feet.	Fair shear strength; moderate and low to moderate shrink-swell potential; medium to high compressibility.	Moderate: moderate permeability; moderately well drained.	Moderate: moderate permeability.
Rapid permeability; poor resistance to piping.	Not needed	Very shallow to unfavorable material; difficult to vegetate; highly erodible.	All features favorable if soil is contained; poor stability if not contained.	Slight except where slopes are more than 6 percent or where there is danger of polluting local water.	Severe: rapid permeability; poor reservoir site material.
All features favorable.	High seasonal water table; slow permeability; fine texture.	Poorly drained; poor workability.	Poor shear strength; very high shrink-swell potential; high compressibility; high seasonal water table.	Severe: slow permeability; high seasonal water table; poorly drained.	Moderate: most features favorable but high organic-matter content; slopes up to 6 percent.
All features favorable.	High seasonal water table; frequently ponded; slow permeability.	Poorly drained; poor workability; frequently ponded.	Poor shear strength; very high shrink-swell potential; high compressibility; high seasonal water table; frequently ponded.	Severe: slow permeability; high seasonal water table; poorly drained; frequently ponded.	Moderate: most features favorable, but high organic-matter content.
Rapid permeability; poor resistance to piping.	Generally not needed.	Shallow depth to fine sand; highly erodible.	Moderately high seasonal water table.	Moderate: somewhat poorly to moderately well drained; may pollute local water sources; moderately high seasonal water table.	Severe: rapid permeability; poor reservoir site material.
All features favorable.	High seasonal water table; moderately slow permeability.	Poorly to somewhat poorly drained.	Fair shear strength; moderate to high shrink-swell potential; medium to high compressibility; high seasonal water table.	Severe: moderately slow permeability; high seasonal water table; poorly to somewhat poorly drained.	Moderate: most features favorable, but high organic-matter content.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
*Flom—Continued Fv—For interpretations of Vallers depressional soil in mapping unit Fv, refer to mapping unit Vd in Vallers series.	Poor: frequently ponded; silty clay loam surface layer.	Not suitable	Poor: high seasonal water table; fair shear strength; fair compaction characteristics; medium to high compressibility; frequently ponded.	Poorly to somewhat poorly drained; high seasonal water table; medium to high compressibility; moderate to high shrink-swell potential; high potential for frost heaving; frequently ponded.	Medium to high compressibility; high seasonal water table; moderate to high shrink-swell potential; fair shear strength; frequently ponded.
Foxhome: FxA	Good	Poor: thin layer of gravelly coarse sand.	Fair: fair stability; fair shear strength; medium to high compressibility in the finer textured underlying material.	Poor to fair stability in upper 2 to 3 feet; medium to high compressibility in finer textured underlying material; moderate potential for frost heaving.	High compacted permeability; poor stability; poor resistance to piping in upper 2 to 3 feet; medium to high compressibility; fair shear strength in finer textured underlying material.
Glyndon: GlA, GlB, Gn	Good to fair: strongly calcareous in places.	Poor: very fine sand mixed with some silt and clay.	Poor: poor compaction characteristics; poor shear strength; poor stability; moderately high seasonal water table.	Poor stability; medium compressibility; severe potential for frost heaving; moderately high seasonal water table.	Medium permeability when compacted; poor compaction characteristics; poor resistance to piping; poor shear strength and stability.
Grimstad: Gr	Good to fair: strongly calcareous in places.	Poor: has a thin layer of fine sand commonly mixed with some silt and clay.	Fair: medium to high compressibility in finer textured underlying material; fair stability; fair shear strength; moderately high seasonal water table; may be used as homogenous material mixing upper 2 to 3 feet with underlying material.	Fair to poor stability; medium to high compressibility; moderate potential for frost heaving in finer textured underlying material; moderately high seasonal water table.	Moderate permeability when compacted; fair to poor resisance to piping in upper 2 to 3 feet; medium to high compressibility in finer textured underlying material.
Hamar: Ha	Fair: loamy fine sand surface layer.	Fair for fine sand; high seasonal water table.	Fair: good to fair erodibility; high seasonal water table; poor to fair stability.	Poorly to somewhat poorly drained; high seasonal water table; poor to fair stability.	High permeability when compacted; high seasonal water table; poor resistance to piping; poor to fair stability.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
All features favorable.	High seasonal water table; moderately slow permeability; frequently ponded.	Poorly drained; frequently ponded.	High seasonal water table; moderate to high shrink-swell potential; medium to high compressibility; frequently ponded.	Severe: high seasonal water table; poorly to somewhat poorly drained; moderately slow permeability; frequently ponded.	Moderate: most features favorable, but high organic-matter content.
Rapid permeability; poor resistance to piping in upper 2 to 3 feet; moderate permeability in the finer textured underlying material.	Not needed	Shallow depth to gravel; moderately to highly erodible.	Fair shear strength; moderate shrink-swell potential and medium to high compressibility in the finer textured underlying material.	Moderate: moderately well drained; moderate permeability in the finer textured underlying material.	Moderate to severe: rapid permeability; poor reservoir site material in upper 2 to 3 feet; moderate permeability in the finer textured underlying material.
Moderate permeability; poor resistance to piping.	Generally not needed.	Very fine sandy material; highly erodible.	Poor shear strength; medium compressibility; moderately high seasonal water table.	Moderate: somewhat poorly to moderately well drained; moderately high seasonal water table.	Severe: moderate permeability; medium permeability when compacted; moderate where slopes are 2 to 6 percent.
Moderately rapid permeability; fair to poor resistance to piping in upper 2 to 3 feet; moderate permeability in the finer textured underlying material.	Not needed	Shallow to fine sandy material; highly erodible.	Fair shear strength; moderate shrink-swell potential and medium to high compressibility in the finer textured underlying material; moderately high seasonal water table.	Moderate: somewhat poorly to moderately well drained; moderate permeability in finer textured underlying material; moderately high seasonal water table.	Moderate: moderately rapid permeability in upper 2 to 3 feet; moderate permeability in the finer textured underlying material.
Rapid permeability; poor resistance to to piping.	Shallow to unfavorable sandy material; high seasonal water table; coarse-textured surface layer.	Shallow to sandy material; poorly to somewhat poorly drained; highly erodible.	High seasonal water table.	Severe: high seasonal water table; poorly to somewhat poorly drained; may pollute local water sources.	Severe: rapid permeability; poor reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
*Hamerly: HeA, HeB, Hm— For interpretations of Vallers soils in Hm, refer to Vallers series.	Fair to good: strongly calcareous in places; may contain some coarse fragments.	Not suitable	Fair: medium to high compressibility; fair shear strength.	Medium to high compressibility; moderate potential for frost heaving.	Medium to high compressibility; fair shear strength.
Hangaard: Hn	Good to fair: shallow to gravel in places.	Fair: has some gravel and coarse sand mixed with considerable fine sand; quantity of gravel is variable.	Fair: high seasonal water table; fair to poor stability.	Poorly to somewhat poorly drained; high seasonal water table; fair to poor stability.	High compacted permeability; high seasonal water table; poor resistance to piping; fair to poor stability.
*Hegne: Ho, Hv— For interpretations of Fargo soils in Ho, refer to Fargo series. For interpretations of Viking soils in Hv, refer to Viking series.	Poor: high clay content; strongly calcareous in places.	Not suitable	Poor: poor shear strength; high shrink-swell potential; high compressibility; fair to poor stability and compaction characteristics; high seasonal water table.	Poorly drained; high seasonal water table; fair to poor stability; high compressibility; high shrink-swell potential; moderate to high potential for frost heaving.	Poor shear strength; high shrink-swell potential; high compressibility; fair to poor stability and compaction characteristics; high seasonal water table.
Kittson: KsA, KsC, KtA, KtB.	Good: contains some coarse fragments in places.	Not suitable	Fair: fair shear strength; moderate shrink-swell potential; medium to high compressibility.	Medium to high compressibility; moderate shrink-swell potential; moderate potential for frost heaving.	Fair shear strength; moderate shrink-swell potential; medium compressibility.
Kratka: Mapped only as undifferentiated unit with Rockwell soils. For interpretations, refer to mapping unit Rk, under the Rockwell series.					
*Langhei: LbC2, LbD2, LbE. For interpretations of Barnes soils in LbC2, LbD2, and LbE, refer to the Barnes series.	Fair to poor: low to moderate organic-matter content; strongly calcareous in places.	Not suitable	Fair: fair shear strength; fair stability.	Medium compressibility; moderate potential for frost heaving; moderate where slopes are 12 to 30 percent.	Fair shear strength, stability, and resistance to piping.
Maddock: MaA, MaC	Fair: loamy fine sand surface layer.	Good for fine sand.	Fair: poor stability.	Poor stability	High compacted permeability; poor stability; poor resistance to piping.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Moderate permeability.	Not needed	Most soil features favorable but moderately erodible.	Fair shear strength; low to moderate shrink-swell potential; medium to high compressibility.	Moderate: somewhat poorly to moderately well drained; moderate permeability in the underlying material.	Moderate: moderate permeability.
Moderate rapid permeability; poor resistance to piping; fair to poor stability.	Shallow to unfavorable gravelly material; high seasonal water table.	Shallow depth to gravelly material; poorly to somewhat poorly drained; moderately to highly erodible.	High seasonal water table.	Severe: high seasonal water table; poorly to somewhat poorly drained; may pollute local water sources.	Severe: moderately rapid permeability; poor reservoir site material.
All features favorable.	High seasonal water table; fine textured; slow permeability affected by microrelief that has numerous draws and pockets.	Poorly drained; poor workability.	Poor shear strength; high shrink-swell potential; high compressibility; high seasonal water table.	Severe: high seasonal water table; poorly drained; slow permeability.	Moderate: most soil features favorable, but high organic-matter content.
Moderate permeability.	Not needed	Most soil features favorable; slopes up to 8 percent.	Fair shear strength; moderate shrink-swell potential; medium to high compressibility.	Slight: moderate permeability; somewhat poorly to moderately well drained.	Moderate: moderate permeability; moderate where slopes are 2 to 8 percent.
Moderate permeability.	Not needed	Soil is very erodible where slopes are more than 6 percent.	Fair shear strength; low to moderate shrink-swell potential; medium compressibility.	Moderate: moderate permeability; moderate where slopes are 6 to 12 percent; severe where slopes are more than 12 percent.	Severe: all slopes are more than 6 percent.
Rapid permeability; poor resistance to piping.	Not needed	Shallow to favorable material; highly erodible.	All features favorable if soil is contained; poor stability if not contained.	Slight except where there may be danger of contamination of local water supplies.	Severe: rapid permeability; moderate where slopes are 2 to 8 percent; poor reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
Markey: Me	Good to mix with mineral soils.	Poor: fine sand occurs below the organic layer; frequently ponded.	Poor: organic layer must be stripped off; high seasonal water table; frequently ponded; underlying sandy material has poor stability.	Organic layer must be stripped off; high seasonal water table; frequently ponded; high potential for frost heaving; very poorly drained.	Organic layer must be stripped off; high seasonal water table; frequently ponded; poor stability; underlying sandy material has high permeability when compacted; poor resistance to piping.
Mavie: Mm	Good to fair: strongly calcareous in places.	Poor: thin layer of gravel; gravel mixed with fines in many places.	Fair: fair to poor stability in upper 2 to 3 feet; high seasonal water table; fair shear strength; moderate shrink-swell potential and medium to high compressibility in finer textured underlying material; may be used for homogenous fill.	Poorly drained; high seasonal water table; fair to poor stability in upper 2 to 3 feet; medium to high compressibility; moderate shrink-swell potential in finer textured underlying material.	High seasonal water table; upper 2 to 3 feet has high permeability when compacted; poor resistance to piping; finer textured underlying material has fair shear strength; moderate shrink-swell potential; medium to high compressibility.
Poppleton: Po	Poor: loamy sand surface layer; low organic-matter content.	Good for fine sand.	Fair: fair workability; poor to fair stability; moderately high seasonal water table.	Poor to fair stability; moderately high seasonal water table.	High permeability when compacted; poor resistance to piping; poor to fair stability.
Rockwell: Rc	Good to fair: strongly calcareous in places.	Poor: thin layer of fine sand mixed with some silt and clay.	Fair: high seasonal water table; fair shear strength and stability; in upper 2 to 3 feet finer textured underlying material has moderate shrink-swell potential; medium to high compressibilty; may be used as homogenous fill.	Poorly drained; high seasonal water table; medium to high compressibility in finer textured underlying material; high potential for frost heaving.	High seasonal water table; upper 2 to 3 feet has fair stability; poor resistance to piping; high permeability when compacted; finer textured material has fair shear strength; medium to high compressibility.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Very high organic-matter content on surface; underlying sandy material has rapid permeability; poor resistance to piping.	Very poorly drained; high seasonal water table; very high organic-matter content.	Very poorly drained; very high organic-matter content; poor workability; underlying sandy material highly erodible.	Very poorly drained; frequently ponded; very high organic-matter content on surface; high seasonal water table.	Severe: high seasonal water table; very poorly drained; frequently ponded.	Severe: moderate over rapid permeability; poor reservoir site material.
Moderate permeability.	High seasonal water table; shallow to gravelly material.	Shallow to gravel; poorly drained.	Finer textured underlying material has fair shear strength; moderate shrink-swell potential; medium to high compressibility; high seasonal water table.	Severe: high seasonal water table; poorly drained; finer textured underlying material has moderate permeability.	Moderate: poor reservoir site material in upper 2 to 3 feet; moderate permeability in finer textured underlying material.
Rapid permeability; poor resistance to piping.	Not needed	Shallow to fine sand; highly erodible; difficult to vegetate.	Moderately high seasonal water table; poor to fair stability unless contained.	Moderate: somewhat poorly to moderately well drained; may pollute local water supplies; moderately high seasonal water table.	Severe: rapid permeability; poor reservoir site material.
Moderately rapid permeability; poor resistance to piping in upper 2 to 3 feet; moderate permeability in finer textured underlying material.	High seasonal water table; shallow to sandy material.	Poorly drained; shallow to sandy material; highly erodible.	High seasonal water table; finer textured underlying material has fair shear strength; moderate shrink-swell potential; medium to high compressibility.	Severe: high seasonal water table; poorly drained; finer textured underlying material has moderate permeability.	Moderate: moderately rapid permeability in upper 2 to 3 feet; moderate permeability in finer textured underlying material; good to fair reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
Rockwell—Continued					
Rk	Poor: frequently ponded.	Poor: thin layer of fine sand; some silt and clay mixed with the sand.	Poor: high seasonal water table; fair shear strength and stability in upper 2 to 3 feet; finer textured underlying material has moderate shrink-swell potential; medium to high compressibility; frequently ponded.	Poorly drained; high seasonal water table; medium to high compressibilty in finer textured underlying material; high potential for frost heaving; frequently ponded.	High seasonal water table; upper 2 to 3 feet has fair stability; poor resistance to piping; high permeability when compacted; finer textured underlying material has fair shear strength; medium to high compressibility; frequently ponded.
Roliss:					
Ro	Good: contains some coarse fragments in places.	Not suitable	Fair: fair shear strength; moderate shrink-swell potential; high seasonal water table; medium to high compressibility.	Poorly drained; high seasonal water table; medium to high compressibility; high potential for frost heaving.	High seasonal water table; fair shear strength; moderate shrink-swell potential; medium to high compressibility.
Rs	Poor: frequently ponded.	Not suitable	Poor: high seasonal water table; fair shear strength; moderate shrink-swell potential; medium to high compressibility; frequently ponded.	High seasonal water table; medium to high compressibility; high potential for frost heaving; frequently ponded.	High seasonal water table; fair shear strength; moderate shrink-swell potential; medium to high compressibility; frequently ponded.
Rondeau: Ru	Fair to mix with mineral soil; strongly calcareous in places.	Not suitable	Not suitable	High seasonal water table; very high organic-matter content; frequently ponded; very poorly drained.	High seasonal water table; very high organic-matter content; frequently ponded; poor stability.
Seelyeville: Sc	Fair to mix with mineral soil.	Not suitable	Not suitable	High seasonal water table; very high organic-matter content; frequently ponded; very poorly drained.	High seasonal water table; very high organic-matter content; frequently ponded; poor stability.
*Sioux: Sd A, Sd B, Sg A, Sg C, Sm E. For interpretations of Maddock soils in mapping unit Sm E, refer to the Maddock series.	Fair to poor: may be shallow to gravelly material; sandy loam surface layer.	Good source of gravel and coarse sand.	Fair to good: fair to poor stability.	Fair to poor stability.	High permeability when compacted; poor resistance to piping; fair to poor stability.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Rapid permeability; poor resistance to piping in upper 2 to 3 feet; moderate permeability in the finer textured underlying material.	High seasonal water table; shallow to sandy material.	Poorly drained; shallow to sandy material; highly erodible; frequently ponded.	High seasonal water table; finer textured underlying material has fair shear strength; moderate shrink-swell potential; medium to high compressibility; frequently ponded.	Severe: high seasonal water table; poorly drained; finer textured underlying material has moderate permeability; frequently ponded.	Moderate to severe: rapid permeability in upper 2 to 3 feet; moderate permeability in finer textured underlying material; good to fair reservoir site material.
All features favorable.	High seasonal water table; moderate to moderately slow permeability.	Poorly drained	High seasonal water table; moderate shrink-swell potential; fair shear strength; medium to high compressibility.	Severe: high seasonal water table; poorly drained; moderate to moderately slow permeability.	Moderate: most features favorable, but high organic-matter content.
All features favorable.	High seasonal water table; moderate to moderately slow permeability; frequently ponded.	Poorly drained; frequently ponded.	High seasonal water table; moderate shrink-swell potential; fair shear strength; medium to high compressibility; frequently ponded.	Severe: high seasonal water table; poorly drained; moderate permeabilty; frequently ponded.	Moderate: most features favorable, but high organic-matter content.
Very high organic-matter content.	Very poorly drained; high seasonal water table; very high organic-matter content.	Very poorly drained; very high organic-matter content; poor stability.	High seasonal water table; very poorly drained; frequently ponded; very high organic-matter content; poor stability.	Severe: high seasonal water table; very poorly drained; very high organic-matter content.	Severe: very high organic-matter content; poor reservoir site material.
Very high organic-matter content.	Very poorly drained; high seasonal water table; very high organic-matter content.	Very poorly drained; very high organic-matter content; poor stability.	High seasonal water table; very poorly drained; frequently ponded, very high organic-matter content; poor stability.	Severe: high seasonal water table; very poorly drained; very high organic-matter content.	Severe: very high organic-matter content; poor reservoir site material.
Rapid permeability; poor resistance to piping.	Not needed	Shallow to gravelly material; moderately to highly erodible.	All features favorable if contained; poor stability if not contained.	Slight except where there may be danger of contamination of local water supplies.	Severe: rapid permeability; moderate where slopes are 2 to 8 percent; severe where slopes are more than 8 percent; poor reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
Sverdrup: SnA, SnC	Good	Good for fine and medium sand.	Good to fair: poor to fair stability.	Poor to fair stability	Poor resistance to piping; rapid permeability when compacted; poor to fair stability.
Swenoda: SwA, SwC	Good	Poor: thin layer of fine sand commonly mixed with some silt and clay.	Good to fair: upper sandy layer has poor to fair stability; finer textured underlying material has fair shear strength; moderate shrink-swell potential and medium to high compressibility.	Poor to fair stability in upper sandy layer; finer textured underlying material has medium to high compressibility; moderate potential for frost heaving.	Upper 2 to 3 feet has high permeability when compacted; poor resistance to piping; poor to fair stability; finer textured underlying material has fair shear strength and moderate shrink-swell potential.
Syrene: Sy	Fair: strongly calcareous in places; sandy loam surface layer.	Fair to poor: gravel often mixed with considerable fines; generally not enough gravel for good source.	Fair to poor: high seasonal water table; occasionally ponded or affected by seep; fair stability; some stones and cobblestones in places.	Poorly drained; high seasonal water table; moderate potential for frost heaving; moderate erodibility; occasionally ponded.	Poor resistance to piping; high seasonal water table; poorly drained; high permeability when compacted.
Towner: To	Fair: loamy fine sand surface layer.	Poor: thin layer of fine sand.	Good to fair: upper sandy layer has poor to fair stability; finer textured underlying material has fair shear strength and moderate shrink-swell potential; medium to high compressibility; moderately high seasonal water table.	Poor to fair stability in upper sandy layer; finer textured underlying material has medium to high compressibility; moderate potential for frost heaving; moderately high seasonal water table.	Upper 2 to 3 feet has high permeability when compacted; poor resistance to piping; fair to poor stability; finer textured material has fair shear strength and moderate shrink-swell potential.
Ulen: UlA, Un	Good to fair: strongly calcareous in places.	Good for fine sand.	Good to fair: poor to fair stability; moderately high seasonal water table.	Poor to fair stability; medium to high compressibility.	Poor resistance to piping; moderate to high permeability when compacted; poor to fair stability.

See footnotes at end of table.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
Moderately rapid permeability; poor resistance to piping.	Not needed	Shallow to sandy material; highly erodible; may be difficult to vegetate.	All features favorable if contained; poor stability if not contained.	Slight except where there is danger of polluting local water supplies.	Severe: moderately rapid permeability; poor reservoir site material; moderate where slopes are 2 to 8 percent.
Rapid permeability; poor resistance to piping in upper sandy layer; moderate permeability in finer textured underlying material.	Not needed	Shallow to sandy material; highly erodible.	Finer textured underlying material has fair shear strength; low to moderate shrink-swell potential; medium to high compressibility.	Moderate: moderate permeability in finer textured underlying material; moderately well drained.	Moderate: rapid permeability in upper sandy layer; moderate permeability in finer textured underlying material.
Moderately rapid permeability; poor resistance to piping.	Shallow to sand and gravel; occasionally ponded; high seasonal water table.	Shallow to sand and gravel; poorly drained; highly erodible.	Fair shear strength; high seasonal water table.	Severe: high seasonal water table; poorly drained; may pollute local water supplies.	Severe: moderately rapid permeability; poor reservoir site material.
Rapid permeability; poor resistance to piping in upper 2 to 3 feet; moderate permeability in finer textured underlying material.	Not needed	Shallow to sandy material; highly erodible; may be difficult to vegetate.	Upper 2 to 3 feet has poor stability unless confined; finer textured underlying material has fair shear strength, moderate shrink-swell potential, and medium to high compressibility.	Moderate: moderate permeability in finer textured underlying material; moderately well drained.	Moderate: rapid permeability in upper sandy layer; moderate permeability in the finer textured underlying material.
Moderately rapid permeability; poor resistance to piping.	Generally not needed.	Shallow to sandy material; highly erodible; may be difficult to vegetate.	Moderately high seasonal water table; poor stability if soil is not contained; good if contained.	Moderate: somewhat poorly to moderately well drained; may pollute local water supplies.	Severe: moderately rapid permeability; poor reservoir site material.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil [1]	Sand and gravel	Subgrade material [2]	Location of local roads and streets	Farm ponds: Embankments
Vallers: Va	Fair: silt loam surface layer; strongly calcareous in places.	Not suitable	Fair: fair shear strength; moderate to high shrink-swell potential; high seasonal water table; medium to high compressibility.	Poorly drained; high seasonal water table; medium to high compressibility; moderate to high shrink-swell potential; high potential for frost heaving.	Fair shear strength; moderate to high shrink-swell potential; moderate to high compressibility; high seasonal water table.
Vd	Poor: frequently ponded; strongly calcareous in places; some coarse fragments in places.	Not suitable	Poor: fair shear strength; moderate to high shrink-swell potential; high seasonal water table; medium to high compressibility; frequently ponded.	Poorly drained; high seasonal water table; medium to high compressibility; moderate to high shrink-swell potential; high potential for frost heaving; frequently ponded.	Fair shear strength; moderate to high shrink-swell potential; moderate to high compressibility; high seasonal water table; frequently ponded.
Viking: Vk	Fair to poor: high clay content in places; some coarse fragments in places.	Not suitable	Poor: poor shear strength; very high shrink-swell potential; high compressibility; poor compaction characteristics; high seasonal water table; poor to fair stability.	Poorly drained; high seasonal water table; fair to poor stability; high compressibility; very high shrink-swell potential; medium to high potential for frost heaving.	Poor shear strength; very high shrink-swell potential; high compressibility; fair to poor compaction characteristics; high seasonal water table.
Wahpeton: WaA, WaB, WaC.	Fair to poor: high clay content.	Not suitable	Poor: poor shear strength; very high shrink-swell potential; high compressibility; fair to poor compaction characteristics.	Fair to poor stability; high compressibility; very high shrink-swell potential; medium to high potential for frost heaving.	Poor shear strength; very high shrink-swell potential; high compressibility; fair to poor compaction characteristics.
Waukon: WkA, WkB, WkB2, WkC, WkD.	Good: some coarse fragments in places.	Not suitable	Fair: fair shear strength; fair stability.	Medium compressibility; moderate potential for frost heaving; moderate where slopes are 12 to 18 percent.	Fair shear strength, stability, and resistance to piping.
Wheatville: Wm	Good to fair: strongly calcareous in places.	Not suitable	Poor: moderately high seasonal water table; poor shear strength; fair to poor stability; fair to poor compaction characteristics; finer textured underlying material has high shrink-swell potential and poor workability.	Somewhat poorly to moderately well drained; moderately high seasonal water table; fair to poor stability; high potential for frost heaving; finer textured underlying material has high compressibility and high shrink-swell potential.	Moderately high seasonal water table; fair to poor stability; poor shear strength; upper 2 to 3 feet has medium permeability when compacted; finer textured underlying material has a high shrink-swell potential.

[1] Ratings refer to the surface layer where erosion is none to slight. Moderately eroded soils are less suited.

properties of the soils—Continued

Soil features affecting—Continued				Soil limitations for sewage disposal	
Farm ponds—Con. Reservoirs	Agricultural drainage	Waterways	Foundation for low buildings	Septic tank absorption fields	Sewage lagoons
All features favorable.	High seasonal water table; medium-textured; moderately slow permeability.	Poorly drained	High seasonal water table; fair shear strength; moderate to high shrink-swell potential; medium to high compressibility.	Severe: high seasonal water table; poorly drained; moderately slow permeability.	Moderate: most features favorable, but high organic-matter content.
All features favorable.	High seasonal water table; medium-textured; moderately slow permeability.	Poorly drained; frequently ponded.	High seasonal water table; fair shear strength; moderate to high shrink-swell potential; medium to high compressibility; frequently ponded.	Severe: high seasonal water table; poorly drained; moderately slow permeability; frequently ponded.	Moderate: most features favorable, but high organic-matter content.
All features favorable.	High seasonal water table; fine textured; slow permeability.	Poorly drained; poor workability.	Poor shear strength; very high shrink-swell potential; high compressibility; high seasonal water table.	Severe: high seasonal water table; poorly drained; slow permeability.	Moderate: most features favorable, but high organic-matter content.
All features favorable.	Generally not needed.	Poor workability	Poor shear strength; very high shrink-swell potential; high compressibility.	Severe: somewhat poorly drained; slow permeability.	Moderate: most features favorable, but high organic-matter content; severe where slopes are 6 to 12 percent.
Moderate permeability.	Not needed	Soil features favorable; slopes up to 18 percent.	Fair shear strength; low to moderate shrink-swell potential.	Moderate: moderate permeability; moderate where slopes are 6 to 12 percent; severe where slopes are more than 12 percent.	Severe where slopes are more than 6 percent; moderate where slopes are 2 to 6 percent; moderate permeability.
Moderate permeability; poor resistance to piping in upper 2 to 3 feet; all features favorable in finer textured underlying material.	Not needed	Very fine sand; highly erodible in upper 2 to 3 feet.	Moderately high seasonal water table; poor shear strength; finer textured underlying material has high compressibility and high shrink-swell potential.	Moderate to severe: slow permeability in finer textured underlying material; somewhat poorly to moderately well drained.	Moderate: moderate permeability in upper 2 to 3 feet; all features favorable in finer textured underlying material.

[2] Refers to material below the surface layer unless otherwise specified.

Maximum dry density is the maximum unit dry weight of the soil when it has been compacted with optimum moisture by the prescribed method of compaction. The moisture content that gives the highest dry unit weight is called the optimum moisture content for the specific method of compaction.

Mechanical analyses show the percentages, by weight, of soil particles that pass sieves of specified sizes. Sand and coarser materials do not pass the No. 200 sieve, while silt and clay do. In a further separation of particle sizes, the clay fraction was determined by the hydrometer method rather than by the pipette method used by most soil scientists.

The tests for *liquid limit* and *plasticity index* measure the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a solid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from solid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Estimated engineering properties

Table 6 provides estimates of soil properties important in engineering. The estimates are based on field classification and descriptions, on physical and chemical tests of selected representative samples, on test data from comparable soils in adjacent areas, and on detailed experience with the individual kind of soil in the survey area.

Depth to bedrock is not given in table 6. It is well beyond the depths to which the soils were investigated, and bedrock does not affect their use in this county.

Depth to seasonal water table is the depth at which free water is in the soil. The ranges shown are depths of water table fluctuation during an average year. Prolonged wet and dry periods result in shallower or deeper depths to water table. The depths shown do not include free water present above the frost line early in spring.

Percentage passing sieve are estimates of the amount of a sample of soil that passes through sieves of various sizes. The number of the sieve refers to the number of openings per inch.

Permeability, as used in table 6, relates only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other conditions or properties that result from use of the soils are not considered.

Available water capacity is that amount of capillary water in the soil available for plant growth after all free water has drained away.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value, and relative terms used to describe soil reaction, are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Engineering interpretations

Table 7 contains selected information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, buildings, and sewage disposal systems. Detrimental or undesirable features are emphasized, but very important desirable features also may be listed. The ratings and interpretations in this table are based on estimated engineering properties of the soils in table 6; on available test data, including those in table 5; and on field experience. While the information applies strictly only to soil depths indicated in table 6, it is reasonably reliable to a depth of about 5 feet for most soils.

Topsoil is a term used to designate a fertile soil or soil material, ordinarily rich in organic-matter content, used as a topdressing for lawns, gardens, roadbanks, and the like. The ratings indicate suitability for such use.

Sand and gravel ratings are based on the probability that delineated areas of the soil contain deposits of sand and gravel. The ratings do not indicate quality or size of the deposits.

Subgrade material is material used as compacted fill. The ratings indicate performance of soil material moved from borrow areas for these purposes.

The location of local roads and streets is influenced by features of the undisturbed soil that affect construction and maintenance of highways, such as drainage, shrink-swell potential, and compactibility.

Farm pond reservoirs hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to permeability and depth to bedrock or other permeable material. *Embankments* require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility.

Agricultural drainage is used to remove excess water from poorly drained areas. Features considered are permeability, texture, structure, depth to the water table, susceptibility to flooding, and availability of outlets.

Waterways are used to allow water to flow in defined channels across the land without causing erosion. Features considered are those that affect the establishment, growth, and maintenance of vegetative cover.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support buildings of not more than three stories. Specific values of bearing strength are not assigned.

Septic tank absorption fields are affected mainly by permeability, location of water table, and susceptibility to flooding. The degree of limitations and the principal reasons for assigning moderate or severe limitations are given.

Sewage lagoons are influenced chiefly by such soil features as permeability, reservoir site material, organic-matter content, and slope. The degree of limitation and the principal reasons for assigning moderate or severe limitations are given.

Formation and Classification of the Soils

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Norman County. The second explains the current system of soil classification and places each soil series represented in the county in the classes of that system.

Factors of Soil Formation

Soil results from the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material accumulated and that has existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and resulting drainage conditions, and (5) and length of time that the forces of soil formation have acted on the soil material. These factors of soil formation are interdependent, and few generalizations can be made regarding any one factor unless the effects of the others are known.

Man has also influenced the development of soils by disturbing the natural balance of certain factors or altering related conditons. In removing natural vegetation and tilling the soil, he has accelerated erosion. Changes in drainage condition, relief, or the effects of relief as induced by man also may influence soil development. Modification of natural differences by adding fertilizers, using organic residues, or cropping without replacing nutrients also alters the soil-forming processes and resulting soil characteristics.

Parent material

Norman County soils formed in calcareous lacustrine deposits in the basin of glacial Lake Agassiz and in calcareous glacial till that has associated areas of alluvium and glacial outwash. A nearly level, calcareous, lacustrine deposit covers approximately three-fourths of the county. These parent materials generally are fine textured (clay) to the west and become progressively coarser to the east, grading into silt, very fine sand, and finally sand and gravel where waters were shallow and gently sloping beach ridges are common. Areas of lake-modified glacial material also occur throughout the glacial lake basin.

A small but unique area of sand dunes has formed in northwestern Sundahl Township. The steeper dunes in this area have slopes up to 60 percent and rise to a height of more than 35 feet. The sand in this area is fine and medium and was deposited as a delta of the Sand Hill River.

The eastern one-fourth of Norman County exhibits a rather complex relief, in which slopes range from gently sloping to steep. Parent materials in this area were deposited by the Des Moines lobe of the Mankato substage of the Late Wisconsin ice sheet. The calcareous, gray and buff drift of this glacial plain is mainly loam. Small pebbles and stones are scattered throughout these parent materials. Associated with this area are relatively small areas of outwash, alluvium, and colluvium that range in texture from loam to gravel. Pockets and draws of poorly drained soils are common on this till plain and commonly are darker colored, finer textured, or more organic than those in the surrounding better drained areas.

Climate

As a soil-forming factor, climate affects the physical, chemical, and biological relationships of the soil. Rainfall, humidity, and frost influence the availability of moisture and the percolation rates. This movement of water in turn dissolves minerals and transports them in the soil mass. Temperature influences formation in that it regulates the growth of organisms and the speed of chemical reactions.

Norman County has a subhumid, midcontinental climate characterized by wide variations in temperature from summer to winter. The winters are long, and the soil is frozen to a depth of 3 to 5 feet for approximately 6 months of the year. During this time, except for some effects of frost action, the soil-forming processes are largely dormant. The growing season averages 120 days, and during this time approximately 60 percent of the annual precipitation is received. It is during this part of the year that the soil-forming processes influenced by climate are most active. The climate is essentially uniform throughout the county; however, differences in vegetation and relief cause small areas to be influenced by microclimates. Additional information on the climate of this county is in the section "General Nature of the County."

Plant and animal life

All forms of life, both in and on the soil, influence the chemical and biological processes of the soil. Bacteria, earthworms, and other forms of animal life aid in the weathering of materials and the decomposition of organic matter. Vegetation, including plants and fungi, influences formation in returning residues to the soil and aiding in decomposition. It also affects formation in the transfer of elements in the soil mass and influences soil pH and, in a close interrelationship with climate and relief, the movement of materials by leaching.

The native vegetation in the glacial lake basin of Norman County was principally tall prairie grasses mixed with wetland reeds and sedges. Fire control had some effect on limiting tree growth in this area. The eastern part of this basin has had an encroachment of trees, with numerous areas of quaking aspen. Grasses and sedges that grew over most of the glacial lake basin added large amounts of organic matter to the soils. The encroachment of forest vegetation seems to have had little influence on soil formation in this area. The till plain in the eastern quarter of the county that developed under medium and tall prairie grasses also had an encroachment of wooded areas, principally bur oak and elm on the well-drained sites. This encroachment again seems to have had little influence. However, on some of the better drained sites, and especially in Bear Park Township, the leaching of materials gives evidence of development under forest vegetation. Such bottom-land hardwoods as ash, elm, and poplar line the banks and narrow terraces

of the major streams in the county. These trees aid in stabilizing these areas, but other effects on soil formation have been minimal.

The activities of animals on formation of soils in the county are of minor importance as compared to the influence of plants. Earthworms and rodents do, however, perform an important function in the transportation and translocation of organic materials. Snails and other marine life also influence soil formation, in that their shells or other skeletal structures increase the carbonate content of the soils. The action of bacteria on soil material and organic matter also is an important factor in the formation of soil.

Relief

Relief influences soil formation through its effect on drainage, aeration, erosion, and vegetation.

The relief of Norman County is a product of deposits of glacial debris and differential sedimentation in the basin of glacial Lake Agassiz and the beach ridges built up along its old shore lines. The cutting action of streams draining the lake basin, melt waters from the till plain, and the ground moraine left by glacial ice also influenced relief.

The relief of the lake basin is level to nearly level, with many slightly concave areas. This commonly results in poorly drained soils that have high organic-matter content and either a gleyed condition or a concentration of carbonates and mottling of varying intensity in the profile. The exception is some of the very sandy and gravelly soils in the eastern part of the lake basin, where steeper slope and better drainage are common.

The influence of relief is more evident on the glacial till plain in the eastern part of the county. Many of the hilltops, knolls, or ridges of the gently sloping to steep topography of this area are occupied by soils that have a very thin, dark surface layer or have the calcareous, gray and buff parent material exposed. These soils commonly resulted from accelerated erosion influenced by rapid runoff, drought, and a lack of protective vegetative cover. Soils downslope from knolls and ridges commonly have a thicker A horizon, a B horizon, and a resulting greater depth to free carbonates. More poorly drained soils in pockets and draws of this area have a development very similar to that of poorly drained soils in the lake basin.

Time

Long periods of time are required to develop a soil profile; however, the length of time to reach a particular level of development is quite variable. Much less time is required for soil to form in humid regions that have dense vegetation than in very cold regions that have little vegetation. Drainage also influences how rapidly a soil develops, and well-drained sites generally develop more rapidly. The nature of parent material also determines how quickly development takes place. Such materials as glacial till or lacustrine sediment develops soil profiles much more rapidly than hard bedrock.

Geologically, the soils of Norman County are young. Most of the parent material was deposited between 9,000 and 12,000 years ago on a glacial till plain and in a lacustrine basin. These materials originated as reworked glacial drift carried by earlier glaciers and had considerable weathering prior to deposition in their present location. This is indicated by a dominance of montmorillonitic clay in the soil.

Many soils in the glacial till plain of the county have fairly well developed profiles and distinct A, B, and C horizons. Although they developed over nearly the same length of time, soils in the glacial lake basin have less distinct horizonation. These soils, however, exhibit dark, highly organic surface layers and commonly have an accumulation of carbonates or a gleyed horizon just below the surface. The differences in development in these areas are basically due to the factors of related relief and drainage. A few soils on recent alluvial deposits adjacent to major drainageways have little or no profile development.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

The system of classifying soils currently used by the National Cooperative Soil Survey was developed in the early sixties (*5*), and was adopted in 1965 (*7*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 8 shows the classification of each soil series of Norman County by family, subgroup, and order, according to the current system. Some of the soils in the county do not fit in a series that has been recognized in the classification system, but recognition of a separate series would not serve a useful purpose. Such soils are named for series they strongly resemble because they differ from such series in ways too small to be of consequence in interpreting their usefulness or behavior. Soil scientists designate such soils as taxadjuncts to the series for which they are named. In this survey soils named in the Barnes, Bearden, Cashel, Colvin, Fargo, Hamerly, Hegne, Seelyeville, and Sioux series are taxadjuncts to those series.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two

TABLE 8.—*Classification of soil series of Norman County*

Series	Family	Subgroup	Order
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Augsburg	Coarse-silty over clayey, frigid	Typic Calciaquolls	Mollisols.
Barnes [1]	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Bearden [1]	Fine-silty, frigid	Aeric Calciaquolls	Mollisols.
Borup	Coarse-silty, frigid	Typic Calciaquolls	Mollisols.
Cashel [1]	Fine, montmorillonitic	Fluventic Haploborolls	Mollisols.
Cathro	Loamy, euic	Terric Borosaprists	Histosols.
Colvin [1]	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Darnen	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Fargo [1]	Fine, montmorillonitic, noncalcareous, frigid	Vertic Haplaquolls	Mollisols.
Flaming	Sandy, mixed	Aquic Haploborolls	Mollisols.
Flom	Fine-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Foxhome	Sandy-skeletal over loamy, mixed	Aquic Haploborolls	Mollisols.
Glyndon	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Grimstad	Sandy over loamy, frigid	Aeric Calciaquolls	Mollisols.
Hamar	Sandy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Hamerly [1]	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols.
Hangaard	Sandy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Hegne [1]	Fine, frigid	Typic Calciaquolls	Mollisols.
Kittson	Fine-loamy, mixed	Aquic Haploborolls	Mollisols.
Kratka	Sandy over loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Langhei	Fine-loamy, mixed, calcareous, frigid	Typic Udorthents	Entisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Markey	Sandy or sandy-skeletal, euic	Terric Borosaprists	Histosols.
Mavie	Sandy-skeletal over loamy, frigid	Typic Calciaquolls	Mollisols.
Poppleton	Mixed, frigid	Aquic Udipsamments	Entisols.
Rockwell	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Roliss	Fine-loamy, mixed, calcareous, frigid	Typic Haplaquolls	Mollisols.
Rondeau	Marly, euic	Limnic Borosaprists	Histosols.
Seelyeville [1]	Euic	Typic Borosaprists	Histosols.
Sioux [1]	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Sverdrup	Sandy, mixed	Udic Haploborolls	Mollisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Syrene	Sandy, frigid	Typic Calciaquolls	Mollisols.
Towner	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Ulen	Sandy, frigid	Aeric Calciaquolls	Mollisols.
Vallers	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Viking	Very fine, montmorillonitic, calcareous, frigid	Typic Haplaquolls	Mollisols.
Wahpeton	Fine, montmorillonitic	Udortic Haploborolls	Mollisols.
Waukon	Fine-loamy, mixed	Mollic Eutroboralfs	Alfisols.
Wheatville	Coarse-silty over clayey, frigid	Aeric Calciaquolls	Mollisols.

[1] These soils are taxadjuncts. They are outside the range of the series with which they are here identified in the following ways:
Barnes soils have a thicker solum than defined for the series.
Bearden and Colvin soils have more clay at a depth below 30 inches.
Cashel soils in this county have darker colors in the A horizon and upper part of the C horizon.
Fargo silty clay loams have less clay in the A horizon and the upper part of the B horizon.
Some of the Hamerly soils have more silt in the Cca horizon.
The Hegne soils in the Hegne-Viking complex have more clay and more coarse fragments in the A and C horizons than is in the range for the series, and the structure of the C horizon is angular blocky instead of platy.
The Seelyeville soils contain more mineral material and free carbonates in the organic soil material.
Some Sioux sandy loams have a thicker mollic epipedon and less gravel in the A horizon and upper part of the C horizon than the defined range for the series, and loamy sand extends to a greater depth.

exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. Table 8 shows that the four soil orders represented in Norman County are Alfisols, Entisols, Histosols, and Mollisols.

Alfisols are moderately dark colored soils formed where trees have encroached upon grasslands. They have no mollic epipedon unless it is associated with an Ap horizon in a cultivated area. A clay-enriched horizon is always present.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Histosols are soils with organic accumulations that range in thickness from 16 to more than 55 inches. These soils differ in kind of fiber, amount of decomposition, reaction, and the nature of underlying material.

Mollisols formed under grass and have a thick, friable, dark-colored surface layer. These soils have a relatively soft or mellow surface layer.

SUBORDER.—Each order has been subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences that result from the climate or vegetation. The suborder is not shown separately in table 8.

GREAT GROUP.—Suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated or those that contain a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 8 because it is the last word in the name of the subgroup.

SUBGROUP.—Great groups are divided into subgroups, one that represents the central (typic) segment of the group and others, called intergrades, that have properties of one group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILY.—Families are separated within a subgroup primarily on the basis of properties important to growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES.—The series consists of a group of soils that formed from a particular kind of parent material and that have genetic horizons that are similar in differentiating characteristics and in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

General Nature of the County

This section is primarily for readers not familiar with Norman County. It tells about the physiography, relief, drainage, and climate of the county. The history and development of the county are discussed, and farming is summarized.

Physiography, Relief, and Drainage

The highest part of Norman County is on morainic hills in the southeastern section. This area is known locally as Frenchman's Bluff and has an elevation of about 1,300 feet. The lowest point is about 820 feet above sea level and occurs in the northwestern corner, where the Red River of the North leaves the county. The maximum difference in elevation, then, is almost 500 feet; however, about two-fifths of the county is less than 900 feet above sea level (*1*). The slope of the western half of the county commonly is 2 or 3 feet per mile, while further east the rim of the glacial Lake Agassiz basin generally rises about 20 feet to the mile. The original glacial topography exists in the extreme eastern part of the county. This topography is rather complex, with uneven, short slopes and numerous depressions and natural drainageways. Soils in this area commonly range from gently sloping to steep. Calcareous, gray and buff glacial drift from the Mankato substage of the Late Wisconsin glaciation occurs throughout the county. In all but the extreme eastern part of the county, where original glacial topography exists, the glacial drift is overlain by sediments of glacial Lake Agassiz.

These sediments are deep-water clay in the western part of the basin and become progressively coarser to the east, grading to silt, very fine sand, and sand and gravel in the slopes and beach ridges near shore. In parts of the basin where lake waters were shallow and covered the area for a relatively short period of time, sediments are very thin and evidence of glacial drift is common.

The Red River of the North drains all of Norman County. Its primary tributaries are the Wild Rice River and the Marsh River. The Sand Hill River drains a small area in the northeastern corner of the county. All these rivers flow west and slightly north to the Red River of the North. Numerous natural draws and creeks also drain the county. An extensive system of ditches has been constructed to aid in draining excess water from farmlands.

Climate [6]

Located near the center of the North American continent, Norman County has a continental climate. Warm summers are a result of the long hours of sun radiation at fairly high altitudes above the horizon. The greatest amount of precipitation occurs during summer, when the southerly winds bring up the low-level moist air from the Gulf of Mexico. Cold winters are a result of relatively low incoming radiation from the sun and advection of the polar and arctic air from the north out of Canada. The frequency and duration of cold spells

[6] By EARL L. KUEHNAST, Minnesota State climatologist, University of Minnesota.

depend on the amount of cold air and the period of time it is advected in from the north.

The climate of the county is uniform, and the greatest variability is in minimum temperatures and summer precipitation. On calm nights, instrument shelter temperatures in low-lying areas are a few degrees lower than average; however, surface ground level temperatures are significantly lower. Rainfall from showers in warm months varies considerably from place to place, but seasonal totals are about the same.

The mean temperature for winter months is 10° F., and for summer months, 68°. On the average, there are 15 days above 90° in summer and 55 days below zero in winter. The record high and low temperatures were both recorded in 1936. The record high of 111° was on July 6, and the record low of −53° was on February 15. Temperature data for Norman County are described in tables 9 and 10.

About 75 percent, or nearly 17 inches, of the annual precipitation falls during the period April through September. Precipitation of 0.01 inch or more can be expected about 102 days per year.

Rainfall intensities of 1 inch per hour every year, 1.8 inches per hour every 10 years, and 2.4 inches per hour every 50 years are expected to occur. Chances of receiving 1 inch of rain per any given week are 30 percent in June, 22 percent in July, and 20 percent in August. Precipitation data are described in table 9. Severe droughts have occurred four times between 1931 and 1963. The length of the drought varies from 1 month to 23 months.

Damaging storms, such as tornadoes and hail and ice storms (glaze), are not numerous, although they can

TABLE 9.—*Temperature and precipitation*

[All data from Ada, Minnesota, except last two columns, which are from Fargo, North Dakota]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly extreme maximum	Average monthly extreme minimum	Average total	1 year in 10 will have:		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	15.3	−4.7	38.0	−29.9	0.50	0.08	1.27	26	5
February	19.6	−2.1	40.2	−26.4	0.52	0.08	1.29	26	3
March	34.1	13.5	55.2	−12.8	0.76	0.09	1.33	11	5
April	54.0	30.5	76.6	13.6	1.86	0.63	3.37	3	2
May	68.4	41.4	87.6	25.1	2.80	0.81	5.62	0	----------
June	76.9	51.7	91.3	36.0	3.82	1.48	7.24	0	----------
July	82.6	56.9	95.1	43.6	3.16	1.03	5.63	0	----------
August	80.9	54.0	94.6	39.3	3.00	0.92	5.52	0	----------
September	70.7	44.1	89.0	26.8	1.94	0.55	4.38	0	----------
October	57.2	33.2	79.5	15.4	1.25	0.22	2.66	(1)	1
November	35.1	17.7	57.4	−6.5	0.83	0.06	1.90	4	2
December	21.4	2.5	40.9	−23.8	0.58	0.10	1.30	20	3
Year	----------	----------	[2] 98.0	[3] −33.0	21.64	15.13	26.66	93	3

[1] Less than half a day.
[2] Average annual highest maximum.
[3] Average annual lowest minimum.

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

[All data recorded at Ada]

Probability	Dates for given probabilities and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 23	May 4	May 16	May 24	June 8
2 years in 10 later than	April 17	April 29	May 10	May 19	June 2
5 years in 10 later than	April 6	April 18	April 29	May 9	May 23
Fall:					
1 year in 10 earlier than	October 17	October 4	September 19	September 17	September 7
2 years in 10 earlier than	November 7	October 10	September 25	September 21	September 12
5 years in 10 earlier than	November 15	October 22	October 8	September 30	September 20

create havoc. The area lies to the northwest of maximum tornado frequency. Norman County reported six tornadoes between 1916 and 1962, and there were 11 hailstorms reported between 1933 and 1962. Localized damage, due to heavy rains, ice storms, wind and hail in connection with thunderstorms, warm fronts, cold fronts, and line squalls, is experienced each year. There are about 34 thunderstorms each year.

The first measurable snowfall of the season generally occurs in November, and the last occurs late in March or early in April (*3*). Severe blizzards are infrequent. The path of the winter storms, which develop in the southwestern section of the country, generally is to the south of this area during winter. Excessive drifting of snow can occur because of frequency of high winds. Afternoon temperatures rarely rise above freezing in winter, and slushy conditions generally occur late in fall or early in spring from alternate freezing and thawing.

Records for Fargo, North Dakota, show the following mean relative humidity readings: January, 6 a.m., 71 percent; noon, 68 percent; 6 p.m., 70 percent; and midnight, 80 percent. July, 6 a.m., 85 percent; noon, 54 percent; 6 p.m., 53 percent; and midnight, 80 percent. There commonly are 89 clear days per year, 110 partly cloudy days, and 166 cloudy days. The greatest mean wind velocity is 15.0 m.p.h. from the north in April; the least is 10.9 m.p.h. from the south in July.

History and Development

Norman County was established in February 1881. The population of the county in 1910 was 13,446. In 1940 the population was 14,746, and by 1970 it had declined to 10,008. The present county seat, Ada, was plotted in December 1881. It is the largest town in the county and has a population of 2,076. Other incorporated villages are Borup, Gary, Halstad, Hendrum, Perley, Shelly, and Twin Valley.

The first railroad entered Norman County in 1872. At present, the Burlington Northern Railroad provides freight service to all parts of the county. Freight can also be trucked to market over three north-south and two east-west highways. These are U.S. Highway 75 and State Highways 9, 32, 113, and 200. The major highways and many county roads are paved or blacktopped, and more county maintained roads are blacktopped each year. Minor roads are on most section lines in the county.

Grain elevators are located throughout the county, and grain crops are marketed mainly in Duluth, Minneapolis, and St. Paul. Sugar beets are stockpiled in the county and are processed at Crookston and Moorhead. Livestock generally is marketed in West Fargo and, occasionally, in South St. Paul. Creameries and plants for processing dairy products are located in the county.

Norman County is mainly farmland and has little potential for recreational development. Some overnight camping areas and wayside rests, however, have been developed along the major highways. A number of towns have municipal parks, and the city of Ada has a golf course and three parks. About 4,600 acres of public and semipublic land in the county are in wildlife management areas.

Farming

Wheat, oats, barley, potatoes, and hay cut from the native prairie grasses were the principal crops produced by the first settlers in Norman County. Wheat is now the most important cash crop, with 2,982,000 bushels produced in 1968. Barley and oats also are important crops. Sugar beets are an important cash crop in the county, but their production is restricted to farmers with an allotted acreage. This acreage is largely on the moderately fine textured and fine textured lacustrine soil in the western half of the county. Sunflowers have gained in importance as demands for sunflower products have increased. Both the confectionary and oil varieties are grown in the county, and a considerable acreage is produced under contract. Some soybeans are grown, 353,600 bushels in 1968. Corn also is grown in the county, most of it for silage and other livestock feed, and a smaller acreage harvested for grain.

Since the 1940's the number of livestock in Norman County has decreased. The number of farmers with livestock as part of their operation also is greatly reduced, although the number of livestock per farmer often is greater. Livestock-oriented farming operations are most common in the eastern one-third of the county. Hay for livestock feed is an important crop, with 58,000 tons of alfalfa hay put up in 1968 (*8*).

In 1964 Norman County had 1,325 farms, with an average size of 394.2 acres. In 1968 the number of farms had dropped to 1,095, with an average size of approximately 460 acres.

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Glossary

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

Calcareous soil. A soil that contains enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Coarse-textured soil. Sand and loamy sand.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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

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

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil. Opposed to altered drainage, which commonly is the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils commonly are very porous and rapidly permeable and have a low water holding capacity.

Somewhat excessively drained soils also are very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and commonly are of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper part of the B horizons and have mottling in the lower part of the B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be lacking or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper part of the profile.

Drift (geology). Material of any sort deposited by geologic processes in one place after having been removed from another; includes drift materials deposited by glaciers and by streams and lakes associated with glaciers.

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

Fine-textured soil. Sandy clay, silty clay, and clay.

Glacial till (geology). Unsorted, nonstratified glacial drift that consists of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottles caused by intermittent waterlogging.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons generally are called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

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

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Marl. An earthy, unconsolidated deposit formed in fresh-water lakes that consists chiefly of calcium carbonate mixed with various amounts of clay or other impurities.

Medium-textured soil. Very fine sandy loam, loam, silt loam, or silt.

Microrelief. Minor surface configurations of the land.

Moderately coarse textured soil. Sandy loam or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

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

Sapric material. Muck. Fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark in color.

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

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

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

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Varves. Distinctly marked annual deposits of sediment, regardless of their origin.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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