Issued December 1966

SOIL SURVEY

TRI-COUNTY AREA

North Dakota

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1956 to 1958. Soil names and descriptions were approved in 1961. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1958. This survey was made cooperatively by North Dakota Agricultural Experiment Station in cooperation with the Soil Conservation Service; it is part of the technical assistance furnished to the Soil Conservation Districts in Cass, Ransom, and Richland Counties.

HOW TO USE THIS SOIL SURVEY REPORT

THIS SOIL SURVEY of Tri-County Area, N. Dak., contains information that can be applied in managing farms and windbreaks; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All the soils of the Tri-County Area are shown on the detailed map at the back of this report. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. 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 and Capability Units" can be used to find information in the report. This guide lists all of the soils of the area in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit or any other group in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show the 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 in the soil descriptions and in the discussions of the groupings for management of tilled crops, pasture, and windbreaks.

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

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in the Tri-County Area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the sections "Climate" and "Physiography, Relief, and Drainage."

Cover picture: Maddock and Hamar soils in native grass.

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Contents

NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued December 1966

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

Series 1957, No. 23, Las Vegas and Eldorado Valleys Area, Nev.
Series 1958, No. 34, Grand Traverse County, Mich.
Series 1959, No. 42, Judith Basin Area, Mont.
Series 1960, No. 31, Elbert County, Colo. (Eastern part)
Series 1961, No. 42, Camden County, N.J.
Series 1962, No. 13, Chicot County, Ark.
Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

SOIL SURVEY OF TRI-COUNTY AREA, NORTH DAKOTA

REPORT BY HOLLIS W. OMODT, FRED W. SCHROER, AND C. R. REDMOND, NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

SOILS SURVEYED BY FRED W. SCHROER, C. E. REDMOND, M. D. SWEENEY, D. D. PATTERSON, AND S. PHILIPPI, NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION, AND E. H. EVENSON AND P. T. CAMPBELL, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

THE TRI-COUNTY AREA, in the southeastern part of North Dakota (fig. 1), is made up of parts of Cass, Ransom, and Richland Counties. It occupies about 428 square miles. The area has an irregular shape. It is 49 miles long from north to south. The maximum width is about 22 miles in the southern part, and the minimum width is only about 1½ miles near the center.

The survey area formerly had a cover of tall grasses, but now most of it is used for crops. The crops are mainly wheat, barley, flax, oats, corn and hay. Wheat and barley are the principal small grains. Beef cattle and hogs provide another important source of income, but more than half of the income is from the sale of grain crops.

It has been proposed that water from the Garrison Reservoir be used to provide water for irrigation in the Tri-County Area. In the soil survey program in North Dakota, the North Dakota State University Agricultural Experiment Station, in cooperation with the Soil Conservation Service, has the primary responsibility for making soil surveys in areas proposed for irrigation. This survey was made after the Tri-County Irrigation District was organized.

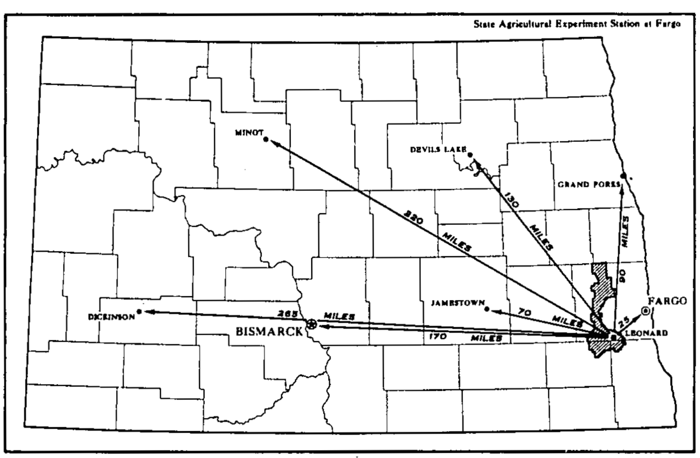

Figure 1.—Location of the Tri-County Area in North Dakota.

Physiography, Relief, and Drainage

The Tri-County survey area lies along the western margin of what was formerly Glacial Lake Agassiz (*18*).[1] Within it are four physiographic areas (fig. 2), each of which has surface features unlike those of the other areas. These are the till plain, the beach area, the Sheyenne Delta, and the lake plain.

The first of these, the till plain, lies along the western edge of the Tri-County survey area. It is 1,100 to 1,200 feet above sea level, but it is lowest in the southern part. The soils of the till plain are undulating to nearly level, but there are numerous low knolls and small, shallow, closed depressions. Because surface drainage is poorly developed in the till plain, most of the runoff collects in the depressions, and the channels of intermittent streams have developed in a few places. These intermittent streams are tributaries of streams that eventually empty into the Red River of the North. A narrow part of the till plain adjacent to Herman Beach has been smoothed by the action of the waters of the glacial lake, and many of the depressions are nearly filled with sediment.

The second physiographic location, the beach area, lies east of the till plain. It extends northward across Cass County from a point about 6 miles north of the line that separates Ransom County from Cass County. The beach area is about 1,000 to 1,100 feet above sea level. Within it is a succession of five roughly parallel beach areas, or ridges, that are 2 to 10 feet high and extend in a north-south direction (fig. 3). These ridges represent the various levels reached by the waters of Glacial Lake Agassiz. The relative size and distinctness of each beach ridge indicates the length of time the water remained at each level.

Herman Beach is the westernmost of these ridges, and it is the largest and most nearly continuous of the five. It represents the highest static level reached by the waters of the lake. East of Herman Beach are the Norcross and Tintah Beaches, but neither of these is as prominent as

[1] Italic numbers in parentheses refer to Literature Cited, p. 91.

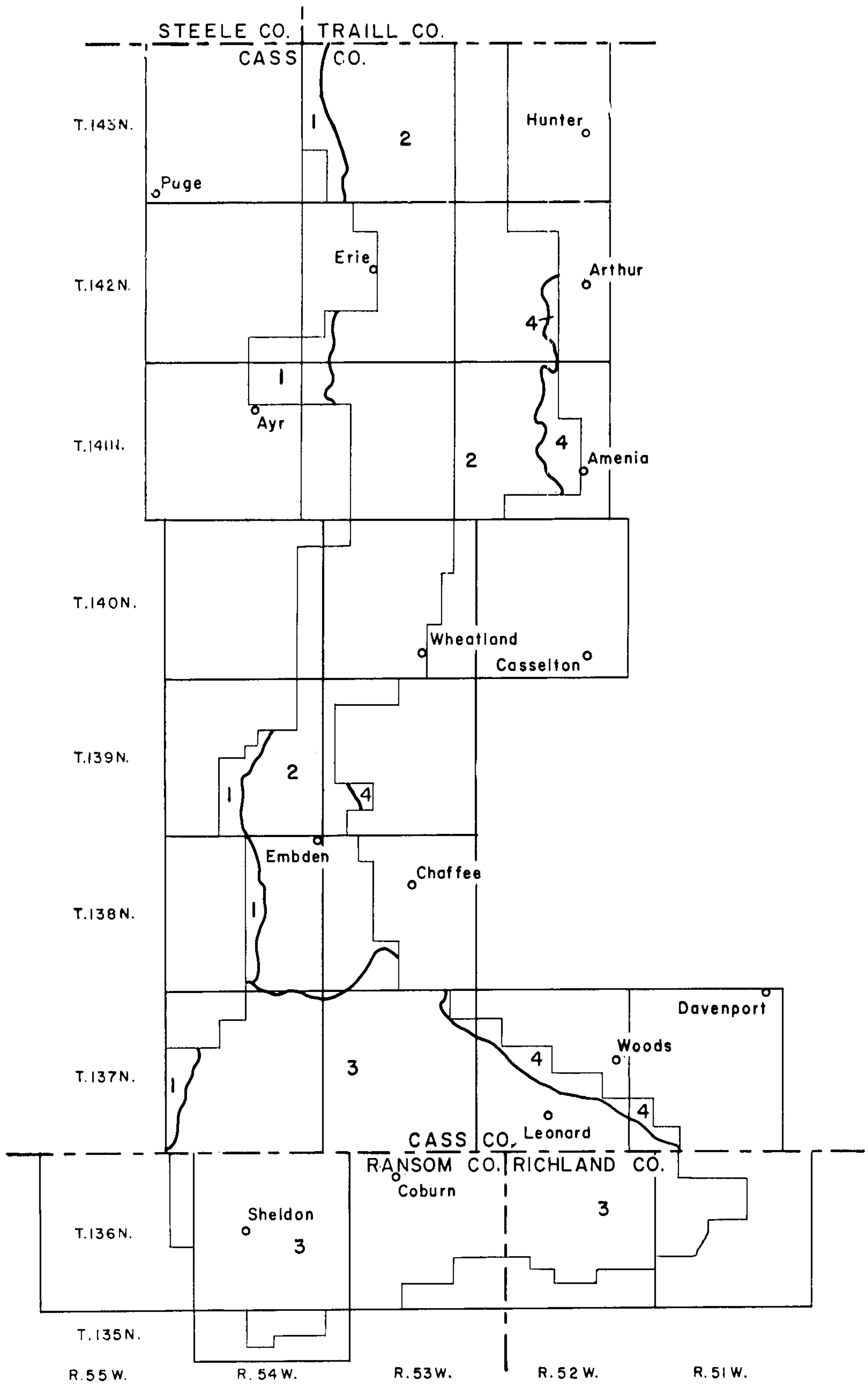

Figure 2.—Physiographic divisions in the Tri-County survey area.
1. Till plain.
2. Beach area.
3. Sheyenne Delta.
4. Lake plain.

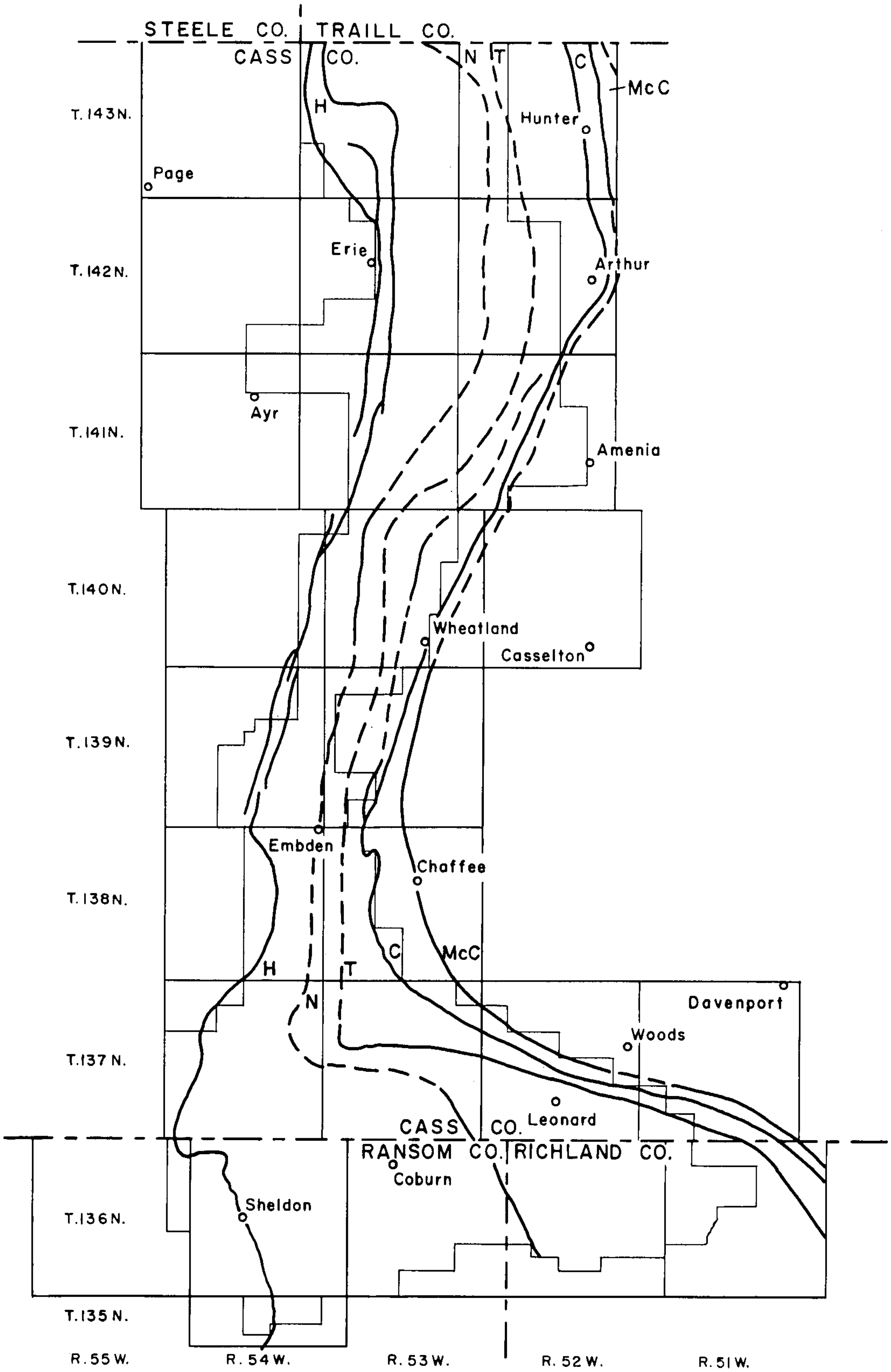

Figure 3.—**Beaches of Glacial Lake Agassiz.**

H = Herman Beach
N = Norcross Beach.
T = Tintah Beach.
C = Campbell Beach.
McC = McCauleyville Beach.

Herman Beach. Campbell Beach, along the eastern edge of the beach area, is a prominent ridge. East of it is McCauleyville Beach, which is low and discontinuous. That beach appears only as a slight rise on the edge of the lake plain. Many other short, discontinuous, low beach ridges are in the area associated with the major beach ridges.

The beach ridges consist mostly of sand and gravel, but the sediments range from moderately coarse textured to medium textured. The areas between the beach ridges are smooth and slope gently to the east. At the eastern base of the beach ridges, the soils are poorly drained as a result of seepage through the coarse-textured beach sediments.

The beach area is drained by the Elm and Rush Rivers, Swan Creek, and a few unnamed intermittent streams. Drainage to the east has been restricted by the beach ridges. Ponding occurred west of the ridges until the water flowed over the ridgetops and entrenched. Nearly all the streams have a southward trend. The Rush River and the stream north of the town of Embden were blocked by the beach ridges, and they flowed southward for several miles before they entrenched eastward to the lake plain.

The third physiographic area, the Sheyenne Delta, is large and nearly level. It is made up of silty and sandy sediments deposited in Glacial Lake Agassiz by the Sheyenne River. The Sheyenne Delta slopes to the northeast with a fall of about 2 feet per mile. From Sheldon to the town of Leonard, a distance of about 13 miles, the elevation drops from 1,079 to 1,053 feet.

The area of the Sheyenne Delta that is west of Herman Beach in Ransom County has some features similar to those of the till plain. In that area are depressions, 10 to 50 acres in size, that lie 20 or more feet below the general level of the plain. This area is covered by a mantle of sediments of lacustrine or deltaic origin.

Moderately coarse textured and coarse textured sediments are dominant in the part of the Delta in and east of Range 53. Evidences of the modification of the original surface features by wind action are common in that part of the Sheyenne Delta. The sandy sediments that were originally deposited have been moved about by wind, and as a result, low dunes are along the southern edge of that area.

Because the soils of the Sheyenne Delta are nearly level and the water from precipitation enters them readily, there is only a small amount of runoff. Surface drainage is provided by the Maple River, which is deeply entrenched in the Delta. An intermittent stream southwest of Sheldon empties into the Maple River north and east of Sheldon. A deep ravine, about 3 miles long, extends to the edge of the Delta northwest of Leonard.

Because of the highly permeable material in the surface layer of the soils and the lack of surface drainage, nearly half of the Sheyenne Delta south of the Maple River has restricted drainage. In that area the water table is within 5 feet of the surface in most years during at least part of the growing season.

The fourth physiographic area, the lake plain, occupies small areas east of the beach area and the Sheyenne Delta. Most of these areas are nearly level. In places, however, there are low ridges and shallow depressions in which the difference in elevation is less than 12 inches from the ridgetop to the bottom of the depression.

Climate

The Tri-County survey area is near the center of North America, latitude 47° N., far from the moderating influence of large bodies of water. The climate is continental and is marked by extremes in temperature. In winter the weather is usually cold, the temperature fluctuates widely, and there are occasional blizzards. In summer the weather is warm, the temperature is somewhat less variable than in winter, and there is 60 to 70 percent of the possible number of hours of sunshine. During July the normal relative humidity at noon is 48 percent. The prevailing winds in winter are northwesterly, and those in summer are usually northwesterly or southeasterly. Hailstorms occur less frequently than they do in the western part of North Dakota. Few tornadoes have occurred in this area.

In the following paragraphs facts about temperature and precipitation in the survey area are given for three places that are considered representative for the area. These are Amenia, in Cass County near the center of the survey area; Fargo, also in Cass County a short distance east of the survey area; and Lisbon, in Ransom County in the southern part of the survey area. Table 1 shows the probabilities of the last freezing temperature in spring and the first in fall at these three locations (*12*).

TABLE 1.—*Probabilities of last freezing temperatures in spring and first in fall* (*12*)

AMENIA

Probability	24° F. or lower	28° F. or lower	32° F. or lower
Spring:			
1 year in 4 later than	May 3	May 13	May 24
1 year in 2 later than	Apr. 25	May 6	May 17
3 years in 4 later than	Apr. 17	Apr. 29	May 10
9 years in 10 later than	Apr. 9	Apr. 22	May 3
Fall:			
1 year in 4 later than	Sept. 28	Sept. 23	Sept. 15
1 year in 2 later than	Oct. 6	Sept. 30	Sept. 21
3 years in 4 later than	Oct. 14	Oct. 7	Sept. 27
9 years in 10 later than	Oct. 22	Oct. 13	Oct. 3

FARGO

Probability	24° F. or lower	28° F. or lower	32° F. or lower
Spring:			
1 year in 4 later than	May 3	May 11	May 20
1 year in 2 later than	Apr. 25	May 4	May 13
3 years in 4 later than	Apr. 17	Apr. 27	May 6
9 years in 10 later than	Apr. 9	Apr. 20	Apr. 29
Fall:			
1 year in 4 later than	Oct. 8	Sept. 27	Sept. 19
1 year in 2 later than	Oct. 16	Oct. 4	Sept. 25
3 years in 4 later than	Oct. 24	Oct. 11	Oct. 1
9 years in 10 later than	Nov. 1	Oct. 17	Oct. 7

LISBON

Probability	24° F. or lower	28° F. or lower	32° F. or lower
Spring:			
1 year in 4 later than	May 4	May 15	May 28
1 year in 2 later than	Apr. 26	May 8	May 21
3 years in 4 later than	Apr. 18	May 1	May 14
9 years in 10 later than	Apr. 10	Apr. 24	May 7

TABLE 1.—*Probabilities of last freezing temperatures in spring and first in fall* (*12*)—Continued

LISBON

Probability	24° F. or lower	28° F. or lower	32° F. or lower
Fall:			
1 year in 4 later than	Sept. 29	Sept. 21	Sept. 14
1 year in 2 later than	Oct. 7	Sept. 28	Sept 20
3 years in 4 later than	Oct. 15	Oct. 5	Sept. 26
9 years in 10 later than	Oct. 23	Oct. 11	Oct. 2

For the period 1931 through 1962, the average temperature for January was 7.0° F. at Amenia, 6.8° at Fargo, and 8.9° at Lisbon. For the same period, the average temperature for July was 71.5° at Amenia and Fargo and 71.7° at Lisbon. The highest recorded temperatures during this period were 115° at Amenia, 114° at Fargo, and 113° at Lisbon. The lowest recorded temperatures were −42° at Amenia, −38° at Fargo, and −40° at Lisbon.

Table 2 shows the average monthly and average annual precipitation at Amenia, Fargo, and Lisbon for the period 1931 to 1962, inclusive. Because about 80 percent of the average annual precipitation of 20 inches occurs during the period April through September, when it is most effective, the growth of crops and pasture plants is favorable. October rainfall is also valuable for the growth of crops in the following year. The total average rainfall from April through October is 16.09 inches at Amenia, 15.35 inches at Fargo, and 16.89 inches at Lisbon, or an average of 16.11 inches for all three places. About 3 inches of precipitation occurs as snow from November through March; some of it is lost as runoff in spring.

The term "dry-subhumid" (*14*) has been used to describe the climate of this area. Dry years, or periods of semiarid or arid climate, are not uncommon. Annual precipitation was below 16 inches in 20 percent of the years on record (*2*). In dry periods that frequently occur during the growing season, the moisture requirements of the crops exceed the amount of moisture available from rainfall and from moisture stored in the soils. In these periods the yield and quality of crops are greatly reduced.

TABLE 2.—*Average monthly and average annual precipitation at Amenia, Fargo, and Lisbon for the period 1931-62*

Month	Precipitation at—		
	Amenia	Fargo	Lisbon
	Inches	*Inches*	*Inches*
January	0. 37	0. 52	0. 48
February	. 45	. 52	. 56
March	. 79	. 74	. 80
April	1. 75	1. 71	1. 93
May	2. 79	2. 12	2. 58
June	3. 62	2. 99	3. 81
July	2. 66	3. 00	2. 72
August	2. 52	2. 85	3. 02
September	1. 54	1. 58	1. 60
October	1. 21	1. 10	1. 23
November	. 76	. 81	. 72
December	. 46	. 57	. 47
Total	18. 92	18. 51	19. 92

How Soils Are Mapped and Classified

Soil scientists made this survey to learn what kinds of soils are in the Tri-County Area, where they are located, and how they can be used.

They went into the survey area knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over this area, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; 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 roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in areas nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

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. Hecla and Fargo, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Hecla fine sand and Hecla fine sandy loam are two soil types in the Hecla series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Hecla fine sandy loam, nearly level, is one of two phases of Hecla fine sandy loam, a soil type that is extensive in the survey area.

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 greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. 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 type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Hamar-Ulen fine sandy loams.

Two or more soils that normally do not occur with any regularity in pattern or in proportions may be mapped together. When this is done, the unit is called an undifferentiated mapping unit and is named for its major soils. Such groups of soils generally consist of two or more series. At least one of the component soils of the group occurs in every delineated area, but all of the component soils may occur in some delineated areas, and more than one, but not all, in others. The individual areas of component soils are large enough so that they could be set apart on a detailed map. For the most part, however, the soils of the group are similar enough in behavior so that their separation is not important for the objectives of the survey. An example of an undifferentiated group is Embden and Hecla fine sandy loams.

Other areas, shown on most soil maps, are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Alluvial land or Gravel pits, and are called land types rather than soils.

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 soils 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 soils. 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 a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. Based on the yield and practice tables and other data, the soil scientists set up trial groups, and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

This section is for persons interested in the soils in areas larger than a farm. Its purpose is to provide a general picture of the soils of the Tri-County survey area. The information it provides is useful in planning general agricultural programs, in planning development of communities, and in locating areas suitable for a specific crop or kind of farming.

A map showing the soil associations of the Tri-County Area has been placed in the back of this report. Each area on the map is identified by a number and a distinctive color. The areas on this map consist of soils that occur in characteristic patterns or positions on the landscape. The most extensive soils within each area, or soil association, is indicated in the name of that association. In some instances a single soil may be dominant in an association. More commonly, two or three soil series are in an association and each of these makes up a significant part of the acreage. Several different soils, for example, make up association 4, Gardena-Glyndon-Eckman association, and association 9, Renshaw-Sioux association. Each area on the general soil map also contains smaller areas of soils other than those specified in the name of the association.

In the text, the soil associations are described in the order in which they are named in the legend on the general soil map. A part of the discussion of each association is mention of the relative extent of the soils in it, the general area in which the soils occur, and some of the uses and limitations of the soils. More detailed information about the soils is given in the sections "Descriptions of the Soils," "Use and Management of Soils," and "Formation and Classification of Soils."

1. Aberdeen Association

Nearly level, somewhat poorly drained, silty soils that have a claypan

In this association are nearly level, mainly somewhat poorly drained soils that have a claypan subsoil. The association is between the towns of Arthur and Amenia, along the eastern edge of the survey area on the boundary between the beach area and the lake plain. It occupies less than 1 percent of the survey area.

Aberdeen soils occupy about three-fourths of the association, and Fargo and Bearden soils occupy about one-fourth. All of these soils have a surface layer of silt loam or silty clay loam and a subsoil of dense, clayey, very slowly permeable material. The lower part of their subsoil and the substratum contain soluble salts and gypsum.

The clayey material in the subsoil restricts the growth of roots and thus limits the productivity of the soils in this association. Yields are highest in the years in which rainfall is uniformly distributed but are lower in years when rainfall is excessive or too low. The soils are likely to become waterlogged in wet years.

The Aberdeen soils are fair for agriculture, but yields are somewhat lower than on the Fargo and Bearden soils. Wheat, barley, flax, corn, and hay are the principal crops.

2. Bearden-Overly-Fargo Association

Nearly level, moderately well drained to poorly drained silt loams to clays

In this association are moderately well drained to poorly drained, nearly level soils of the lake plain and a few small, nearly level patches of soils of the beach area. The association occupies about 3 percent of the county.

Bearden, Overly, and Fargo soils are dominant in the association, and they are about equal in extent. All of these soils have developed in moderately fine textured or fine textured lake sediments. The texture of their surface layer is silt loam to clay. The surface layer contains a large amount of organic matter, and the available moisture capacity is high.

The Bearden soils have a surface layer of dark-colored silty clay loam or silt loam that is high in content of lime. Just beneath the surface layer is a layer of light-colored silty clay loam where calcium carbonate has accumulated. The Bearden soils are moderately well drained or somewhat poorly drained. In many years they have a high water table in spring.

The Overly soils have a thick, black surface layer of silty clay loam. They are moderately well drained.

The Fargo soils also have a thick, black surface layer, but the texture of their surface layer is silt loam to clay. The Fargo soils are poorly drained and have a very slowly permeable subsoil of olive-gray clay. Surface drains can be used to remove the excess water.

All of the soils of this association are well suited to cultivated crops. Yields of all of the crops commonly grown in the survey area are high on the Overly and Bearden soils. Yields are lower on the Fargo soils because the Fargo soils have poorer drainage and finer texture than the Overly and Bearden soils. Although all of the soils of this association are productive, crops grown on them respond to applications of phosphate and nitrogen fertilizer.

3. Embden-Glyndon-Egeland Association

Nearly level, well-drained or somewhat poorly drained loams or fine sandy loams

The soils of this association are nearly level, well-drained or somewhat poorly drained loams or fine sandy loams of the beach area and the Sheyenne Delta. They are adjacent to the Maple River. The association occupies about 20 percent of the area surveyed.

Embden and Glyndon soils each occupy about 40 percent of the association, and Egeland soils occupy about 10 percent. The rest of the association consists of Gardena, Eckman, and other minor soils.

The Embden, Glyndon, and Egeland soils formed in moderately coarse textured and medium-textured beach sediments and deltaic sediments of Glacial Lake Agassiz. All of them have a dark-colored surface layer that is high in content of organic matter. The Glyndon soils have high available moisture capacity, but the available moisture capacity of the Embden and Egeland soils is moderate.

The Embden soils have a thick, dark-colored surface layer of fine sandy loam. They are moderately well drained and occupy nearly level or slightly concave areas, where they formed in moderately coarse textured material. The Embden soils are highly susceptible to wind erosion if they are cultivated.

The Glyndon soils also have a dark-colored surface layer, and they have a light-colored, medium-textured layer of lime accumulation immediately beneath the surface layer. They formed in medium-textured material. The Glyndon soils are moderately well drained or somewhat poorly drained, and they have a seasonal high water table.

The Egeland soils have a surface layer that is thinner than that of the Embden soils. They are well drained and occupy slightly higher positions than those occupied by the Embden and Glyndon soils. They formed in moderately coarse textured material. The Egeland soils are highly susceptible to wind erosion.

The Glyndon soils are the most productive of any of the soils of this association. The Embden soils are more productive than the Egeland. Wheat, barley, oats, flax, corn, and hay are the main crops. All of these soils have moderate to high natural fertility, but phosphate and nitrogen fertilizer increase yields. Response to fertilizer is more consistent on the Glyndon soils than on the Embden and Egeland because of the higher moisture-holding capacity of the Glyndon soils.

4. Gardena-Glyndon-Eckman Association

Nearly level, well-drained to somewhat poorly drained loams

Nearly level, well-drained to somewhat poorly drained loams, in the nearly level parts of the beach area and the western part of the Sheyenne Delta make up this association. These soils developed in medium-textured lake sediments, but more than 30 percent of the association is underlain by glacial till or by fine-textured lake sediments. The association occupies about 34 percent of the survey area.

Gardena soils occupy about 50 percent of this association, Glyndon soils about 30 percent, and Eckman soils about 5 percent. Minor soils are the Embden, Renshaw, and Egeland.

All of the soils of this association contain a large amount of organic matter, but the Gardena soils contain more organic matter than the other soils. The available moisture capacity is high in all of these soils.

The Gardena soils have a thick, black, loamy surface layer. They are moderately well drained.

The Glyndon soils have a surface layer that is thinner than that of the Gardena soils, and their surface layer is high in content of lime. The Glyndon soils are nearly level, are moderately well drained to somewhat poorly drained, and have a seasonal high water table. For these soils surface drainage is required to obtain consistently high yields.

The Eckman soils also have a surface layer that is thinner than that of the Gardena soils. They are in slightly higher areas than the Gardena and Glyndon soils, and they are well drained.

The soils of this association are well suited to cultivated crops, but yields are generally higher on the Gardena and Glyndon soils than on the Eckman soils. This is because the Eckman soils occupy slightly higher positions, and there is more runoff than on the Glyndon and Gardena soils.

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Although all of these soils are productive, crops grown on them generally respond well to applications of phosphate and nitrogen fertilizer.

5. Hecla-Hamar-Ulen Association

Nearly level and gently undulating, moderately well drained to poorly drained, sandy soils

This association is made up of nearly level or gently undulating, moderately well drained to poorly drained, sandy soils of the Sheyenne Delta and the northern part of the beach area. It is the most extensive association of the Sheyenne Delta and occupies about 18 percent of the survey area.

Soils of the Hecla series occupy about 50 percent of the association, and soils of the Hamar and Ulen series each occupy about 20 percent. Minor soils are those of the Embden, Tiffany, and Arveson series. All of the soils of this association have a dark-colored surface layer and developed in moderately coarse textured or coarse textured sediments. They are moderate to low in fertility, have a moderate to high content of organic matter, and have low available moisture capacity. A seasonally high water table is at a depth of less than 5 feet in many places.

The Hecla soils have a thick, black surface layer that is moderately coarse textured. They are nearly level or gently undulating and occur at a slightly higher elevation than the Hamar and Ulen soils. In many places within this association they occupy areas less than 5 feet higher than those occupied by the Hamar soils. The Hecla soils are moderately well drained. They are highly susceptible to wind erosion.

The Hamar soils also have a thick, black surface layer that is coarse textured. They are nearly level and occupy low areas of the association. The Hamar soils are poorly drained and have a water table at a depth of less than 5 feet during most of the growing season. They, like the Hecla soils, are highly susceptible to wind erosion.

The Ulen soils have a thinner surface layer than the Hecla and Hamar soils, but their surface layer is black. They contain a light-colored zone of lime accumulation. The Ulen soils are nearly level. They occupy slightly higher areas than the Hamar soils and slightly lower areas than the Hecla soils. Ulen soils are moderately well drained to somewhat poorly drained.

Corn, oats, barley, wheat, and hay are the main crops grown on this association, and part of the association is used for native pasture. The soils are well suited to native pasture but are less well suited to field crops. In seasons when rainfall is above normal, wetness is a serious problem where field crops are grown. Crops grown on these soils respond to applications of phosphate and nitrogen fertilizer.

6. La Prairie-Fairdale Association

Nearly level, moderately well drained loams on flood plains

Moderately well drained loams on flood plains and on the higher bottom lands make up this association. These soils are mainly in the valleys of the Maple and Rush Rivers. The association occupies less than 3 percent of the survey area.

La Prairie and Fairdale soils make up most of this association, but minor areas are occupied by Lamoure and Borup soils. The La Prairie and Fairdale soils are about equal in extent. They occur together in a complex pattern in some areas where the bottom lands are dissected by numerous old stream channels. In places their value for agriculture is diminished by the small size of the areas and the presence of the old stream channels.

The soils of this association have developed in medium-textured sediments that were deposited recently by streams. They have high moisture-holding capacity.

The La Prairie soils are dark colored and are moderately well drained. They are nearly level and are on high bottom lands that are seldom flooded. The areas are commonly bordered by or are encircled by abandoned stream channels.

The Fairdale soils have a moderately dark colored surface layer and a light-colored subsoil. They are moderately well drained.

The soils of this association are productive and are well suited to cultivated crops. Crops grown on them, however, respond well to applications of phosphate and nitrogen fertilizer.

7. Maddock-Hamar Association

Gently undulating to hilly, somewhat excessively drained to poorly drained, sandy soils

This association is on the Sheyenne Delta along the eastern and southern boundaries of the survey area. The areas are gently undulating in some places and hummocky to hilly or dunelike in others. Blowout areas and overblown areas are common. The association occupies about 2 percent of the survey area. It is made up of sandy soils that are somewhat excessively drained to poorly drained.

This association consists mainly of Maddock and Hamar soils, but small areas of Hecla and Ulen soils are included. The Maddock soils are more extensive than the Hamar.

All of these soils developed in sands deposited by wind. They are dark colored or moderately dark colored, low to high in content of organic matter, and low in available moisture capacity.

The well-drained to somewhat excessively drained Maddock soils occupy the higher parts of the association, or the hummocks, low ridges, and dunes. They are dark colored and coarse textured. These soils are moderately fertile, but they are highly susceptible to wind erosion. Moderate erosion has already occurred in the areas that have been cultivated. The content of organic matter is moderate to low.

The Hamar soils occupy the low areas between the hummocks and low ridges. They, like the Maddock soils, are dark colored and coarse textured. The Hamar soils contain a large amount of organic matter. They are poorly drained, but their moisture-holding capacity is low.

The soils of this association are well suited to native pasture and hay, but yields of field crops are low on the Maddock soils. If the Maddock soils are cultivated, they require intensive practices that control erosion. The Hamar soils are moderately productive. Unless drainage is provided, however, they are not suited to legumes or to crops that are planted early in spring.

8. Overly-Gardena Association

Nearly level, moderately well drained loams to silty clay loams

This soil association consists of nearly level, moderately well drained soils on the lake plain in the southwestern corner of the county. The association occupies about 2 percent of the survey area.

Overly and Gardena soils make up most of the association. They developed in medium-textured and moderately fine textured lake sediments underlain by glacial till. These soils are dark colored, are high in content of organic matter, and have high available moisture capacity.

The surface layer of the Overly soils is thick, black silt loam or silty clay loam, and their subsoil is very dark grayish-brown silt loam to silty clay loam. The profile of the Gardena soils is similar to that of the Overly soils, except that the texture of their surface layer and subsoil is loam. The loamy glacial till that underlies these soils is at a depth of 4 to 5 feet.

The soils of this association are well suited to cultivated crops. Wheat, barley, flax, oats, corn, and hay are the principal crops.

9. Renshaw-Sioux Association

Nearly level to rolling, well-drained and excessively drained soils that are shallow to gravel and coarse sand

This association occupies long, narrow strips on beach ridges in the beach area and is on terraces adjacent to the valley of the Maple River. It makes up only about 2 percent of the survey area. The soils are well drained or excessively drained and are shallow over gravel and coarse sand.

Renshaw and Sioux soils occupy most of the association. These soils are dark colored, and they developed in medium-textured to moderately coarse textured sediments. Gravel and coarse sand are near the surface. Small areas of Divide, Spottswood, and Fordville soils are included in this association.

The Renshaw soils are well drained. They are on terraces and beach ridges and are underlain by gravel and sand at a depth of 10 to 24 inches. Their available moisture capacity is moderate to low.

The Sioux soils are excessively drained. They are on the crests of beach ridges and on the edges of terraces. They have a dark-colored, medium-textured or moderately coarse textured surface layer and are underlain by gravel and sand at a depth of less than 10 inches. Their moisture-holding capacity is low.

Areas of the Renshaw soils of this association are fair for cultivated crops where gravel and sand are more than 15 inches beneath the surface. The shallower Renshaw soils and the Sioux soils are poorly suited to cultivated crops. In many places, however, where small areas of these shallow soils occur with more productive soils, they are farmed with the more productive soils.

10. Svea-Hamerly-Barnes Association

Nearly level to undulating, well-drained to somewhat poorly drained loams

This association is mainly on the till plain along the western edge of the survey area, but it is partly within the beach area. It occupies about 6 percent of the survey area. The soils are loamy, are well drained to somewhat poorly drained, and are nearly level or undulating.

Svea soils occupy about 40 percent of the association, Hamerly soils about 25 percent, and Barnes soils about 20 percent. Small areas of Buse, Vallers, Tetonka, and Parnell soils make up the rest of the association.

The Svea, Hamerly, and Barnes soils developed in loamy glacial till. They have a dark colored or moderately dark colored surface layer, a high to moderate content of organic matter, and high available moisture capacity. Their fertility ranges from high to moderate.

The Svea soils are moderately well drained, and they are in nearly level or in concave areas. Their surface layer is thick and black.

The Hamerly soils are moderately well drained or somewhat poorly drained. Their surface layer is moderately thick, is dark colored or moderately dark colored, and is calcareous in most places. Unlike the Svea and Barnes soils, the Hamerly soils have a light-colored layer of lime accumulation just beneath the surface layer. Their content of organic matter is moderately high, and their moisture-holding capacity is high. The Hamerly soils are affected by a seasonal high water table during part of the year.

The Barnes soils are well drained. They have a moderately thick, dark-colored surface layer. Their content of organic matter is moderate, and their moisture-holding capacity is high.

All of the soils of this association are well suited to cultivated crops, but the Svea soils are the most productive. In spring, seeding may be delayed on the Hamerly soils because those soils are likely to be wet. Wheat, barley, oats, corn, and hay are the principal crops. The crops respond well to applications of phosphate and nitrogen fertilizer.

11. Ulen-Hecla Association

Nearly level, moderately well drained or somewhat poorly drained, sandy soils

Except for one tract in the northern part of the survey area, this association occupies low, nearly level areas on the Sheyenne Delta. It occupies about 5 percent of the survey area. The soils are moderately well drained or somewhat poorly drained and are sandy.

Ulen soils occupy more than 60 percent of the association, and Hecla soils occupy about 15 percent. The rest of the association consists of Hamar, Embden, and Arveson soils.

The Ulen and Hecla soils developed in coarse textured and moderately coarse textured material, and they have a dark-colored surface layer. Their content of organic matter is moderate, and their available moisture capacity is low. The Ulen and Hecla soils are highly susceptible to wind erosion.

The Ulen soils have a surface layer that is calcareous in most places. Their subsoil is light colored and is highly calcareous. These soils are moderately well drained or somewhat poorly drained, but their moisture-holding capacity is low. In most years a seasonal high water table is less than 5 feet from the surface during much of the growing season.

The Hecla soils occupy slightly higher areas than the Ulen soils, and they are moderately well drained. They are moderately high in content of organic matter but have low moisture-holding capacity.

The soils of this association are fairly well suited to cultivated crops, and most of the association is used for field crops. Wetness often delays seeding on the Ulen soils, however, and wetness is a hazard on those soils in years when rainfall is above normal during the growing season.

Descriptions of the Soils

This section describes the soil series and the mapping units in the Tri-County Area. The procedure is first to describe each soil series, and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs.

Each soil series contains a description of the soil profile, the major layers from the surface downward. This profile is considered typical, or representative, for all the soils of the series. If the profile for a given mapping unit differs from this typical profile, the differences are stated in the description of the mapping unit, or they are apparent in the name of the mapping unit. Some technical terms are used in describing soil series and mapping units, simply because there are no nontechnical terms that convey precisely the same meaning. Many of the more commonly used terms are defined in the Glossary.

The acreage and proportionate extent of the mapping units are shown in table 3. Detailed technical descriptions of soil series are given in the section "Formation and Classification of Soils." At the back of the report is a list of the mapping units in the county and a designation of the capability unit each mapping unit is in. The page where each of these groups is described is also given.

Aberdeen Series

In the Aberdeen series are somewhat poorly drained soils developed in medium-textured to fine-textured glacial lake sediments. These soils are in nearly level areas or in slight depressions.

The surface layer is black, slightly acid silt loam 6 to 15 inches thick. It has weak crumb and fine granular structure and is friable when moist and slightly sticky when wet.

The subsurface layer is very dark gray or gray, slightly acid very fine sandy loam, loam, or silt loam that has platy structure. It is very friable when moist and slightly sticky and slightly plastic when wet. The thickness of the subsurface layer ranges from 2 to 5 inches.

The subsoil is a very dark grayish-brown, mildly alkaline silty clay loam to clay. It has moderate prismatic and moderate columnar structure but breaks easily to strong blocky structure. In places the upper part of the prisms breaks easily to platy structure. The surfaces of the prisms and blocks are coated with distinct clay films. The subsoil is very hard when dry, very firm when moist, and very sticky and very plastic when wet. It is 10 to 15 inches thick.

The substratum is dark grayish-brown to olive-gray silty clay loam to clay. It is moderately alkaline, calcareous, and moderately saline. Soluble salts and segregations of gypsum and lime are common. The upper part of the substratum has a high content of exchangeable sodium.

The Aberdeen soils have a thicker surface layer and subsurface layer than the Exline soils, and the salts have been leached from their subsoil. Unlike the Fargo and Bearden soils, they have a gray subsurface layer. Also, their subsoil has prismatic and columnar structure instead of blocky structure like that of the Fargo subsoil. The Aberdeen soils lack the layer of lime accumulation immediately beneath the surface layer that is typical in the Bearden soils.

Most areas of the Aberdeen soils are used for crops.

Aberdeen silt loam (0 to 2 percent slopes) (Ad).—This is the only Aberdeen soil mapped in the county. It is in nearly level areas or in slight depressions on the lake plain. The surface layer is black, friable silt loam that contains a moderate amount of organic matter and is 6 to 15 inches thick. The subsurface layer is dark-gray loam 2 to 5 inches thick. The subsoil is very dark grayish-brown clay to silty clay loam.

Permeability is moderate in the surface layer and subsurface layer, but it is slow in the subsoil and very slow in the substratum. Water enters this soil readily, but it moves downward very slowly through the profile. After a large amount of rain has fallen, this soil has a perched water table just above the subsoil. The substratum contains soluble salts and segregations of gypsum. The density of the subsoil and the salts and gypsum in the substratum limit the depth to which roots can penetrate.

Much of the time, this soil is droughty because of the shallow root zone, or it is too wet for tillage because of the slow movement of water through the profile. In spring, tillage and planting are often delayed because this soil is wet. The excess surface water can be removed by using surface drains.

Most areas of this soil are farmed, and wheat, barley, oats, flax, corn, and hay are the crops commonly grown. Yields are good in years when rainfall is uniformly distributed. They are poor in unusually wet or unusually dry years. (Capability unit IIIs–2)

Alluvial Land

Alluvial land (0 to 2 percent slopes) (Ak).—This miscellaneous land type is on bottom lands along narrow intermittent drainageways that lack a well-defined stream channel. Most areas are hummocky. The hummocks are 1 to 2 feet high and 3 to 5 feet apart. Drainage is very poor, and seepage is received from adjacent areas. At times, this land type is covered by runoff from higher areas. The water table is at or near the surface during the growing season.

The upper part of the soil material is black and is high in content of organic matter. Its texture ranges from sandy loam to silty clay loam.

All of this land type is used for pasture. (Capability unit Vw–1)

Arveson Series

The Arveson series consists of poorly drained soils developed in moderately coarse textured or coarse textured sediments deposited in glacial lakes. These soils are in

TABLE 3.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
	Acres	*Percent*
Aberdeen silt loam	1,250	0.5
Alluvial land	1,456	.5
Arveson fine sandy loam	2,232	.8
Arveson fine sandy loam, moderately shallow	260	.1
Arveson fine sandy loam, very wet	119	[1]
Arveson loam	535	.2
Barnes loam, undulating	1,034	.4
Barnes-Buse loams, rolling	1,047	.4
Barnes-Buse loams, strongly rolling	690	.2
Barnes-Svea loams, undulating	665	.2
Bearden silt loam	2,374	.9
Bearden silty clay loam	781	.3
Bearden soils, saline	518	.2
Bearden-Overly silt loams	766	.3
Borup silt loam	3,207	1.2
Borup silt loam, very wet	348	.1
Buse loam, hilly	734	.3
Dimmick clay	55	[1]
Divide loam	262	.1
Eckman loam, nearly level	1,379	.5
Eckman loam, undulating	1,285	.5
Eckman loam, rolling	395	.1
Eckman loam, till substratum, undulating	857	.3
Egeland fine sandy loam, nearly level	1,749	.6
Egeland fine sandy loam, undulating	800	.3
Embden fine sandy loam	24,413	8.9
Embden-Gardena complex	735	.3
Embden-Glyndon fine sandy loams	5,051	1.8
Embden and Hecla fine sandy loams	6,795	2.5
Exline complex	283	.1
Fairdale silt loam, levee	764	.3
Fargo clay	379	.1
Fargo silt loam	414	.2
Fargo silty clay loam	2,165	.8
Fargo silty clay loam, saline	56	[1]
Fargo-Exline silty clay loams	148	.1
Fordville loam, nearly level	486	.2
Fordville loam, undulating	519	.2
Fordville sandy loam, nearly level	998	.4
Fordville sandy loam, undulating	758	.3
Fresh water marsh	2,216	.8
Gardena loam, very deep, nearly level	11,296	4.1
Gardena loam, very deep, undulating	314	.1
Gardena loam, deep, nearly level	3,375	1.2
Gardena loam, moderately shallow, nearly level	1,783	.6
Gardena loam, moderately shallow, undulating	161	.1
Gardena loam, till substratum, nearly level	21,519	7.8
Gardena-Eckman loams, till substratum, nearly level	690	.3
Gardena-Glyndon loams, nearly level	5,097	1.8
Gardena-Glyndon loams, till substratum, nearly level	6,448	2.4
Glyndon loam, very deep, nearly level	20,306	7.4
Glyndon loam, very deep, undulating	621	.2
Glyndon loam, deep, nearly level	5,380	2.0
Glyndon-Borup loams, strongly saline, nearly level	398	.1
Glyndon and Gardena loams, nearly level	1,032	.4
Glyndon and Hamerly loams, saline, nearly level	5,963	2.2
Gravel pits	339	.1
Hamar fine sandy loam	590	.2
Hamar-Ulen fine sandy loams	8,217	3.0
Hamar-Ulen loamy fine sands	1,069	.4
Hamerly complex, undulating	342	.1
Hamerly loam, nearly level	1,883	.7
Hamerly-Barnes loams, undulating	543	.2
Hecla fine sand, nearly level	654	0.2
Hecla fine sandy loam, nearly level	9,067	3.3
Hecla fine sandy loam, moderately shallow, nearly level	885	.3
Hecla loamy fine sand, loamy substratum, nearly level	2,446	.9
Hecla loamy fine sand, moderately shallow, nearly level	149	.1
Hecla sandy loam, loamy substratum, nearly level	329	.1
Hecla soils, nearly level	1,685	.6
Hecla and Embden fine sandy loams, nearly level	347	.1
Hecla-Hamar complex, hummocky, eroded	1,845	.7
Hecla and Hamar loamy fine sands, nearly level	22,796	8.3
Hecla-Ulen fine sandy loams, nearly level	1,036	.4
Hecla-Ulen fine sandy loams, loamy substratum, nearly level	213	.1
Lamoure silty clay loam	50	[1]
La Prairie and Fairdale soils	2,345	.8
La Prairie silt loam	1,818	.7
Maddock fine sandy loam, nearly level	304	.1
Maddock fine sandy loam, undulating	293	.1
Maddock fine sandy loam, rolling	378	.1
Maddock loamy fine sand, nearly level	539	.2
Maddock loamy fine sand, undulating	812	.3
Maddock soils, hilly	334	.1
Maddock loamy fine sand, moderately shallow, nearly level	370	.1
Maddock-Hamar complex, severely eroded	2,515	.9
Overly silt loam, nearly level	3,640	1.3
Overly silt loam, saline, nearly level	199	.1
Overly silty clay loam, nearly level	757	.3
Overly-Exline complex, nearly level	555	.2
Overly-Gardena loams, nearly level	5,461	2.0
Parnell soils	208	.1
Perella silt loam	169	.1
Perella silty clay loam	132	[1]
Rauville soils	178	.1
Renshaw and Sioux loams, nearly level	463	.2
Renshaw and Sioux loams, undulating	876	.3
Renshaw and Sioux sandy loams, nearly level	850	.3
Renshaw and Sioux sandy loams, rolling	1,013	.4
Sioux gravelly loam	183	.1
Sioux and Renshaw loams, rolling	319	.1
Spottswood loam, loamy substratum, nearly level	1,302	.5
Spottswood sandy loam, loamy substratum, nearly level	2,072	.7
Spottswood-Embden sandy loams, nearly level	846	.3
Spottswood-Gardena loams, nearly level	1,150	.4
Stirum-Glyndon complex	887	.3
Svea-Barnes loams	8,448	3.1
Svea-Hamerly loams	1,465	.5
Tetonka silt loam	435	.2
Tiffany fine sandy loam	135	[1]
Ulen complex, saline	810	.3
Ulen fine sandy loam	14,859	5.4
Ulen fine sandy loam, loamy substratum	1,891	.7
Ulen fine sandy loam, moderately shallow	493	.2
Ulen-Gardena fine sandy loams	287	.1
Vallers loam	589	.2
Zell fine sandy loam, undulating	256	.1
Zell loam, undulating	428	.2
Zell loam, strongly rolling	3,204	1.2
Water	194	.1
Total	274,308	100.0

[1] Less than 0.1 percent.

low, nearly level areas and in shallow depressions. Generally, the water table is within 3 feet of the surface during most of the growing season, but it is at or near the surface in years of high rainfall. Sedges and tall grasses are the dominant vegetation.

The surface layer is black, moderately alkaline and calcareous fine sandy loam or loam 8 to 24 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky and slightly plastic when wet.

The subsoil is moderately alkaline and strongly calcareous, gray to light brownish-gray fine sandy loam to loam that is 10 to 20 inches thick. It has coarse, weak, blocky and crumb structure and is very friable when moist and slightly sticky and slightly plastic when wet.

The substratum is dark grayish-brown, moderately alkaline and calcareous fine sandy loam to fine sand, and it has distinct olive-brown and dark yellowish-brown mottles. Generally, it is loose and structureless, but where it is fine sandy loam, it has very weak crumb structure. In some places there are thin layers of silt loam or silty clay loam below a depth of 48 inches.

The Arveson soils occur with the Ulen, Hecla, Hamar, Tiffany, and Embden soils. They have a greater number of distinct mottles in their substratum than the Ulen soils. Unlike the Hecla, Hamar, Tiffany, and Embden soils, they have a high content of lime in the subsoil. Also, the Arveson subsoil lacks the dark grayish-brown color that is typical of the Hecla, Egeland, and Embden subsoil. The Arveson soils developed in coarser textured material than the Glyndon soils.

Most areas of the Arveson soils are used for native pasture and hay.

Arveson fine sandy loam (0 to 2 percent slopes) (An).—Most areas of this soil are on the Sheyenne Delta. The soil is in low, nearly level areas or in slight depressions (fig. 4). The surface layer is black, very friable fine sandy loam that is calcareous and is 8 to 12 inches thick. The subsoil is light brownish-gray, strongly calcareous, very friable fine sandy loam.

In most years the water table is less than 3 feet from the surface during most of the growing season, but it is at or near the surface in wet years. A slowly permeable layer is at a depth of more than 48 inches, but permeability is moderately rapid above this layer. The available moisture capacity is fair. This soil is moderate in content of organic matter. It is highly susceptible to wind erosion.

Figure 4.—**A depression in which Arveson fine sandy loam occurs. Hecla fine sandy loam is in the higher areas.**

Most areas of this soil are grazed or used to grow hay. The soil is well suited to grazing and hay, and yields of forage are high. The soil is also suitable for cultivation if surface drains can be installed. Corn, oats, wheat, barley, flax, and hay can be grown where drainage has been provided. Some undrained areas of this soil that occur in fields with better drained soils are cultivated. The farming practices and choice of crops are controlled, however, by the wetness of the season. (Capability unit IIIw–1)

Arveson fine sandy loam, moderately shallow (0 to 2 percent slopes) (Ar).—This soil occupies small areas in shallow depressions and in other low areas. It is on the Sheyenne Delta and in the beach area. The surface layer is black fine sandy loam 8 to 12 inches thick, and the subsoil is light brownish-gray, strongly calcareous fine sandy loam. The substratum, which is at a depth of 20 to 36 inches, is gray, mottled silt loam to silty clay.

Permeability is moderately rapid above the substratum and is slow or very slow in the substratum. This soil has fair available moisture capacity and a moderate content of organic matter.

This soil is highly susceptible to wind erosion if it is cultivated. It is used mainly for hay and grazing to which it is well suited, and yields of forage are high. The soil is also suitable for cultivation if surface drains can be installed to remove the excess water. Where artificial drainage has been established, corn, oats, wheat, barley, and flax are grown, and those areas are also used for hay. Also used for cultivated crops are some undrained areas of this soil that are in fields with better drained soils. Farming methods and the choice of crops vary according to the wetness of the season. The cultivated areas that have not been drained are poorly suited to corn and legumes. (Capability unit IIIw–1)

Arveson fine sandy loam, very wet (0 to 2 percent slopes) (Av).—This soil is in the deeper depressions on the Sheyenne Delta. Its surface layer is black fine sandy loam that is calcareous in most places and is 8 to 12 inches thick. The subsoil is strongly calcareous, light brownish-gray fine sandy loam.

Permeability is moderately rapid, and the available moisture capacity is fair. The content of organic matter is moderate to high. This soil is more poorly drained than the other Arveson soils mapped in the survey area. The water table is at or near the surface during most of the growing season.

All of this soil is grazed or is used to grow hay. This soil is better suited to pasture plants and hay than to cultivated crops, but it is also suited to cultivated crops if it is drained. Drainage outlets are available in only a few areas, however, because of the location of this soil in depressions. (Capability unit IIIw–3)

Arveson loam (0 to 2 percent slopes) (Aw).—This soil is in shallow depressions and in low, nearly level areas on the Sheyenne Delta. Its surface layer is black, friable loam that is calcareous in most places and is 8 to 18 inches thick. The subsoil is light brownish-gray, strongly calcareous fine sandy loam.

Permeability is moderate in the surface layer and moderately rapid in the subsoil. The substratum is slowly permeable and is at a depth of 5 to 10 feet. This soil has fair to good available moisture capacity and a moderate to high content of organic matter. In most years the water table is within 3 feet of the surface, but in wet years it is at or near the surface during most of the growing season.

Most areas of this soil are in pasture or used to grow hay. The soil is well suited to pasture and hay, but it is also suitable for cultivation if the excess water can be removed by using shallow surface drains. Some undrained areas of this soil that occur with better drained soils are cultivated. If this soil has not been drained, it is poorly suited to corn and legumes. Farming operations and the cropping sequence vary according to the wetness of the season. (Capability unit IIw–2)

Barnes Series

The Barnes series consists of well-drained soils developed in loam glacial till that is friable and calcareous. These soils have slopes of 2 to 12 percent and are in convex areas. The dominant vegetation was mid and tall grasses.

The surface layer is black, slightly acid to mildly alkaline loam 4 to 8 inches thick. It has moderate crumb and granular structure and is friable when moist and slightly sticky and slightly plastic when wet.

The subsoil is very dark grayish-brown loam 6 to 18 inches thick. Generally it has moderate prismatic structure, but the structure is compound moderate prismatic and blocky in some places. The subsoil is friable when moist and slightly sticky and slightly plastic when wet. In some profiles faint patches of clay films are on the surfaces of the prisms and blocks. The upper part of the subsoil is neutral, and the lower part is mildly or moderately alkaline.

The subsoil is underlain by a layer of grayish-brown to light grayish-brown, moderately alkaline loam to clay loam where lime has accumulated. This layer has weak blocky structure. It is hard when dry, friable when moist, and slightly sticky and slightly plastic when wet.

The lower part of the substratum, just beneath the layer of lime accumulation, is light olive-brown loam that has a few, distinct, reddish-brown and yellowish-brown mottles. This material is calcareous and moderately alkaline, and it is slightly to moderately saline. It is friable when moist and slightly sticky and plastic when wet. In most profiles the lower part of the substratum contains gypsum crystals.

The Barnes soils occur with the Buse, Svea, and Hamerly soils. Their profile is somewhat similar to that of the Buse soils, except that it contains a very dark grayish-brown, noncalcareous subsoil. The Barnes soils have a thinner surface layer than the Svea soils. Also, they are shallower over a layer where lime has accumulated and have a substratum that contains fewer mottles. Unlike the Eckman soils, the Barnes soils have pebbles, stones, and angular grains of coarse sand throughout the profile because they developed in glacial till instead of sorted lake sediments. The Barnes soils developed in loam glacial till instead of in moderately coarse textured lake sediments like the Egeland soils.

The Barnes soils are used mostly for field crops. The principal crops are wheat, barley, oats, flax, corn, alfalfa, and tame hay.

Barnes loam, undulating (2 to 5 percent slopes) (BaB).—This soil is on the crests and sides of low knolls on the till plain. The surface layer is black, very friable loam 6 to 8 inches thick. The subsoil is very dark grayish-brown, friable loam that is underlain by a lighter colored layer where lime has accumulated. Depth to this lighter colored layer is 14 to 22 inches.

Areas mapped as this soil include areas of the Svea, Hamerly, and Buse soils. Mapping the included soils separately is not feasible, because the areas are too small.

Permeability is moderate in the subsoil and slow in the substratum. This soil has good available moisture capacity and a moderate content of organic matter. In general, it is only slightly susceptible to erosion by wind and water. On the crests of knolls where fields have been plowed in fall, however, this soil is moderately susceptible to wind erosion when it is not protected by a cover of snow. The hazard of water erosion is greatest in the early part of the growing season, when crops have not grown enough to provide a good cover.

This soil is well suited to cultivation. Under good management good yields of wheat, barley, oats, flax, corn, and hay are obtained. (Capability unit IIe–3)

Barnes-Buse loams, rolling (5 to 8 percent slopes) (BbC).—In this complex the Barnes soil is dominant but the Buse soil occupies 20 to 40 percent of the acreage. The soils are on the sides of shallow drainageways and on knolls. The Barnes soil is in lower areas than the Buse soil, which is on the crests of the knolls and on the shoulders of the side slopes. In many places where the Buse soil is on the crest of a cultivated knoll, it is lighter colored than the surrounding areas. This is because in places the subsoil has been exposed as a result of erosion or part of the subsoil has been mixed with the surface layer by tillage.

The Barnes soil has a black loam surface layer 4 to 7 inches thick. The Buse soil has a black to dark grayish-brown surface layer and a light brownish-gray subsoil. Both the surface layer and subsoil are loam.

Both the Barnes and Buse soils have a moderately permeable subsoil and a slowly permeable substratum, and they have good available moisture capacity. The content of organic matter is moderate in the Barnes soil. It is low in the Buse soil, and the supply of available phosphorus and nitrogen are also low in that soil. The Barnes soil is moderately susceptible to water erosion. The Buse soil is moderately susceptible to both wind and water erosion because of its low content of organic matter, weak structure, and location on the knolls. Water erosion is most likely to occur in spring before crops have grown enough to provide a good cover.

These soils are suited to wheat, barley, oats, and hay, and most areas are cultivated. The soils are not well suited to corn, because of the hazard of water erosion if tilled crops are grown. (Capability unit IIIe–5)

Barnes-Buse loams, strongly rolling (8 to 12 percent slopes) (BbD).—The soils in this complex are on the side slopes of stream valleys that are entrenched in the till plain. The Barnes soil is about halfway down the side slopes. It is below the Buse soil, which is on the crests and on the upper part of the slopes. The acreage of this unit is about evenly divided between these two soils.

The profile of the Barnes soil is like the one described for the Barnes series, but the surface layer and subsoil are slightly thinner and the layer of lime accumulation is nearer the surface. The surface layer is black, very friable loam 4 to 6 inches thick. The subsoil is very dark grayish-brown, friable loam that has prismatic structure. Depth to the layer where lime has accumulated is less than in the other Barnes soils. The surface layer of the Buse soil is black to grayish-brown, friable loam.

The soils of this complex have a moderately permeable subsoil and a slowly permeable substratum. Available moisture capacity is good. The Barnes soil is moderate and the Buse soil is low in content of organic matter. These soils are highly susceptible to water erosion.

Because of the hazard of erosion, these soils are better suited to pasture than to cultivated crops. Most areas are used for grazing, but a few areas are cultivated. If these soils are cultivated, the best suited crops are wheat, barley, and hay. The soils are poorly suited to corn because of the hazard of water erosion. (Capability unit IVe–5)

Barnes-Svea loams, undulating (2 to 5 percent slopes) (BdB).—In this complex the Barnes soil is in gently sloping, convex areas on the sides and crests of low knolls. The Svea soil is between the knolls or in concave areas on side slopes below the Barnes soil. The Barnes soil makes up 60 to 75 percent of this complex, and the Svea soil makes up 15 to 30 percent.

The surface layer of the Barnes soil is black, very friable loam that is 6 to 8 inches thick and has moderate crumb structure. The surface layer of the Svea soil is black, very friable loam 8 to 20 inches thick, and the subsoil is very dark grayish-brown, friable loam to light clay loam.

Included in areas mapped as this complex are areas of Hamerly soils adjacent to small, shallow depressions. Also included are areas of Tetonka soils in the depressions, and some smaller areas of Tetonka soils that are indicated on the map by the symbol used for depressions. Other inclusions are areas of Buse soils that are on the crests of the knolls and are less than 1 acre in size.

These Barnes and Svea soils have a moderately permeable subsoil and a slowly permeable substratum. The Barnes soil is moderate and the Svea soil is high in content of organic matter. These soils are slightly susceptible to wind erosion and water erosion; the hazard of erosion is greatest early in the growing season.

These soils are well suited to cultivation. Yields of wheat, barley, oats, corn, and hay are good. (Capability unit IIe–3)

Bearden Series

The Bearden series is made up of moderately well drained or somewhat poorly drained soils developed in sediments of silt loam to silty clay loam deposited in glacial lakes. These soils are nearly level. In most years the water table is less than 5 feet from the surface. The native vegetation was tall grasses.

The surface layer is black, moderately alkaline and calcareous silt loam to silty clay loam 8 to 14 inches thick. It has moderate, fine, granular structure. The surface layer is very friable or friable when moist and is slightly sticky and slightly plastic when wet. In places wedge-shaped tongues of soil material from the surface layer extend downward as much as 10 inches into the subsoil.

The subsoil is grayish-brown to light-gray silt loam to silty clay loam that is 10 to 20 inches thick and contains an accumulation of lime. It has weak, coarse, prismatic and weak blocky structure and is hard when dry, friable when moist, and sticky and plastic when wet. The subsoil is moderately alkaline and is slightly saline in places.

The substratum is light olive-brown to light yellowish-brown silt loam or silty clay loam that is moderately alkaline and slightly saline. In the lower part of the substratum are many, distinct, light-gray and olive-brown mottles.

The Bearden soils are good for farming. The are used mainly for field crops.

Bearden silt loam (0 to 2 percent slopes) (Be).—This soil is most extensive in nearly level areas of the lake plain. The surface layer is black, calcareous, very friable silt loam 8 to 14 inches thick. The subsoil is grayish-brown to light-gray, strongly calcareous, friable silty clay loam. The substratum is olive-brown, calcareous silty clay loam.

Permeability is moderate in the subsoil and slow in the substratum. The available moisture capacity is good. The content of organic matter is moderate to high. In many years the water table is less than 5 feet from the surface early in the growing season. Surface drainage is slow, and surface drains are needed if excess water from snowmelt and heavy rains is to be removed. This soil is moderately susceptible to wind erosion, especially in areas where part of the light-colored subsoil has been brought to the surface by tillage. Crops grown in these areas may show signs of yellowing early in the growing season.

Generally, this soil is well suited to cultivation, and nearly all areas are cultivated. Corn, wheat, barley, oats, flax, and hay are the crops commonly grown, and yields are high. (Capability unit IIe–1)

Bearden silty clay loam (0 to 2 percent slopes) (Bf).—This soil is most extensive on the nearly level lake plain. Its subsoil is moderately permeable, and its substratum is slowly permeable. The content of organic matter is moderate. In many years the water table is within 5 feet of the surface early in the growing season. Surface drainage is slow, and surface drains are needed to remove the excess water from snowmelt and heavy rains.

In some places part of the light-colored subsoil has been brought to the surface by tillage. In those areas this soil is moderately susceptible to wind erosion. It is also low in content of organic matter. Crops grown in those areas are likely to show signs of yellowing early in the growing season.

This soil is well suited to cultivation, and nearly all of the acreage is cultivated. Yields of wheat, flax, barley, corn, and hay are high. (Capability unit IIe–1)

Bearden soils, saline (0 to 2 percent slopes) (Bg).—These soils are in nearly level areas of the lake plain along the eastern margin of the beach area. They have a surface layer of silt loam or silty clay loam, and their surface layer and subsoil contain soluble salts. Included in the areas mapped as these soils are areas of saline Glyndon soils that are smaller than 3 acres in size.

Permeability is moderate in the subsoil and slow in the substratum. These soils have good available moisture capacity. The content of organic matter is moderate. The water table is high for longer periods than in the other Bearden soils.

These soils are suited to cultivation, but crop yields are reduced by salinity. The best suited crops are wheat, barley, flax, and hay. Corn is poorly suited. (Capability unit IIIs-6)

Bearden-Overly silt loams (0 to 2 percent slopes) (Bh).—These soils are on the lake plain. The Bearden soil is on slight rises in areas 1 to 2 feet higher than those occupied by the Overly soil. The proportions of Bearden and Overly soils vary in different areas, but each of these soils makes up at least 30 percent of every area.

When these soils are moist, the surface layer of the Bearden soil is a black, very friable, calcareous silt loam. The Bearden soil has a subsoil of grayish-brown, friable, strongly calcareous silty clay loam. The surface layer of the Overly soil is also a black, very friable silt loam. The subsoil is dark grayish-brown, friable silty clay loam. After these Bearden and Overly soils have been cultivated and have dried, the areas have a patchy appearance because the Bearden soil dries to a lighter color than the Overly. Included are areas of Perella silty clay loam less than 1 acre in size.

The soils of this complex have a moderately permeable subsoil and a slowly permeable substratum. The content of organic matter is moderate in the Bearden soil and high in the Overly, but both soils have good available moisture capacity. In many years the Bearden soil has a water table at a depth of less than 5 feet early in the growing season. These soils are moderately susceptible to wind erosion in areas where part of the Bearden subsoil has been mixed with the surface layer.

These soils are well suited to cultivation. Yields of wheat, barley, oats, flax, corn, and hay are high. (Capability unit IIe-1)

Borup Series

In the Borup series are poorly drained soils developed in sediments of very fine sandy loam to silt loam deposited in glacial lakes. These soils are in shallow depressions and in low, nearly level areas. Generally, the water table is within 3 feet of the surface during most of the growing season, but it is at or near the surface in wet years. The native vegetation was tall grasses, sedges, and rushes.

The surface layer is black, mildly to moderately alkaline and calcareous silt loam to very fine sandy loam 8 to 20 inches thick. It has fine granular structure and is very friable when moist and slightly sticky and slightly plastic when wet.

The subsoil is dark-gray to gray, strongly calcareous, moderately alkaline silt loam to very fine sandy loam 10 to 24 inches thick. It has weak blocky and granular structure and is hard when dry, friable when moist, and slightly sticky and slightly plastic when wet. A few large, white segregations of lime are in the lower part.

The substratum is olive, moderately alkaline silt loam to fine sand that has many light olive-brown and dark yellowish-brown mottles. The texture is coarser with increasing depth.

The Borup soils are finer textured than the Hecla and Embden soils, and their subsoil is gray and calcareous instead of very dark grayish brown and free of lime. The substratum of the Borup soils is more mottled and has duller hues than that of the Glyndon soils. The Borup soils are more poorly drained and have a more strongly mottled substratum than the Ulen soils. They lack the very dark grayish-brown, noncalcareous subsoil that is typical in the Gardena and Eckman soils.

The Borup soils are used mainly for pasture or hay. The drained areas, however, are used to grow field crops. Also, some undrained areas in fields of better drained soils are used intermittently for field crops.

Borup silt loam (0 to 2 percent slopes) (Bo).—This soil is in low, nearly level areas and in shallow depressions, mostly on the Sheyenne Delta. The surface layer is black, calcareous, very friable silt loam 8 to 18 inches thick. The subsoil is dark-gray, strongly calcareous, friable silt loam, and the substratum is olive to pale-yellow fine sand. Included in the areas mapped as this soil are areas of Glyndon and Ulen soils that are less than 1 acre in size.

This Borup soil is moderately permeable and has good available moisture capacity. The content of organic matter is high. In most years the water table is less than 3 feet from the surface during much of the growing season, but it is at or near the surface in wet years. In some places part of the subsoil has been brought to the surface by tillage. Crops grown in those areas are likely to show signs of yellowing early in the growing season.

Most areas of this soil are in pasture or are used to grow hay. This soil is well suited to pasture and hay, and high yields of forage are obtained. Undrained areas of this soil are poorly suited to corn and legumes. If surface drains can be established, this soil is also suitable for cultivation, and corn, wheat, oats, barley, flax, and hay can be grown. Some undrained areas are cultivated, but farming practices and choice of crops depend upon the wetness of the season. (Capability unit IIw-2)

Borup silt loam, very wet (Bp).—This soil is in the deeper depressions on the Sheyenne Delta. In most years it has water ponded on the surface early in the growing season and is wet at or near the surface until late in summer. This soil has moderate permeability and good available moisture capacity.

Nearly all areas of this soil are grazed or used for growing hay. The soil is also well suited to field crops if surface drainage is established. (Capability unit IIIw-2)

Buse Series

The Buse series consists of excessively drained soils developed in friable, calcareous loam glacial till. These soils are in convex areas where the slopes are between 5 and 30 percent. They are on knolls and hills and on the sides of stream valleys. The native vegetation was mainly mid and short grasses.

The surface layer is black loam 4 to 8 inches thick. It has fine crumb and granular structure and is friable when moist and slightly sticky and slightly plastic when wet. In most places the surface layer is slightly calcareous and moderately alkaline. Cobbles and stones are common on the surface.

The subsoil is dark grayish-brown, calcareous and moderately alkaline loam, 6 to 20 inches thick. It has weak prismatic and blocky structure and is hard when dry, friable when moist, and slightly sticky when wet. In most places the subsoil contains some additional lime that has moved downward from the surface layer, which is partly leached.

Underlying the subsoil is the substratum of moderately alkaline and calcareous, pale-olive loam. The substratum contains enough soluble salts to be slightly to moderately saline.

In cultivated areas the surface layer is dark brown to grayish brown. There are variable amounts of pebbles, cobbles, and stones throughout the profile.

The Buse soils lack the very dark grayish-brown subsoil that is typical of the Barnes and Svea soils, and they have a thinner surface layer than the Svea soils. Their subsoil contains less lime than that of the Hamerly soils, and their substratum has fewer mottles than the Hamerly substratum. Unlike the Zell soils, the Buse soils developed in glacial till in which there is a random distribution of pebbles and cobbles.

The steeper areas of Buse soils are used for pasture. Many of the more gently sloping areas are cultivated along with adjacent soils.

Buse loam, hilly (12 to 30 percent slopes) (BuD).—This soil is on the crests and on the steep, upper side slopes of stream valleys in the till plain. It is most extensive in the valleys of the more deeply entrenched streams. The surface layer is black, very friable loam 4 to 8 inches thick. It has fine crumb and granular structure and is slightly calcareous in most places. The subsoil is dark grayish-brown, calcareous loam that has weak to moderate blocky structure. The substratum is olive, calcareous loam.

Permeability is moderate in the subsoil and slow in the substratum. The available moisture capacity is good, but this soil is somewhat droughty because runoff is excessive. If it is cultivated, this soil is highly susceptible to water erosion. The content of organic matter is low.

This soil is better suited to pasture than to cultivated crops. Most of it is grazed. (Capability unit VIe–2)

Dimmick Series

In the Dimmick series are very poorly drained soils developed in clayey sediments deposited in glacial lakes. These soils are in shallow depressions and in swales. The native vegetation was sedges, rushes, and grasses.

The surface layer is black, neutral clay 10 to 20 inches thick. It has strong, fine, granular and blocky structure and is hard when dry, firm when moist, and sticky and plastic when wet.

The subsoil is weakly defined and grades from the surface layer to the substratum. It is very dark gray to olive-gray, weakly calcareous and moderately alkaline clay, 24 to 36 inches thick. This subsoil has strong, fine, blocky structure and is hard when dry, very firm when moist, and very sticky and very plastic when wet.

The subsoil grades to a substratum of olive-gray, moderately alkaline clay that has common, distinct, dark-brown and brown mottles. This substratum is structureless and is hard when dry, very firm when moist, and very sticky and very plastic when wet. Segregations of gypsum crystals are common.

The Dimmick soils have a thicker surface layer than the Fargo soils, and they lack the wedge-shaped tongues of black soil material that extend downward from the surface layer into the substratum. Unlike the Perella soils, the Dimmick soils have a subsoil and substratum of clay instead of silty clay loam.

The areas of Dimmick soils that have been drained are used for field crops. The areas that have not been drained are grazed or used for growing hay.

Dimmick clay (0 to 2 percent slopes) (Dc).—This is the only Dimmick soil mapped in this survey area. It is in shallow depressions on the lake plain. The surface layer is black clay 12 to 20 inches thick. It has strong, fine, blocky and granular structure and is firm when moist and very sticky when wet. The subsoil is very dark gray clay that is very firm when moist and sticky when wet.

This soil has very slow permeability and is very poorly drained. In many years it has water ponded on the surface until midsummer. The available moisture capacity is good. The content of organic matter is high.

This soil is suitable for cultivation, but surface drains are needed for removing excess water. Only in dry seasons can crops be grown in areas that have not been drained. (Capability unit IIIw–2)

Divide Series

In the Divide series are soils that are moderately deep and moderately well drained or somewhat poorly drained. These soils developed in loam glacial lake sediments underlain by gravel and gravelly coarse sand. The native vegetation was tall and mid grasses.

The surface layer is black, moderately alkaline and slightly calcareous loam. It has moderate, fine, granular structure and is very friable when moist and slightly sticky and slightly plastic when wet. The surface layer is 10 to 17 inches thick.

The subsoil is dark grayish-brown sandy loam or loam 5 to 15 inches thick. It is strongly calcareous and moderately alkaline, contains pebbles that are coated with lime, and contains white and light-gray segregations of lime. It has weak, prismatic and blocky structure and is very friable when moist and slightly sticky and slightly plastic when wet.

The substratum is gravel and gravelly coarse sand that is strongly calcareous in the upper part. The gravel is more than 5 feet thick in most places. In most years the water table reaches the top of the gravel.

Varying amounts of rounded pebbles are in the surface layer and subsoil. Depth to gravel and coarse sand ranges from 20 to 36 inches.

Divide soils occur with the Spottswood, Fordville, Renshaw, and Sioux soils. They have a thinner surface layer than the Spottswood soils. Unlike the Fordville, Renshaw, and Spottswood soils, the Divide soils are calcareous below the surface layer. The Divide soils are thicker over a gravelly substratum than the Sioux soils, and their surface layer is underlain by loamy soil material rather than by coarse sand and gravel. Divide soils are distinguished from the Glyndon and Hamerly soils by the gravelly substratum that is lacking in the Glyndon and Hamerly soils.

Most areas of Divide soils are used for crops.

Divide loam (0 to 2 percent slopes) (Dv).—This is the only Divide soil mapped in the survey area. It is on the lower side of the beach ridges and receives moisture from seepage. The surface layer is black, calcareous loam 8 to 17 inches thick. It has fine granular structure and is very friable. The subsoil is dark-gray, strongly calcareous loam that has weak prismatic and blocky structure. A substratum of coarse sand and gravel is at a depth of 20 to 36 inches.

This soil has a moderately permeable subsoil and a rapidly permeable substratum. It has good to fair available moisture capacity. The content of organic matter is moderate. In most years the water table is less than 5 feet from the surface during the early part of the growing season.

In some places tillage has mixed part of the lighter colored subsoil with the black soil material in the surface layer. In those areas this soil is moderately susceptible to wind erosion. Crops grown in these light-colored areas show signs of yellowing early in the growing season.

This soil is suitable for cultivation. Wheat, barley, oats, flax, corn, and hay are commonly grown, and yields are fair. (Capability unit IIIs-4)

Eckman Series

The Eckman series consists of deep, well-drained soils developed in loam sediments deposited by glacial lakes. These soils are nearly level to rolling and have convex relief. The native vegetation was mid and tall grasses.

The surface layer is black, slightly acid or neutral loam 5 to 8 inches thick. It has moderate crumb structure and is very friable when moist and slightly sticky and slightly plastic when wet.

The subsoil is very dark grayish-brown very fine sandy loam to silt loam 10 to 20 inches thick. It has weak to moderate, coarse, prismatic structure that in places breaks easily to weak blocky structure. In those places there are faint patches of clay films on the surfaces of the prisms. The subsoil is friable when moist and slightly sticky and slightly plastic when wet. Generally it is neutral.

Below the subsoil is a moderately alkaline, strongly calcareous layer of lime accumulation. This layer is light olive-brown to grayish-brown very fine sandy loam to loam and is 6 to 14 inches thick. It has weak blocky structure and is friable when moist and slightly sticky when wet.

The layer of lime accumulation grades to a layer of light olive-brown, calcareous loam to fine sandy loam. Loamy fine sand occurs in a few areas at a depth of 36 to 60 inches. In an area on the western edge of the Sheyenne Delta, these soils are underlain by friable loam glacial till at a depth of 24 to 36 inches.

Generally, these soils have a loam texture throughout their profile, but the surface layer is silt loam in some areas. The color of the subsoil grades from very dark grayish brown in the upper part to light olive brown in the lower part. In some places the lower part of the subsoil is mildly alkaline. Below the subsoil the soil material is commonly coarser textured with increasing depth.

The Eckman soils have a thinner surface layer than the Gardena soils and less mottling in their subsoil and substratum. They have a clearly expressed subsoil unlike that of the Zell soils. The Eckman soils developed in pebble-free, water-sorted material instead of in glacial till like that in which the Barnes soils developed. They have a substratum that lacks the gravel and coarse sand typical in the substratum of the Renshaw and Fordville soils. The Eckman soils developed in loam instead of in fine sandy loam like the Egeland soils. Their subsoil is leached of lime instead of being limy like that of the Glyndon soils.

Eckman loam, nearly level (0 to 2 percent slopes) (EcA).—This soil is in the higher, nearly level parts of the beach area, on the Sheyenne Delta, and near the valleys of entrenched streams. The surface layer is black, very friable loam that has fine crumb structure and is 5 to 8 inches thick. The subsoil is dark grayish-brown, friable silt loam that has moderate prismatic and weak blocky structure. It is underlain by light olive-brown, strongly calcareous, very friable very fine sandy loam. The substratum is light olive-brown very fine sandy loam to fine sandy loam. Included in the areas mapped as this soil are areas of Overly and Gardena soils that are less than 2 acres in size.

This Eckman soil is moderately permeable. It has good available moisture capacity. The content of organic matter is moderate.

This soil is well suited to cultivation, and nearly all areas are used for crops. Yields of wheat, barley, oats, corn, flax, and hay are good. (Capability unit IIe-2)

Eckman loam, undulating (2 to 5 percent slopes) (EcB).—This soil is in areas of smooth slopes and convex relief. It has a profile similar to the one described for the series, except that it has a slightly thinner surface layer and subsoil and is shallower over the layer of lime accumulation.

This soil is moderately permeable and has good available moisture capacity. It contains a moderate amount of organic matter. The soil is slightly susceptible to water erosion, especially early in spring before the crops have grown enough to provide a ground cover adequate for protection.

Most areas are cultivated, and the main crops are wheat, barley, flax, oats, corn, and hay. Yields are slightly lower than on the nearly level Eckman loam. (Capability unit IIe-3)

Eckman loam, rolling (5 to 8 percent slopes) (EcC).—This soil is in small, narrow areas on the side slopes of shallow stream valleys. It is in the beach area and on the Sheyenne Delta. The surface layer is black, very friable loam that has fine crumb structure and is about 6 inches thick. The subsoil is dark grayish-brown, friable loam that has weak prismatic and blocky structure. This soil is shallower over a layer of lime accumulation than Eckman loam, nearly level, and Eckman loam, undulating.

Permeability is moderate in both the subsoil and substratum, and the available moisture capacity is good. The content of organic matter is moderate. This soil is moderately susceptible to water erosion if it is cultivated.

This soil is suitable for cultivation. Nearly all areas are used for crops, but yields are low. The crops are mainly wheat, barley, oats, flax, corn, and hay. This soil is poorly suited to corn because of the hazard of water erosion. In most places contour stripcropping is not feasible, because this soil has irregular slopes and is in areas of limited size. (Capability unit IIIe-5)

Eckman loam, till substratum, undulating (2 to 5 percent slopes) (EgB).—This soil is most extensive in the southwestern corner of the survey area, near the boundary of the Sheyenne Delta and the till plain. Its surface layer and subsoil are slightly thinner than typical for the Eckman series, and the layer of lime accumulation is nearer the surface. Depth to the substratum of friable glacial till is 24 to 36 inches.

This soil is moderately permeable and has good available moisture capacity. The content of organic matter is moderate. If this soil is cultivated, it is slightly susceptible to water erosion, especially early in spring.

Most areas of this soil are cultivated. Fair yields of wheat, barley, flax, corn, and hay are obtained. (Capability unit IIe–3)

Egeland Series

In the Egeland series are deep, well-drained soils that developed in moderately coarse textured sediments deposited in glacial lakes. Mid and tall grasses were the dominant native vegetation.

The surface layer is black, neutral fine sandy loam that has weak crumb structure and is 6 to 10 inches thick. It is very friable when moist and slightly sticky when wet.

The subsoil is very dark grayish-brown to dark-brown, neutral fine sandy loam that is 10 to 22 inches thick and has weak prismatic structure. It is very friable when moist and slightly sticky when wet.

The subsoil grades to a substratum of dark-brown, grayish-brown, or yellowish-brown fine sandy loam to fine sand. In places a light olive-brown, moderately calcareous layer of lime accumulation is just below the subsoil.

The Egeland soils have a subsoil of fine sandy loam instead of one of loamy fine sand like that of the Maddock soils. They have a thinner surface layer and less mottling below the subsoil than the Embden soils. The surface layer and subsoil of the Egeland soils are fine sandy loam instead of loam like those of the Eckman soils. The Egeland soils lack the calcareous subsoil that is typical of the Ulen soils, and their subsoil and substratum lack mottling instead of being mottled like those of the Tiffany soils.

Most areas of the Egeland soils are used for crops.

Egeland fine sandy loam, nearly level (0 to 2 percent slopes) (EnA).—This soil is in slightly higher areas than adjacent soils. It is on terraces adjacent to stream valleys that are entrenched in beach and delta sediments. The surface layer is black, very friable fine sandy loam 6 to 10 inches thick. The subsoil is very dark grayish-brown fine sandy loam. Included in the areas mapped as this soil are areas of Maddock and Embden soils that are too small to be mapped separately.

Permeability is moderately rapid, and available moisture capacity is low. The content of organic matter is moderate. This soil is highly susceptible to wind erosion.

This soil is suitable for cultivation, and most areas are used for crops. The crops commonly grown are wheat, barley, corn, oats, and hay. Yields are low to fair. In cultivated areas it is necessary to use practices that help to control wind erosion. (Capability unit IIIe–1)

Egeland fine sandy loam, undulating (2 to 5 percent slopes) (EnB).—This soil is in small areas on the Sheyenne Delta and in the beach area, mainly on the side slopes of shallow drainageways. Its profile is similar to the one described for the series, except that the surface layer is 6 to 8 inches thick. Included in the areas mapped as this soil are areas of Maddock fine sandy loam that are smaller than 3 acres.

Permeability is moderately rapid, and available moisture capacity is low. The content of organic matter is moderate to low. This soil is highly susceptible to wind erosion if it is cultivated.

Most areas of this soil are cultivated. Wheat, corn, barley, oats, and hay are the crops commonly grown, and yields are low. Practices that help to control wind erosion are necessary in the cultivated areas. (Capability unit IIIe–1)

Embden Series

The Embden series consists of deep, moderately well drained soils developed in moderately coarse textured sediments deposited in glacial lakes. These soils are in nearly level or slightly concave areas. The native vegetation was mainly tall grasses.

The surface layer is black, neutral fine sandy loam or sandy loam that is 10 to 22 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky when wet.

The surface layer grades to a subsoil of very dark grayish-brown, neutral fine sandy loam that is 10 to 20 inches thick. The subsoil has weak blocky structure and is very friable when moist and slightly sticky when wet.

In most places the subsoil is underlain by a layer of olive-brown, moderately alkaline fine sandy loam where lime has accumulated. This layer has a few prominent, reddish-brown and strong-brown mottles and is 6 to 20 inches thick. It is very friable when moist and slightly sticky when wet.

Below this layer of lime accumulation, the substratum is olive-brown, slightly calcareous fine sandy loam to fine sand. It is mottled with reddish brown and dark reddish brown, and the number of mottles increases with increasing depth. Coarser textured soil material is below a depth of 48 inches.

The Embden soils occur with the Egeland, Ulen, Tiffany, Gardena, Glyndon, and Hecla soils. They have a thicker surface layer and more mottles in the substratum than the Egeland soils, and a lime-free subsoil instead of a strongly calcareous one like the Ulen soils. Their subsoil lacks the mottling typical of the Tiffany subsoil. The profile of the Embden soils is moderately coarse textured instead of medium textured like that of the Gardena and Glyndon soils. Their subsoil is finer textured that that of the Hecla soils.

Nearly all areas of the Embden soils are used for crops.

Embden fine sandy loam (0 to 5 percent slopes) (Eo).—This soil is most extensive on the Sheyenne Delta and in the northern part of the beach area. It is more extensive than any other soil in this survey area. In about 400 acres, the slopes are stronger than 2 percent; in the rest of the acreage, this soil is in nearly level or slightly concave areas (fig. 5).

The surface layer is black, very friable fine sandy loam 10 to 22 inches thick. The subsoil is very dark grayish-brown fine sandy loam. It is underlain by a layer of olive-brown, moderately calcareous fine sandy loam where lime has accumulated.

Included in the areas mapped as this soil are small areas of Embden soils that have a substratum of loamy glacial till at a depth of about 36 inches. These areas are north of Township 139. Also included are areas of the Hecla, Glyndon, Ulen, and Gardena soils less than 2 acres in size.

Permeability is moderately rapid. This soil has fair available water capacity and a moderate to high content of organic matter. In cultivated areas it is highly susceptible to wind erosion.

Figure 5.—**A field where oats have been swathed. Embden fine sandy loam is in the foreground, and Egeland fine sandy loam is on the low ridges in the background.**

This soil is well suited to cultivation, and most areas are used for crops. Fair yields of wheat, corn, oats, barley, and hay are obtained, except in years of prolonged dry periods. (Capability unit IIIe–1)

Embden-Gardena complex (0 to 2 percent slopes) (Ep).—Generally, about 70 percent of this complex is Embden fine sandy loam and about 30 percent is Gardena loam. The proportions of each soil vary from place to place.

The Embden soil has a profile like the one described for Embden fine sandy loam, except that its substratum is slowly permeable silty clay loam to silty clay and is at some depth between 36 and 60 inches. The Gardena soil has a surface layer of black, very friable loam 10 to 20 inches thick and a subsoil of very dark grayish-brown, friable loam. A slowly permeable substratum is at a depth of 36 to 60 inches.

Included in the areas mapped as these soils are areas of Hecla fine sandy loam. These areas are less than 3 acres in size.

Permeability is moderately rapid above the slowly permeable substratum of the Embden soil and moderate above the substratum of the Gardena soil. The available moisture capacity of the Embden soil is fair, and that of the Gardena soil is good. Both of these soils are moderate to high in content of organic matter. In cultivated areas the Embden soil is highly susceptible to wind erosion and the Gardena soil is moderately susceptible.

Most areas of these soils are cultivated. Yields of crops grown on the Gardena soil are higher than those grown on the Embden soil. Yields of crops grown on the Embden soil decline sharply in years when there are prolonged dry periods. (Capability unit IIIe–1)

Embden-Glyndon fine sandy loams (0 to 2 percent slopes) (Es).—This complex consists of Embden and Glyndon fine sandy loams so intricately mixed it was not practical to map them separately. The proportions of either soil in any area ranges from 20 to 80 percent. The Embden soil has a profile similar to the one described for the series. The surface layer of the Glyndon soil is black, calcareous, very friable fine sandy loam 6 to 12 inches thick. It is underlain by a subsoil of light brownish-gray, strongly calcareous, friable loam.

The Embden soil has moderately rapid permeability and fair available moisture capacity. The Glyndon soil has moderate permeability and good available moisture capacity. The water table is within 5 feet of the surface of the Glyndon soil in many years, but water is ponded on the surface during part of the growing season in very wet years. Surface drains are needed to remove this excess water. These Embden and Glyndon soils are highly susceptible to wind erosion if they are cultivated. They have a moderate content of organic matter.

Most of the acreage is cultivated. Wheat, corn, barley, oats, and hay are the crops commonly grown, and yields are good. During prolonged periods of dry weather, yields of crops grown on the Embden soil are lower than those grown on the Glyndon soil. (Capability unit IIIe-4)

Embden and Hecla fine sandy loams (0 to 2 percent slopes) (Et).—These soils are most extensive in the beach area. The Embden soil has a black surface layer, and its surface layer and subsoil are fine sandy loam. The Hecla soil also has a black surface layer, but its surface layer and subsoil are loamy fine sand. Both soils are underlain by a substratum of slowly permeable silt loam to silty clay at some depth between 20 and 60 inches. Included in the areas mapped as these soils are areas of Ulen fine sandy loam that are less than 2 acres in size.

Generally, permeability is moderately rapid, but it is slow in the substratum of these soils. The available moisture capacity is low. These soils are highly susceptible to wind erosion if they are cultivated. They have a moderate content of organic matter.

Most areas of these soils are cultivated, and wheat, corn, oats, barley, and hay are the crops commonly grown. Yields are fair, except in years when there are prolonged periods of dry weather. (Capability unit IIIe–3)

Exline Series

In the Exline series are poorly drained soils that are nearly level. These soils developed in medium-textured or moderately fine textured sediments deposited in glacial lakes. The native vegetation was mid and short grasses.

The surface layer is black to very dark gray, mildly alkaline loam to silty clay loam that has weak crumb structure. It is generally very friable or friable when moist and slightly sticky or sticky when wet. In cultivated areas where part of the subsoil is mixed with the surface layer, however, the present surface layer is very hard when dry, very firm when moist, and very sticky and very plastic when wet. In most places the surface layer is less than 4 inches thick, but the thickness ranges from 1 to 10 inches.

A dark-gray subsurface layer of slightly acid or neutral silt loam to very fine sandy loam separates the surface layer and subsoil. This subsurface layer is less than 3 inches thick. It has weak platy structure, is very friable when moist, and is slightly sticky when wet.

The subsoil is very dark grayish-brown or grayish-brown to light olive-brown clay loam to silty clay that has strong, medium, columnar structure. The surfaces of the columnar aggregates are coated with prominent clay films. The subsoil is very hard when dry, very firm when moist, and very sticky and very plastic when wet. It is strongly alkaline, and its lower part is moderately to strongly saline. Threadlike segregations of salts are between the columns, and clusters of salts are common inside the aggregates in the lower part of the subsoil.

Beneath the subsoil is grayish-brown and light olive-brown silt loam to silty clay mottled with light gray and light brownish gray in the lower part. This material is strongly alkaline and moderately to strongly saline. Segregations of gypsum and other salts are common.

The Exline soils have columnar structure instead of compound prismatic and blocky structure like the Aberdeen soils, and their subsoil contains salts. They are finer textured than the Stirum soils, and they have a gray, leached subsurface layer. Also, their subsoil has more strongly developed columnar structure. Unlike the Fargo and Overly soils, the Exline soils have a leached subsurface layer. They also have columnar structure in the subsoil, and their subsoil contains salts.

The Exline soils are used mainly for pasture. Where they occur in complexes with the Fargo and Overly soils, however, they are cultivated.

Exline complex (0 to 2 percent slopes) (Ex).—The soils of this complex are in the central part of Cass County. They occur in small, shallow depressions in a complex pattern with Fargo, Overly, and Gardena soils. The surface layer of these Exline soils is black, very friable loam 2 to 6 inches thick. Their subsurface layer is gray and very friable, and it is 1 to 4 inches thick. The subsoil is very dark grayish-brown silty clay loam to silty clay that has strong columnar structure. Accumulations of soluble salts and gypsum are in the lower part of the subsoil and in the substratum.

Permeability is very slow; only a few roots penetrate the dense claypan in the subsoil. The available moisture capacity is low because of the shallow depth of rooting. During periods of intense rainfall, the surface layer is saturated because drainage of water through the subsoil is very slow.

The soils of this complex are mainly in pasture. They are poorly suited to cultivation. (Capability unit VIs–1)

Fairdale Series

The Fairdale series consists of moderately well drained soils developed in recently deposited stream sediments. These soils have a weakly developed profile. They are on natural levees and on the flood plains of streams where they receive fresh deposits of sediments during floods. The native vegetation was trees and grass.

The surface layer is dark-gray to grayish-brown, slightly calcareous and moderately alkaline silt loam 3 to 8 inches thick. It has weak crumb or granular structure. The surface layer is very friable when moist and slightly sticky when wet.

The surface layer is underlain by light-colored to dark-colored layers of alluvium that range from silt loam to fine sand in texture; the texture is between a silt loam and fine sandy loam in most places, but loamy fine sand and fine sand are at a depth of more than 30 inches in a few places. This underlying material ranges from dark grayish brown to brown in color. It is moderately alkaline and calcareous and is very friable. In many places the profile contains the dark-colored former surface layer of a buried soil.

The Fairdale soils occur with the La Prairie soils. They have a lighter colored surface layer than those soils, and their subsoil is calcareous instead of noncalcareous.

The Fairdale soils are used for pasture and for field crops.

Fairdale silt loam, levee (0 to 5 percent slopes) (Fa).—This soil is on the low first bottoms of stream valleys and is most extensive along the Rush River. Shallow abandoned stream channels are common in some areas.

The surface layer is dark grayish-brown, very friable silt loam 4 to 7 inches thick. The subsoil and substratum consist of layered dark grayish-brown to pale-brown alluvium that has a texture of fine sandy loam to silt loam. In some places the profile contains the dark-colored former surface layer of a buried soil that has been covered by more recent deposits.

This Fairdale soil has good available moisture capacity and moderate to moderately slow permeability. The content of organic matter is moderate to low.

Most areas of this soil are cultivated, but the shallow abandoned channels are often wet or ponded in some places. As a result, tillage is likely to be delayed in wet years if surface drainage has not been established. This soil is well suited to wheat, barley, oats, corn, and hay. (Capability unit IIc–1)

Fargo Series

In the Fargo series are deep, poorly drained soils developed in fine-textured sediments deposited in glacial lakes. These soils are in nearly level areas on the lake plain. The native vegetation was tall grasses.

The surface layer is black, neutral or mildly alkaline silt loam to clay 10 to 20 inches thick. Where the surface layer is silt loam, it has medium crumb and granular structure and is very friable when moist and slightly sticky when wet. Where it is clay, it has fine blocky structure and is hard when dry, very firm when moist, and very sticky and very plastic when wet.

The subsoil is olive-gray, neutral to moderately alkaline clay 10 to 20 inches thick. It is slightly calcareous in most places. The subsoil has strong, fine, blocky structure and is hard when dry, very firm when moist, and very sticky and very plastic when wet.

The subsoil grades to a substratum of olive-gray, calcareous and moderately alkaline, slightly saline clay in which segregations of gypsum crystals are common. The lower part of the substratum is mottled with dark yellowish brown and dark brown.

These soils shrink as they dry and expand as they become wet. During prolonged dry periods, the cracks in these soils are 1 to 3 inches wide at the surface. They taper downward to a depth of 36 inches in some places. Soil material from the black surface layer falls or is washed into these cracks and forms wedge-shaped tongues. The distance between the tongues varies widely, but an interval of 1 to 5 feet is common.

The Fargo soils occur with the Overly, Bearden, Dimmick, Aberdeen, and Exline soils. They are finer textured than the Overly and Bearden soils and have a thinner surface layer than the Dimmick soils. They lack the gray subsurface layer typical of the Aberdeen and Exline soils, and their subsoil has blocky structure instead of prismatic and columnar structure.

Nearly all areas of the Fargo soils are used for crops.

Fargo clay (0 to 2 percent slopes) (Fc).—This soil is in nearly level areas on the lake plain. Slight differences in elevation are numerous in these areas, but they generally do not exceed 12 inches. The surface layer is black, firm clay that has strong, fine, granular and blocky structure and is 10 to 20 inches thick. The subsoil is olive-gray clay that has strong, fine, blocky structure. It is very firm when moist and very hard when dry, and the lower part is calcareous. The substratum is similar to the subsoil, except that it is calcareous, has mottles, and contains segregations of gypsum crystals.

This soil has very slow permeability. Surface drainage is slow, and surface drains are needed to remove the excess water from snowmelt or heavy rains.

Because this soil is very hard when dry and very sticky when wet, it can be tilled only within a narrow range of moisture content. Fall plowing is necessary so that the tilth of the surface layer will be improved by the effects of freezing and thawing and of wetting and drying. When the soil is plowed in fall, it is generally in good condition for preparation of the seedbed in spring. Fall plowing, however, causes a hazard of wind erosion (fig. 6) during open winters and early in spring when the temperature fluctuates above and below freezing. The alternate freezing and thawing cause the surface soil to break down to a mulch of fine, light-weight granules that are easily transported by wind. This fine material can fill roadside ditches and other drainage ditches in a single day. Because this soil is nearly level and its texture is uniform, the hazard of erosion is the same over an entire field.

Most areas of this soil are cultivated. The soil is well suited to wheat, barley, oats, flax, corn, and hay, and yields are high. Where surface drainage has not been established, however, it is less well suited to corn than to close-growing crops, because wetness may delay or prevent cultivation. (Capability unit IIw-1)

Fargo silt loam (0 to 2 percent slopes) (Fg).—This soil is on the nearly level lake plain adjacent to the beach area. It developed in a thin mantle of silty sediments that were washed from the beaches and were deposited over clayey lake sediments. The surface layer is 12 to 20 inches thick.

Permeability is very slow in the subsoil and substratum, and available moisture capacity is good. Surface drains are needed to remove the excess water. Unlike Fargo clay, this soil can be tilled within a wide range of moisture content and it is only slightly susceptible to wind erosion.

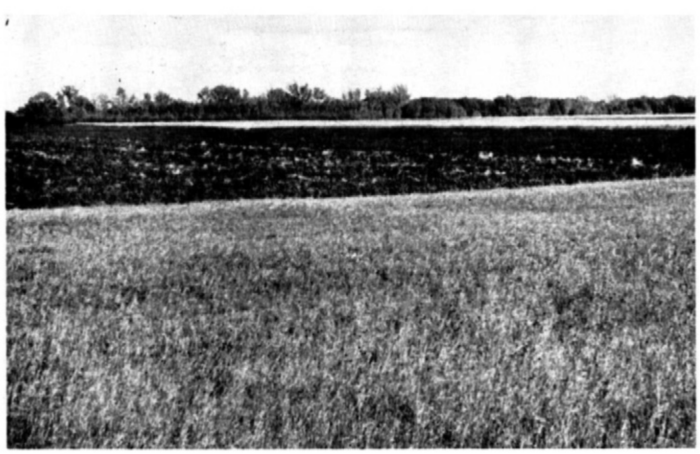

***Figure 6.*—Fargo clay plowed in fall and protected from wind erosion by leaving the surface trashy. The field windbreak in the background also protects this soil.**

Nearly all areas are cultivated. Yields of wheat, barley, oats, flax, corn, and hay are high. (Capability unit IIw-1)

Fargo silty clay loam (0 to 5 percent slopes) (Fh).—This soil is on the lake plain adjacent to the beach area in the central part of Cass County. The surface layer is black, friable silty clay loam that has moderate, fine, granular structure and is 10 to 20 inches thick. The subsoil and substratum are olive-gray very fine clay.

Surface drains are needed to remove excess water. Permeability is very slow in the subsoil and substratum. Available moisture capacity is good.

This soil is used for crops. Wheat, barley, oats, flax, corn, and hay are the crops commonly grown, and yields are high. (Capability unit IIw-1)

Fargo silty clay loam, saline (0 to 2 percent slopes) (Fk).—This soil occupies a small acreage adjacent to the eastern edge of the beach area. Its surface layer contains soluble salts as a result of seepage from the beach area.

Surface drainage is needed to remove excess water. The control of seepage from the beach area may be made feasible by installing drains to intercept ground water that is moving laterally.

Yields of crops grown on this soil are reduced by the salinity. Grasses and legumes are commonly grown and are more tolerant of salt than other crops. Rye, oats, barley, and wheat are crops that have moderate to low tolerance to salinity. This soil is poorly suited to corn and soybeans, which have low tolerance to soluble salts. (Capability unit IIIs-6)

Fargo-Exline silty clay loams (0 to 2 percent slopes) (Fn).—About 70 percent of this complex is Fargo silty clay loam, and about 30 percent is Exline silty clay loam. The Exline soil is in small areas, 20 to 50 feet across, and it occurs at random within areas of the Fargo soil.

The Fargo soil in this complex has a profile similar to the one described for the Fargo series. The Exline soil has a thin surface layer of black, friable silty clay loam and a gray, very thin subsurface layer. Its subsoil is silty clay loam to silty clay that has strong columnar structure and is very firm when moist and very sticky when wet.

Both the Fargo and Exline soils have a slowly permeable subsoil and substratum. Available moisture capacity is high in the Fargo soil and low in the Exline soil. Generally, the root zone in the Exline soil is restricted to the surface layer, but a few roots can penetrate the subsoil. In places where part of the Exline subsoil has been brought to the surface by tillage, the soil material disperses when wet and is very hard and crusts when dry. In those places tilth is poor and little, if any, growth of crops takes place. Because the Exline soil occurs within areas of the Fargo soil, the moisture content of the Exline soil largely determines the time of farming operations.

Good yields of crops are obtained on the Fargo soil, and poor yields are obtained on the Exline soil. These soils are better suited to wheat, barley, oats, and hay than to other crops. They are poorly suited to corn because the Exline soil dries so slowly after rains that cultivation is often delayed. (Capability unit IIIs-2)

Fordville Series

The Fordville series consists of well-drained soils developed in medium-textured to moderately coarse textured glacial lake sediments. These soils are underlain by gravel and coarse sand at a moderate depth. They are in nearly level or gently undulating areas on beach ridges and stream terraces.

The surface layer is black, neutral or slightly acid loam to sandy loam 4 to 10 inches thick. It has granular structure and is very friable when moist and slightly sticky when wet.

The subsoil is very dark brown to very dark grayish-brown, neutral loam to sandy loam 12 to 20 inches thick. It has moderate prismatic and weak blocky structure and is very friable or friable when moist and slightly sticky when wet.

Underlying the subsoil is a layer of dark grayish-brown, neutral coarse sandy loam to gravelly loam that is 4 to 8 inches thick. Beneath this layer is stratified coarse sand and gravel that is calcareous in the upper part. The under sides of the pebbles in the upper part of this material are heavily coated with lime.

The thickness of the profile above the gravel and coarse sand ranges from 24 to 36 inches. Rounded pebbles occur in all layers.

The Fordville soils occur with the Renshaw, Sioux, and Spottswood soils. They are deeper over gravel than the Renshaw and Sioux soils. Unlike the Sioux soils, the Fordville soils have a subsoil. They have a thinner surface layer than the Spottswood soils.

Most areas of the Fordville soils are cultivated.

Fordville loam, nearly level (0 to 2 percent slopes) (WeA).—This soil is most extensive on the beach ridges and stream terraces near the Maple River. The surface layer is black, friable loam 4 to 10 inches thick. The subsoil is very dark grayish-brown, friable loam that has moderate prismatic structure. Gravelly coarse sand and gravel are at a depth of 20 to 36 inches.

Included in the areas mapped as this soil are areas of Renshaw and Spottswood soils. These areas are smaller than 2 acres in size.

This soil is somewhat droughty but has fair available moisture capacity. Permeability is moderate in the subsoil and rapid in the substratum. The content of organic matter is moderate.

Most areas of this soil are cultivated. Wheat, barley, oats, flax, corn, and hay are the crops commonly grown, and yields are low. (Capability unit IIIs–1)

Fordville loam, undulating (2 to 5 percent slopes) (WeB).—This soil is on beach ridges and stream terraces. Its surface layer is slightly thinner than the one in the profile described for Fordville loam, nearly level, or 4 to 8 inches thick.

This soil is somewhat droughty but has fair to good available moisture capacity. Permeability is moderate in the subsoil and rapid in the substratum. The content of organic matter is moderate.

Most areas of this soil are cultivated. Wheat, barley, flax, oats, corn, and hay are the main crops grown. (Capability unit IIIs–1)

Fordville sandy loam, nearly level (0 to 2 percent slopes) (WsA).—This soil is on low beach ridges and in nearly level, adjacent interbeach areas. Its surface layer is black sandy loam. The subsoil is very dark brown loam that has moderate prismatic structure and breaks readily to weak blocky aggregates. Included in the areas mapped as this soil are small areas of Renshaw soils.

This soil is somewhat droughty but has fair available moisture capacity. Permeability is moderate in the subsoil and rapid in the substratum. The content of organic matter is moderate. If this soil is cultivated, it is highly susceptible to wind erosion.

Most areas are cultivated. The crops commonly grown are wheat, barley, oats, corn, and hay. (Capability unit IIIe–6)

Fordville sandy loam, undulating (2 to 5 percent slopes) (WsB).—This soil has a slightly thinner surface layer than is typical for the series. It has fair available moisture capacity. Permeability is moderate in the subsoil and rapid in the substratum. This soil is somewhat droughty and is highly susceptible to wind erosion if it is cultivated. The content of organic matter is moderate.

This soil is used mostly for crops. Wheat, barley, corn, oats, and hay are the crops commonly grown, but yields are low. (Capability unit IIIe–6)

Fresh Water Marsh

Fresh water marsh (Fw) is a miscellaneous land type in large, deep, closed depressions, mainly south and west of the town of Sheldon. The areas are covered by water most of the time, except during periods of prolonged drought. Cattails, sedges, and rushes grow along the margins where the water is shallow; in the center is open water. The underlying material is glacial till, local alluvium, and lake sediments that range from loamy fine sand to silt loam in texture.

This land type supplies water for livestock. It is also used by migratory waterfowl. (Not placed in a capability unit)

Gardena Series

In the Gardena series are deep, moderately well drained soils developed in medium-textured sediments deposited in glacial lakes. These soils are in nearly level or slightly concave sloping areas. The native vegetation was mainly tall grasses.

The surface layer is black, neutral or slightly acid loam or silt loam 10 to 20 inches thick. It has moderate crumb and granular structure and is very friable when moist and slightly sticky when wet.

The subsoil is very dark grayish-brown very fine sandy loam to silt loam 6 to 16 inches thick. It has weak prismatic and subangular blocky structure and is very friable when moist and slightly sticky when wet. The upper part is neutral, and the lower part is moderately alkaline.

Underlying the subsoil is a layer of grayish-brown, moderately alkaline loam to fine sandy loam in which lime has accumulated. This layer has weak blocky structure and is friable when moist and slightly sticky when wet. Beneath this layer is light olive-brown, moderately alkaline and calcareous loam to fine sand that is mottled with light grayish brown below a depth of 36 inches. The coarser textured material is in the lower part, except in areas where glacial till or other contrasting material occurs.

The Gardena soils have a medium-textured subsoil instead of a moderately coarse textured subsoil like that of the Embden soils. They are leached of lime to a greater depth than the Glyndon soils. The Gardena soils have a thicker surface layer and more mottled underlying material than the Eckman soils. They are coarser textured than the Overly soils. The Gardena soils developed in water-sorted material that is free of pebbles, instead of in unsorted glacial till like the Svea soils.

The Gardena soils are highly productive. Most areas are used for crops.

Gardena loam, very deep, nearly level (0 to 2 percent slopes) (GbA).—This soil is on the Sheyenne Delta and in the beach area. The surface layer is black, very friable loam that is 10 to 20 inches thick and has fine crumb and subangular blocky structure. The subsoil is very dark grayish-brown, friable silt loam that has prismatic structure. It is underlain by a substratum of grayish-brown to light olive-brown, calcareous loam to fine sandy loam.

This soil is moderately permeable and has good available moisture capacity. It is high in content of organic matter. The cultivated areas are only slightly susceptible to wind erosion.

This soil is well suited to cultivation. Yields of wheat, barley, flax, corn, oats, and hay are high. (Capability unit IIc–1)

Gardena loam, very deep, undulating (2 to 5 percent slopes) (GbB).—This soil is on the sides of shallow drainageways. Its surface layer is slightly thinner than the one in the profile described for the series, or 10 to 16 inches thick.

This soil is moderately permeable, has good available water capacity, and is moderate to high in content of organic matter. It is moderately susceptible to water erosion.

This soil is productive, and nearly all the areas are cultivated. The main crops are wheat, barley, oats, corn, flax, and hay. (Capability unit IIe–3)

Gardena loam, deep, nearly level (0 to 2 percent slopes) (GcA).—This soil is mostly on the lake plain adjacent to the beach area. Its surface layer is black, thick, very friable loam. Its subsoil is very dark grayish brown. Between a depth of 36 and 60 inches, the substratum is finer textured than that underlying the very deep Gardena loams and has a texture of silt loam to silty clay loam. Areas mapped as this soil include areas of Embden and Glyndon soils that are smaller than 2 acres in size.

The available moisture capacity is good. Permeability is moderate in the subsoil and slow in the substratum. The content of organic matter is high.

This soil is highly productive and is well suited to cultivation. Wheat, barley, flax, corn, and hay are the crops commonly grown. (Capability unit IIc–1)

Gardena loam, moderately shallow, nearly level (0 to 2 percent slopes) (GdA).—This soil is on the lake plain. It developed in moderately deep loamy material that washed from the beach area and was deposited over finer textured lake sediments. The profile is similar to the one described for Gardena loam, deep, nearly level, except that a slowly permeable substratum is at some depth between 20 and 36 inches. The texture of the substratum ranges from silt loam to silty clay.

Areas mapped as this soil include areas of Glyndon loam and Fargo silt loam. These included areas are smaller than 2 acres in size.

Permeability is moderate in the subsoil. It is slow in the substratum. The content of organic matter is high.

This soil is used mainly for crops. Yields of wheat, barley, flax, oats, corn, and hay are high. (Capability unit IIc–1)

Gardena loam, moderately shallow, undulating (2 to 5 percent slopes) (GdB).—This soil is on low ridges on the lake plain. It has a slowly permeable substratum at some depth between 20 and 36 inches. The subsoil is moderately permeable. Available moisture capacity is good, and the content of organic matter is high. The soil is susceptible to water erosion.

Wheat, corn, oats, barley, flax, and hay are grown on this soil. Yields are good. (Capability unit IIe–3)

Gardena loam, till substratum, nearly level (0 to 2 percent slopes) (GeA).—This soil is most extensive in the beach area in Cass County. It developed in lake sediments underlain by loam glacial till. Depth to the glacial till ranges from 24 to 60 inches.

The surface layer is black, very friable loam 10 to 18 inches thick. The subsoil is very dark grayish-brown loam that has prismatic structure. Generally, the texture in the layer below the subsoil is loam to fine sandy loam, except that a thin layer of gravelly or cobbly sand or coarse sand occurs in most areas between the lake sediments and the underlying glacial till. The underlying glacial till is grayish-brown to light brownish-gray, calcareous loam.

Permeability is moderate in the subsoil and moderate to slow in the underlying glacial till. The available moisture capacity is good.

Most areas of this soil are cultivated. Wheat, corn, oats, barley, flax, and hay are the crops commonly grown, and yields are high. (Capability unit IIc–1)

Gardena-Eckman loams, till substratum, nearly level (0 to 2 percent slopes) (GfA).—The soils of this complex are in Ransom County in the southwestern part of the survey area. The Gardena soil is nearly level and is in concave areas. The Eckman soil is in slightly higher convex areas. The Gardena soil occupies 50 to 75 percent of the acreage in this complex, and the Eckman soil, 25 to 45 percent.

The Gardena soil has a surface layer of black, very friable loam 10 to 18 inches thick, and the Eckman soil has a surface layer of black, very friable loam about 8 inches thick. Both the Gardena and Eckman soils have a subsoil of very dark grayish-brown, friable loam that has prismatic structure. Depth to glacial till ranges from 24 to 60 inches.

Both the Gardena and Eckman soils have a moderately permeable subsoil. Their substratum is moderately to slowly permeable. The Gardena soil has a high content of organic matter, and the Eckman soil has a moderate content.

The soils in this complex are used mainly for crops. Wheat, corn, flax, barley, oats, and hay are the crops commonly grown. (Capability unit IIc–1)

Gardena-Glyndon loams, nearly level (0 to 2 percent slopes) (GgA).—Most areas of these soils are in the beach area and along the edge of the lake plain. The proportions of the Gardena and Glyndon soils vary in different areas, but each of these soils occupies at least 20 percent of every area of this complex.

The Gardena soil has a surface layer of black, very friable loam 10 to 20 inches thick and a subsoil of very dark grayish-brown, friable loam. The Glyndon soil has a surface layer of black, very friable, slightly calcareous loam 8 to 15 inches thick and a subsoil of light-colored, strongly calcareous loam to very fine sandy loam. Both of these soils have a substratum of grayish-brown, friable, calcareous loam to fine sandy loam.

Both the Gardena and Glyndon soils have a moderately permeable subsoil and substratum. In most years the Glyndon soil has a water table within 5 feet of the surface during the early part of the growing season. The content of organic matter is high in the Gardena soil and moderate in the Glyndon soil.

The soils of this complex are used mainly for crops. Yields of wheat, corn, oats, barley, flax, and hay are high. (Capability unit IIc-1)

Gardena-Glyndon loams, till substratum, nearly level (0 to 2 percent slopes) (GkA).—The soils of this complex are in the beach area. They developed in lake sediments that are 24 to 60 inches thick over glacial till. The proportions of both the Gardena and Glyndon soils vary in different areas, but each of these soils occupies at least 20 percent of every area mapped as this complex. The profiles of the Gardena and Glyndon soils of this complex are similar to the profiles described for the Gardena and Glyndon soils, except that glacial till is at a depth of 24 to 60 inches.

Permeability of the subsoil is moderate, and that of the substratum is moderately slow. In most years the water table is less than 5 feet from the surface of the Glyndon soil during the early part of the growing season.

These soils are used for crops. Wheat, corn, barley, oats, and flax are the crops commonly grown. (Capability unit IIc-1)

Glyndon Series

The Glyndon series consists of deep, moderately well drained or somewhat poorly drained, nearly level soils developed in medium-textured sediments deposited in glacial lakes. In most years the water table is within 5 feet of the surface during the early part of the growing season. Tall grasses were the dominant native vegetation.

The surface layer is black, calcareous and mildly alkaline fine sandy loam to loam 6 to 16 inches thick. It has weak crumb and subangular blocky structure and is very friable when moist and slightly sticky when wet.

The subsoil is a layer of light brownish-gray, moderately alkaline very fine sandy loam to silt loam where lime has accumulated. It has weak blocky structure and is friable when moist and slightly sticky when wet. It has a few prominent mottles. In places there is a gray transitional layer between the dark-colored surface layer and the light-colored subsoil.

Beneath the subsoil is grayish-brown to dark yellowish-brown loam to fine sand that is moderately alkaline and slightly saline. In most areas the texture of this material is loam or fine sandy loam. The lower part is the coarsest textured, except in areas underlain by glacial till or other contrasting material.

The Glyndon soils occur with the Hamerly, Borup, Gardena, Embden, and Stirum soils. They developed in pebble-free, water-sorted material, instead of in unsorted glacial till like the Hamerly soils. The substratum of the Glyndon soils is brighter colored than that of the Borup soils, and it contains fewer mottles. The Glyndon soils lack the very dark grayish-brown, lime-free subsoil that is typical of the Gardena, Eckman, and Embden soils. They are finer textured than the Embden and Ulen soils.

The Glyndon soils have a finer textured subsoil than the Stirum soils, and their subsoil has weak blocky structure instead of weak, coarse, columnar structure like the Stirum subsoil. The Glyndon soils are coarser textured than the Bearden soils.

Nearly all areas of these soils are used for crops.

Glyndon loam, very deep, nearly level (0 to 2 percent slopes) (GmA).—This soil is in the northern part of Cass County, mainly in the beach area. It is in broad, shallow depressions and in nearly level areas. The surface layer is black, very friable, calcareous loam 6 to 16 inches thick. The subsoil is strongly calcareous loam or silt loam that is friable and has weak subangular blocky structure. The substratum is friable, calcareous loam to loamy fine sand.

Permeability is moderate in the subsoil and substratum. The available moisture capacity is good, and this soil contains a moderate amount of organic matter. In many years the water table is less than 5 feet from the surface early in the growing season. In years of excessive rainfall, it is near the surface during most of the growing season. At times, wetness delays seeding. Surface drainage is needed to remove the excess water.

In some fields tillage has brought part of the light-colored subsoil to the surface. In those areas this soil has a patchy appearance because it is light colored in some places and dark colored in other places. In light-colored areas the surface layer is strongly calcareous and is low in content of organic matter. It also has weak structure and is moderately susceptible to wind erosion if cultivated. Crops grown in these areas show signs of yellowing as a result of poor aeration or a deficiency in plant nutrients.

This Glyndon soil is used mostly for crops. Yields of wheat, barley, oats, flax, corn, and hay are high. (Capability unit IIe-1)

Glyndon loam, very deep, undulating (2 to 5 percent slopes) (GmB).—This soil is on the sides of shallow drainageways and on the lower side slopes of beach ridges. Its surface layer is thinner than the one in the profile described for Glyndon loam, very deep, nearly level, but is similar in other respects. Areas mapped as this soil include areas of Ulen fine sandy loam; Glyndon loam, till substratum; and Glyndon loam, moderately shallow, that are smaller than 2 acres in size.

In some cultivated fields tillage has brought part of the light-colored subsoil to the surface. In those areas this soil has a patchy appearance because it is light colored in some places and dark colored in other places. In the light-colored areas, the surface layer has weak structure and is low in content of organic matter. Where these light-colored areas are cultivated, they are moderately susceptible to erosion by wind and water.

In many years the water table is within 5 feet of the surface during the early part of the growing season. The high water table is caused by seepage from adjacent higher areas. In some years seeding is delayed by wetness.

This soil is used mostly for crops. Wheat, barley, flax, oats, corn, and hay are the main crops grown. Early in the growing season, crops grown in the light-colored areas are likely to show signs of yellowing because of a deficiency in plant nutrients. (Capability unit IIe-1)

Glyndon loam, deep, nearly level (0 to 2 percent slopes) (GnA).—This soil is mostly on the western edge of the lake plain. It has a profile similar to the one described for Glyndon loam, very deep, nearly level, except that it has a slowly permeable substratum at a depth of 36 to 60 inches.

Some areas of this soil have a light-colored surface layer because part of the subsoil has been brought to the surface by tillage. In these light-colored areas, the soil material has weak structure, is low in content of organic matter, and is moderately susceptible to wind erosion if the soil is cultivated.

In many years the water table is above the slowly permeable substratum early in the growing season. In years when precipitation is above average, however, the water table is high most of the time and is at or near the surface occasionally.

This soil is used mainly for crops. Wheat, barley, corn, flax, oats, and hay are the crops commonly grown, and yields are high. At times, seeding is delayed because this soil is wet. Surface drains are needed to remove the excess water. (Capability unit IIe-1)

Glyndon-Borup loams, strongly saline, nearly level (0 to 2 percent slopes) (GsA).—The soils of this complex are in small, widely scattered areas. The Glyndon soil is somewhat poorly drained. The Borup soil is poorly drained. The profiles of the Glyndon and Borup soils are similar to the profiles described for the Glyndon and Borup series, except that they contain soluble salts.

The soils of this complex have a moderately permeable subsoil and substratum. In most years the water table is within 5 feet of the surface of the Glyndon soil early in the growing season. In the Borup soil it is within 3 feet of the surface much of the time. These soils have a high content of soluble salts.

The soils of this complex are best suited to pasture. Because of the high content of soluble salts, the yields of crops commonly grown are greatly reduced, even in years when the supply of available moisture is favorable. (Capability unit VIs-1)

Glyndon and Gardena loams, nearly level (0 to 2 percent slopes) (GtA).—The soils of this unit are mostly in the beach area, where differences in elevation are 12 inches or less. The Glyndon soil is on slight rises, and the Gardena soil is in the lower areas. The extent of the Glyndon and Gardena soils in this unit is about the same, but the proportions are not the same in different areas.

The profiles of the Glyndon and Gardena soils are similar to the profiles described for the Glyndon and Gardena series, except that both soils have a slowly permeable substratum at some depth between 24 and 60 inches. The surface layer of the Glyndon soil in this unit is calcareous in most places. In areas of these soils where part of the Glyndon subsoil has been brought to the surface by tillage, the surface has a patchy appearance because the soil material is light colored in some places and dark colored in other places. In the light-colored areas the soil material is low in content of organic matter, has weak structure, and is moderately susceptible to wind erosion. Also, crops grown in these light-colored areas show signs of yellowing early in the growing season because of a deficiency of plant nutrients.

In most years the water table is within 5 feet of the surface of the Glyndon soil early in the growing season. At times, seeding is delayed because of wetness. Surface drains are needed to remove excess water in some areas.

These soils are used mainly for crops. Wheat, barley, corn, flax, oats, and hay are the crops commonly grown, and yields are high. (Capability unit IIe-1)

Glyndon and Hamerly loams, saline, nearly level (0 to 2 percent slopes) (GuA).—These soils are within the beach area. The proportions of the Glyndon and Hamerly soils vary widely in different areas. Both the Hamerly and Glyndon soils have a surface layer 6 to 12 inches thick. Where part of the subsoil has been brought to the surface by tillage, light-colored patches are common. In these light-colored areas, the soil material is low in content of organic matter, has weak structure, and is moderately susceptible to wind erosion if the soils are cultivated. A slowly permeable substratum of glacial till and lake sediments is common in the Glyndon soil at a depth of 24 to 60 inches.

The soils in this unit have a moderately permeable loam subsoil and a moderately to slowly permeable loam substratum. In most years the water table is within 5 feet of the surface in spring and early in summer. These soils have good available moisture capacity and a moderate content of organic matter. In years of normal rainfall, the content of soluble salts within the root zone is great enough that the growth of plants is affected. In extended dry periods the growth, vigor, and yields of crops are greatly reduced.

Most areas of these soils are cultivated, and wheat, flax, barley, and hay are the crops commonly grown. Yields are only fair in dry years, but they are good in years when rainfall is adequate and is uniformly distributed throughout the growing season. (Capability unit IIIs-6)

Gravel Pits

Gravel pits (Gv) are on the more distinct beach ridges and on the edges of terraces near the Maple River. They are in areas where sand and gravel have been removed for road construction and other purposes. These areas were not leveled after the sand and gravel were removed. Sweetclover, weeds, and a few cottonwood trees have become established in parts of these areas and provide limited cover for wildlife. (Not placed in a capability unit)

Hamar Series

In the Hamar series are deep, somewhat poorly drained or poorly drained soils developed in sandy sediments deposited in glacial lakes. These soils are in low areas and in slight depressions. In most years they have a water table within 3 feet of the surface. The native vegetation was tall grasses and sedges.

The surface layer is black, neutral or slightly acid fine sandy loam to loamy fine sand that has crumb structure and is 10 to 30 inches thick. Where the surface layer is more than 15 inches thick, the lower part is mottled with dark brown and yellowish brown.

The subsoil is grayish-brown sandy loam to fine sand that has faint olive-brown and dark-brown mottles. It is slightly acid to mildly alkaline.

The substratum is grayish-brown, mildly alkaline and slightly calcareous sandy loam to loamy fine sand that has prominent, common mottles of dark gray, reddish yellow, and dark brown. The upper part has strongly contrasting mottles, and the lower part has faint ones. In some places below a depth of 42 inches, there are layers of silt loam or silty clay loam less than 2 inches thick.

The Hamar soils occur with the Hecla, Maddock, and Ulen soils. They have a more strongly mottled subsoil and substratum than the Hecla and Maddock soils. They lack a layer of lime accumulation beneath the surface layer like that in the Ulen soils. The Hamar soils are coarser textured than the Tiffany soils.

The Hamar soils are used mainly for pasture. In some areas, however, they are cultivated with adjacent soils.

Hamar fine sandy loam (0 to 2 percent slopes) (Ha).—This soil is in low areas and in shallow depressions on the Sheyenne Delta. Most areas mapped as this soil are smaller than 10 acres in size. The surface layer is black, very friable fine sandy loam 10 to 30 inches thick. The subsoil is grayish-brown loamy fine sand mottled with dark brown. The substratum is light brownish-gray loamy fine sand that is strongly mottled with reddish yellow and olive brown.

Permeability is rapid in the subsoil and substratum, and the available moisture capacity is low. The content of organic matter is high to moderate. In most years the water table is within 3 feet of the surface in spring and in summer. In wet years, however, it is at or near the surface during most of the frost-free season.

This soil is used mainly for hay and grazing, but some areas are in fields with other soils and are cultivated with the other soils. Except in dry years, seeding is usually delayed because of wetness. This soil is suitable for cultivation if it is drained, but it is highly susceptible to wind erosion if it is cultivated. Oats, millet, flax, and hay are the crops best suited to areas without drainage. Corn, wheat, and barley can be grown where drainage has been established. (Capability unit IIIw–1)

Hamar-Ulen fine sandy loams (0 to 2 percent slopes) (Hb).—The soils of this complex are more extensive on the Sheyenne Delta than in other areas. Both soils are in broad, low areas, but the Hamar soil is in slightly lower areas than the Ulen soil. The Hamar soil occupies at least 50 percent of the acreage, and the Ulen soil occupies 15 to 50 percent.

The Hamar soil has a profile like the one described for Hamar fine sandy loam. The Ulen soil has a surface layer of black, very friable fine sandy loam. Its surface layer is slightly calcareous in most places and is 8 to 12 inches thick. The subsoil is grayish-brown, strongly calcareous fine sandy loam. It is underlain by a substratum of olive-brown, calcareous fine sandy loam to loamy fine sand.

These soils have a rapidly permeable subsoil and substratum. The available moisture capacity is low to fair, and the content of organic matter is moderate. In cultivated areas these soils are highly susceptible to wind erosion.

In most years the Hamar soil has a water table within 3 feet of the surface until early in summer. This water table is within 5 feet of the surface during most of the frost-free period. Water is ponded on the Hamar soil in wet years for periods of 1 to several months. The Ulen soil generally has a water table within 5 feet of the surface during the early part of the growing season. In wet years the water table is at or near the surface.

These soils are used for field crops and for hay and pasture. Surface drainage is needed to remove the excess water. If the soils have been drained, they are suited to corn, wheat, oats, barley, and hay. In the undrained areas, the crops grown and the tillage operations vary according to the wetness of the season. Seeding is often delayed in the undrained areas, and crops cannot be planted in wet years. Crop yields are fair to good, and an excellent growth of grasses is produced for hay and grazing. (Capability unit IIIe–4)

Hamar-Ulen loamy fine sands (0 to 2 percent slopes) (Hc).—The soils of this complex are most extensive on the Sheyenne Delta. They are in low, nearly level or slightly undulating areas, but the Ulen soil is in slightly higher areas than the Hamar soil. The Hamar soil occupies at least 50 percent of the acreage of this complex, and the Ulen soil occupies 15 to 50 percent. The profiles of the Hamar and Ulen soils are similar to the profiles described for the Hamar and Ulen series.

Permeability of both the Hamar and Ulen soils is rapid. Available moisture capacity is low or very low. In most years the water table is within 3 feet of the surface of the Hamar soil during most of the growing season; it is within 5 feet of the surface of the Ulen soil during most of the growing season, but it is within 3 feet in spring and early in summer. Water is frequently ponded on the Hamar soil, but it is ponded on the Ulen soil only in years when the amount of precipitation is high.

These soils are highly susceptible to wind erosion. The soils are used mainly for hay and pasture, but some areas are cultivated. In the cultivated areas intensive practices are needed that will control erosion. Crop yields are generally low in years when rainfall is normal. They are good when rainfall is above average, but not excessive, and when it is uniformly distributed. (Capability unit IVe–3)

Hamerly Series

The Hamerly series consists of deep, moderately well drained or somewhat poorly drained soils developed in calcareous, loamy glacial till. These soils are in nearly level or slightly convex areas adjacent to small, shallow depressions. In most years the water table is within 5 feet of the surface. The native vegetation was tall and mid grasses.

The surface layer is black loam 6 to 14 inches thick. It has moderate granular and weak blocky structure and is friable when moist and slightly sticky and slightly plastic when wet. The surface layer is calcareous and moderately alkaline. In a few places it is slightly saline.

The subsoil is light brownish-gray, strongly calcareous loam 8 to 20 inches thick. It has weak, coarse, prismatic and blocky structure and is friable when moist and slightly sticky when wet. In a few areas the subsoil is moderately saline.

The substratum is light olive-brown, calcareous loam. It has light brownish-gray, yellowish-brown, and reddish-brown mottles that increase in number and contrast with increasing depth. The substratum is slightly saline in most areas, and segregations of gypsum crystals are common. All layers contain varying amounts of pebbles, cobbles, and angular grains of coarse sand.

The Hamerly soils occur with the Buse, Barnes, Svea, Tetonka, Vallers, and Glyndon soils. They have a more mottled substratum than the Buse soils. Unlike the Barnes and Svea soils, the Hamerly soils have a subsoil that lacks the very dark grayish-brown color typical of the subsoil in the Barnes and Svea soils. They lack the gray subsurface layer that is typical of the Tetonka soils, and unlike the Tetonka soils they have free lime throughout the profile. The substratum of the Hamerly soils has fewer mottles than that of the Vallers soils. The Hamerly soils developed in glacial till instead of in pebble-free, water-sorted material like that in which the Glyndon soils developed.

The Hamerly soils are used mainly for crops.

Hamerly complex, undulating (2 to 5 percent slopes) (HdB).—The soils of this complex are on the sides of knolls and shallow drainageways on the till plain. They are mostly in the southwestern corner of the survey area. The surface layer is black, friable, calcareous loam. It is 6 to 14 inches thick in most places, but its thickness varies with slight differences in the level of the water table. The subsoil is light brownish-gray, very strongly calcareous, friable loam. The substratum is light olive-brown, calcareous loam that has yellowish-brown and reddish-brown mottles.

These Hamerly soils have a moderately permeable subsoil and a slowly permeable substratum. Available moisture capacity is good. In some places these soils are light colored where part of the subsoil has been mixed with the surface layer by tillage. In the light-colored areas that are cultivated, the soil material is low in content of organic matter, has weak structure, and is moderately susceptible to wind erosion.

Areas mapped as these soils include areas of Tetonka soils in shallow depressions, which are shown on the map by a symbol for depressions, and of Vallers soils on the edges of the depressions. Also included are Buse soils on the crests of knolls. None of the areas of included soils are more than 1 acre in size.

In most years the water table is within 5 feet of the surface in spring and early in summer. Seeding is delayed at times because of wetness. Shallow surface drains are needed to remove the excess water.

Most areas of these soils are cultivated. The crops commonly grown are barley, wheat, oats, flax, and hay, and yields are good. (Capability unit IIe–1)

Hamerly loam, nearly level (0 to 2 percent slopes) (HeA).—This soil is on the edge of the till plain adjacent to the beach area. It has a moderately permeable subsoil and a slowly permeable substratum. Patches where the surface layer is light colored occur where tillage has mixed part of the subsoil with the surface layer. In these light-colored areas, the soil material is low in content of organic matter, has weak structure, and is moderately susceptible to wind erosion.

In most years the water table is within 5 feet of the surface in spring and early in summer. Then, seeding is delayed by wetness and shallow surface drains are needed to remove the excess water.

This soil is used mostly for crops, mainly wheat, barley, flax, corn, oats, and hay. Under good management yields are generally high. (Capability unit IIe–1)

Hamerly-Barnes loams, undulating (2 to 5 percent slopes) (HgB).—Most areas of these soils are on the till plain in the northern part of Cass County. The Hamerly soil is on the low rises adjacent to shallow drainageways and depressions, and the Barnes soil is on the higher knolls. Hamerly loam makes up 40 to 60 percent of the acreage, and Barnes loam makes up 30 to 50 percent.

The Hamerly soil has a profile similar to the one described for the Hamerly series, except that its surface layer is 6 to 10 inches thick. The Barnes soil has a surface layer of black, very friable loam 6 to 8 inches thick.

Included in the areas mapped as these soils are areas of Parnell and Buse soils that are smaller than 1 acre in size. The included Parnell soils are in small depressions, and the Buse soils are on the crests of small knolls.

Permeability is moderate in the subsoil and moderately slow to slow in the substratum. In most years the water table is within 5 feet of the surface of the Hamerly soil in spring and early in summer. Surface drains are needed to remove the excess water. The Barnes and Hamerly soils have good available moisture capacity. Generally, they are moderate in content of organic matter.

In some places light-colored areas are on the crests of knolls and low rises in fields where part of the subsoil has been mixed with the surface layer by tillage. In the light-colored areas that are cultivated, the soil material has weak structure, is low in content of organic matter, and is moderately susceptible to erosion by wind and water.

These soils are used mostly for crops, mainly wheat, barley, flax, oats, corn, and hay. Yields are good. (Capability unit IIe–1)

Hecla Series

In the Hecla series are deep, nearly level, moderately well drained soils developed in sandy sediments deposited in glacial lakes. The native vegetation was tall grasses.

The surface layer is black to very dark brown, neutral fine sandy loam, loamy fine sand, and fine sand 14 to 40 inches thick. It has very weak to weak crumb and blocky structure. Where the surface layer is fine sandy loam or loamy fine sand, it is very friable; where it is fine sand, it is structureless and loose.

The subsoil is very dark grayish-brown, noncalcareous and neutral loamy fine sand or fine sand that is 4 to 18 inches thick. It is mottled with very dark brown and is structureless and loose.

The subsoil grades to a substratum of dark grayish-brown fine sand to loamy fine sand that is loose and structureless. The substratum has many dark-brown mottles, except in some areas where the lower part is contrasting loam and silty clay loam. Generally, the substratum has no free lime within 60 inches of the surface, but it is slightly calcareous in some places.

The Hecla soils occur with the Maddock, Embden, Egeland, Hamar, Ulen, and Tiffany soils. They have a thicker surface layer and a more mottled substratum than the Maddock soils, and they are coarser textured than the Embden and Egeland soils. The Hecla soils are less mottled than the Hamar soils, and they lack the layer of lime accumulation typical of the Ulen soils. They are coarser textured and less mottled than the Tiffany soils.

The Hecla soils are used for crops and native pasture.

Hecla fine sand, nearly level (0 to 2 percent slopes) (HkAx).—This soil is on the Sheyenne Delta. It has a surface layer of black, very friable or loose fine sand 14 to 40 inches thick. The subsoil is dark-gray to very dark grayish-brown fine sand. Beneath the subsoil is brown, loose fine sand that is mottled with brownish yellow. This soil is noncalcareous throughout the profile.

This soil has rapid permeability and low available moisture capacity. The content of organic matter is moderate to high.

This soil is used for grazing and for growing hay. It is not suitable for cultivation, because it is highly susceptible to wind erosion. Grazing should be carefully managed so that a good stand of adapted grasses and an adequate ground cover will be maintained. (Capability unit VIe-1)

Hecla fine sandy loam, nearly level (0 to 2 percent slopes) (HlAx).—Some areas of this soil are on the Sheyenne Delta in the southern part of the survey area. Others are in the beach area in the northern part of Cass County. The surface layer is black, very friable fine sandy loam. It is 8 to 20 inches thick and has weak crumb and blocky structure. The subsoil is very dark grayish-brown, loose loamy fine sand. Beneath the subsoil is dark-brown sand and loamy fine sand mottled with olive brown.

This soil has low to fair available moisture capacity. Permeability of the subsoil and substratum is rapid. The soil is highly susceptible to wind erosion. One evidence of wind erosion is an accumulation of soil material along field boundaries and fence lines. Another is a plow layer that is lighter colored than the part of the surface layer below plow depth.

Most areas of this soil are in cultivated crops, mainly wheat, barley, oats, corn, and hay. Generally, yields are fair, but they are low in dry years because of the limited available moisture capacity. In cultivated areas a combination of practices that will control wind erosion is generally needed for protection against erosion. (Capability unit IIIe-1)

Hecla fine sandy loam, moderately shallow, nearly level (0 to 2 percent slopes) (HmA).—This soil is in small areas on the Sheyenne Delta and in the beach area. Its profile is similar to the one described for Hecla fine sandy loam, nearly level, except that the substratum is loam glacial till or loam to silty clay loam lake sediments at a depth of 20 to 36 inches. Areas mapped as this soil include areas of Ulen and Embden fine sandy loams too small to be mapped separately.

This Hecla soil has a rapidly permeable subsoil and a slowly permeable substratum. Available moisture capacity is fair to good because of the favorable available moisture capacity of the substratum. After a large amount of rain has fallen, this soil has a perched water table above the slowly permeable substratum. This water table restricts the depth to which roots can penetrate. The content of organic matter is moderate. This soil is highly susceptible to wind erosion if it is cultivated.

Most areas of this soil are cultivated, and wheat, barley, oats, corn, and hay are the main crops. Yields are slightly higher than on Hecla fine sandy loam, nearly level, because of the higher available moisture capacity in the lower part of the root zone. In cultivated areas a combination of practices that will control wind erosion is necessary for protection against erosion. (Capability unit IIIe-3)

Hecla loamy fine sand, loamy substratum, nearly level (0 to 2 percent slopes) (HoAx).—This soil is most extensive on the Sheyenne Delta. It is in nearly level or very gently undulating areas. The surface layer is black to very dark grayish-brown loamy fine sand that has very weak crumb structure. The subsoil is loose, dark grayish-brown loamy sand. Thin layers of silt loam and silty clay loam that have moderately slow permeability are at some depth between 36 and 60 inches. Included in the areas mapped as this soil are small, low areas of Hamar loamy fine sand that are too small to be mapped separately.

Generally, this Hecla soil has a rapidly permeable subsoil and a slowly permeable substratum. It has very low available moisture capacity. The content of organic matter is moderate. This soil is highly susceptible to wind erosion, and many areas are already moderately eroded. In some areas drifted soil material has accumulated along field boundaries, fence lines, and field windbreaks. The plow layer in the eroded areas is lighter colored than the surface layer below plow depth.

Most areas of this soil are cultivated, but yields are low. Corn, oats, wheat, and hay are the main crops. (Capability unit IVe-1)

Hecla loamy fine sand, moderately shallow, nearly level (0 to 2 percent slopes) (HpAx).—The profile of this soil is similar to the one described for Hecla loamy fine sand, loamy substratum, except that the substratum is silt loam to silty clay loam. The substratum is at some depth between 20 and 36 inches.

This soil has low available moisture capacity. Permeability is rapid in the subsoil and moderately slow in the substratum. In years when there has been a large amount of precipitation, this soil has a perched water table above the substratum. The content of organic matter is moderate. The soil is highly susceptible to wind erosion if it is cultivated, and many areas have already been moderately eroded by wind.

Areas of this soil are small and scattered. Therefore, most areas are cultivated in fields with other soils. The crops commonly grown are wheat, barley, oats, corn, and hay, and yields are low. In cultivated areas intensive practices that control wind erosion are needed to protect this soil. (Capability unit IVe-1)

Hecla sandy loam, loamy substratum, nearly level (0 to 2 percent slopes) (HrA).—Most areas of this soil are in the beach ridge area north of the Maple River. The surface layer is black to very dark gray, very friable sandy loam. It has weak crumb structure and is 12 to 20 inches thick. The subsoil is dark grayish-brown coarse sand. The upper part of the substratum is coarse sand, but thin layers of silt loam are at a depth of 48 to 60 inches.

This soil has low available moisture capacity. The subsoil and the upper part of the substratum are rapidly permeable. The lower part of the substratum is slowly permeable. The content of organic matter is moderate. Cultivated areas of this soil are highly susceptible to wind erosion.

Most areas of this soil are cultivated, but this soil is droughty and yields are poor to fair. The commonly grown crops are wheat, barley, corn, and hay. In the cultivated areas practices that control erosion are needed. (Capability unit IIIe-3)

Hecla soils, nearly level (0 to 2 percent slopes) (HsAx).—This complex is made up of Hecla loamy fine sand and Hecla fine sandy loam. Although these soils are nearly level, they are in areas where the topography is mainly gently undulating. The Hecla loamy fine sand is in slightly higher areas than the Hecla fine sandy loam.

The soils of this complex have a rapidly permeable subsoil and substratum. Their available moisture capacity is low. The content of organic matter is moderate. These soils are highly susceptible to wind erosion. Most cultivated areas are already moderately eroded, especially the areas of cultivated loamy fine sand in the slightly higher areas. In places drifted soil material has accumulated along the boundaries of fields and along windbreaks and fence lines.

These soils are used mostly for crops, mainly corn, wheat, barley, oats, and hay. Yields are low. (Capability unit IVe–1)

Hecla and Embden fine sandy loams, nearly level (0 to 2 percent slopes) (HtAx).—The soils of this unit are mainly near the western edge of the Sheyenne Delta in Cass County. The proportions of Hecla and Embden fine sandy loams in each area range from 20 to 80 percent.

The Hecla soil has a subsoil of loamy fine sand, and the Embden soil has a subsoil of very dark grayish-brown fine sandy loam. Both of these soils have a substratum of loamy sand to sand.

The soils in this unit have low to fair available moisture capacity. Permeability is moderately rapid in the subsoil and substratum. The content of organic matter is moderate. In most places these soils are highly susceptible to wind erosion, and some areas are already eroded.

Most areas of these soils are cultivated. Wheat, corn, oats, barley, and hay are the crops commonly grown, and yields are fair. (Capability unit IIIe–1)

Hecla-Hamar complex, hummocky, eroded (HuB2).—This complex is made up of Hecla fine sand and of Hamar loamy fine sand. The Hecla soil is on hummocks 4 to 6 feet high, and the Hamar soil is in the many small depressions. In places these soils are severely eroded; many of the small depressions are former blowouts. The Hecla soil is more eroded than the Hamar soil. It makes up 70 to 80 percent of the acreage in the complex. The Hecla soil has a profile similar to the one described for the Hecla series, except that the dark-colored surface layer is thinner, or 8 to 15 inches thick. The Hamar soil has a profile similar to the one described for the Hamar series.

The soils of this complex are rapidly permeable and have very low available moisture capacity. In most years the water table is within 3 feet of the surface of the Hamar soil during much of the growing season and is at or near the surface of that soil in spring and early in summer.

These soils are suited to grazing if management is intensive. Careful control of the stocking rate and of the distribution of grazing is necessary to maintain a cover of desirable grasses. (Capability unit VIe–1)

Hecla and Hamar loamy fine sands, nearly level (0 to 2 percent slopes) (HvAx).—The soils of this unit are in gently undulating areas. Most of the areas are on the Sheyenne Delta. The Hecla soil is more extensive than the Hamar, and it is in areas that are 1 to 3 feet higher than those occupied by the Hamar soil. It occupies 15 to 40 percent of the acreage of this unit. The profiles of these soils are similar to the profiles described for the Hecla and Hamar series.

Included in the areas mapped as these soils are areas of Ulen and Arveson soils that are too small to be mapped separately.

The soils of this unit have a rapidly permeable subsoil and substratum and very low available moisture capacity. In most years the water table is within 3 feet of the surface of the Hamar soil during most of the frost-free season and at or near the surface in spring and early in summer. Seeding is often delayed by the wetness of the Hamar soil. The content of organic matter is moderate to high. In most cultivated areas these soils are moderately eroded; windblown sand has accumulated along field boundaries, fence lines, and field windbreaks in many places. The soils are highly susceptible to further erosion.

Most areas of these soils are cultivated. Corn, wheat, oats, barley, and hay are the crops commonly grown. Yields of wheat, oats, and barley are low, but yields of corn and hay are fair to good. Intensive practices that control wind erosion are needed to protect these soils. (Capability unit IVe–1)

Hecla-Ulen fine sandy loams, nearly level (0 to 2 percent slopes) (HxAx).—The soils of this complex are in gently undulating areas in the beach area in the northern part of Cass County. The Hecla soil is in areas that are slightly higher than those occupied by the Ulen soil. The Hecla soil occupies at least 50 percent of each area mapped as this complex. The profiles of the Hecla and Ulen soils are similar to the profiles described for Hecla fine sandy loam, nearly level, and Ulen fine sandy loam. The Hecla surface layer is 14 to 20 inches thick, and the Ulen surface layer is 6 to 14 inches thick.

The soils of this complex have fair available moisture capacity. Permeability is moderately rapid in the subsoil. It is generally rapid in the substratum, but it is slow in the substratum of the Ulen soil at a depth of more than 60 inches. In most years the water table is within 3 feet of the surface of the Ulen soil in spring and early in summer, but in years of unusually high rainfall it is at or near the surface during much of the growing season. The soils of this complex have a moderate content of organic matter. They are highly susceptible to wind erosion if they are cultivated. Some erosion has already taken place in most areas, and soil material has accumulated along field boundaries, fence lines, and field windbreaks.

These soils are suited to crops, and most areas are cultivated. Wheat, barley, oats, corn, and hay are the crops commonly grown, and yields are fair. (Capability unit IIIe–4)

Hecla-Ulen fine sandy loams, loamy substratum, nearly level (0 to 2 percent slopes) (HyAx).—The soils of this complex are in the beach area north of the Maple River. Their profiles are similar to the profiles described for the Hecla and Ulen series, except that a substratum of silt loam and silty clay loam is at some depth between 36 and 60 inches.

Permeability is moderately rapid in the subsoil and moderately slow to slow in the substratum. The available moisture capacity is fair. In most years the water table is within 3 feet of the surface of the Ulen soil in spring and early in summer. In years when rainfall is much above normal, the water table is at or near the surface during most of the growing season. The content of organic matter is moderate. The soils of this complex are highly susceptible to wind erosion if they are cultivated. In most places some wind erosion has already taken place; soil material has accumulated along field boundaries, fence lines, and field windbreaks.

The soils are suitable for cultivation. The crops commonly grown are oats, corn, barley, flax, and hay, and yields are fair. (Capability unit IIIe-3)

Lamoure Series

The Lamoure series consists of somewhat poorly drained soils developed in moderately fine textured alluvium. These soils are on bottom lands along the Maple River. The native vegetation was sedges and tall grasses.

The surface layer is black, mildly alkaline silty clay loam 20 to 30 inches thick. It has weak blocky and moderate granular structure. When moist, it is very friable, but when wet, it is slightly sticky and plastic.

The subsoil is calcareous, moderately alkaline, olive-brown silty clay loam 8 to 14 inches thick. It has moderate blocky and granular structure and is friable when moist and slightly sticky and plastic when wet.

The subsoil grades to a substratum that consists of layers of olive-brown, slightly calcareous sandy loam, fine sandy loam, and silt loam that are less than 6 inches thick. These layers are friable when moist and slightly sticky when wet.

The Lamoure soils have a substratum that contains fewer mottles and is coarser textured than that of the Perella soils. They are finer textured than the Tiffany soils and are coarser textured than the Dimmick soils.

The Lamoure soils are used for crops.

Lamoure silty clay loam (0 to 2 percent slopes) (La).—This is the only Lamoure soil mapped in the survey area. It is in only one area on the bottom lands along the Maple River. The surface layer is black to very dark gray, friable silty clay loam that is 20 to 30 inches thick and has moderate granular structure. The subsoil is olive-brown, calcareous silty clay loam that is friable and has moderate blocky structure. The substratum consists of strata of olive-brown fine sandy loam alternating with strata of silty clay loam.

This soil has moderately slow permeability and good available moisture capacity. It receives seepage from adjoining areas. The content of organic matter is high.

All of this soil is used for crops, mainly wheat, barley, oats, flax, and hay. Yields are fair. (Capability unit IIw-3)

La Prairie Series

The La Prairie series consists of moderately well drained soils developed in medium-textured, recently deposited alluvium. These soils are on high bottom lands in stream valleys. The native vegetation was mainly trees and tall grasses.

The surface layer is black silt loam 7 to 20 inches thick. It has granular structure and is very friable when moist and slightly sticky when wet. This layer has been leached of lime and is neutral.

The subsoil is very dark grayish-brown silt loam to very fine sandy loam. It has weak prismatic structure and is friable when moist and slightly sticky when wet. The subsoil is slightly calcareous in places and is moderately alkaline.

The substratum is variable in color and texture. It contains thin layers of differing texture in many places, but the texture is generally between a silt loam and a fine sandy loam. In some places the substratum contains the dark-colored former surface layer of a buried soil.

The La Prairie soils have a thicker, darker colored surface layer than the Fairdale soils. They are coarser textured than the Overly soils and finer textured than the Embden soils. Their subsoil lacks the olive-brown color that is typical of the Lamoure subsoil.

Some areas of La Prairie soils are used for crops. Areas that are dissected by stream channels are used for native pasture.

La Prairie and Fairdale soils (Lf).—The soils of this unit are on bottom lands along the Maple and Rush Rivers and Swan Creek. The areas are cut by former stream channels that have steep side slopes, are 20 to 40 feet wide, and 5 to 10 feet deep. The La Prairie soils occupy high bottom lands; the Fairdale soils are in lower positions and are subject to flooding.

The surface layer of the La Prairie soils is black, very friable silt loam 8 to 20 inches thick, and their subsoil is very friable, very dark grayish-brown silt loam. In some areas the substratum contains a dark-colored surface layer of a buried soil. The surface layer of the Fairdale soils is very dark grayish-brown silt loam, and their subsoil is brown, very friable very fine sandy loam to silt loam. The underlying alluvium is stratified, brown to dark grayish-brown silt loam to loamy sand. The Fairdale soils are generally calcareous.

The soils of this unit have good available moisture capacity and a moderately permeable subsoil and substratum. The La Prairie soils are high in content of organic matter and moderate in content of available phosphorus. The Fairdale soils are low in content of both organic matter and available phosphorus.

The La Prairie and Fairdale soils are used mostly for pasture. Cultivating these soils is not feasible, because the areas are too small, narrow, and difficult to reach. (Capability unit VIe-2)

La Prairie silt loam (0 to 2 percent slopes) (Lp).—This soil is on high bottom lands in the valley of the Maple River. Included with it in mapping are areas of Rauville and Fairdale soils less than 1 acre in size.

This soil has good available moisture capacity and is high in content of organic matter. Permeability of the subsoil is moderate, but the permeability of the substratum is moderately slow.

Most areas of this soil are cultivated. Wheat, barley, oats, flax, corn, and hay are the main crops, and yields are high. (Capability unit IIc-1)

Maddock Series

In the Maddock series are deep, well-drained or somewhat excessively drained soils developed in coarse-textured sediments deposited in glacial lakes. These coarse-textured sediments were blown about and scattered by wind after the water in the glacial lakes receded. These soils are on low convex ridges and hummocks that are 1 to several feet higher than the adjacent soils. The vegetation was mid and tall grasses.

The surface layer is very dark gray to dark grayish-brown, neutral fine sandy loam, loamy fine sand, and fine sand 4 to 14 inches thick. It has weak to very weak crumb and blocky structure and is very friable when moist and slightly sticky when wet.

The subsoil is dark grayish-brown or grayish-brown, neutral or mildly alkaline loamy fine sand or fine sand 8 to 16 inches thick. It is structureless in most places, but it has very weak blocky structure in some places. The subsoil is very friable or loose when moist.

The substratum is mainly brown to yellowish-brown loamy fine sand or fine sand, but it is loam, silt loam, or silty clay loam in some places. In places the lower part of the substratum contains a small amount of free lime.

The Maddock soils occur with the Hecla, Ulen, and Hamar soils. They have a thinner surface layer and a lighter colored subsoil than the Hecla soils, and they lack mottling in the substratum. Their subsoil lacks the accumulation of lime that is typical in the subsoil of the Ulen soils. The Maddock soils are lighter colored than the Hamar soils, and they lack the mottling that is typical in those soils. They have a coarser textured subsoil than the Egeland and Embden soils.

The Maddock soils are used for native pasture, hay, and field crops.

Maddock fine sandy loam, nearly level (0 to 2 percent slopes) (MaAx).—This soil is on the Sheyenne Delta and in the beach area. It is at a slightly higher elevation than the adjacent soils. The surface layer is very dark grayish-brown fine sandy loam, and the subsoil is dark grayish-brown loamy fine sand. The substratum is yellowish-brown loamy fine sand or fine sand. Areas mapped as this soil include areas of Hecla and Egeland fine sandy loams that are smaller than 3 acres in size.

This Maddock soil has a rapidly permeable subsoil and substratum and low available moisture capacity. Its content of organic matter is moderate to low. If it is cultivated, this soil is highly susceptible to wind erosion. In most of the cultivated areas, it has already been moderately eroded by wind; drifting soil material has accumulated along field boundaries and fence lines in some places.

Most areas of this soil are cultivated. Wheat, barley, corn, and hay are the main crops, and yields are low. (Capability unit IIIe–2)

Maddock fine sandy loam, undulating (2 to 5 percent slopes) (MaBx).—This soil is mostly in areas adjacent to stream valleys and drainageways. Its surface layer is thinner than the one in the profile described for Maddock fine sandy loam, nearly level.

The available moisture capacity is low. Permeability is rapid in both the subsoil and substratum. This soil is moderate to low in content of organic matter. In cultivated areas this soil is highly susceptible to wind erosion and is moderately eroded in most places. In some of the eroded areas, drifting soil material has accumulated along field boundaries or fence lines.

Most areas are cultivated. The crops commonly grown are corn, oats, and hay, but yields are low. (Capability unit IIIe–2)

Maddock fine sandy loam, rolling (5 to 8 percent slopes) (MaCx).—This soil is on the sides of shallow drainageways entrenched in the Sheyenne Delta adjacent to the lake plain. Its surface layer is thinner than the one in the profile described for Maddock fine sandy loam, nearly level.

Permeability is rapid in the subsoil and substratum, and the available moisture capacity is low. The content of organic matter is low. In most of the cultivated areas, this soil has been moderately eroded by wind, and it is highly susceptible to further erosion if it is cultivated. The surface layer is lighter colored in the areas that have been cultivated than in areas that have remained in native grass.

Most areas of this soil are used for grazing, but some areas are cultivated. Barley, oats, and hay are the crops commonly grown, but yields are low. (Capability unit IIIe–2)

Maddock loamy fine sand, nearly level (0 to 2 percent slopes) (MdAx).—This soil is on slight ridges that are 1 to 2 feet above the general level of adjacent areas. It is mainly on the Sheyenne Delta.

Permeability is rapid in the subsoil and substratum, and the available moisture capacity is low. The content of organic matter is moderate to low. This soil is highly susceptible to wind erosion if it is cultivated. Where it has been cultivated, moderate erosion has already occurred in most places.

Most areas of this soil are cultivated, but yields are low. Hay, corn, and oats are the principal crops. (Capability unit IVe–2)

Maddock loamy fine sand, undulating (0 to 5 percent slopes) (MdBx).—This soil is on low ridges, mainly on the Sheyenne Delta. It has a profile similar to that of Maddock fine sandy loam, nearly level, except that the surface layer, 6 to 10 inches thick, is loamy fine sand.

This soil has a rapidly permeable subsoil and substratum and very low available moisture capacity. The content of organic matter is low to moderate. In cultivated areas this soil is highly susceptible to wind erosion. In most areas that have been cultivated, moderate erosion has already taken place.

More than half of the acreage is cultivated, but yields are low. Hay, corn, and oats are the principal crops. (Capability unit IVe–2)

Maddock soils, hilly (5 to 30 percent slopes) (MhD).—These soils are on the side slopes of stream valleys and in duned areas where the difference between the lowest and highest elevation is more than 20 feet. The dark-colored surface layer is fine sandy loam, loamy sand, or fine sand 1 to 6 inches thick. In other respects the profile is within the range described for the series.

Permeability is rapid, and available moisture capacity is low or very low. These soils are highly susceptible to wind erosion.

These soils are used for grazing. The vegetation, however, is mainly a sparse growth of short and mid grasses, sand bluestem, and prairie sandreed. (Capability unit VIe–1)

Maddock loamy fine sand, moderately shallow, nearly level (0 to 2 percent slopes) (MkAx).—This soil is on narrow terraces adjacent to stream valleys. Most areas are on the Sheyenne Delta. In most places the surface layer is dark grayish-brown loamy fine sand. It is lighter colored in cultivated areas, however, than in areas that have not been cultivated. The subsoil is grayish-brown loamy fine sand. The substratum, at some depth between 20 and 36 inches, is light olive-brown clay.

Permeability is rapid in the subsoil and moderately slow to very slow in the clay substratum. Available moisture capacity is low in the surface layer and subsoil and good in the substratum. In cultivated areas this soil is highly susceptible to wind erosion and is moderately eroded in most places. The content of organic matter is low to moderate.

Most areas of this soil are cultivated. Hay, corn, and oats are the main crops grown, but yields are low. (Capability unit IVe–2)

Maddock-Hamar complex, severely eroded (Mx3).—The soils of this complex are on the Sheyenne Delta. They have been severely eroded by wind, and small blowouts are common. The Maddock soil is on hummocks and low dunes 6 to 20 feet high, and the Hamar soil is in low areas. Maddock fine sand occupies about 75 percent of the acreage, and Hamar loamy fine sand about 25 percent. In the profile of the Maddock soil, the dark-colored former surface layer of a buried soil is common. These soils have been covered by drifting sand.

The Maddock soil is rapidly permeable and has very low available moisture capacity. In most years the Hamar soil has a water table at or near the surface early in the growing season. This water table usually drops during the growing season.

The soils of this complex are used for grazing and are suited to limited grazing if they are carefully managed. The Maddock soil supports a sparse growth of sand bluestem and prairie sandreed in addition to some short and mid grasses. The Hamar soil supports a more luxuriant growth of big bluestem, switchgrass, and slough sedge. Willows, cattails, and rushes are in the deeper blowouts. (Capability unit VIe–1)

Overly Series

The Overly series consists of deep, moderately well drained soils developed in medium-textured and moderately fine textured sediments deposited in glacial lakes. These soils are in nearly level areas. The native vegetation was tall grasses.

The surface layer is black, neutral silt loam to silty clay loam 10 to 20 inches thick. It has strong granular and blocky structure. In areas where the surface layer is silt loam, it is very friable when moist and slightly sticky and slightly plastic when wet. In other areas it is hard when dry, friable to firm when moist, and sticky and plastic when wet. Wedge-shaped tongues of soil material from the surface layer extend downward into the subsoil.

The subsoil is very dark grayish-brown to very dark brown silty clay loam that has strong blocky and granular structure. The upper part is neutral, and the lower part is moderately alkaline.

A grayish-brown layer of lime accumulation underlies the subsoil. This layer is moderately alkaline, has moderate blocky structure, and is firm when moist and sticky when wet. The soil material in the layer of lime accumulation generally grades to a layer of light olive-brown, calcareous and moderately alkaline silty clay loam, but it grades to silt loam or silty clay in some places. The lower part of this material is mottled and is slightly saline. Alternate layers, less than 1 inch thick, of silt loam, silty clay loam, or silty clay occur in some areas below a depth of 42 inches.

The Overly soils are coarser textured than the Fargo soils and finer textured than the Gardena soils. They lack the calcareous subsoil that is typical in the Bearden profile, and they have a less mottled subsoil and substratum than are typical in the Perella profile.

Nearly all areas of the Overly soils are cultivated.

Overly silt loam, nearly level (0 to 2 percent slopes) (OaA).—Most areas of this soil are on the lake plain. The surface layer is black, very friable silt loam 10 to 20 inches thick. The subsoil is very dark grayish-brown silty clay loam that has weak prismatic, moderate blocky, and strong granular structure. The substratum is light olive-brown silty clay loam mottled with dark brown. Included in the areas mapped as this soil are areas of Bearden silt loam smaller than 1 acre in size.

This soil has good available moisture capacity. Permeability is moderate in the subsoil and moderately slow or slow in the substratum. The content of organic matter is high.

Nearly all of the acreage is cultivated. Wheat, barley, oats, flax, corn, soybeans, and hay are the main crops grown, and yields are high. (Capability unit IIc–1)

Overly silt loam, saline, nearly level (0 to 2 percent slopes) (ObA).—This soil is at the edge of the lake plain in areas affected by seepage from the Sheyenne Delta. It contains enough soluble salts that the growth of some crops is affected. The profile is similar to the one described for Overly silt loam, nearly level, except that soluble salts are within the root zone.

This soil has good available moisture capacity. Permeability is moderate in the subsoil and moderately slow to slow in the substratum. The content of organic matter is high.

Wheat, barley, flax, and hay are the crops commonly grown. Yields are fair in years of normal rainfall. They are lower in years when dry periods are long enough to intensify the effect of salts upon the growing crops. (Capability unit IIIs–6)

Overly silty clay loam, nearly level (0 to 2 percent slopes) (OcA).—This soil is on the nearly level lake plain. Included in the areas mapped as this soil are areas of Fargo and Bearden silty clay loams smaller than 1 acre in size.

Available moisture capacity is good. Permeability is moderately slow in the subsoil and moderately slow or slow in the substratum. The content of organic matter is high.

Wheat, barley, flax, corn, soybeans, and hay are the crops commonly grown. Yields are high. (Capability unit IIc–1)

Overly-Exline complex, nearly level (0 to 2 percent slopes) (OxA).—This complex consists of Overly and Exline soils that occur in an intricate pattern. The Exline soil is in areas that are 6 to 12 inches lower than those occupied by the Overly soil. In this complex the Overly soil is dominant, and the Exline soil occupies only 20 to 40 percent of the acreage. The proportions of Overly and Exline soils vary for each area mapped.

The Overly and Exline soils of this complex have profiles similar to those described for the Overly and Exline series. In both soils the texture of the surface layer is silt loam and silty clay loam. The Exline soils have a thin surface layer and a claypan subsoil. In many places part of the claypan subsoil has been mixed into the surface layer by tillage. This exposed clayey material disperses and flows during rains. It is very sticky when wet and it dries to a very hard, impermeable crust (fig. 7).

These soils have good available moisture capacity. The permeability of the Overly soil is moderate in the subsoil

***Figure 7.*—An area of Overly-Exline complex, nearly level. Part of the Exline subsoil has been brought to the surface by tillage, and it now makes up the surface layer. Where this has occurred, the present surface layer is dispersed, crusted, and cloddy.**

and moderately slow to slow in the substratum. The Exline soils have a subsoil and substratum that are very slowly permeable.

These soils are used for growing wheat, barley, flax, hay, pasture, and corn. Yields are fair. (Capability unit IIIs–2)

Overly-Gardena loams, nearly level (0 to 2 percent slopes) (OyA).—Most areas of this complex are in the southwestern part of the survey area, adjacent to the till plain. The Overly soil occupies 55 to 75 percent of the acreage, and the Gardena soil occupies 25 to 45 percent. The profiles of the Overly and Gardena soils are like the profiles described for the Overly and Gardena series, except that these soils are underlain by glacial till at a depth of 4 to 5 feet.

Both of these soils have good available moisture capacity. Permeability is moderate in the subsoil and moderately slow to slow in the substratum. The content of organic matter is high.

Nearly all of the acreage is cultivated. Wheat, barley, flax, oats, corn, and hay are the major crops, and yields are high. (Capability unit IIc–1)

Parnell Series

In the Parnell series are deep, poorly drained soils developed in local alluvium underlain by glacial till. These soils are in deep, closed depressions. Except in dry years, they are ponded until midsummer or later. In wet years they are ponded during the entire growing season. The native vegetation was sedges, tall grasses, and rushes.

The surface layer is black, neutral silt loam to silty clay loam 12 to 24 inches thick. It has crumb, granular, and blocky structure and is friable when moist and slightly sticky when wet.

The subsoil is gray, neutral clay loam or silty clay loam that has distinct dark yellowish-brown and light-gray mottles. It has weak prismatic and moderate blocky structure and is hard when dry, firm when moist, and sticky when wet.

The substratum is olive-gray to dark grayish-brown clay loam or loam strongly mottled with light gray and dark yellowish brown. It is calcareous in most places and moderately alkaline.

Below the pebble-free local alluvium in the surface layer and subsoil are pebbles, other stones, and angular grains of coarse sand that are typical of glacial till. The thickness of the local alluvium varies from one area to another.

The Parnell soils lack the gray, platy subsurface layer that is typical of the Tetonka soils. They developed in local alluvium underlain by glacial till instead of in water-sorted lake sediments like those in which the Perella soils developed. They have a more mottled subsoil and substratum than the Barnes and Svea soils. Unlike those soils, the Parnell soils have a subsoil where clay has accumulated, and they lack a layer of lime accumulation. They lack the distinct layer of lime accumulation beneath the surface layer that is typical of the Hamerly soils.

The Parnell soils are used mainly for pasture or growing hay. However, some areas that have been drained are cultivated, and some areas that have not been drained are cultivated in dry years.

Parnell soils (0 to 2 percent slopes) (Pa).—These are the only Parnell soils mapped in the survey area. They are in deep, closed depressions on the till plain. The surface layer is black, thick, friable silt loam and clay loam 12 to 24 inches thick. The subsoil is gray clay loam that has strong, fine, blocky structure. The substratum is olive-gray, firm clay loam mottled with light gray and dark yellowish brown.

Water is intermittently ponded on these soils. In years when rainfall is normal, water is ponded until late in summer. In a wet year or after a wet year, water may be ponded throughout the growing season. These soils have good available moisture capacity. Permeability is moderately slow in the subsoil and slow in the substratum. The content of organic matter is high.

The Parnell soils are well suited to cultivation, and in dry years or after a succession of dry years, they can be cultivated. High yields of wheat, barley, millet, and flax are obtained if the soils are dry enough for cultivation. In most undrained areas the soils are used for grazing, growing hay, and supplying water for livestock. Waterfowl also use these areas as a resting place when they migrate in fall and in spring. (Capability unit IIIw–2)

Perella Series

The Perella series consists of deep, poorly drained soils developed in medium-textured and moderately fine textured sediments deposited in glacial lakes. These soils are in shallow depressions on the lake plain. The native vegetation was sedges and tall grasses.

The surface layer is black, slightly acid or neutral silt loam to silty clay loam that is 10 to 20 inches thick. It has moderate granular and blocky structure. Where the surface layer is silty clay loam, it is friable when moist and slightly sticky and slightly plastic when wet. Where it is silt loam, it is very friable.

The subsoil is olive-gray to dark-gray, neutral silty clay loam that is 10 to 16 inches thick and is faintly mottled with light gray. It has weak prismatic and moderate blocky structure. Distinct patches of clay films are on the vertical surfaces of the aggregates. The subsoil is firm when moist and sticky and plastic when wet.

The subsoil grades to a substratum of olive-gray silty clay loam that is mottled with yellowish brown and dark brown. The substratum is slightly calcareous and moderately alkaline, and it contains clusters of gypsum crystals.

The Perella soils occur with the Overly, Bearden, and Gardena soils. They lack the distinct layer of lime accumulation below the surface layer that is typical of the Bearden soils. The Perella soils have a more mottled subsoil and substratum than the Overly and Gardena soils. They are finer textured than the Tiffany soils.

The Perella soils are used mainly for grazing and growing hay. The areas that have been drained are cultivated.

Perella silt loam (0 to 2 percent slopes) (Pe).—This soil is in shallow depressions on the lake plain. The surface layer is black, very friable silt loam 10 to 20 inches thick, and the subsoil is olive-gray, firm silty clay loam. The substratum is olive-gray, firm silty clay loam mottled with yellowish brown and dark brown.

Water is intermittently ponded on this soil. In years of normal rainfall and in wet years, water is ponded until late in the growing season. Permeability is moderately slow in the subsoil and slow in the substratum. This soil has good available moisture capacity and is high in content of organic matter.

In dry years or in areas where surface drainage has been established, this soil is well suited to wheat, oats, barley, flax, and other crops that are commonly grown. Areas where surface drainage has not been established are used mainly for grazing or growing hay, but they are used occasionally for growing crops. (Capability unit IIw-3)

Perella silty clay loam (0 to 2 percent slopes) (Pr).—This soil is in shallow depressions. It is on the lake plain.

Available moisture capacity is good. Permeability is moderately slow in the subsoil and slow in the substratum. The content of organic matter is high.

This soil is well suited to cultivation in dry years or in areas where it has been drained. Yields of wheat, barley, flax, oats, millet, and other crops commonly grown are very good. Areas where surface drainage has not been established are used mainly for grazing or growing hay, but they are used occasionally for growing crops. (Capability unit IIw-3)

Rauville Series

In the Rauville series are deep soils that are very poorly drained. These soils developed in alluvium consisting of layers that vary in texture but that are generally medium textured or moderately fine textured. They are in oxbows, abandoned stream channels, and on the outer edges of the bottom lands along streams. The native vegetation was sedges, rushes, and tall grasses.

The surface layer is black, neutral to moderately alkaline silt loam to silty clay loam 16 to 30 inches thick. It has moderate granular and blocky structure and is very friable when moist and slightly sticky when wet.

The surface layer grades to a subsoil of black to very dark gray silt loam to silty clay loam that contains a few thin layers of fine sandy loam. The number of faint dark-brown and dark grayish-brown mottles increases in the lower part of the subsoil. The subsoil is moderately alkaline and contains some free lime.

The substratum consists of layers of alluvium that range from sandy loam to silty clay loam in texture. It is mottled with olive brown and very dark grayish brown.

The Rauville soils have a thicker, darker surface layer than the Perella and Lamoure soils. They have a darker, grayer subsoil and a more mottled substratum than the La Prairie soils. Unlike the Parnell soils, which have a glacial till subsoil and substratum, the Rauville soils developed in pebble-free stratified alluvium.

The Rauville soils are used for native pasture and for growing hay.

Rauville soils (0 to 2 percent slopes) (Ra).—These are the only Rauville soils mapped in the survey area. They are in oxbows, in stream channels, and on the outer edges of bottom lands that receive seepage from the adjacent higher areas.

The surface layer is black, friable silt loam and silty clay loam 16 to 30 inches thick. The upper part has moderate granular structure, but the structure grades to moderate blocky in the lower part.

The subsoil is dark-gray to olive-gray silt loam or silty clay loam. It has weak prismatic and moderate blocky structure and is mottled with dark brown and very dark brown. The substratum consists of sediments that are stratified and range from sandy loam to silty clay loam in texture. It ranges from gray to very dark gray in color and is strongly mottled with olive brown and very dark brown.

The available moisture capacity is good. Permeability is moderately slow in the subsoil and slow in the substratum. In most years these soils have a water table at or near the surface until late in summer. The water table is within 3 feet of the surface during the entire growing season.

These soils are used for growing hay. They are also used for grazing late in summer. (Capability unit Vw-1)

Renshaw Series

The Renshaw series consists of well-drained soils that are shallow over gravel and coarse sand. These soils developed in medium-textured or moderately coarse textured outwash over gravel and coarse sand. They are in nearly level to rolling areas on terraces and beach ridges. The native vegetation was mid and short grasses.

The surface layer is black loam to sandy loam 4 to 10 inches thick. It has moderate crumb and weak blocky structure and is very friable when moist and slightly sticky and slightly plastic when wet. The surface layer is leached of lime and is neutral or slightly acid.

The subsoil is very dark grayish-brown to dark grayish-brown, neutral loam and sandy loam 4 to 10 inches thick. It has moderate prismatic structure and is friable when moist and slightly sticky when wet.

The substratum consists of layers of gravel and coarse sand that vary greatly in thickness. The lower sides of the pebbles in the upper part of the substratum are heavily coated with lime.

The combined thickness of the surface layer and subsoil over gravel ranges from 8 to 20 inches. It is most commonly between 12 and 18 inches.

The Renshaw soils occur with the Sioux, Spottswood, Divide, and Fordville soils. They are deeper over gravel than the Sioux soils, and unlike the Sioux soils, they have a distinct subsoil. They have a thinner surface layer than the Spottswood soils. The subsoil of the Renshaw soils lacks the accumulation of lime that is typical in the Divide subsoil. Unlike the Fordville soils, the Renshaw soils have a substratum of gravel and sand just below the subsoil. The gravelly substratum distinguishes the Renshaw soils from the Barnes and Eckman soils.

The Renshaw soils are used for pasture and crops.

Renshaw and Sioux loams, nearly level (0 to 2 percent slopes) (RnA).—These soils are mostly on beach ridges and on the edges of terraces adjacent to the valley of the Maple River. The Renshaw soil occupies about 70 percent of the acreage, and the Sioux soil occupies about 30 percent.

The Renshaw soil has a surface layer of black, friable loam 4 to 10 inches thick. Its subsoil is dark grayish-brown, friable loam that has prismatic structure. The substratum of gravel or gravelly sand is at a depth of 10 to 20 inches. The Sioux soil has a surface layer of black, friable loam 4 to 8 inches thick. The surface layer is underlain by gravel and coarse sand.

Available moisture capacity is low to very low in the Renshaw soil and very low in the Sioux. Permeability is moderate in the subsoil and rapid in the substratum of both the Renshaw and Sioux soils.

These soils are droughty, and most areas are used for pasture. In cultivated areas yields are good only in years when the distribution of rainfall is especially favorable. (Capability unit VIs–2)

Renshaw and Sioux loams, undulating (2 to 5 percent slopes) (RnB).—These soils are on the convex crests and gentle side slopes of beach ridges. The Renshaw soil is dominant, but the Sioux soil occupies at least 40 percent of the acreage. The profiles of the Renshaw and Sioux soils are similar to the profiles described for the Renshaw and Sioux loams, nearly level, except that coarse-textured material is nearer the surface.

Permeability is moderate to rapid, and available moisture capacity is low or very low. These soils are poorly suited to cultivation. If they are cultivated, they are moderately to highly susceptible to wind erosion. (Capability unit VIs–2)

Renshaw and Sioux sandy loams, nearly level (0 to 2 percent slopes) (RsA).—These soils are on nearly level beach ridges. The Renshaw soil makes up 55 to 80 percent of the acreage.

Depth to the coarse-textured substratum ranges from 8 to 20 inches. The substratum of these soils contains less gravel than that of the undulating Renshaw and Sioux loams.

The soils of this unit have low or very low available moisture capacity. Permeability is moderate to rapid. These soils are droughty and are highly susceptible to wind erosion if they are cultivated. Yields of crops grown on them are good only in years when the distribution of rainfall is especially favorable during the growing season. (Capability unit VIs–2)

Renshaw and Sioux sandy loams, rolling (2 to 8 percent slopes) (RsC).—These soils are on the side slopes of prominent beach ridges. Their profiles are similar to the profiles described for the Renshaw and Sioux series, except that gravel and coarse sand are nearer the surface.

These soils are droughty and have low to very low available moisture capacity. They are poorly suited to cultivation and are highly susceptible to wind erosion if they are cultivated. (Capability unit VIs–2)

Sioux Series

In the Sioux series are excessively drained soils that are shallow over gravel and coarse sand. These soils developed in medium-textured or moderately coarse textured outwash sediments. They are on beach ridges and terraces. The native vegetation was short and mid grasses.

The surface layer is black, neutral loam to sandy loam 4 to 10 inches thick. It has moderate crumb and weak blocky and prismatic structure and is very friable when moist and slightly sticky when wet.

A substratum of stratified gravel and coarse sand is just below the surface layer. The upper part is calcareous, and the lower sides of the pebbles are coated with lime.

The Sioux soils occur with the Renshaw soils. Unlike the Divide, Renshaw, Spottswood, and Fordville soils, the Sioux soils lack a subsoil and have a gravelly substratum just beneath the surface layer. The substratum of the Sioux soils is gravelly instead of loamy like that of the Zell and Buse soils.

The Sioux soils are used mainly for grazing.

Sioux gravelly loam (2 to 30 percent slopes) (Sa).—Most areas of this soil are on the edges of terraces adjacent to the valley of the Maple River. Some areas are on beach ridges. The surface layer is dark-colored gravelly loam 4 to 8 inches thick. It is underlain by gravel and coarse sand.

This soil has very low available moisture capacity. It is too droughty for crops and is used mainly for grazing. It is also a source of gravel for road construction. (Capability unit VIs–2)

Sioux and Renshaw loams, rolling (5 to 12 percent slopes) (SbC).—The soils in this unit are on the side slopes of the higher beach ridges. The Sioux soil occupies about 70 percent of the acreage.

The surface layer of the Sioux soil is black loam to gravelly loam. It is 4 to 10 inches thick and is underlain by gravel and coarse sand. The surface layer of the Renshaw soil is black, friable loam that is 4 to 6 inches thick. The subsoil is dark grayish-brown loam that has prismatic structure. Depth to the substratum of gravel and coarse sand is 10 to 14 inches.

The soils of this unit have very low or low available moisture capacity. Nearly all areas are used for pasture. (Capability unit VIs–2)

Spottswood Series

The Spottswood series consists of moderately well drained soils developed in medium-textured or moderately coarse textured sediments deposited in glacial lakes. These soils are in gently sloping areas near the base of the beach ridges. They are moderately thick over gravel and coarse sand. The native vegetation was tall and mid grasses.

The surface layer is black, neutral loam to sandy loam 10 to 22 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky when wet.

The subsoil is very dark grayish-brown to very dark brown, noncalcareous and neutral to mildly alkaline loam and sandy loam 6 to 15 inches thick. It has weak prismatic and blocky structure and is friable when moist and slightly sticky when wet.

In most places the upper part of the substratum is grayish-brown gravelly loam to gravelly sandy loam 6 to 12 inches thick. It contains a large amount of lime and is moderately alkaline.

Stratified gravel and coarse sand underlie the limy layer in most places, but they are just beneath the subsoil in some places. Depth to the gravel and coarse sand ranges from 20 to more than 36 inches, but it is most commonly between 24 and 36 inches.

The thickness of the gravel and coarse sand is variable and becomes thinner with increasing distance from the crests of the beach ridges. In places the layer of gravel is less than 12 inches thick.

The Spottswood soils occur with the Fordville, Renshaw, Divide, Embden, and Gardena soils. They have a thicker surface layer than the Fordville and Renshaw soils. The Spottswood soils are distinguished from the Embden and Gardena soils by the substratum of gravel and coarse sand. They lack the limy subsoil that is typical of the Divide soils.

Most areas of the Spottswood soils are cultivated.

Spottswood loam, loamy substratum, nearly level (0 to 2 percent slopes) (ScA).—This soil is mainly in the beach area. It is on low beach ridges and in areas adjacent to the beach ridges where the deposits of coarse-textured material are thinner than in some other areas. The surface layer is black, friable loam 10 to 20 inches thick. The subsoil is very dark grayish-brown, friable loam that has moderate prismatic structure. The substratum consists of gravel and coarse sand that is 1 to 6 feet thick over loam or clay loam. Depth to the substratum is 24 to 36 inches.

The available moisture capacity is fair to good. Permeability is moderate in the subsoil. It is rapid in the upper part of the substratum and moderately slow in the lower part. This soil is high to moderate in content of organic matter.

Most areas of this soil are cultivated. Wheat, barley, flax, corn, and hay are the main crops, and yields are good. (Capability unit IIIs–5)

Spottswood sandy loam, loamy substratum, nearly level (0 to 2 percent slopes) (SdA).—This soil is on low beach ridges and in adjacent areas. The surface layer is black, very friable sandy loam 10 to 20 inches thick. The subsoil is very dark grayish-brown to very dark brown sandy loam that has weak prismatic structure. Depth to the substratum is generally between 24 and 36 inches, but it is as much as 48 inches in some places. The substratum is coarse textured and is 1 to 6 feet thick. It is underlain by loam or clay loam.

The available moisture capacity is fair. Permeability is moderately rapid in the subsoil, rapid in the upper part of the substratum, and moderately slow in the lower part of the substratum. This soil is highly susceptible to wind erosion if it is cultivated. The content of organic matter is moderate to high.

Most areas of this soil are cultivated. Yields of wheat, barley, oats, corn, and hay are fair to good. (Capability unit IIIe–6)

Spottswood–Embden sandy loams, nearly level (0 to 2 percent slopes) (SmA).—The soils of this complex are on the lower slopes of prominent beach ridges, on low beaches, and on terraces adjacent to stream valleys. The Spottswood soil has a profile similar to that described for the Spottswood soils that have a loamy substratum. Gravel and sand are at a depth of 36 to 60 inches, however, and loam or clay loam are within 5 feet of the surface. The Embden soil has a thick surface layer of black, very friable sandy loam and a subsoil of sandy loam.

Permeability is moderately rapid in the subsoil of the Spottswood soil and rapid in the substratum. It is moderately rapid in both the subsoil and substratum of the Embden soil. Both the Spottswood and Embden soils have fair available moisture capacity. These soils are highly susceptible to wind erosion. The content of organic matter is moderate to high.

Most areas of these soils are cultivated. Wheat, oats, corn, barley, and hay are the main crops, and yields are fair. (Capability unit IIIe–6)

Spottswood-Gardena loams, nearly level (0 to 2 percent slopes) (SoA).—The soils in this complex are most extensive in the beach area. They are on low beach ridges and on terraces that are adjacent to the valley of the Maple River. The proportions of Spottswood and Gardena soils are variable in different areas, but the Spottswood soil is more extensive than the Gardena. It occupies at least 30 percent of each area mapped.

The Spottswood soil has a surface layer of black, friable loam 10 to 16 inches thick; a subsoil of very dark grayish-brown, friable loam; and a substratum of gravel and coarse sand. Depth to the substratum ranges from 36 to 60 inches. The Gardena soil has a profile similar to the one described for Gardena loam, very deep, nearly level.

These soils have good available moisture capacity. Permeability of the Spottswood soil is moderate in the subsoil and rapid in the substratum. The permeability of the Gardena soil is moderate in the subsoil and moderately slow in the substratum. These soils are high in content of organic matter.

The soils of this complex are cultivated. Yields of wheat, barley, flax, oats, corn, and hay are good. (Capability unit IIIs–5)

Stirum Series

In the Stirum series are poorly drained, nearly level soils developed in moderately coarse textured sediments deposited in glacial lakes. These soils have a water table within 5 feet of the surface in most years. The native vegetation was mid and tall grasses.

The surface layer is black, calcareous and moderately alkaline fine sandy loam to silt loam 6 to 14 inches thick. It has weak crumb, granular, and blocky structure, and is slightly hard when dry, very friable when moist, and slightly sticky when wet. In some areas the surface layer is slightly saline.

The subsoil is very dark gray fine sandy loam 10 to 20 inches thick. It has weak, very coarse, columnar or prismatic structure. The subsoil is calcareous and strongly alkaline, and it contains clusters of gypsum crystals and flecks of soluble salts. It is hard when dry, friable when moist, and sticky and plastic when wet.

Beneath the subsoil is a layer of light brownish-gray fine sandy loam that has weak, coarse, columnar structure. This layer is strongly calcareous and strongly alkaline. It contains clusters of gypsum and soluble salts and is very hard when dry, very friable when moist, and sticky when wet. The lower part of this layer of lime accumulation grades to grayish-brown or olive-brown, strongly alkaline fine sandy loam that is mottled with light gray, very dark brown, and dark yellowish brown. The fine sandy loam contains common segregations of gypsum crystals and is very hard when dry, very friable when moist, and sticky when wet.

The Stirum soils are coarser textured than the Glyndon soils, and unlike the Glyndon soils, they have a strongly alkaline subsoil and weak columnar structure in the layer beneath the surface layer. The columnar structure and strongly alkaline subsoil distinguish the Stirum soils from the Ulen. The Stirum soils lack the leached surface layer, the gray subsurface layer, and the strong columnar structure that are typical of the Exline soils, and they do not have the leached surface layer and subsurface layer that are typical of the Aberdeen soils.

The Stirum soils are used for pasture and field crops.

Stirum-Glyndon complex (0 to 2 percent slopes) (St).—The soils of this complex are in the beach area south and west of Embden. The Stirum soil has a surface layer of black, calcareous, friable sandy loam to silt loam 6 to 12 inches thick. The subsoil is dark-gray to light brownish-gray, strongly alkaline and strongly calcareous fine sandy loam. It has coarse columnar or prismatic structure, has gray coatings on the surfaces of the columns and prisms, and contains segregations of soluble salts and gypsum. The substratum is light brownish gray to olive brown and is mottled with gray and dark yellowish brown. The Glyndon soil has a profile similar to the one described for Glyndon loam, very deep, nearly level, except that soluble salts are within the root zone.

The soils of this complex have good available moisture capacity. The Stirum soil has a subsoil and substratum that are slowly to very slowly permeable. The Glyndon soil has moderate permeability in the subsoil and moderately slow permeability in the substratum. The content of organic matter is moderate in both of these soils.

These soils are used for crops and pasture. Wheat, barley, flax, and hay are the crops commonly grown. Yields are reduced by salinity. The soils are poorly suited to corn, and yields of small grains and hay are low. (Capability unit IIIs-3)

Svea Series

The Svea series consists of deep, moderately well drained soils developed in friable, loam glacial till. They are in nearly level or concave and gently sloping areas on the till plain. The native vegetation was tall grasses.

The surface layer of these soils is black, slightly acid or neutral loam 9 to 20 inches thick. It has moderate granular and blocky and weak prismatic structure and is very friable when moist and slightly sticky when wet.

The subsoil is very dark brown to very dark grayish-brown loam to clay loam 4 to 12 inches thick. It has weak to moderate prismatic and blocky structure. Faint patches of clay films are on the vertical surfaces of the aggregates. The subsoil is friable when moist and slightly sticky and slightly plastic when wet. The upper part of the subsoil is neutral; the lower part is mildly alkaline.

An olive-brown to grayish-brown, moderately alkaline layer of lime accumulation, 6 to 16 inches thick, underlies the subsoil. This layer has a loam texture and weak blocky structure, and it is friable when moist and slightly sticky when wet. It grades to olive-brown, moderately alkaline and calcareous loam that has a few distinct mottles of dark yellowish brown, yellowish brown, and very dark brown.

Stones and pebbles that are typical of the glacial till in the area occur in varying amounts in all horizons of the profile and in the substratum.

The Svea soils occur with the Barnes, Buse, Tetonka, and Hamerly soils. They have a thicker surface layer than the Barnes soils. They also have a thicker surface layer than the Buse soils, and they have a distinct lime-free subsoil that is lacking in the Buse soils. The Svea soils lack the leached, platy subsurface layer that is typical in the Tetonka soils, and they lack the calcareous layer of lime accumulation, just beneath the surface layer, that is typical in the Hamerly soils. The Svea soils are coarser textured than the Overly soils and finer textured than the Embden. They developed in unsorted glacial till instead of in water-sorted, pebble-free lake sediments like those in which the Gardena soils developed.

Nearly all areas of the Svea soils are cultivated.

Svea-Barnes loams (0 to 2 percent slopes) (Sx).—The soils of this complex are in nearly level or gently undulating areas of the till plain. The Svea soil is in nearly level and slightly concave areas, and the Barnes soil is in slightly higher convex areas. The proportion of the acreage occupied by the Svea soil ranges from 55 to 80 percent.

The Svea soil has a thick surface layer of black, friable loam 9 to 20 inches thick. Its subsoil is very dark grayish brown, and it has weak to moderate, medium, prismatic structure. The Barnes soil has a surface layer of black, friable loam 6 to 8 inches thick. Its subsoil is very dark grayish brown and has moderate, medium, prismatic structure.

Included in the areas mapped as these soils are areas of Hamerly soils that are smaller than 1 acre in size. Also included are areas of Tetonka soils in depressions that are indicated by a symbol for depressions on the map.

The soils of this complex have good available moisture capacity. Permeability is moderate in the subsoil and moderately slow to slow in the substratum. The Svea soils have a high content of organic matter, and the Barnes soils have a moderate content.

Most areas are cultivated. Wheat, barley, flax, corn, and hay are the main crops, and yields are high. (Capability unit IIc-1)

Svea-Hamerly loams (0 to 2 percent slopes) (Sy).—The soils of this complex are in gently undulating areas of the till plain. The Hamerly soil is in convex areas that are slightly higher than the concave areas of Svea soil. The proportions of the Svea and Hamerly soils vary widely in different areas, but each of these soils occupies at least 30 percent of every area.

The Svea soil has a profile similar to the one described for the Svea series. The Hamerly soil has a surface layer of black, friable, calcareous loam 6 to 14 inches thick. Its subsoil is grayish-brown to light brownish-gray, strongly calcareous loam. In places tillage has brought part of the light-colored subsoil to the surface.

Included in the areas mapped as this soil are areas of the Barnes soil smaller than 1 acre in size. Also included are areas of Tetonka soils that are shown by a symbol for depressions on the soil map.

The soils of this complex have good available moisture capacity. Permeability is moderate in the subsoil and moderately slow or slow in the substratum. In most years the Hamerly soil has a water table within 5 feet of the surface in spring and early in summer. The Svea soil has a high content of organic matter, and the Hamerly soil has a moderate content.

Most of the acreage is tilled. The main crops are wheat, barley, flax, corn, and hay, and yields are good. (Capability unit IIe–1)

Tetonka Series

In the Tetonka series are deep, poorly drained soils developed in medium-textured local alluvium. These soils are underlain by glacial till. They are in small, shallow, closed depressions and are subject to frequent and intermittent ponding. The native vegetation was sedges and tall grasses.

The surface layer is very dark gray to black silt loam that is slightly acid or medium acid and is 6 to 20 inches thick. It has moderate granular structure and is very friable when moist and slightly sticky when wet.

The subsurface layer is gray to very dark gray, strongly acid very fine sandy loam to silt loam 2 to 10 inches thick. It has platy structure and is very friable when moist and slightly sticky when wet.

The subsoil is dark grayish-brown to very dark gray, moderately acid to strongly acid silty clay loam to silty clay 14 to 24 inches thick. It has compound weak prismatic and strong blocky structure. The subsoil is enriched with clay that has moved downward from the surface layer and subsurface layer. It is hard when dry, firm when moist, and sticky and plastic when wet.

The subsoil grades to a dark grayish-brown substratum. The texture of the substratum is generally loam or clay loam, but the lower part of the substratum contains layers of fine sandy loam in some places. The substratum has yellowish-brown, dark brown, and very dark brown mottles. It is medium acid in most places, but it is mildly alkaline in a few places.

In most places the surface layer is free of pebbles. The subsoil and substratum contain variable amounts of the pebbles and stones typical of local glacial till.

The Tetonka soils occur with the Barnes, Svea, Hamerly, Vallers, and Parnell soils, but they have a gray, platy subsurface layer that is lacking in those soils. Unlike the Barnes and Svea soils, the Tetonka soils have a subsoil where clay has accumulated, instead of a subsoil where there are only faint patches of clay films on the surfaces of the aggregates. Also, little if any lime has accumulated in their subsoil. The Tetonka soils have a noncalcareous subsoil that is lacking in the Vallers and Hamerly soils.

The drained areas of Tetonka soils are cultivated. The undrained areas are generally pastured, but they are cultivated in dry years.

Tetonka silt loam (0 to 2 percent slopes) (Tk).—This is the only Tetonka soil mapped in the survey area. It is in shallow closed depressions and is most extensive in the southwestern part of the survey area. Many areas of this soil that are smaller than 1 acre in size are shown by the symbol for depressions on the soil map. The surface layer is black, very friable silt loam 6 to 20 inches thick. The subsurface layer is dark-gray, very friable silt loam that has strong, thin, platy structure and is strongly mottled with dark yellowish brown. The subsoil is very dark gray clay loam to silty clay that has strong, fine, blocky structure. The substratum is mainly clay loam to loam. In places the soil material is stratified below a depth of 4 feet.

In most years this soil is ponded in spring and after heavy rains during the growing season. It is ponded during the growing season in wet years.

Permeability is slow in the subsoil and moderately slow to slow in the substratum. The available moisture capacity is good.

This soil occurs in small areas that are managed in fields with other soils. It is used for pasture and field crops. Where surface drainage has been established, yields of wheat, barley, corn, and hay are good. In dry years undrained areas in cultivated fields are usually planted to late-seeded flax and millet. (Capability unit IIw–3)

Tiffany Series

In the Tiffany series are deep, nearly level, poorly drained soils that developed in moderately coarse textured sediments deposited in glacial lakes. These soils are in low areas. In most years the water table is less than 3 feet from the surface in spring and early in summer. The native vegetation was sedges and tall grasses.

The surface layer is black fine sandy loam 15 to 30 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky when wet. Where the surface layer is thicker, its lower part is mottled with very dark brown and dark yellowish brown.

The subsoil is dark grayish-brown fine sandy loam that is strongly mottled with very dark brown and dark yellowish brown. It is 8 to 16 inches thick, has weak crumb structure, and is neutral in reaction.

The substratum is light brownish-gray to light-gray fine sandy loam to loamy fine sand mottled with yellowish brown, dark yellowish brown, and very dark brown. The mottling increases with increasing depth. Generally, the substratum is calcareous and is mildly or moderately alkaline.

The Tiffany soils occur with the Hecla, Hamar, Embden, and Ulen soils. They are generally finer textured than the Hecla and Hamar soils, and they have a more mottled subsoil and substratum than the Hecla and Embden soils. In contrast to the Ulen soils, they have a subsoil that is neutral in reaction.

Most areas of the Tiffany soils are cultivated.

Tiffany fine sandy loam (0 to 2 percent slopes) (Tf).—This is the only Tiffany soil mapped in the survey area. It is in small, shallow depressions in the Sheyenne Delta and the northern part of the beach area. The surface layer is black, very friable fine sandy loam, and the subsoil is grayish-brown fine sandy loam. The substratum is fine sandy loam to fine sand. The subsoil and substratum are mottled with dark yellowish brown and yellowish brown.

The available moisture capacity is fair, and the permeability of the subsoil and substratum is moderately rapid. The water table is generally less than 3 feet from the surface in spring and early in summer of most years. In years of high rainfall, however, it is at or near the surface during most of the growing season. The soil is high in content of organic matter.

The areas of this soil are small and are generally cultivated with adjacent soils. This soil is productive if it has been drained, but it is highly susceptible to wind erosion if it is cultivated. Corn, wheat, barley, flax, and hay are common crops in areas that have been drained. In the drier years, flax and millet are the common crops in areas that have not been drained. (Capability unit IIIw–1)

Ulen Series

The Ulen series consists of deep soils that are moderately well drained or somewhat poorly drained. These soils developed in moderately coarse textured to coarse textured sediments deposited in glacial lakes. They are in low, nearly level areas. The water table is within 5 feet of the surface in most years, but it is at or near the surface during the entire growing season in unusually wet years. The native vegetation was tall grasses and sedges.

The surface layer is black, moderately alkaline fine sandy loam to loamy fine sand 8 to 15 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky when wet.

The subsoil is very dark gray to dark grayish-brown, calcareous and moderately alkaline fine sandy loam to loamy fine sand 6 to 20 inches thick. It has weak blocky and crumb structure and is hard when dry, very friable when moist, and slightly sticky when wet.

The underlying material is olive brown and is dominantly fine sandy loam to loamy fine sand. It is mottled with brown and very dark grayish brown. The number of mottles is greater in the lower part of the substratum than in the upper part. In some places layers of very fine sandy loam, loam, or silt loam less than 2 inches thick are at a depth of 42 inches or less.

The profile is calcareous below a depth of 10 inches. It is calcareous at the surface in most places.

Ulen soils occur with the Hecla, Embden, Maddock, Egeland, Hamar, and Tiffany soils. Unlike the Hecla, Embden, Maddock, and Egeland soils, the Ulen soils have a strongly calcareous subsoil. The Ulen soils have a less mottled subsoil and substratum than the Hamar and Tiffany soils, and their subsoil is calcareous instead of noncalcareous.

Most areas of the Ulen soils are used for crops.

Ulen complex, saline (0 to 2 percent slopes) (Uc).—This complex consists of an intricate mixture of moderately saline and nonsaline Ulen soils. The surface layer of these soils is black fine sandy loam that is 8 to 15 inches thick. The subsoil is dark grayish-brown, strongly calcareous fine sandy loam. In about half the areas, the subsoil contains soluble salts, and there are salts in the surface layer in some places. The substratum is mainly fine sandy loam, but thin layers of loam and silty clay loam occur in some places below a depth of 5 feet.

The soils of this complex have fair available moisture capacity and a moderate content of organic matter. Permeability is moderately rapid in the subsoil and moderately rapid to moderately slow in the substratum. The soils are somewhat poorly drained, but the degree of wetness varies greatly. In most years the water table is at a depth of less than 5 feet early in the growing season. In seasons when rainfall is excessive, however, water may be ponded on the surface during much of the growing season.

Most areas of these soils are cultivated, although the soils are highly susceptible to wind erosion if they are cultivated. Wheat, barley, flax, corn, and hay are the crops commonly grown. The soluble salts greatly reduce yields in dry years. (Capability unit IIIs–6)

Ulen fine sandy loam (0 to 2 percent slopes) (Uf).—This soil is extensive on the Sheyenne Delta and in the beach area. Its profile is like the one described for Ulen fine sandy loam in Ulen complex, saline.

This soil has a moderate content of organic matter and fair available moisture capacity. Permeability is moderately rapid in the subsoil and substratum. In most years the water table is within 5 feet of the surface early in the growing season. During the rest of the growing season, depth to the water table varies according to the amount of precipitation. The water table may be at or near the surface during much or all of the growing season when there is a large amount of rainfall. If it is cultivated, this soil is highly susceptible to wind erosion.

This soil is used mostly for cultivated crops. Wheat, barley, corn, flax, and hay are the commonly grown crops, but yields are only fair. (Capability unit IIIe–4)

Ulen fine sandy loam, loamy substratum (0 to 2 percent slopes) (Um).—This soil is on the Sheyenne Delta and in the northern part of the beach area. The surface layer is black, very friable fine sandy loam. The subsoil is dark grayish brown and is strongly calcareous. The substratum is loam to clay loam and is at some depth between 36 and 60 inches. Included in the areas mapped as this soil are small areas of Hecla and Embden fine sandy loams that have a loamy substratum.

This Ulen soil has a moderate content of organic matter and fair available moisture capacity. Permeability is moderately rapid in the subsoil and moderately slow or slow in the substratum. In most years the water table is at a depth of less than 5 feet early in the growing season. In years when the amount of rainfall has been unusually large, however, the water table is at or near the surface during much of the growing season. If this soil is cultivated, it is highly susceptible to wind erosion.

This soil is used mostly for cultivated crops. Wheat, corn, barley, flax, and hay are the commonly grown crops, but yields are only fair. (Capability unit IIIe–4)

Ulen fine sandy loam, loamy substratum (0 to 2 percent slopes) (Un).—This soil has a profile similar to the one described for Ulen fine sandy loam, loamy substratum, except that the loamy substratum is at some depth between 20 and 36 inches instead of at a depth of 36 to 60 inches.

This soil has a moderate content of organic matter and fair available moisture capacity. Permeability is moderately rapid in the subsoil and moderately slow to slow in

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the substratum. In most years the water table is at a depth of 5 feet early in the growing season. In years when the amount of rainfall has been unusually large, however, the water table is at or near the surface during much of the growing season. This soil is highly susceptible to wind erosion.

This soil is used mostly for cultivated crops. Wheat, corn, barley, flax, and hay are the commonly grown crops, but yields are only fair. (Capability unit IIIe–4)

Ulen-Gardena fine sandy loams (0 to 2 percent slopes) (Us).—The soils in this complex are mostly in the beach area north of Embden. The proportions of Ulen and Gardena soils vary in different areas, but each of these soils occupies at least 25 percent of every area.

The Ulen soil has a profile like the one described for the Ulen series. The Gardena soil has a surface layer of black fine sandy loam and a subsoil of very dark grayish-brown loam that has prismatic structure. Its substratum is loam to fine sandy loam.

The Ulen soil has fair available moisture capacity. It has moderately rapid permeability in the subsoil and moderately rapid to moderately slow permeability in the substratum. In most years the water table is within 5 feet of the surface during the early part of the growing season. The Gardena soil has good available moisture capacity. Permeability is moderate in the subsoil and moderately slow in the substratum. If these soils are cultivated, they are highly susceptible to wind erosion. The content of organic matter is moderate in the Ulen soil and high in the Gardena soil.

The soils of this complex are used mostly for cultivated crops. Wheat, barley, corn, flax, and hay are the crops commonly grown, and yields are good. (Capability unit IIIe–4)

Vallers Series

In the Vallers series are deep, poorly drained soils developed in loamy glacial till. These soils are in nearly level or slightly convex areas. In most years the water table is at a depth of less than 3 feet. The native vegetation was sedges and tall grasses.

The surface layer is black to very dark gray, moderately alkaline loam 6 to 14 inches thick. It has moderate blocky and granular structure, and it is friable when moist and slightly sticky and slightly plastic when wet.

The surface layer grades through a very dark gray or dark gray, moderately alkaline, strongly calcareous transitional layer to a light olive-gray to gray subsoil. The subsoil is loam to clay loam. It has weak prismatic and moderate blocky structure and is hard when dry, friable when moist, and slightly sticky and slightly plastic when wet. The lower part is mottled light olive brown.

The subsoil grades to a substratum of olive-brown to gray loam. The substratum is moderately alkaline and calcareous and is slightly to moderately saline. The number of dark yellowish-brown and yellowish-brown mottles increases with increasing depth. The consistence is the same as that of the subsoil.

Variable amounts of pebbles and stones occur throughout the profile.

The Vallers soils occur with the Barnes, Svea, Hamerly, and Tetonka soils. Unlike the Barnes and Svea soils, they have a layer of lime accumulation directly below the surface layer. They have a more strongly mottled and a duller colored subsoil and substratum than the Hamerly soils. The Vallers soils have a zone of lime accumulation directly beneath the surface layer that is not present in the Tetonka soils. They developed in glacial till instead of in water-sorted glacial lake sediments like the Borup soils.

The Vallers soils occupy only a small acreage. They are used mainly for pasture.

Vallers loam (0 to 2 percent slopes) (Vr).—This is the only Vallers soil mapped in the survey area. It is on the till plain on slight rises and rims adjacent to shallow, closed depressions. The surface layer is black, friable, calcareous loam 6 to 14 inches thick. The subsoil is olive-brown to gray, very strongly calcareous loam that has weak prismatic and moderate blocky structure. The substratum is gray to olive-gray loam mottled with a yellowish color.

This soil has good available moisture capacity. Permeability is moderate in the subsoil and moderately slow to slow in the substratum. In most years the water table is within 3 feet of the surface during the early part of the growing season. The content of organic matter is moderate.

Areas of this soil are small and are generally managed with the Hamerly, Svea, Barnes, and other more extensive soils. In many years, however, this soil is too wet for cultivation and for growing crops, and most of the areas are used for hay or pasture. This soil is poorly suited to corn. Wheat, barley, and flax are grown in years that are not too wet. (Capability unit IIw–2)

Zell Series

The Zell series consists of excessively drained soils developed in medium-textured glacial lake sediments. These soils are on the side slopes of stream valleys that are entrenched in the Sheyenne Delta and beach area. The native vegetation was mid and short grasses.

The surface layer is black to very dark brown, moderately alkaline loam or fine sandy loam 4 to 10 inches thick. It has weak crumb and blocky structure and is very friable when moist and slightly sticky when wet.

The surface layer grades to a subsoil of brown to light yellowish-brown, calcareous and moderately alkaline silt loam 6 to 12 inches thick. The subsoil is very friable when moist and slightly sticky when wet.

The substratum is yellowish-brown and light yellowish-brown, calcareous and moderately alkaline silt loam. It is very friable when moist and slightly sticky when wet. In places below a depth of 24 inches, there are layers of fine sandy loam less than 2 inches thick. The entire profile and substratum are calcareous.

The Zell soils occur with the Eckman and Gardena soils, but they lack the very dark grayish-brown subsoil that is typical of those soils. The Zell soils lack the mottling in the substratum that is typical of the Glyndon soils. They also lack the gravelly substratum that is typical of the Sioux soils. Unlike the Buse soils, the Zell soils developed in pebble-free water-sorted material.

Areas of the Zell soils are small. They are used mainly for pasture.

Zell fine sandy loam, undulating (2 to 8 percent slopes) (ZfB).—This soil is on the edge of the Sheyenne Delta and on the sides of shallow drainageways entrenched in the Delta. The surface layer is black to very dark gray, very friable fine sandy loam 6 to 10 inches thick. The subsoil is brown to light yellowish-brown, calcareous, friable silt loam. The substratum is yellowish-brown to light yellowish-brown, calcareous, friable silt loam.

The available moisture capacity is fair. Permeability is moderate in the subsoil and moderately slow in the substratum. This soil is highly susceptible to wind and water erosion. The content of organic matter is moderate to low.

Most areas are cultivated. Wheat, barley, oats, and hay are the commonly grown crops, but yields are low. (Capability unit IVe–4)

Zell loam, undulating (2 to 8 percent slopes) (ZmB).—This soil is on the side slopes of shallow stream valleys entrenched in the Sheyenne Delta and beach area. The surface layer is black, very friable loam 6 to 10 inches thick. The subsoil is brown to yellowish-brown, calcareous, friable silt loam that has weak, very coarse, blocky structure. The substratum is generally yellowish-brown, friable, calcareous silt loam. Below a depth of 36 inches, however, it contains thin layers of fine sandy loam to very fine sand.

This soil has good available moisture capacity. Permeability is moderate in the subsoil and moderately slow in the substratum. The content of organic matter is moderate to low. In places tillage has brought part of the light-colored subsoil to the surface. In these light-colored areas the soil material has weak structure, is low in content of organic matter, and is highly susceptible to erosion by wind and water.

Most areas of this soil are cultivated. Wheat, oats, barley, and hay are the main crops, but yields are low. (Capability unit IVe–4)

Zell loam, strongly rolling (8 to 45 percent slopes) (ZmD).—This soil is on the steep sides of deeply entrenched stream valleys in the Sheyenne Delta and beach area. The surface layer is black, friable loam 4 to 6 inches thick. The subsoil is light yellowish-brown, calcareous silt loam, and the substratum is generally a yellowish-brown, calcareous silt loam. Below a depth of 36 inches, however, the substratum contains thin layers of very fine sandy loam and fine sand.

The available moisture capacity is good. Permeability is moderate in the subsoil and moderately slow in the substratum. This soil is susceptible to water erosion because it has steep slopes and water runs off rapidly. The content of organic matter is moderate to low.

This soil is used mostly for pasture. It is better suited to pasture than to cultivated crops. (Capability unit VIe–2)

Use and Management of Soils

This section discusses the use and management of the soils of the Tri-County Area for crops and pasture, and also their suitability for windbreaks, irrigation, and engineering uses.

Management of Soils for Crops

Soils used for field crops require management practices that protect them from erosion, use moisture effectively, and maintain fertility, the content of organic matter, and good tilth. In this section soils that require similar management practices are grouped into capability units and these units are discussed. Also, predicted average yields of the principal crops are given for two levels of management.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable the soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated 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* means that water in or on the soil will interfere 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 country, indicates that the chief limitation is a climate that is too cold or too dry.

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

Within the subclasses are the capability units, groups of soils 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 identified by numbers assigned locally, for example, IIe–1 or IIIe–2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows.

Class I. Soils that have few limitations that restrict their use. (None in the Tri-County Area.)

Class II. Soils that have some limitations that reduce the choice of plants or that require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe–1. Deep, dark-colored, nearly level or undulating, well-drained to somewhat poorly drained soils that have a medium-textured to moderately fine textured, calcareous surface layer and a seasonal high water table.
  - Unit IIe–2. Deep, dark-colored, nearly level, well-drained soils that have a medium-textured surface layer.
  - Unit IIe–3. Deep, dark-colored, undulating, well drained or moderately well drained soils that have a medium-textured surface layer.
- Subclass IIw. Soils that have moderate limitations because of excess water.
  - Unit IIw–1. Deep, dark-colored, nearly level, poorly drained soils that have a medium-textured to fine-textured surface layer and a fine-textured subsoil and substratum.
  - Unit IIw–2. Deep, dark-colored, nearly level, poorly drained soils that have a medium-textured or moderately fine textured surface layer and a high water table.
  - Unit IIw–3. Deep, dark-colored, nearly level, poorly drained soils that have a medium-textured and moderately fine textured surface layer; in depressions and on bottom lands.
- Subclass IIc. Soils that have moderate limitations in the choice of plants because of unfavorable temperature or lack of moisture.
  - Unit IIc–1. Deep, dark-colored, nearly level, moderately well drained soils that have a medium-textured to moderately fine textured surface layer.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe–1. Deep, dark-colored, nearly level or undulating, well drained or moderately well drained soils that have a moderately coarse textured surface layer.
  - Unit IIIe–2. Deep, dark-colored, nearly level to rolling, somewhat excessively drained or well-drained soils that have a moderately coarse textured surface layer and a coarse textured subsoil and substratum.
  - Unit IIIe–3. Deep, dark-colored, nearly level, moderately well drained soils that have a moderately coarse textured surface layer and a medium-textured to moderately fine textured substratum.
  - Unit IIIe–4. Deep, dark-colored, nearly level, moderately well drained or somewhat poorly drained soils that have a moderately coarse textured surface layer and a seasonal high water table.
  - Unit IIIe–5. Deep, dark-colored, rolling, well-drained or excessively drained soils that have a medium-textured surface layer.
  - Unit IIIe–6. Moderately deep or deep, dark-colored, nearly level to undulating, well drained or moderately well drained soils that have a moderately coarse textured surface layer and a gravelly substratum.
- Subclass IIIw. Soils that have severe limitations because of excess water.
  - Unit IIIw–1. Nearly level, somewhat poorly drained or poorly drained, slightly to moderately saline soils that have a moderately coarse textured surface layer.
  - Unit IIIw–2. Deep, dark-colored, nearly level, poorly drained or very poorly drained soils that have a medium-textured or fine-textured surface layer and a seasonal high water table.
  - Unit IIIw–3. Deep, dark-colored, nearly level, poorly drained soils that have a moderately coarse textured surface layer.
- Subclass IIIs. Soils that have severe limitations of moisture capacity or tilth.
  - Unit IIIs–1. Moderately deep, dark-colored, nearly level or undulating, well-drained soils that have a medium-textured surface layer and a gravelly substratum.
  - Unit IIIs–2. Nearly level, moderately well drained to poorly drained soils that have a medium-textured and moderately fine textured surface layer and a dense, dispersed subsoil.
  - Unit IIIs–3. Nearly level, somewhat poorly drained or poorly drained soils that have a medium-textured to moderately coarse textured surface layer and a dispersed subsoil.
  - Unit IIIs–4. Moderately deep, nearly level, moderately well drained or somewhat poorly drained soils that have a medium-textured surface layer, a gravelly substratum, and a seasonal high water table.
  - Unit IIIs–5. Moderately deep to deep, dark-colored, nearly level, moderately well drained soils that have a medium-textured surface layer and a gravelly substratum.
  - Unit IIIs–6. Nearly level, moderately well drained to poorly drained, slightly to moderately saline soils that have a moderately coarse textured to fine-textured surface layer.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.
  - Unit IVe–1. Deep, dark-colored, nearly level, moderately well drained or somewhat poorly drained soils that have a coarse-textured surface layer.
  - Unit IVe–2. Deep, dark-colored, nearly level to undulating, well-drained to excessively drained soils that have a coarse-textured surface layer.
  - Unit IVe–3. Deep, dark-colored, nearly level, moderately well drained or somewhat poorly drained soils that have a coarse-textured surface layer and a seasonal high water table.
  - Unit IVe–4. Deep, undulating, excessively drained soils that have a medium-textured to moderately coarse textured surface layer.

Unit IVe-5. Deep, strongly rolling, well-drained and excessively drained soils that have a medium-textured surface layer.

Class V. Soils not likely to erode that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.

Unit Vw-1. Deep, dark-colored, very poorly drained soils of low bottom lands.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited chiefly by risk of erosion if protective cover is not maintained.

Unit VIe-1. Deep, nearly level to hilly, moderately well drained to excessively drained soils that have a coarse-textured surface layer.

Unit VIe-2. Deep, strongly rolling to hilly, excessively drained or moderately well drained soils that have a medium-textured surface layer.

Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Unit VIs-1. Nearly level, poorly drained, strongly saline soils.

Unit VIs-2. Nearly level to rolling, excessively drained to well-drained soils that have a medium-textured or moderately coarse textured surface layer and are shallow over gravel and coarse sand.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation, and that restrict their use largely to grazing, woodland, or wildlife. (None in the Tri-County Area.)

Class VIII. Soils and landforms that, without major reclamation, have limitations that preclude their use for commercial production of plants and restrict their use to recreation, wildlife, water supply, or esthetic purposes. (None in the Tri-County Area.)

CAPABILITY UNIT IIe-1

In this capability unit are deep, dark-colored soils that are nearly level or undulating. These soils are well drained to somewhat poorly drained, and they have a seasonal high water table. Their surface layer is calcareous and is friable or very friable loam to silty clay loam. Their subsoil is also friable or very friable and ranges from very fine sandy loam to silty clay loam in texture. The soils in this unit are—

Bearden silt loam.
Bearden silty clay loam.
Bearden-Overly silt loams.
Glyndon loam, very deep, nearly level.
Glyndon loam, very deep, undulating.
Glyndon loam, deep, nearly level.
Glyndon and Gardena loams, nearly level.
Hamerly complex, undulating.
Hamerly loam, nearly level.
Hamerly-Barnes loams, undulating.
Svea-Hamerly loams.

These soils are highly productive. All of them but the Barnes are moderately well drained or somewhat poorly drained. The Barnes soil is well drained. Water enters these soils readily, but surface drainage is slow. In most years the water table is within 5 feet of the surface of the Bearden, Glyndon, and Hamerly soils in spring and early in summer. Surface drains are desirable for removing the excess water. Permeability is moderately slow or slow.

The soils of this unit are easily tilled, and roots penetrate them readily. The content of organic matter is moderate to high. The Overly, Gardena, and Svea soils are moderate in content of available phosphorus and available nitrogen, but the content of these plant nutrients is low in the other soils. Crops grown on all of these soils respond well to applications of phosphorus and nitrogen fertilizer. Wheat, barley, flax, corn, oats, alfalfa, bromegrass, and soybeans are the crops commonly grown.

Most areas of these soils are plowed in fall. In the plowed areas the surface should be left rough and cloddy over winter. Such a surface reduces the velocity of the wind passing over it and minimizes the hazard of wind erosion when the soils are not protected by snow, crop residue, or a cover crop. Good protection is provided if a narrow band of partly covered stubble is left at the edges of the furrows. Field windbreaks are effective in reducing the velocity of the wind and thus protecting the soils from wind erosion.

In some places the surface layer is lighter colored than it originally was because material from the subsoil has been mixed into it by tillage. In these areas of mixing, the structure of the surface layer is more easily broken down than is that of the original surface layer, because the material from the subsoil has a high content of lime. These lighter colored areas are moderately susceptible to wind erosion. Crops grown on them are likely to show signs of chlorosis, a yellowing of the leaves.

CAPABILITY UNIT IIe-2

Only Eckman loam, nearly level, which is deep and well drained, is in this unit. It has a surface layer of dark-colored, friable loam and a subsoil of very fine sandy loam to silt loam. In most places the underlying material is coarser textured than that in the surface layer and subsoil.

Permeability is moderate in the subsoil and underlying material, and the available moisture capacity is good. Roots can penetrate deeply. Tilth is good, and this soil can be cultivated at a moisture content that ranges from near field capacity to the wilting point of most plants.

The content of organic matter is moderate. Crops grown on this soil respond well to applications of phosphorus and nitrogen fertilizer. The crops commonly grown are wheat, barley, flax, corn, oats, alfalfa, and bromegrass.

Many areas of this soil are plowed in fall. In these areas the surface should be left rough and cloddy over winter, to reduce the surface velocity of the wind passing over it, to catch snow, and to prevent soil blowing. Field windbreaks also provide effective protection from soil blowing.

CAPABILITY UNIT IIe-3

In this capability unit are deep, dark-colored, undulating soils that are well drained or moderately well drained. These soils have a surface layer of very friable loam and a subsoil of friable loam. The surface layer of the Gardena and Svea soils is thicker than that of the Barnes and Eckman soils. The soils in this unit are—

Barnes loam, undulating.
Barnes-Svea loams, undulating.
Eckman loam, undulating.
Eckman loam, till substratum, undulating.
Gardena loam, very deep, undulating.
Gardena loam, moderately shallow, undulating.

All of these soils have a moderately permeable subsoil and good available moisture capacity. The Gardena and Svea soils are moderately well drained, and the Barnes and Eckman soils are well drained.

The content of organic matter is moderate to high. The supply of available nitrogen is moderate, and the supply of available phosphorus is moderate to low. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied. Wheat and barley are the main crops grown on these soils, but flax, corn, oats, alfalfa, and bromegrass are also commonly grown.

Fall plowing and summer fallowing are common practices. Cultivating fall-plowed fields at right angles to the direction of the prevailing strong winds and leaving those fields rough and cloddy in winter protect the soils, which are slightly susceptible to wind erosion. The rough surface reduces the velocity of the wind passing over it. Other practices that protect these soils from wind erosion are growing flax or some other cover crop, providing field windbreaks, and using wind stripcropping.

These soils are moderately susceptible to water erosion. Water erosion is most likely early in the growing season before the crops have made enough growth to provide an effective cover. It is also a hazard where the soils are summer fallowed. Stubble mulching and maintaining a cloddy, porous surface layer will reduce the hazard of water erosion. Mulching with manure or straw also provides protection on the crests of knolls that are most likely to erode during open winters. Where there are shallow depressions, surface drains are desirable for removing surface water. Draining the depressions makes farming operations easier and gives the farmer a wider choice of crops.

CAPABILITY UNIT IIw-1

This capability unit consists of deep, dark-colored, nearly level soils that are poorly drained. These soils are on the lake plain. They have a dark-colored surface layer of silt loam to clay and a clayey subsoil and substratum. The soils in this unit are—

Fargo clay.
Fargo silt loam.
Fargo silty clay loam.

Permeability is slow or very slow in the subsoil and substratum. The available moisture capacity is good. In most years the water table is within 5 feet of the surface until midsummer. Surface drainage is slow, and drains are necessary to remove the excess water.

Fargo silt loam is easily tilled. The other soils can be effectively tilled only within a limited range of moisture content, for they are hard when dry and very sticky and plastic when wet. The content of organic matter is high, and the soils have a moderate supply of available nitrogen and phosphorus. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied. Wheat, barley, flax, corn, soybeans, oats, alfalfa, and bromegrass are the crops commonly grown.

A suitable seedbed cannot be prepared in spring unless these soils have been plowed in fall. Fall plowing allows time for the clods to slake and break down to granules through alternate wetting and drying and freezing and thawing. In areas where the texture of the surface layer is clay or silty clay loam, however, fall tillage creates a serious problem of wind erosion. The soils are especially susceptible to erosion if the following winter is an open one when the temperature rises above the freezing point during the day and falls below the freezing point during the night. Then, the clods may slake rapidly and break down to granules of light weight that are easily picked up and moved by wind. This drifting soil material accumulates in drainage ditches and in ditches along roadsides. There it impedes or prevents the removal of excess water.

Because of the granulation and nearly level topography, these soils are subject to wind erosion that starts at the same time throughout the entire field. This is in contrast to the soils of capability unit IIe-3, which are subject to wind erosion that starts in small areas. A narrow band of partly covered stubble that extends above the surface at the edges of furrows will effectively protect the soils from wind erosion. Field windbreaks are also effective. However, a large amount of snow may accumulate in the areas adjacent to these windbreaks. Then, farming operations are delayed in spring because these soils dry slowly.

CAPABILITY UNIT IIw-2

In this capability unit are deep, dark-colored soils that are nearly level. These soils are poorly drained and have a high water table. They have a surface layer of very friable loam or silt loam, and their surface layer is calcareous in most places. Generally, their subsoil is strongly calcareous loam or silt loam, but the Arveson soil has a subsoil of fine sandy loam.

The soils in this unit are—

Arveson loam.
Borup silt loam.
Vallers loam.

In most years the water table is within 3 feet of the surface until midsummer. In wet years it is at or near the surface during most or all of the growing season. Available moisture capacity is good. Permeability is moderate.

These soils have good tilth, and roots penetrate them readily. The content of organic matter is high in the Arveson and Borup soils and moderate in the Vallers soil. The supply of available nitrogen is moderate, and the supply of available phosphorus is low. Crops grown on these soils respond well if a fertilizer containing nitrogen and phosphorus is applied.

Where surface drainage has been established, these soils can be used for crops. They are suited to wheat, barley, flax, oats, alfalfa, bromegrass, and corn. The use of the undrained areas for crops is controlled by the wetness of the soils at seeding time. In dry years, wheat, barley, and oats are planted after these soils have dried in spring. Some areas of these soils occur in fields with soils that are better drained, and they are used for late-seeded flax and millet. The undrained areas are poorly suited to corn and legumes. They are best treated like the soils in capability unit Vw-1.

Most of the acreage is used for pasture or native hay. The Arveson and Borup soils provide good sites for farm ponds and shallow wells that can be used as a source of water for livestock.

CAPABILITY UNIT IIw-3

In this capability unit are deep, dark-colored, nearly level soils that are poorly drained. These soils are on bottom lands and in depressions. They have a surface layer of friable silt loam to silty clay loam and a subsoil of firm to friable silty clay loam to silty clay. The soils in this unit are—

Lamoure silty clay loam.
Perella silt loam.
Perella silty clay loam.
Tetonka silt loam.

These soils have good available moisture capacity. Permeability is moderately slow to slow. Except for the Lamoure soil, these soils are generally ponded after the snow melts in spring and after heavy rains. The Lamoure soil receives some seepage from adjoining areas.

The content of organic matter is high in all the soils of this unit. The supply of available nitrogen and available phosphorus is moderate. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied.

Where surface drainage has been established, these soils are suited to crops. Wheat, barley, oats, flax, alfalfa, and bromegrass are grown in the drained areas, and yields are very good. The undrained areas are also used for crops when they are not too wet. Late-seeded flax and millet are commonly grown in the undrained areas, and wheat, barley, and oats can be grown in dry years.

The soils are usually plowed in fall. Because of their location in depressions and on bottom lands, plowing the soils in fall does not make them more susceptible to erosion.

CAPABILITY UNIT IIc-1

This capability unit consists of deep, dark-colored, nearly level soils that are moderately well drained. These soils have a surface layer of dark-colored, very friable or friable loam to silty clay loam. Their subsoil is very friable or friable very fine sandy loam to silty clay loam. The soils in this unit are—

Fairdale silt loam, levee.
Gardena loam, deep, nearly level.
Gardena loam, very deep, nearly level.
Gardena loam, moderately shallow, nearly level.
Gardena loam, till substratum, nearly level.
Gardena-Eckman loams, till substratum, nearly level.
Gardena-Glyndon loams, nearly level.
Gardena-Glyndon loams, till substratum, nearly level.
La Prairie silt loam.
Overly silt loam, nearly level.
Overly silty clay loam, nearly level.
Overly-Gardena loams, nearly level.
Svea-Barnes loams.

These soils are highly productive. They have fewer limitations than other soils of the survey area. They have good available moisture capacity. Most of the precipitation enters these soils and is available to plants. Permeability to air and water is moderate to moderately slow.

Roots readily penetrate these soils to a great depth. All of these soils, except the Overly, can be easily tilled at a moisture content that ranges from near field capacity to the wilting point of most plants. In most of these soils, the content of organic matter is high, but it is low in the Fairdale soil. Crops grown on these soils respond if a fertilizer containing phosphorus and nitrogen is applied. Wheat, barley, flax, corn, oats, alfalfa, and bromegrass are commonly grown.

Fallowing in summer is used to conserve moisture in these soils and to control weeds that are not easily killed by herbicides. The seeding of flax is sometimes delayed in spring, so that wild oats will have time to germinate and can be killed when the seedbed is prepared for the flax.

These soils are commonly plowed in fall. Although they are resistant to erosion, they should be left rough and cloddy. A rough surface reduces the velocity of the wind passing over it, traps snow where it falls, and minimizes blowing or washing of the soil material. A narrow band of partly covered stubble left at the edges of the furrows will also protect these soils. Field windbreaks are effective in reducing the velocity of the wind near the surface of the soils, and they thus reduce wind erosion.

CAPABILITY UNIT IIIe-1

In this capability unit are deep, dark-colored, nearly level or undulating soils that are well drained or moderately well drained. The surface layer of these soils is very friable fine sandy loam. The subsoil of the Embden and Egeland soils is fine sandy loam, and that of the Hecla soils is loamy fine sand. The soils in this unit are—

Egeland fine sandy loam, nearly level.
Egeland fine sandy loam, undulating.
Embden fine sandy loam.
Embden-Gardena complex.
Hecla and Embden fine sandy loams, nearly level.
Hecla fine sandy loam, nearly level.

These soils have low to fair available moisture capacity and moderate to moderately rapid permeability. Nearly all the precipitation enters them, and there is little, if any, surface runoff. The Egeland soils are well drained, and the other soils are moderately well drained.

These soils are easily tilled when the content of moisture is between air dry and field capacity. They are highly susceptible to wind erosion if they are cultivated.

The content of organic matter is moderate. Although these soils are somewhat droughty, good response is obtained in most years if fertilizer is applied. The response to fertilizer is poor, however, in years when precipitation is low during the growing season.

Corn, oats, alfalfa, bromegrass, barley, and wheat are commonly grown crops. In some areas and in some years, corn grown on these soils shows symptoms of a slight deficiency of zinc.

Crop residue is left on the surface of these soils until the seedbed has been prepared in spring. Wind stripcropping, field windbreaks, and stubble-mulch tillage are practices used to protect these soils from erosion. Two or more practices that control wind erosion are required for protection.

These soils are left fallow in summer to kill weeds that are difficult to control with the herbicides now used. Fallowing does not increase the amount of moisture stored in these soils, however, because the available moisture capacity is too low. In fallow fields the soils can be protected from erosion by using buffer strips made up of a few rows of corn. These buffer strips can be spaced at intervals of a few rods.

CAPABILITY UNIT IIIe-2

In this capability unit are deep, dark-colored, nearly level to rolling soils that are somewhat excessively drained or well drained. These soils occur in small areas. Their surface layer is fine sandy loam. Their subsoil is loamy fine sand to sand, and their substratum is also coarse textured. The soils in this unit are—

Maddock fine sandy loam, nearly level.
Maddock fine sandy loam, undulating.
Maddock fine sandy loam, rolling.

These soils have low available moisture capacity and moderately rapid permeability. Most of the precipitation enters them, but during periods when there is a large amount of rainfall, much of the moisture percolates downward beyond the reach of roots.

The content of organic matter is moderate to low. These soils are low in available nitrogen and available phosphorus.

The nearly level and undulating soils of this unit are in cultivated fields with associated soils. Commonly grown crops are oats, barley, wheat, alfalfa, and bromegrass. These soils are droughty, and they are therefore best suited to early maturing crops.

These soils are highly susceptible to wind erosion if they are cultivated, and most of the areas are already moderately eroded. Field windbreaks, stubble-mulch tillage, wind stripcropping, minimum tillage, and a cropping system that includes grasses and legumes are effective practices for controlling erosion. A combination of two or more of these practices is needed if these soils are to be effectively protected.

CAPABILITY UNIT IIIe-3

This capability unit consists of deep, dark-colored, nearly level soils that are moderately well drained. These soils have a surface layer of very friable fine sandy loam or sandy loam. The Embden soil has a subsoil of fine sandy loam, and the other soils have a subsoil of loamy fine sand. All of the soils have a substratum of loam to silty clay below a depth of 20 to 36 inches. The soils in this unit are—

Embden and Hecla fine sandy loams.
Hecla fine sandy loam, moderately shallow, nearly level.
Hecla sandy loam, loamy substratum, nearly level.
Hecla-Ulen fine sandy loams, loamy substratum, nearly level.

These soils have fair to low available moisture capacity. Permeability is moderately rapid in the subsoil and moderately slow to slow in the substratum. Nearly all of the rainfall enters these soils, and there is little, if any, surface runoff.

The content of organic matter is moderate, and the supply of available nitrogen and available phosphorus is low. Except in dry years, good response is obtained from applications of nitrogen and phosphorus fertilizer. The crops most commonly grown are corn, oats, bromegrass, alfalfa, wheat, and barley.

If these soils are cultivated, they are highly susceptible to wind erosion. Crop residue from the previous year is often left standing until preparation of the seedbed is started in spring. Windbreaks, wind stripcropping, and stubble-mulch tillage are commonly used and are effective in controlling wind erosion. The soils are seldom summer fallowed, except for controlling weeds, because their available moisture capacity is too limited for the storing of much moisture. Growing corn in buffer strips and keeping tillage to a minimum are other effective practices for controlling wind erosion.

CAPABILITY UNIT IIIe-4

In this capability unit are deep, dark-colored, nearly level soils that are moderately well drained or somewhat poorly drained. These soils have a seasonal high water table. Their surface layer is very friable fine sandy loam that is calcareous in most places. Their subsoil is very fine sandy loam to loam, and the subsoil of the Glyndon, Ulen, and Gardena soils is light colored and strongly calcareous. The soils in this unit are—

Embden-Glyndon fine sandy loams.
Hamar-Ulen fine sandy loams.
Hecla-Ulen fine sandy loams, nearly level.
Ulen fine sandy loam.
Ulen fine sandy loam, loamy substratum.
Ulen fine sandy loam, moderately shallow.
Ulen-Gardena fine sandy loams.

The available moisture capacity is good in the Glyndon soil, low in the Hecla soil, and fair in the other soils. Permeability is moderate to moderately rapid. In most years the water table is within 3 to 5 feet of the surface of the Ulen and Glyndon soils in spring and early in summer. In years when there is a large amount of rainfall, the water table is at or near the surface during most or all of the growing season. Nearly all of the precipitation enters these soils. The moisture in excess of field capacity percolates downward to the water table.

These soils have a moderate to high content of organic matter. The supply of available nitrogen is moderate to low, and the supply of available phosphorus is low. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied.

Corn, oats, barley, wheat, flax, alfalfa, and bromegrass are grown on these soils. In some years seeding is delayed because of wetness.

Where these soils are cultivated, they are highly susceptible to wind erosion. Among the practices used to control wind erosion are field windbreaks, stubble-mulch tillage, minimum tillage, wind stripcropping, corn grown in buffer strips, and management of crop residue. A combination of two or more of these practices is necessary to reduce the velocity of the wind at the surface and thus control erosion.

CAPABILITY UNIT IIIe-5

In this capability unit are deep, dark-colored, rolling soils that are well drained or excessively drained. These soils have a surface layer of very friable loam and a subsoil of friable loam. The Buse subsoil is light colored and calcareous. The soils in this unit are—

Barnes-Buse loams, rolling.
Eckman loam, rolling.

Available moisture capacity is good. Surface drainage is rapid, and a large amount of water runs off these soils. Permeability is moderate.

The soils in this group are easily tilled at a moisture content that ranges from the wilting point of most plants to near field capacity. They have a moderate to low content of organic matter. The supply of available nitrogen is also moderate to low, and that of available phosphorus is low. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied. Yields of wheat, barley, oats, corn, flax, alfalfa, and bromegrass are fair to good.

These soils are in small areas that are cultivated in fields with less sloping soils. They are moderately to highly susceptible to water erosion. Generally, the hazard of water erosion is reduced if the cropping system includes legumes and sod crops and if corn is not grown too frequently. Stubble-mulch tillage, good management of crop residue, and plowing in spring, if feasible, effectively reduce water erosion.

The Buse soil is susceptible to wind erosion because it is on the crests of knolls and is more exposed to the wind than the other soils. The hazard of erosion is reduced by the use of stubble-mulch tillage, growing cover crops on fall-plowed or summer-fallowed fields, and practicing ridge cultivation. It is also reduced by leaving the surface rough and cloddy. Applying a mulch of straw or manure and using rough or emergency tillage help to protect the soils that are actively eroding.

CAPABILITY UNIT IIIe-6

In this capability unit are moderately deep or deep, dark-colored soils that are nearly level to undulating and are well drained or moderately well drained. All of these soils have a surface layer of very friable sandy loam and a subsoil of loam to fine sandy loam. The Fordville and Spottswood soils have a substratum of gravelly coarse sand and gravel at a depth of 24 to 60 inches, and the Embden soil has a substratum of fine sandy loam to loamy fine sand. The soils in this unit are—

Fordville sandy loam, nearly level.
Fordville sandy loam, undulating.
Spottswood sandy loam, loamy substratum, nearly level.
Spottswood-Embden sandy loams, nearly level.

Available moisture capacity is fair to good. These soils have a moderately permeable subsoil. The Fordville soils are well drained, and the Spottswood and Embden soils are moderately well drained. Water enters them readily, and there is only a small amount of runoff.

The content of organic matter is moderate to high. The supply of available phosphorus is low, and the supply of available nitrogen is low to moderate. The soils of this unit are suitable for cultivation. The crops commonly grown are wheat, corn, barley, oats, alfalfa, and hay, and yields are fair to good.

Where these soils are cultivated, they are highly susceptible to wind erosion. Field windbreaks, management of crop residue, stubble-mulch tillage, and wind stripcropping are practices used to control erosion. Also, tillage is kept to a minimum and corn is planted in buffer strips. A combination of at least two of these practices is required to effectively control wind erosion.

CAPABILITY UNIT IIIw-1

In this capability unit are soils that are generally deep and that are dark colored, nearly level, and somewhat poorly drained or poorly drained. They have a surface layer of fine sandy loam. The subsoil of the Arveson and Tiffany soils is very friable fine sandy loam. In the Arveson soils it is light colored and strongly calcareous. The Hamar soil has a subsoil of loamy fine sand. The soils in this unit are—

Arveson fine sandy loam.
Arveson fine sandy loam, moderately shallow.
Hamar fine sandy loam.
Tiffany fine sandy loam.

The available moisture capacity is fair in the Arveson and Tiffany soils and low in the Hamar soil. All of these soils have moderate permeability. In most years the water table is within 3 feet of the surface in spring and early in summer.

These soils have a moderate to high content of organic matter. The supply of available nitrogen is moderate to low, and the supply of available phosphorus is low. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied.

Surface drainage is needed to remove the excess water and to permit timely farming operations. Where the drainage has been improved, the soils are suited to wheat, corn, barley, oats, flax, alfalfa, and bromegrass. If they are cultivated, these soils are highly susceptible to wind erosion. Practices that provide protection are wind stripcropping, minimum tillage, stubble-mulch tillage, and field windbreaks. Also, corn is planted in buffer strips and grasses and legumes are included in the cropping system.

CAPABILITY UNIT IIIw-2

This capability unit consists of soils that are deep, dark colored, and nearly level. These soils are poorly drained or very poorly drained. They have a surface layer and subsoil of silt loam to clay. The soils in this unit are—

Borup silt loam, very wet.
Dimmick clay.
Parnell soils.

Generally, these soils are slowly permeable, but the Borup soil is moderately permeable. Except in dry years, the water table is at or near the surface in spring and early in summer. The available moisture capacity is good.

The content of organic matter is high. The supply of available nitrogen and available phosphorus is moderate.

Where drainage has been established, these soils are highly productive. The drained areas are suited to wheat, barley, oats, flax, millet, bromegrass, and corn. The undrained areas are rarely seeded to wheat, barley, and oats. Only in dry years are late-seeded flax and millet grown. The undrained areas are best treated like the soils in capability unit Vw-1.

CAPABILITY UNIT IIIw-3

Arveson fine sandy loam, very wet, is the only soil in this capability unit. This soil is deep, dark colored, nearly level, and poorly drained. Its surface layer is very friable fine sandy loam, and its subsoil is light-colored, strongly calcareous fine sandy loam.

This soil has fair available moisture capacity and is moderately permeable. Except in unusually dry years, the water table is at or near the surface much of the time.

The content of organic matter is moderate to high. The supply of available nitrogen is moderate, and the supply of available phosphorus is low.

If drainage has been established, this soil is suited to wheat, barley, oats, corn, flax, millet, and bromegrass. In dry years late-seeded flax or millet can be grown in areas that have not been drained.

If this soil is cultivated, it is highly susceptible to wind erosion. A combination of two or more practices that control erosion are needed where crops are grown. Surface drainage is necessary if crops are grown year after year.

CAPABILITY UNIT IIIs-1

The soils of this capability unit are moderately deep, dark colored, well drained, and nearly level or undulating. Their surface layer and subsoil are friable loam, and they have a substratum of gravelly coarse sand and gravel at some depth between 20 and 36 inches. The soils in this unit are—

Fordville loam, nearly level.
Fordville loam, undulating.

These soils have fair available moisture capacity. They are moderately permeable and somewhat droughty.

The content of organic matter is moderate. The supply of available phosphorus and available nitrogen is low.

In years when rainfall is favorably distributed during the growing season, good yields of wheat, barley, oats, flax, alfalfa, corn, and bromegrass are obtained. In dry years yields are only fair.

These soils are moderately susceptible to wind erosion if they are cultivated. Management of crop residue, stubble-mulch tillage, minimum tillage, wind stripcropping, corn grown in buffer strips, and field windbreaks are practices that are used to reduce the velocity of the wind near the surface of the ground. The practice of summer fallowing has little, if any, value for increasing the storage of moisture in these soils because of the moderate depth to the coarse-textured substratum.

CAPABILITY UNIT IIIs-2

In this capability unit are nearly level soils that are moderately well drained to poorly drained. These soils have a surface layer of silt loam to silty clay loam and a subsoil of silty clay loam to clay. The Aberdeen and Exline soils contain a claypan, or layer of dense, dispersed soil material, that severely restricts the growth of roots. The soils in this unit are—

Aberdeen silt loam.
Fargo-Exline silty clay loams.
Overly-Exline complex, nearly level.

The Fargo and Overly soils have good available moisture capacity and moderately slow to slow permeability. The Exline and Aberdeen soils also have good available moisture capacity. Because of their shallow root zone, however, they hold only a small amount of moisture available to plants.

The Aberdeen soil can be tilled without serious difficulty. The Exline soils are difficult to till, and they cause problems in tilling other soils because they are randomly distributed within areas of other soils. In many places part of the Exline subsoil has been brought to the surface by tillage. In those areas the soil material disperses when wet and forms hard crusts and clods when dry. Tillage operations, therefore, depend largely upon the content of moisture in the Exline soils.

Wheat, barley, flax, oats, alfalfa, and bromegrass are grown on the Aberdeen soil. Yields on this soil are good in years when the distribution of rainfall is uniform throughout the growing season. Good yields are obtained on the Fargo and Overly soils, but yields are poor on the Exline soils (fig. 8). In fields where the Fargo and Overly soils are farmed with the Exline soils, yields on the Fargo and Overly soils are reduced in many years because farming operations are delayed until the Exline soils are dry enough to till.

Figure 8.—**Area of Exline soil where yields are poor.**

CAPABILITY UNIT IIIs-3

Only soils of the Stirum-Glyndon complex are in this capability unit. These soils are nearly level and are somewhat poorly drained or poorly drained. They have a surface layer of calcareous fine sandy loam to silt loam and a dispersed subsoil of strongly calcareous, saline fine sandy loam to loam. In addition, the Stirum subsoil is strongly alkaline and contains a large amount of exchangeable sodium. The soluble salts, however, counteract the effects of the sodium, and they limit dispersion.

These soils have good available moisture capacity. Permeability is moderate in the Glyndon soil and slow in the Stirum. In most years the water table is within 3 feet of the surface in spring and early in summer.

The supply of available nitrogen is moderate to low. The supply of available phosphorus is low.

These soils are used for pasture and for wheat, barley, oats, flax, alfalfa, and bromegrass. They are poorly suited to corn, and yields of hay and close-growing crops are fair.

The chief problems in managing these soils are salinity, alkalinity, and wetness. A cropping system that includes, at regular intervals, alfalfa or other deep-rooted plants that require a large amount of moisture will help to lower the water table. This lowering takes place because deep-rooted plants use moisture to a greater depth than do other plants. After the water table has been lowered, water that enters the soil will dissolve the soluble salts and move them deeper in the soil. Thus, the salinity of the root zone is reduced.

Summer fallowing is seldom practiced on these soils. When soils are summer fallowed, the water table generally rises, surface evaporation increases, and salts are precipitated in the surface layer. When the water table is high during dry periods, the capillary water brings additional salts to the upper part of the root zone. If the water table is low during the time the soils are summer fallowed, salts are leached downward. The salts are leached out of the root zone if there is enough moisture.

CAPABILITY UNIT IIIs-4

Divide loam is the only soil in this capability unit. It is moderately deep, nearly level, and moderately well drained or somewhat poorly drained. This soil has a surface layer of very friable loam. Just below the surface layer is light-colored, strongly calcareous loam. The substratum is gravel and coarse sand at some depth between 20 and 36 inches. In most years the water table is less than 5 feet from the surface in spring and early in summer.

This soil is moderately permeable and has good to fair available water capacity. It is moderate in content of organic matter. Its supply of available phosphorus is low, and the supply of available nitrogen is moderate to low. The crops grown on this soil respond well to applications of a fertilizer containing nitrogen and phosphorus. Wheat, oats, barley, flax, corn, alfalfa, and bromegrass are the crops commonly grown, and yields are good to fair.

Generally, this soil is plowed in fall. By plowing at that time, the wetness early in spring is avoided, and a rough, cloddy surface is left to protect the soil during winter. The hazard of wind erosion is not serious, because this soil is in low areas on the leeward side of beach ridges where it is protected from strong winds.

CAPABILITY UNIT IIIs-5

In this capability unit are moderately deep to deep, dark-colored, nearly level soils that are moderately well drained. These soils have a surface layer and subsoil of friable loam. The substratum of the Spottswood soils is gravel and coarse sand that varies in thickness and is at some depth between 24 and 60 inches. The substratum of the Gardena soil is loam to fine sandy loam. The soils in this unit are—

Spottswood loam, loamy substratum, nearly level.
Spottswood-Gardena loams, nearly level.

Available moisture capacity is fair to good. Permeability is moderate in the subsoil. It is rapid where the substratum is gravelly and moderately slow where the substratum is loamy.

These soils have a high to moderate content of organic matter. The supply of available phosphorus is moderate to low, and the supply of available nitrogen is moderate. Except in dry years, good response is received if a fertilizer containing nitrogen and phosphorus is applied. Among the crops grown on these soils are wheat, barley, oats, corn, flax, alfalfa, and bromegrass.

Fall-plowed areas are left rough and cloddy so that these soils will be protected from wind erosion. Field windbreaks, wind stripcropping, and stubble-mulch tillage are other practices used to protect these soils.

CAPABILITY UNIT IIIs-6

This capability unit consists of nearly level, moderately well drained to poorly drained soils that are slightly to moderately saline. The surface layer of these soils is fine sandy loam to silty clay loam, and their subsoil is clay to fine sandy loam. The subsoil of all except the Fargo and Overly soils is light colored and strongly calcareous. The soils in this unit are—

Bearden soils, saline.
Fargo silty clay loam, saline.
Glyndon and Hamerly loams, saline, nearly level.
Overly silt loam, saline, nearly level.
Ulen complex, saline.

In these soils the soluble salts in the surface layer and subsoil affect the growth of crops. The degree of salinity varies from year to year, as well as within each growing season. Available moisture capacity is good to fair. Permeability ranges from moderate in the Ulen subsoil to slow in the Fargo subsoil. In most years a seasonal water table is less than 5 feet from the surface of all the soils except the Overly.

The content of organic matter is moderate to high. The supply of available phosphorus is low. Wheat, oats, barley, flax, alfalfa, and bromegrass are commonly grown on these soils. Yields depend upon the amount and distribution of rainfall, but they range from poor to good.

Only the Ulen soil of this unit is highly susceptible to wind erosion if it is cultivated. A combination of two or more practices that control wind erosion are needed for effective protection.

Salinity is the chief problem in mapping. If drainage is established to remove the excess surface water or to intercept seepage, the water table is lowered and salinity is reduced. The salinity will increase, however, when the water table is high. During periods when the water table is low, water enters these soils and leaches the salts to a depth below the root zone. If the cropping system includes a deep-rooted crop that requires a large amount of water, alfalfa for example, the water table is lowered and the leaching of salts out of the root zone is increased.

CAPABILITY UNIT IVe-1

In this capability unit are deep, dark-colored, nearly level soils that are moderately well drained or somewhat poorly drained. These soils have a surface layer and subsoil of loamy fine sand. The soils in this unit are—

Hecla loamy fine sand, loamy substratum, nearly level.
Hecla loamy fine sand, moderately shallow, nearly level.
Hecla soils, nearly level.
Hecla and Hamar loamy fine sands, nearly level.

In many places these soils have been moderately eroded by wind. In those areas drifted soil material has accumulated in field windbreaks and along field boundaries and fence lines. In eroded areas the color of the plow layer in many places is lighter than the color of the surface layer below plow depth, because drifted soil material has covered the original surface layer.

Available moisture capacity is low to very low. Permeability is moderately rapid in the subsoil. Water enters these soils rapidly, and no precipitation is lost through surface runoff. Water in excess of field capacity percolates downward to the water table.

The content of organic matter is moderate to high, and the supply of available nitrogen is moderate to low.

Much of the acreage is cultivated. Corn, oats, alfalfa, bromegrass, wheat, barley, flax, and rye are grown, and yields are fair to good.

These soils are highly susceptible to wind erosion if they are cultivated. Intensive practices that control wind erosion are needed. Minimum tillage, field windbreaks, wind stripcropping, stubble-mulch tillage, corn planted in buffer strips, and the seeding of a grass-legume mixture are among the practices used. A combination of these practices is necessary to provide effective protection.

CAPABILITY UNIT IVe-2

The soils in this capability unit are deep, dark colored, nearly level to undulating, and well drained to excessively drained. They have a surface layer and subsoil of loamy fine sand. The soils in this unit are—

Maddock loamy fine sand, nearly level.
Maddock loamy fine sand, undulating.
Maddock loamy fine sand, moderately shallow, nearly level.

In most cultivated areas these soils have been moderately eroded by wind. Drifted soil material has accumulated in places along field boundaries and fence lines. These soils have very low to low available moisture capacity and are droughty. Permeability is rapid.

The content of organic matter is moderate. The supply of available nitrogen and available phosphorus is low. The soils in this unit are used for native pasture and for crops, mainly alfalfa, bromegrass, corn, and oats. Yields are low.

Because these soils are highly susceptible to wind erosion, a combination of practices is necessary to effectively protect them if they are cultivated. The commonly used practices are managing crop residue, providing field windbreaks, using stubble-mulch tillage, keeping tillage to a minimum, and wind stripcropping.

CAPABILITY UNIT IVe-3

Only Hamar-Ulen loamy fine sands is in this capability unit. The soils of this complex are deep, dark colored, and nearly level. They are moderately well drained or somewhat poorly drained and have a seasonal high water table. The surface layer of these soils is loamy fine sand, and their subsoil is fine sandy loam to loamy fine sand. The Ulen subsoil is light colored and strongly calcareous.

These soils have very low or low available moisture capacity and moderately rapid permeability. All of the moisture from precipitation enters them. The moisture in excess of field capacity is added to the water table. In most years the water is within 3 to 5 feet of the surface, but in wet years it is at or near the surface during much or all of the growing season.

The content of organic matter is moderate. The supply of available nitrogen and available phosphorus is low.

Most of the acreage is used for pasture. Except in dry years, cultivated areas are seeded late. Millet, corn, oats, and bromegrass are grown, and yields are fair.

These soils are highly susceptible to wind erosion. Wind stripcropping, minimum tillage, stubble-mulch tillage, field windbreaks, sod crops, and corn in buffer strips are practices that effectively control erosion. A combination of these practices is necessary for effectively protecting the soils from wind erosion.

CAPABILITY UNIT IVe-4

In this capability unit are deep, undulating soils that are excessively drained. These soils have a surface layer and subsoil of friable loam to fine sandy loam. Their subsoil is light colored and calcareous. In places tillage has mixed part of the subsoil with the surface layer. The soils in this unit are—

Zell fine sandy loam, undulating.
Zell loam, undulating.

These soils have good available moisture capacity and moderate permeability. Water enters them readily, but much of the moisture received in heavy rains is lost through surface runoff.

The content of organic matter is moderate to low. The supply of available phosphorus and available nitrogen is low. Good response is obtained if a fertilizer containing nitrogen and phosphorus is applied.

Most of the acreage is cultivated with adjacent soils. Wheat, barley, flax, oats, alfalfa, and bromegrass are the main crops, but corn is also grown. Yields are fair to good.

Water erosion is the main hazard. Practices that reduce the hazard of water erosion are minumum tillage, stubble-mulch tillage, and a suitable cropping system. This cropping system includes bromegrass and alfalfa, but corn is not grown frequently.

CAPABILITY UNIT IVe-5

Only Barnes-Buse loams, strongly rolling, is in this capability unit. The soils of this mapping unit are deep and well drained or excessively drained. They are on the side slopes of stream valleys that are entrenched in the till plain. Their surface layer and subsoil are loam. The Buse subsoil is light colored and calcareous.

These soils have good available moisture and are moderately permeable. Water enters them readily, but much of the moisture received during heavy rains is lost through surface runoff.

The content of organic matter is moderate to low. The supply of available nitrogen and available phosphorus is low.

Most of the acreage is in pasture, but some areas are cultivated along with adjacent soils. Wheat, barley, alfalfa, and bromegrass are the main crops, and yields are fair to good. The soils are poorly suited to corn because they are rolling and water erosion is a hazard.

Including grasses and alfalfa in the cropping system is a good practice for controlling erosion. Other practices that effectively control water erosion are stubble-mulch tillage, minimum tillage, and planting across the slope, where feasible.

CAPABILITY UNIT Vw-1

In this capability unit are deep, dark-colored, very poorly drained soils. These soils are on low bottom lands. The texture of the surface layer and subsoil ranges from loam to silty clay loam. The soils in this group are—

Alluvial land.
Rauville soils.

These soils are too wet for cultivation, and the establishment of artificial drainage is seldom feasible. In most years the water table is at or near the surface until early summer and is within 3 feet of the surface throughout the growing season. During wet years the water table remains at or near the surface.

The dominant vegetation on these soils is sedges, prairie cordgrass, rushes, and cattails. Slough sedge and prairie cordgrass provide a large amount of forage that becomes coarse and unpalatable unless it is closely grazed. Where close grazing is not practical, mowing will permit a new growth that is more palatable. Reed canarygrass and Garrison creeping foxtail are adapted tame grasses that grow well in areas subject to prolonged flooding.

CAPABILITY UNIT VIe-1

In this capability unit are deep, nearly level to hilly soils that are moderately well drained to excessively drained. The surface layer of these soils is loamy fine sand to sand, and their subsoil is fine sand or loamy fine sand. The thickness of the surface layer varies, but the Hecla soils have a surface layer that is as thick as 40 inches in a few places. The soils in this unit are—

Hecla fine sand, nearly level.
Hecla-Hamar complex, hummocky, eroded.
Maddock soils, hilly.
Maddock-Hamar complex, severely eroded.

All of the precipitation enters these soils, but the available moisture capacity is low to very low and permeability is moderately rapid. In most years the Hamar soils have a seasonal high water table within 5 feet of the surface. The soils of the Hecla-Hamar and Maddock-Hamar complexes have been severely eroded by wind. The hilly Maddock soils are in duned areas.

Big bluestem, switchgrass, sideoats grama, and indiangrass are common on the Hecla soils, and prairie cordgrass and slough sedge grow extensively on those soils in wet years. On the Hamar soils, big bluestem, switchgrass, prairie cordgrass, and slough sedge are the common plants; in wet years cattails and rushes flourish. Sand bluestem, prairie sandreed, Canada wildrye, sideoats grama, and little bluestem are native grasses on the Maddock soils.

The soils of this unit are highly susceptible to erosion. Their surface soil is loose. Erosion may be started if livestock are allowed to graze closely or trample the soils excessively, so that the cover of plants is reduced or destroyed (fig. 9). A mulch can be applied on areas without cover, such as blowouts and drifts, and those areas can be excluded from grazing until a cover of plants is reestablished.

CAPABILITY UNIT VIe-2

In this capability unit are deep, strongly rolling to hilly, channeled soils that are excessively drained or moderately well drained. Except for the La Prairie and Fairdale soils, these soils have a thin surface layer of loam and a subsoil that is calcareous and loamy. The La Prairie and Fairdale soils are in narrow, channeled areas of bottom lands adjacent to streams. They are moderately well drained and are occasionally flooded. The soils in this unit are—

Buse loam, hilly.
La Prairie and Fairdale soils.
Zell loam, strongly rolling.

On the Buse and Zell soils, the native vegetation was little bluestem, western wheatgrass, needle-and-thread, blue grama, needleleaf sedge, fringed sagewort, and silverleaf scurfpea. On the Fairdale and La Prairie soils, it was ash, American elm, big bluestem, switchgrass, and snowberry. Bluegrass is now dominant in many areas. Overgrazing increases the number of less desirable plants, reduces the cover of plants, and increases runoff and water erosion in the steeper areas.

Figure 9.—**An area of Maddock soils where excessive trampling has damaged the vegetation and erosion has begun.**

CAPABILITY UNIT VIs-1

In this capability unit are nearly level, poorly drained soils that are strongly saline. The soils in this unit are—

Exline complex.
Glyndon-Borup loams, strongly saline, nearly level.

These soils are not suited to crops, because they are strongly saline. Also, the Exline soils have a dense, strongly alkaline claypan.

The native vegetation was inland saltgrass and western wheatgrass. On much of the Glyndon-Borup complex, the dominant vegetation is now inland saltgrass. Kentucky bluegrass grows in some areas of the Exline complex.

Some of the acreage that has been cultivated in the past has been seeded to grass for tame pasture. Western wheatgrass is an adapted native grass on these soils. Because it germinates and develops a stand slowly, it should be seeded with slender and intermediate wheatgrasses that establish a vigorous stand in a short time but die out after 2 or 3 years of use.

CAPABILITY UNIT VIs-2

In this capability unit are nearly level to rolling soils that are excessively drained to well drained. These soils have a surface layer and subsoil of loam, gravelly loam, or sandy loam. In most places they are shallow, or less than 15 inches deep, over a substratum of gravel and coarse sand. The soils in this unit are—

Renshaw and Sioux loams, nearly level.
Renshaw and Sioux loams, undulating.
Renshaw and Sioux sandy loams, nearly level.
Renshaw and Sioux sandy loams, rolling.
Sioux gravelly loam.
Sioux and Renshaw loams, rolling.

The soils of this unit are permeable. They have low available moisture capacity and are droughty.

Some areas are cultivated. Wheat, corn, oats, alfalfa, and bromegrass are grown, but yields are poor. Many areas have been seeded to alfalfa and bromegrass and are used for tame pasture and hay. Crested wheatgrass is well suited to these soils. The native vegetation was blue grama, western wheatgrass, needleleaf sedge, needle-and-thread, and fringed sagewort.

Predicted yields

Table 4 gives estimated crop yields per acre under two levels of management for each soil mapped in the Tri-County survey area. The yields shown in columns A are to be expected under average management. Those shown in columns B are to be expected if the farmer uses the best techniques and management practices available at the present time.

Some farmers are now exceeding the yields estimated in columns B. It is expected that yields will increase in the future, as improved varieties of plants are grown, new techniques are developed, and additional knowledge is gained from research and experience. The following are

TABLE 4.—*Predicted estimated average acre yields of the principal crops under average and improved management*

Soil	Wheat		Oats		Barley		Corn		Adapted hay	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Aberdeen silt loam	16	20	35	45	22	30	27	35	2.0	2.6
Alluvial land										
Arveson fine sandy loam [1]		24		48		32		55	1.2	1.5
Arveson fine sandy loam, moderately shallow [1]		24		48		32		55	1.2	1.5
Arveson fine sandy loam, very wet [1]		24		48		32				
Arveson loam [1]		26		50		34		55	1.2	1.5
Barnes loam, undulating	20	28	42	58	30	36	32	45	1.4	1.8
Barnes-Buse loams, rolling	14	20	30	40	22	30	30	40	1.2	1.5
Barnes-Buse loams, strongly rolling	12	18	22	34	16	24			1.0	1.2
Barnes-Svea loams, undulating	22	30	44	60	30	38	35	48	1.7	2.0
Bearden silt loam	28	38	55	70	36	48	50	65	2.7	3.5
Bearden silty clay loam	28	38	55	70	36	48	50	65	2.7	3.5
Bearden soils, saline	16	22	27	34	24	35	25	34	1.8	2.5
Bearden-Overly silt loams	28	38	55	70	36	48	50	65	2.7	3.5
Borup silt loam [1]		26		50		34		55	1.2	1.6
Borup silt loam, very wet [1]		26		50		34				
Buse loam, hilly									.8	1.0
Dimmick clay [1]		32		55		42		50	2.0	3.5
Divide loam	18	22	35	45	20	28	30	40	1.4	1.8
Eckman loam, nearly level	20	27	40	50	27	35	35	50	1.7	2.0
Eckman loam, undulating	18	26	35	45	25	34	32	45	1.4	1.8
Eckman loam, rolling	14	20	30	40	22	28	30	40	1.2	1.5
Eckman loam, till substratum, undulating	18	26	40	50	25	34	35	50	1.7	2.0
Egeland fine sandy loam, nearly level	14	20	28	40	20	28	30	40	1.0	1.5
Egeland fine sandy loam, undulating	14	20	28	40	20	28	30	40	1.0	1.3
Embden fine sandy loam	18	24	35	45	22	30	35	55	1.5	2.0
Embden-Gardena complex	22	30	40	50	30	40	35	55	1.5	2.5
Embden-Glyndon fine sandy loams	22	30	40	50	28	38	30	55	1.5	2.5
Embden and Hecla fine sandy loams	16	22	30	40	20	28	35	50	1.0	1.7
Exline complex									.7	1.0
Fairdale silt loam, levee	22	33	40	60	30	42	30	55	1.5	2.5
Fargo clay	25	32	42	60	32	42	40	55	2.2	3.2
Fargo silt loam	25	32	42	60	32	42	40	55	2.2	3.2
Fargo silty clay loam	25	32	42	60	32	42	40	55	2.2	3.2
Fargo silty clay loam, saline	16	22	25	40	20	32	22	35	1.8	2.5
Fargo-Exline silty clay loams	15	20	22	38	20	28	18	30	1.2	1.8
Fordville loam, nearly level	14	20	30	40	20	26	26	40	1.5	2.0
Fordville loam, undulating	14	20	30	40	20	26	26	40	1.0	1.5
Fordville sandy loam, nearly level	12	18	25	35	17	24	22	35	1.0	1.5
Fordville sandy loam, undulating	12	18	25	35	17	24	20	35	1.0	1.3
Fresh water marsh										
Gardena loam, very deep, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Gardena loam, very deep, undulating	22	30	40	55	30	40	40	60	1.8	2.8
Gardena loam, deep, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Gardena loam, moderately shallow, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Gardena loam, moderately shallow, undulating	22	30	40	55	29	38	40	60	1.8	2.8
Gardena loam, till substratum, nearly level	25	36	45	65	34	46	45	65	2.2	3.2
Gardena-Eckman loams, till substratum, nearly level	24	32	40	55	32	42	40	60	2.0	3.0
Gardena-Glyndon loams, nearly level	26	36	45	65	34	42	38	65	2.2	3.2
Gardena-Glyndon loams, till substratum, nearly level	26	36	45	65	32	42	38	65	2.2	3.2
Glyndon loam, very deep, nearly level	28	38	45	65	36	48	40	60	2.2	3.2
Glyndon loam, very deep, undulating	22	30	35	55	28	38	33	50	2.2	3.2
Glyndon loam, deep, nearly level	28	38	45	65	36	48	40	60	2.2	3.2
Glyndon-Borup loams, strongly saline, nearly level									.7	.9
Glyndon and Gardena loams, nearly level	28	38	50	70	36	48	40	60	2.2	3.2
Glyndon and Hamerly loams, saline, nearly level	16	22	25	36	20	30	20	30	1.4	2.0
Gravel pits										
Hamar fine sandy loam	14	18	25	35	18	24	25	40	1.0	1.5
Hamar-Ulen fine sandy loams	15	20	30	40	20	26	30	45	1.0	1.8
Hamar-Ulen loamy fine sands	12	16	24	30	16	22	20	35	1.0	1.8
Hamerly complex, undulating	22	30	40	55	28	38	27	37	1.3	2.0
Hamerly loam, nearly level	26	34	45	60	30	40	30	45	1.5	2.2
Hamerly-Barnes loams, undulating	22	30	40	55	28	36	30	40	1.3	2.0
Hecla fine sand, nearly level										
Hecla fine sandy loam, nearly level	15	20	30	40	20	26	30	50	1.0	1.5
Hecla fine sandy loam, moderately shallow, nearly level	16	22	32	44	22	28	30	52	1.2	1.7
Hecla loamy fine sand, loamy substratum, nearly level	12	16	25	34	16	22	28	36	1.2	1.7
Hecla loamy fine sand, moderately shallow, nearly level	12	16	25	34	16	22	28	36	1.2	1.7
Hecla sandy loam, loamy substratum, nearly level	15	20	30	40	20	26	30	50	1.2	1.7
Hecla soils, nearly level	13	17	26	32	18	24	28	45	1.2	1.8

See footnote at end of table.

TABLE 4.—*Predicted estimated average acre yields of the principal crops under average and improved management*—Con.

Soil	Wheat		Oats		Barley		Corn		Adapted hay	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Hecla and Embden fine sandy loams, nearly level	16	22	30	40	22	28	30	50	1.2	1.8
Hecla-Hamar complex, hummocky, eroded	------	------	------	------	------	------	------	------	------	------
Hecla and Hamar loamy fine sands, nearly level	10	16	20	30	16	22	25	40	1.2	2.0
Hecla-Ulen fine sandy loams, nearly level	16	22	30	40	22	28	30	45	1.2	2.2
Hecla-Ulen fine sandy loams, loamy substratum, nearly level	16	22	30	40	22	28	30	45	1.5	2.5
Lamoure silty clay loam	18	30	35	55	28	38	25	50	1.5	2.5
La Prairie and Fairdale soils	------	------	------	------	------	------	------	------	------	------
La Prairie silt loam	28	38	55	75	36	48	45	65	2.2	3.2
Maddock fine sandy loam, nearly level	9	13	16	22	12	16	20	30	1.0	1.5
Maddock fine sandy loam, undulating	8	12	16	22	12	16	20	30	1.0	1.5
Maddock fine sandy loam, rolling	8	12	16	22	12	16	15	25	1.0	1.5
Maddock loamy fine sand, nearly level	8	10	14	20	10	14	15	25	1.0	1.5
Maddock loamy fine sand, undulating	8	10	14	20	10	14	15	25	1.0	1.5
Maddock soils, hilly	------	------	------	------	------	------	------	------	------	------
Maddock loamy fine sand, moderately shallow, nearly level	9	12	20	25	12	16	18	32	1.0	1.5
Maddock-Hamar complex, severely eroded	------	------	------	------	------	------	------	------	------	------
Overly silt loam, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Overly silt loam, saline, nearly level	16	22	30	40	24	35	------	------	1.0	1.5
Overly silty clay loam, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Overly-Exline complex, nearly level	15	20	30	40	20	26	------	------	1.8	2.5
Overly-Gardena loams, nearly level	28	38	55	75	38	50	45	65	2.2	3.2
Parnell soils [1]	------	30	------	60	------	40	------	55	------	2.5
Perella silt loam [1]	------	32	------	60	------	40	------	55	1.5	2.5
Perella silty clay loam [1]	------	32	------	60	------	40	------	55	1.5	2.5
Rauville soils	------	------	------	------	------	------	------	------	------	------
Renshaw and Sioux loams, nearly level	------	------	------	------	------	------	------	------	------	------
Renshaw and Sioux loams, undulating	------	------	------	------	------	------	------	------	------	------
Renshaw and Sioux sandy loams, nearly level	------	------	------	------	------	------	------	------	------	------
Renshaw and Sioux sandy loams, rolling	------	------	------	------	------	------	------	------	------	------
Sioux gravelly loam	------	------	------	------	------	------	------	------	------	------
Sioux and Renshaw loams, rolling	------	------	------	------	------	------	------	------	------	------
Spottswood loam, loamy substratum, nearly level	20	26	40	50	24	34	30	45	1.5	2.2
Spottswood sandy loam, loamy substratum, nearly level	16	20	30	40	22	28	30	45	1.4	2.0
Spottswood-Embden sandy loams, nearly level	16	20	30	40	22	28	35	50	1.4	2.0
Spottswood-Gardena loams, nearly level	22	30	40	55	28	38	35	55	1.5	2.2
Stirum-Glyndon complex	12	16	20	25	16	20	------	------	1.0	1.5
Svea-Barnes loams	26	34	45	60	32	44	35	55	1.5	2.2
Svea-Hamerly loams	24	32	40	55	28	38	32	50	1.5	2.2
Tiffany fine sandy loam	14	24	30	45	22	30	30	55	1.4	2.0
Tetonka silt loam [1]	------	30	------	60	------	40	------	45	1.5	2.5
Ulen complex, saline	12	16	20	30	17	22	------	------	1.0	1.5
Ulen fine sandy loam	16	24	30	40	24	30	35	55	1.4	2.0
Ulen fine sandy loam, loamy substratum	16	24	30	40	24	30	26	55	1.5	2.0
Ulen fine sandy loam, moderately shallow	15	24	30	40	24	30	26	55	1.5	2.0
Ulen-Gardena fine sandy loams.	20	28	40	50	30	38	32	60	1.7	2.2
Vallers loam	19	24	35	50	28	30	24	40	1.2	1.6
Zell fine sandy loam, undulating	12	18	25	35	17	24	------	------	1.0	1.3
Zell loam, undulating	12	18	25	35	16	22	------	------	1.0	1.5
Zell loam, strongly rolling	------	------	------	------	------	------	------	------	1.0	1.3

[1] Yields are for drained areas only.

among the management practices used to obtain the yields shown in columns B:

1. Erosion is effectively controlled.
2. Only the best varieties of seed are selected for planting, and only seed of good quality is planted.
3. A proper planting rate is used.
4. Weeds, insects, and diseases are controlled.
5. Tillage, seeding, and harvest operations are timely.
6. The kinds and amounts of fertilizer applied are based on the results of soil tests.
7. The soils are adequately drained.
8. A good cropping system is used.

Management of Soils for Pasture

The grazing season in the Tri-County survey area is about 6 months long. It extends from early in May to early in November. The native pastures in the survey area are mainly on the Hecla, Hamar, and Ulen soils of association 5; on the Maddock and Hamar soils of association 7; on the Renshaw and Sioux soils of association 9; and on the Ulen and Hecla soils of association 11.

Native pastures produce the best yields when part of the growth is allowed to remain from one season to the next. Also, in pastures where part of the growth is allowed to remain until the next season, a larger proportion of the stand consists of adapted and desirable grasses than where most of the growth is removed each season. If the native pasture on well-drained soils is to remain in good condition, about half of the annual growth should be left at the end of the season. On somewhat poorly drained or poorly drained soils, where the growth of the grasses is more luxuriant than on well-drained soils, about one-fourth of the annual growth should remain.

Some native grasses are weakened and eventually die if they are grazed every spring. Therefore, grazing should be rotated between different pastures in spring, so that the same pasture will not be grazed in spring for 2 successive years. This practice of rotating pastures also helps to maintain the vigor of the desirable grasses. If it is not practical to rotate spring grazing on native pasture, tame pasture should be provided for grazing early in the season.

Pastures in poor condition as the result of heavy grazing can be improved by fertilizing, controlling weeds, and excluding livestock from grazing. Limited trials indicate that a nitrogen fertilizer may be effective in restoring the vigor of native grasses that have been overgrazed. In pastures that are very weedy, the grasses are weakened and yields are lowered as a result of competition with weeds. Controlling the weeds by spraying with a chemical has proved to be effective in increasing both the yield and the vigor of the grasses.

Tame pastures in the survey area commonly consist of a mixture of bromegrass and alfalfa, which are adapted to all the soils suitable for cultivation. They should be managed so that grazing is begun when the plants have grown to a height of about 6 inches. The stocking rate on these pastures should be high enough that both the grass and alfalfa are grazed. When the plants have been grazed until their height is only about 3 inches, livestock ought to be moved to another pasture until the plants have again attained a height of 6 to 8 inches. A low grazing rate results in heavy grazing of the alfalfa and light grazing of the grass. If the grass develops seedstalks, clipping is necessary in pastures that are lightly grazed.

Tame pastures that consist of grasses, without legumes, ought to have a nitrogen fertilizer added. Field trials indicate that when a nitrogen fertilizer is added to these pastures yields of forage and the content of protein are

TABLE 5.—*Estimated height, in feet, of mature*

[Absence of a figure indicates that the site is not suitable

Soil series	Shrubs					
	Caragana	Chokecherry	Honey-suckle	Lilac	Plum	Russian-olive
Aberdeen	-----	-----	-----	-----	-----	-----
Arveson [1]	-----	15	8	10	9	28
Barnes	10	9	8	6	-----	18
Bearden	12	15	8	10	8	25
Borup [1]	-----	12	10	8	6	20
Buse	9	6	6	5	-----	12
Dimmick	-----	-----	-----	-----	-----	-----
Divide	-----	12	8	8	8	20
Eckman	12	10	10	8	-----	22
Egeland	10	12	8	8	-----	20
Embden	12	15	10	10	8	25
Exline	-----	-----	-----	-----	-----	-----
Fairdale	12	12	10	10	-----	25
Fargo	12	15	10	10	8	25
Fordville	10	10	6	6	-----	15
Gardena	12	15	10	10	8	25
Glyndon	12	15	10	10	8	25
Hamar [1]	-----	-----	10	10	7	25
Hamerly	10	12	7	8	6	20
Hecla	12	15	10	10	8	25
Lamoure [1]	-----	12	7	8	6	20
La Prairie	12	12	10	10	-----	25
Maddock	8	8	6	6	-----	18
Overly	12	15	10	10	8	25
Parnell	-----	-----	-----	-----	-----	-----
Perella [1]	12	15	10	10	8	25
Rauville	-----	-----	-----	-----	-----	-----
Renshaw	8	-----	5	5	-----	12
Sioux	-----	-----	-----	-----	-----	-----
Spottswood	11	10	8	8	7	20
Stirum	-----	-----	-----	-----	-----	-----
Svea	12	9	8	6	-----	18
Tetonka [1]	12	15	10	10	8	25
Tiffany [1]	12	15	10	10	8	25
Ulen	12	15	-----	10	8	25
Vallers [1]	10	12	7	8	6	20
Zell	10	6	7	8	-----	12

[1] Heights given are for trees in drained areas.

increased. If alfalfa is grown on soils that are low in phosphorus, a phosphorus fertilizer should be applied.

Excluding livestock from grazing permits the grasses to regain their vigor, but considerable time may be needed for improving the pasture, especially if the area is weedy. Because of the time required for improving native pasture by excluding livestock, this practice is less desirable than fertilizing with nitrogen and controlling the weeds.

When pastures do not produce enough forage for livestock, it is important for supplemental pasture to be available. Piper sudangrass provides a good supplemental pasture.

The distribution of grazing can be improved by distributing the water supply so that water will be available in different parts of the range. It can also be improved by placing salt and other mineral supplements in areas that are lightly grazed or that are far from the water supply.

Soils that are marginal in productivity and that are retired to grass permanently or for a long period should be seeded to adapted species. For example, reed canarygrass and Garrison creeping foxtail are well suited to the soils of capability unit Vw–1; western wheatgrass is well suited to the soils of capability unit VIs–1; and crested wheatgrass is well suited to the soils of capability unit VIs–2. Additional information about adapted species and about suitable seeding rates, seeding times, and seeding methods can be obtained from the county agent, from a representative of the Soil Conservation District, or from North Dakota State University.

Management of Windbreaks

Most of the trees grown in the survey area have been planted to protect farmsteads and fields from wind. The only native woodland consisting mainly of American elm and green ash occupies a narrow strip of bottom land along the Maple River. The Tri-County survey area lies within the most favorable area in North Dakota for trees and shrubs, zone A of Hoag and Schultz (*3*). Therefore, this area is well suited to farmstead and field windbreaks. Table 5 gives, for each soil series represented in the sur-

shrubs and trees suitable for windbreaks

for windbreaks or that the tree is not suited to the site]

Trees												
American elm	Ash	Box-elder	Black Hills spruce	Colorado spruce	Eastern redcedar	Rocky Mountain juniper	Ponderosa pine	Hack-berry	Siberian or dropmore elm	White and golden willow	Cotton-wood	Siberian crab
55	50	50	40	40	20	20	55	40	---	40	80	25
35	30	---	---	---	18	18	35	28	40	---	---	18
60	45	35	40	40	20	20	50	40	45	40	80	25
40	38	28	32	32	20	20	40	30	---	30	80	20
25	25	---	---	---	12	15	24	18	25	---	---	---
												12
40	40	30	35	35	18	18	45	35	40	30	70	20
44	35	---	---	---	18	18	40	35	50	---	---	20
40	37	28	---	---	18	18	42	32	35	---	65	20
55	45	50	40	40	25	20	60	40	45	50	80	25
48	40	50	30	30	20	20	65	35	50	40	80	25
60	50	50	40	40	20	20	55	40	50	40	75	25
---	20	---	---	---	12	12	25	20	25	---	---	---
60	45	50	40	40	20	20	60	40	45	50	80	25
60	45	50	40	40	20	20	50	40	45	40	80	25
---	45	35	40	40	18	20	50	40	45	50	80	25
40	38	30	30	30	20	20	40	35	38	35	68	20
55	45	45	40	40	20	20	55	40	45	40	80	25
45	35	50	35	35	20	20	40	30	---	35	65	20
48	40	50	30	30	20	20	60	35	50	40	80	25
35	30	25	---	---	12	12	35	25	30	---	55	15
60	40	50	40	40	20	20	65	40	50	45	75	25
50	40	50	40	40	20	20	55	40	50	50	75	25
---	25	---	---	---	12	12	---	---	30	---	---	---
32	28	40	32	32	18	18	50	35	40	40	70	20
45	40	50	35	35	20	20	60	35	40	40	70	20
50	40	50	40	40	20	20	55	40	50	50	75	25
55	45	50	40	40	20	20	50	40	45	50	80	25
50	45	40	40	40	35	20	50	40	40	40	80	25
40	38	30	30	30	18	15	40	35	38	30	68	20
30	20	---	---	---	15	12	30	20	30	---	---	---

vey area, the estimated height, in feet, of mature shrubs and trees suitable for windbreaks.

Farmstead windbreaks.—In farmstead windbreaks trees and shrubs are planted in multiple rows to protect the farmstead and feedlots from wind and drifting snow. These windbreaks consist of 6 to 12 rows of trees, generally planted on the north and west sides of the farmstead area, the direction from which blow the prevailing strong winds of winter. Included in these windbreaks should be evergreens and shrubs that hold the snow and thus prevent it from accumulating in the farmstead and feedlots.

The location of the farmstead generally determines the site on which the windbreak should be placed, so that protection will be provided from wind and snow. The soils should be examined before the trees are planted, and unfavorable soil qualities ought to be corrected if feasible. The kinds of trees chosen for planting need to be suitable for the site.

Before trees are planted in an area where drainage is restricted, the soils need to be drained. Where drainage is not feasible, species that tolerate wetness ought to be planted. Because the appearance of the farmstead windbreak is important, trees and shrubs should not be planted if they are susceptible to chlorosis, or yellowing, as the result of poor drainage and poor aeration.

Among the species adapted to dry sites are buffaloberry, caragana, and Russian-olive. Species adapted to wet areas are red-osier dogwood and cottonwood. Shrubs and trees that are resistant to chlorosis and that are commonly used in windbreaks are boxelder, buffaloberry, caragana, chokecherry, Rocky Mountain juniper, lilac, Russian-olive, and spruce. Russian-olive and Siberian salt-tree are adapted to saline areas.

Field windbreaks.—These are strips, or belts, of trees and shrubs planted as a barrier against prevailing winds to protect cultivated fields from wind erosion. The trees are planted either in single or multiple rows, generally on the north and west sides of fields. The number of single-row plantings is increasing. Several single-row plantings, with spaces between the rows, are preferred to a single multiple-row planting. They provide the same protection as is provided by a multiple-row windbreak, and they protect a larger area with the same number of trees.

The spacing of the rows depends upon the height of the mature trees in the windbreak and the susceptibility of the soils to erosion. If no other practices are used to protect the soils, the maximum spacing between windbreaks is 10 times the height of the mature trees in the windbreak plus a distance of 3 rods where the soils are fine sandy loams, a distance of 10 rods where the soils are clays, and a distance of 40 rods where the soils are loams to silty clay loams.

The windbreaks need protection from fire, grazing, insects, and diseases. Measures for controlling insects and diseases should be used as soon as feasible after the trees are planted. Current information about controlling insects and diseases can be obtained from the county agent or a local representative of the Soil Conservation Service.

TABLE 6.—*Irrigation ratings, limitations,*

Map symbol	Mapping unit	Limitations
Ad	Aberdeen silt loam	Slow permeability in the subsoil and very slow permeability in the substratum; salinity.
Ak	Alluvial land	Not applicable
An	Arveson fine sandy loam	Slow permeability in the substratum below a depth of 48 inches; fair available moisture capacity; low fertility.
Ar	Arveson fine sandy loam, moderately shallow	Slow or very slow permeability in the substratum; fair available moisture capacity; low fertility.
Av	Arveson fine sandy loam, very wet	Fair available moisture capacity; low fertility
Aw	Arveson loam	Fair available moisture capacity; low fertility
BaB	Barnes loam, undulating	Undulating topography; slow permeability in the substratum; salinity.
BbC	Barnes-Buse loams, rolling	Rolling topography; slow permeability in the substratum; salinity.
BbD	Barnes-Buse loams, strongly rolling	Strongly rolling topography; slow permeability in the substratum; salinity.
BdB	Barnes-Svea loams, undulating	Undulating topography; slow permeability in the substratum; salinity.
Be	Bearden silt loam	Moderately slow to slow permeability in the substratum; salinity; seasonal high water table.
Bf	Bearden silty clay loam	Slow permeability in the substratum; salinity; seasonal high water table.
Bg	Bearden soils, saline	Moderate permeability in the subsoil and slow permeability in the substratum; salinity; high water table.
Bh	Bearden-Overly silt loams	Slow permeability in the substratum; salinity; seasonal high water table.
Bo	Borup silt loam	Salinity of the subsoil and substratum; high water table
Bp	Borup silt loam, very wet	Water table at or near the surface
BuD	Buse loam, hilly	Hilly topography
Dc	Dimmick clay	Permeability very slow in the subsoil and substratum; high water table.

Management of Soils Under Irrigation

The Tri-County Area receives an average annual precipitation of about 20 inches, approximately four-fifths of which falls during the growing season. In many years dry periods reduce the yields and quality of crops. Because of this, it is anticipated that irrigation would significantly benefit the agriculture of the area.

Under irrigation a wider number of crops can be grown, especially on soils that have low available moisture capacity. Also, on nearly all tillable soils, yields of crops can be stabilized in dry years. Furthermore, crops that require the full growing season to mature can be used to replace most of the early maturing small grains, such as those now grown in the Tri-County Area.

The relief throughout most of the survey area is favorable for irrigation. In about 90 percent of the acreage, the soils are nearly level. The slopes are between 3 and 5 percent in about 6 percent of the acreage, and they are 6 percent or greater in about 4 percent. In the sloping areas the cost of leveling is an important consideration if gravity irrigation is to be used. The cost of such a system must be considered in relation to the gains to be derived from increased yields. The choice of a proper system of water distribution can minimize the disadvantage of unfavorable slope.

Most of the soils in the Tri-County Area that are suitable for irrigation are on the Sheyenne Delta and in the beach area. The Sheyenne Delta slopes gently to the northeast and has a drop of about 2 feet to the mile. Practically all of the precipitation that falls within the Sheyenne Delta enters the soils. The beach area is at about the same elevation as the Sheyenne Delta, and it slopes gently eastward between the beach ridges. At each beach ridge, there is a rather sharp change in elevation within a short distance.

When irrigation is to be established in the Tri-County survey area, drainage will be necessary in some places. The Sheyenne Delta has no natural drainage, except for a few short coulees along the edges of the delta. In the beach area water accumulates at the base of the beach ridges, and it is likely that interceptor drains would be needed in those areas and at the edge of the lake plain. In a number of places, till substratum phases of soils have been mapped along the eastern edge of the beach area. The thin mantle of lake sediments overlying the glacial till indicates that much or all of the beach area from here to the till plain on the west is underlain by glacial till. Depth to the underlying till varies within short distances because of the undulating topography of the glacial till deposits. Unless water entering Glacial Lake Agassiz or the waters of the lake smoothed the surface of the till at the time of mantling, it is probable that the irregular topography of the underlying till forms basins that could fill with water under irrigation and require extensive drainage.

Table 6 rates the soils of the Tri-County survey area according to their relative suitability for irrigation. The five ratings are *very good*, *good*, *fair*, *poor*, and *unsuitable*. For soils given a rating of "poor," there are serious man-

and management problems

Without leveling and drainage: Gravity	Without leveling and drainage: Sprinkler	With leveling and drainage: Gravity	With leveling and drainage: Sprinkler	Management problems
Unsuitable	Poor	Unsuitable	Poor	Waterlogging; salting.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigable.
Poor	Poor	Fair to good	Fair to good	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Poor	Poor	Fair to good	Fair to good	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Unsuitable	Poor	Fair	Fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Poor	Good	Good	Improving and maintaining fertility.
Poor	Fair to good	Good to fair	Good	Waterlogging; salting; distributing water; controlling erosion by wind and water.
Unsuitable	Poor	Poor to fair	Fair	Waterlogging; salting; distributing water; controlling erosion by wind and water.
Unsuitable	Unsuitable to poor	Poor to unsuitable	Poor	Waterlogging; salting; distributing water; controlling erosion by wind and water.
Poor	Fair to good	Good to fair	Good	Waterlogging; salting; distributing water; controlling erosion by wind and water.
Poor	Poor to fair	Fair to good	Fair to good	Waterlogging; salting.
Poor	Poor to fair	Fair to good	Good to fair	Waterlogging; salting.
Unsuitable	Unsuitable	Poor to fair	Poor to fair	Waterlogging; salting.
Poor	Poor to fair	Good to fair	Good	Waterlogging; salting.
Poor	Poor	Good	Good	Waterlogging; salting.
Unsuitable	Poor	Good	Good	Waterlogging.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigated.
Unsuitable	Unsuitable to poor	Unsuitable	Poor	Waterlogging; salting.

TABLE 6.—*Irrigation ratings, limitations,*

Map symbol	Mapping unit	Limitations
Dv	Divide loam	Fair available moisture capacity; seasonal high water table; low fertility.
EcA	Eckman loam, nearly level	None
EcB	Eckman loam, undulating	Undulating topography
EcC	Eckman loam, rolling	Rolling topography
EgB	Eckman loam, till substratum, undulating	Undulating topography; permeability of the substratum; salinity
EnA	Egeland fine sandy loam, nearly level	Low available moisture capacity; low fertility
EnB	Egeland fine sandy loam, undulating	Undulating topography; low available moisture capacity; low fertility.
Eo	Embden fine sandy loam	Fair available moisture capacity; low fertility
Ep	Embden-Gardena complex	Slow permeability in the substratum; fair available moisture capacity; low fertility.
Es	Embden-Glyndon fine sandy loams	Fair available moisture capacity; seasonal high water table; low fertility.
Et	Embden and Hecla fine sandy loams	Slow permeability in the substratum; low available moisture capacity; low fertility.
Ex	Exline complex	Alkalinity; salinity; dispersion; very slow permeability
Fa	Fairdale silt loam, levee	Unfavorable topography
Fc	Fargo clay	Very slow permeability in the substratum; salinity; high water table.
Fg	Fargo silt loam	Very slow permeability in the substratum; salinity; high water table.
Fh	Fargo silty clay loam	Very slow permeability in the substratum; salinity; high water table
Fk	Fargo silty clay loam, saline	Subsoil and substratum saline and have slow permeability; high water table.
Fn	Fargo-Exline silty clay loams	Alkalinity; dispersion; subsoil and substratum saline and have slow permeability.
WeA	Fordville loam, nearly level	Fair available moisture capacity; low fertility
WeB	Fordville loam, undulating	Unfavorable topography; fair available moisture capacity
WsA	Fordville sandy loam, nearly level	Fair available moisture capacity; low fertility
WsB	Fordville sandy loam, undulating	Unfavorable topography; fair available moisture capacity; low fertility.
Fw	Fresh water marsh	Not applicable
GbA	Gardena loam, very deep, nearly level	None
GbB	Gardena loam, very deep, undulating	Undulating topography
GcA	Gardena loam, deep, nearly level	None
GdA	Gardena loam, moderately shallow, nearly level	Slow permeability in the substratum
GdB	Gardena loam, moderately shallow, undulating	Undulating topography
GeA	Gardena loam, till substratum, nearly level	Moderate to slow permeability in the substratum; salinity
GfA	Gardena-Eckman loams, till substratum, nearly level	Moderate to slow permeability in the substratum; salinity
GgA	Gardena-Glyndon loams, nearly level	Seasonal high water table
GkA	Gardena-Glyndon loams, till substratum, nearly level	Moderately slow permeability in the substratum; salinity; seasonal high water table.
GmA	Glyndon loam, very deep, nearly level	Seasonal high water table; low fertility
GmB	Glyndon loam, very deep, undulating	Undulating topography; seasonal high water table; low fertility
GnA	Glyndon loam, deep, nearly level	Slow permeability in the substratum; salinity; high water table; low fertility.
GsA	Glyndon-Borup loams, strongly saline, nearly level	Salinity; high water table; moderate permeability in the substratum; low fertility.
GtA	Glyndon and Gardena loams, nearly level	Slow permeability in the substratum; seasonal high water table; low fertility.
GuA	Glyndon and Hamerly loams, saline, nearly level	Salinity; moderate to slow permeability in the substratum; low fertility.
Gv	Gravel pits	Not applicable
Ha	Hamar fine sandy loam	Low available moisture capacity; seasonal high water table; low fertility.
Hb	Hamar-Ulen fine sandy loams	Low available moisture capacity; seasonal high water table; low fertility.
Hc	Hamar-Ulen loamy fine sands	Low available moisture capacity; seasonal high water table; low fertility.
HdB	Hamerly complex, undulating	Undulating topography; slow permeability in the substratum; salinity; seasonal high water table; low fertility.
HeA	Hamerly loam, nearly level	Slow permeability in the substratum; salinity; seasonal high water table; low fertility.

and management problems—Continued

Without leveling and drainage		With leveling and drainage		Management problems
Gravity	Sprinkler	Gravity	Sprinkler	
Poor to fair	Fair	Good	Good	Improving and maintaining fertility.
Fair	Very good	Very good	Very good	None.
Poor	Good	Very good	Very good	Distributing water; controlling erosion by wind and water.
Unsuitable	Poor	Poor to fair	Fair	Distributing water; controlling erosion by wind and water.
Poor	Fair	Good to fair	Good	Waterlogging; salting; distributing water; controlling erosion by wind and water.
Poor to fair	Good to fair	Good to fair	Good to fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Good to fair	Good to fair	Good to fair	Distributing water; controlling wind and water erosion; improving and maintaining fertility.
Fair	Good	Good	Good	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Poor to fair	Fair	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Poor to fair	Fair	Good	Good	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Poor to good	Poor to good	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigable.
Poor	Fair	Very good	Very good	Soil is not irrigable.
Unsuitable	Poor	Poor to unsuitable	Poor	Waterlogging; salting.
Unsuitable	Poor	Poor to unsuitable	Poor	Waterlogging; salting.
Unsuitable	Poor	Poor to unsuitable	Poor	Waterlogging, salting.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigable.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigable.
Fair	Good	Good	Good	Improving and maintaining fertility.
Poor	Good	Good	Good	Improving and maintaining fertility; distributing water; controlling water erosion.
Fair	Good	Good	Good	Controlling wind erosion; maintaining fertility.
Poor	Good	Good	Good	Controlling wind erosion; improving and maintaining fertility; distributing water.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil is not irrigable.
Fair	Very good	Very good	Very good	None.
Poor	Fair	Very good	Very good	Distributing water; controlling water erosion.
Fair	Very good	Very good	Very good	None.
Poor	Good	Good to very good	Good to very good	Waterlogging.
Poor	Good	Good to very good	Good to very good	Distributing water; erosion; waterlogging.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Fair to poor	Fair	Very good	Very good	Waterlogging.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Poor	Fair	Very good	Very good	Waterlogging; improving and maintaining fertility.
Poor	Fair to poor	Good	Very good	Waterlogging; distributing water; improving and maintaining fertility; controlling water erosion.
Poor	Fair	Poor	Fair	Waterlogging; salting; improving and maintaining fertility.
Unsuitable	Unsuitable	Fair	Fair	Waterlogging; salting; improving and maintaining fertility.
Poor	Fair	Poor to good	Fair	Waterlogging; improving and maintaining fertility.
Unsuitable	Unsuitable	Fair	Fair	Waterlogging; salting; improving and maintaining fertility.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Not irrigable.
Poor	Fair to poor	Fair	Fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair to poor	Fair	Fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Poor to fair	Poor to fair	Fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Fair to good	Good	Distributing water; water erosion; waterlogging; salting; improving and maintaining fertility.
Poor	Fair	Fair to good	Good	Waterlogging; salting; improving and maintaining fertility.

TABLE 6.—*Irrigation ratings, limitations,*

Map symbol	Mapping unit	Limitations
HgB	Hamerly-Barnes loams, undulating	Undulating topography; moderately slow to slow permeability in the substratum; salinity; seasonal high water table.
HkAx	Hecla fine sand, nearly level	Very low available moisture capacity; low fertility
HlAx	Hecla fine sandy loam, nearly level	Low available moisture capacity; low fertility
HmA	Hecla fine sandy loam, moderately shallow, nearly level	Slow permeability in the substratum; low available moisture capacity; low fertility.
HoAx	Hecla loamy fine sand, loamy substratum, nearly level	Very low available moisture capacity; low fertility; slow permeability in the substratum.
HpAx	Hecla loamy fine sand, moderately shallow, nearly level	Low available moisture capacity; low fertility; moderately slow permeability in the substratum.
HrA	Hecla sandy loam, loamy substratum, nearly level	Low available moisture capacity; low fertility
HsAx	Hecla soils, nearly level	Low available moisture capacity; low fertility
HtAx	Hecla and Embden fine sandy loams, nearly level	Low available moisture capacity; low fertility
HuB2	Hecla-Hamar complex, hummocky, eroded	Very low available moisture capacity; high water table; low fertility; unfavorable topography.
HvAx	Hecla and Hamar loamy fine sands, nearly level	Rapid permeability in the subsoil and substratum; very low available moisture capacity; high water table.
HxAx	Hecla-Ulen fine sandy loams, nearly level	Fair available moisture capacity; seasonal high water table; low fertility; slow permeability in the substratum.
HyAx	Hecla-Ulen fine sandy loams, loamy substratum, nearly level.	Fair available moisture capacity; seasonal high water table; low fertility.
La	Lamoure silty clay loam	Permeability moderately slow in the substratum; high water table
Lf	La Prairie and Fairdale soils	Unfavorable topography; low fertility
Lp	La Prairie silt loam	Moderately slow permeability in the substratum.
MaAx	Maddock fine sandy loam, nearly level	Low available moisture capacity; low fertility
MaBx	Maddock fine sandy loam, undulating	Unfavorable topography; low available moisture capacity; low fertility.
MaCx	Maddock fine sandy loam, rolling	Unfavorable topography; low available moisture capacity; low fertility.
MdAx	Maddock loamy fine sand, nearly level	Very low available moisture capacity; low fertility
MdBx	Maddock loamy fine sand, undulating	Unfavorable topography; very low available moisture capacity; low fertility.
MhD	Maddock soils, hilly	Unfavorable relief; very low available moisture capacity; low fertility.
MkAx	Maddock loamy fine sand, moderately shallow, nearly level.	Moderately slow or very slow permeability in the substratum; low available moisture capacity; low fertility.
Mx3	Maddock-Hamar complex, severely eroded	Unfavorable topography
OaA	Overly silt loam, nearly level	Moderately slow or slow permeability in the substratum; salinity
ObA	Overly silt loam, saline, nearly level	Moderately slow or slow permeability in the substratum; salinity; seepage.
OcA	Overly silty clay loam, nearly level	Moderately slow or slow permeability in the substratum; salinity
OxA	Overly-Exline complex, nearly level	Alkalinity; dispersion; high water table; moderately slow or slow permeability in the substratum.
OyA	Overly-Gardena loams, nearly level	Moderately slow or slow permeability in the substratum
Pa	Parnell soils	Slow permeability in the substratum; high water table
Pe	Perella silt loam	Slow permeability in the substratum; high water table
Pr	Perella silty clay loam	Slow permeability in the substratum; high water table
Ra	Rauville soils	Slow permeability in the substratum; high water table
RnA	Renshaw and Sioux loams, nearly level	Low available moisture capacity; shallow over gravel; low fertility
RnB	Renshaw and Sioux loams, undulating	Unfavorable topography; low available moisture capacity; shallow over gravel; low fertility.
RsA	Renshaw and Sioux sandy loams, nearly level	Low available moisture capacity; shallow over gravel; low fertility
RsC	Renshaw and Sioux sandy loams, rolling	Unfavorable topography; low available moisture capacity; shallow over gravel; low fertility.
Sa	Sioux gravelly loam	Unfavorable topography; very low available moisture capacity; very shallow over gravel; low fertility.
SbC	Sioux and Renshaw loams, rolling	Unfavorable topography; low available moisture capacity; shallow over gravel; low fertility.
ScA	Spottswood loam, loamy substratum, nearly level	Fair available moisture capacity; seepage; slow permeability in the lower part of the substratum.

and management problems—Continued

Without leveling and drainage		With leveling and drainage		Management problems
Gravity	Sprinkler	Gravity	Sprinkler	
Poor	Fair	Fair to good	Good	Waterlogging; salting; improving and maintaining fertility; distributing water; water erosion.
Poor	Poor to fair	Poor	Poor to fair	Wind erosion; improving and maintaining fertility; distributing water.
Poor to fair	Good to fair	Good to fair	Good to fair	Controlling wind erosion; improving and maintaining fertility.
Poor to fair	Good to fair	Good to fair	Good to fair	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Poor to fair	Fair	Controlling wind erosion; distributing water; improving and maintaining fertility; waterlogging.
Poor	Fair	Fair	Fair	Controlling wind erosion; distributing water; improving and maintaining fertility; waterlogging.
Poor	Fair	Fair to good	Fair to good	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Fair to good	Fair to good	Controlling wind erosion; distributing water; improving and maintaining fertility.
Poor	Fair	Good to fair	Good to fair	Controlling wind erosion; improving and maintaining fertility.
Unsuitable	Poor	Poor	Fair	Controlling wind erosion; distributing water; improving and maintaining fertility.
Poor	Poor to fair	Poor to fair	Fair	Waterlogging; distributing water; controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Good to fair	Good to fair	Controlling wind erosion; improving and maintaining fertility; waterlogging.
Poor	Fair	Good to fair	Good to fair	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Good to fair	Good to fair	Waterlogging.
Unsuitable	Poor to fair	Very good to good	Very good	Improving and maintaining fertility.
Fair	Very good	Very good	Very good	Waterlogging.
Poor	Fair to good	Fair	Fair to good	Controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Fair	Fair	Controlling wind erosion; distributing water; improving and maintaining fertility.
Unsuitable	Fair	Fair	Fair	Distributing water; controlling wind erosion; improving and maintaining fertility.
Poor	Poor	Poor	Poor	Controlling wind erosion; distributing water; improving and maintaining fertility.
Unsuitable	Poor	Poor	Poor	Controlling wind erosion; improving and maintaining fertility; distributing water.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil not irrigable.
Poor to unsuitable	Fair	Fair to unsuitable	Fair	Waterlogging; controlling wind erosion; improving and maintaining fertility; distributing water.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil not irrigable.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Unsuitable	Unsuitable	Poor	Poor	Waterlogging; salting.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Soil not irrigable.
Fair	Good	Good to very good	Very good to good	Waterlogging.
Unsuitable	Unsuitable to poor	Poor to unsuitable	Poor to fair	Waterlogging.
Unsuitable	Unsuitable to poor	Poor to unsuitable	Poor to fair	Waterlogging.
Unsuitable	Unsuitable to poor	Poor to unsuitable	Poor to fair	Waterlogging.
Unsuitable	Unsuitable to poor	Fair	Good	Waterlogging.
Unsuitable	Fair	Poor	Fair	Distributing water; improving and maintaining fertility.
Unsuitable	Poor to fair	Unsuitable	Poor to fair	Distributing water; improving and maintaining fertility; controlling water erosion.
Unsuitable	Fair	Poor	Fair	Distributing water; improving and maintaining fertility; controlling wind erosion.
Unsuitable	Poor to fair	Unsuitable	Poor to fair	Distributing water; improving and maintaining fertility; controlling wind erosion.
Unsuitable	Poor	Unsuitable	Poor	Unfavorable topography; improving and maintaining fertility; distributing water; controlling water erosion.
Unsuitable	Poor	Unsuitable	Poor	Unfavorable topography; improving and maintaining fertility; distributing water; controlling water erosion.
Fair	Good	Good	Good	Seepage from adjacent areas; waterlogging.

TABLE 6.—*Irrigation ratings, limitations,*

Map symbol	Mapping unit	Limitations
SdA	Spottswood sandy loam, loamy substratum, nearly level	Fair available moisture capacity; low fertility; seepage; slow permeability in the lower part of the substratum.
SmA	Spottswood-Embden sandy loams, nearly level	Fair available moisture capacity; low fertility; seepage
SoA	Spottswood-Gardena loams, nearly level	Seepage
St	Stirum-Glyndon complex	Alkalinity; moderate to very slow permeability in the subsoil and moderately slow to very slow permeability in the substratum; salinity; high water table; soil dispersion.
Sx	Svea-Barnes loams	Moderately slow or slow permeability in the substratum; salinity
Sy	Svea-Hamerly loams	Moderately slow or slow permeability in the substratum; salinity; high water table.
Tf	Tiffany fine sandy loam	Fair available moisture capacity; high water table; low fertility
Tk	Tetonka silt loam	Moderately slow to slow permeability in the subsoil and substratum
Uc	Ulen complex, saline	Fair available moisture capacity; moderately rapid to moderately slow permeability in the substratum; salinity; high water table.
Uf	Ulen fine sandy loam	Fair available moisture capacity; high water table; low fertility
Um	Ulen fine sandy loam, loamy substratum	Moderately slow to slow permeability in the substratum; fair available moisture capacity; low fertility; high water table.
Un	Ulen fine sandy loam, moderately shallow	Moderately slow to slow permeability in the substratum; high water table; low fertility.
Us	Ulen-Gardena fine sandy loams	Moderately rapid to moderately slow permeability in the substratum; fair available moisture capacity; low fertility.
Vr	Vallers loam	Moderately slow or slow permeability in the substratum; salinity; high water table; low fertility.
ZfB	Zell fine sandy loam, undulating	Unfavorable topography; low fertility
ZmB	Zell loam, undulating	Unfavorable topography; low fertility
ZmD	Zell loam, strongly rolling	Unfavorable topography

agement problems, or serious management problems may be expected within a short period after the soils are placed under irrigation. The ratings given for suitability for irrigation are based almost exclusively on the characteristics of the soil. In preparing these ratings it was assumed that the soil is to be leveled and drained, unless it is steep or hilly or has characteristics that make it unsuitable for irrigation. Examples of soils that are not suitable for irrigation are Buse loam, hilly, and the soils of the Exline complex.

Limitations for irrigation are also indicated in table 6. The limitations of unfavorable topography and poor drainage can generally be corrected by leveling and draining the soils, but some of the soils have other limitations that affect management. Bearden silt loam, for example, is saline, has moderately slow or slow permeability in the substratum, and has a seasonally high water table. After this soil has been drained and leveled, the salinity and moderately slow or slow permeability in the substratum make careful management necessary to prevent salting and waterlogging.

Limited information is available on which to base estimated yields for irrigated soils. The proportionate increase in yields under irrigation will be lowest, however, on those soils that produce best under dryland farming. Soils that are somewhat droughty, and that therefore do not make high yields under dryland farming, will have a higher proportionate increase in yields. The following are yields that may be expected under good management on irrigated Eckman and Gardena soils and on other irrigated soils that are well suited to crops: Corn yields of 90 bushels of grain or 20 tons of silage; alfalfa yields of 5 to 6 tons per acre; potato yields of 400 bushels per acre; and sugar beet yields of 20 tons per acre. Although these yields are good, the greatest benefits derived from irrigation are the more stable yields and the protection from losses caused by drought.

Soils comparable to the Eckman and Gardena soils have been irrigated at the North Dakota State University Irrigation Experiment Station at Carrington in the central part of North Dakota. At this station, the growing season is shorter, the temperatures are lower, and less precipitation is received than in the Tri-County survey area.

Olson and Hemstad (*8*) report yields of irrigated crops as compared with yields obtained under dryland farming at the Carrington station for the 3-year period 1962–64. A summary of their information is given in table 7. In brief, table 7 shows that response to irrigation is better for corn, potatoes, and other crops that require a long or fairly long growing season than it is for small grains.

In evaluating the information given in table 7, two factors should be considered. First, the dryland crops for which yields were determined were grown on land that was fallowed the previous year; and second, in the period covered by the table (1962–64) rainfall was above normal for this area. It is likely, therefore, that the proportionate

and management problems—Continued

Without leveling and drainage		With leveling and drainage		Management problems
Gravity	Sprinkler	Gravity	Sprinkler	
Fair	Good	Good	Good	Controlling wind erosion; seepage from adjacent areas; improving and maintaining fertility; waterlogging.
Fair	Good	Good	Good	Controlling wind erosion; seepage from adjacent areas; improving and maintaining fertility.
Fair	Good	Very good	Very good	Seepage from adjacent areas.
Unsuitable	Poor to unsuitable	Poor to unsuitable	Poor to unsuitable	Waterlogging; salting; dispersion; poor tilth; improving and maintaining fertility.
Fair	Good to fair	Good to fair	Good	Waterlogging; salting.
Poor	Fair	Good to fair	Good	Waterlogging; salting.
Poor	Poor to fair	Good	Good	Waterlogging; salting; controlling wind erosion; improving and maintaining fertility.
Unsuitable	Unsuitable to poor	Poor to unsuitable	Poor to fair	Improving and maintaining fertility; waterlogging.
Unsuitable	Poor	Fair to good	Good	Waterlogging; salting; controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Good	Good	Waterlogging; salting; controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Good	Good	Waterlogging; controlling wind erosion; improving and maintaining fertility.
Poor	Fair	Good	Good	Waterlogging; controlling wind erosion; improving and maintaining fertility; salting.
Poor	Fair	Good	Good	Waterlogging; salting; controlling wind erosion; improving and maintaining fertility.
Unsuitable	Poor	Fair	Fair	Waterlogging; improving and maintaining fertility; salting.
Unsuitable	Poor	Poor to fair	Fair	Controlling wind erosion; improving and maintaining fertility; distributing water.
Unsuitable	Poor	Poor to fair	Fair	Distributing water; controlling erosion by wind and water; improving and maintaining fertility.
Unsuitable	Unsuitable	Unsuitable	Unsuitable	Distributing water; controlling erosion by wind and water; maintaining and improving fertility.

TABLE 7.—*Yields of crops under irrigation expressed as a percentage of the yield obtained under dryland farming*

Crop	1962	1963	1964	3-year average
	Percent	*Percent*	*Percent*	*Percent*
Hard red spring wheat	140	111	83	111
Durum wheat	133	96	85	105
Barley	134	98	134	122
Oats	111	92	103	102
Flax	------	157	143	150
Potatoes	102	238	223	188
Corn harvested:				
For grain	143	281	174	199
For silage	------	219	152	186

increases were lower for this period than the increases to be expected over a longer period that would include years of normal and below-normal precipitation.

Use of Soils for Engineering

By studying the soil descriptions in this report, engineers can learn a great deal about the soils that will affect their use in roads and other structures. Following are some general comments about these characteristics that are particularly significant to engineers.

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Dispersion, that is, the deflocculation of the soil and its suspension in water, is high in the Aberdeen, Exline, and Stirum soils. It is moderate in the saline phases of the Borup, Fargo, Glyndon, Hamerly, and Overly soils. Dispersion is low in the other soils.

The shrink-swell potential is high for the Bearden, Dimmick, Exline, Fargo, Lamoure, Overly, Parnell, and Perella soils. The other soils have a low shrink-swell potential.

Susceptibility to frost action is high in the Bearden, Borup, Dimmick, Exline, Fargo, Lamoure, Parnell, Rauville, Stirum, and Vallers soils. It is moderate in the Aberdeen, Arveson, Divide, Glyndon, Hamar, Hamerly, Tetonka, and Tiffany soils and slight in the Barnes, Buse, Eckman, Fairdale, Gardena, La Prairie, Svea, and Zell soils. The rest of the soils are not susceptible to frost action.

As a *source of topsoil*, the Gardena, La Prairie, Spottswood, and Svea soils, and the Overly soils that are not saline are excellent. The Barnes, Eckman, and Embden soils and the Bearden and Glyndon soils that are not saline are good sources. The Divide, Egeland, Fordville, Lamoure, and Tiffany soils, and the Fargo and Ulen soils that are not saline are fair sources. The Aberdeen, Arveson, Buse, Dimmick, Fairdale, Hamar, Hecla, Maddock, Parnell, Perella, Renshaw, Vallers, and Zell soils, and the Borup and Hamerly soils that are not saline are poor sources. Soils not suitable as a source of topsoil are the saline soils and the Exline, Rauville, Sioux, and Stirum soils.

Gravel and sand can be obtained from the Divide, Fordville, Renshaw, Sioux, and Spottswood soils. The gravel contains some shale.

Surface drainage is needed in some places on the Arveson, Egeland, Embden, Hamar, Hecla, Maddock, Stirum, Tiffany, and Ulen soils. Those soils are susceptible to erosion, however, and the side slopes of drains are unstable. The other soils in the survey area are resistant to erosion, except where the sides of the drainageways are steep.

Formation and Classification of Soils

This section has three main parts. First, the major factors of soil formation are discussed in terms of their effect on the soils of the Tri-County survey area. Then, the two systems used in the United States for classifying soils are briefly defined, the soils are placed in these two systems, and the great soil groups are discussed. Finally, the soil series are described in detail. For representative soil series, laboratory data are given in the section "Physical and Chemical Analyses of Soils."

Factors of Soil Formation

The kind of soil that develops in a given place depends upon the five factors of soil formation, parent material, climate, living organisms, relief, and time. The influence of each factor differs from place to place.

Climate and living organisms are the active factors of soil formation, and the kinds of living organisms in an area, in turn, depend upon the climate. Parent material influences the texture and fertility of the soil. Relief influences the relationships among soil, water, and plants by its effect upon the amount of runoff and the amount of water that enters the soil. Other factors being equal, time also affects the degree to which a soil develops. Each of these five factors and the influence they have had on the development of soils in the survey area are discussed briefly in the following paragraphs.

Parent Material.—In the Pleistocene epoch, the survey area was covered by the Mankato substage of the Late Wisconsin glaciation. During that period, glacial till, glacial lake sediments, and eolian and alluvial sediments were deposited and became the parent material of the soils in this area. This parent material was exposed to the processes of soil formation for about ten thousand years.

The glacial till in the survey area is calcareous loam of mixed mineralogy. Unlike the glacial lake sediments and the eolian and alluvial sediments, it is unsorted and contains particles that range from very coarse sand to clay in size. In addition, it contains pebbles and cobbles and other stones that occur in variable amounts throughout the material. The sediments deposited in glacial lakes range from loamy fine sand to clay in texture, but the texture of the eolian sediments is dominantly fine sand and loamy fine sand. In most places the texture of the stream valley alluvium is silt loam to silty clay loam, but there are thin layers of fine sandy loam in places.

The parent material of glacial lake origin occurs in a definite pattern, according to the way it was deposited. The coarser textured glacial material is along the outer margins of the lake, and the finer textured material is mainly toward the center of the lake. The alluvial sediments are coarser near the stream channel and finer at a greater distance from the point of overflow. In both the material of glacial lake origin and the alluvium, the coarser textured material is deposited in areas where the movement of water is greatest.

Parent material that is dominantly coarse textured or fine textured influences greatly the formation of soils. Also, parent material in which a specific mineral is dominant influences the formation of soils by its mineralogical composition. Soils formed from sandy parent material that is high in content of quartz, for example, have low available moisture capacity and rapid permeability, and they are low in plant nutrients. Soils formed in loamy parent material generally have good available moisture capacity and a good supply of plant nutrients. Typical of soils formed in dominantly coarse-textured material are the Maddock soils, formed in eolian sand. The Fargo soils, on the other hand, reflect the slow permeability and poor drainage of dominantly fine-textured parent material. They shrink when dry and swell when wet because of the high content of expanding 2:1 lattice clay in the parent material.

The pattern in which the parent material was deposited affects the kind of soil that develops. Stratified material, for example, may cause the lateral movement of water and the development of a water table so that the upward movement of water exceeds the downward movement. If this has occurred, intrazonal soils such as the Bearden, Arveson, and Stirum may develop, depending upon the amount of calcium carbonate or content of sodium in the upward-moving water.

Climate.—The climate of the survey area is subhumid continental. Winters are cold and summers are warm. The average annual precipitation is about 19 inches, and about 80 percent of the precipitation occurs in the period April through September. The climate is uniform throughout the survey area. Tall grasses are the dominant vegetation in this kind of climate.

The components of climate that affect the formation of soils are precipitation, temperature, humidity, and wind. Water is essential for chemical reactions to take place in the weathering of parent material. It is also necessary for the growth of plants and animals and for the removal of the end products of decomposition in solution. Temperature affects the rate of chemical reaction and the activity of living organisms. In winter chemical reaction and the activity of living organisms are essentially at a standstill during the period when the temperature is lowest and the smallest amount of precipitation is received. When the temperature is high, the greatest biological activity takes place and the greatest amount of precipitation is received. During the period when the temperature is high, the maximum weathering occurs and the decomposition of organic matter is most extensive.

In the survey area the average relative humidity at noon is about 48 percent during the month of July. At that time the air can take up a large amount of moisture transpired from plants or evaporated from the soils. This rather low level of humidity increases the losses of water by transpiration and evaporation. It also reduces the efficiency with which plants use and soils retain water. Transpiration and evaporation are rapid when the relative humidity is low, the temperature is high, and there is wind or air movement across the plants and soils.

Well-drained soils, such as the Barnes and Eckman, appear to reflect the maximum influence of climate upon their development. These soils have been leached free of lime to a depth of 14 to 20 inches. The soluble salts have been leached to a depth of more than 36 inches, and in some places they have been entirely leached out of the soil profile. A longer time would be needed for a significant amount of clay to form and accumulate in the soil profile.

Living Organisms.—The kind of vegetation in an area depends mainly upon the climate. Wherever the climate is modified by local relief, however, the kinds of plants vary according to the position on the landscape. Grasses were the dominant native vegetation in the Tri-County survey area, and tall grasses were more abundant than other kinds.

Grasses use a large amount of calcium and magnesium. They bring these elements to the surface in their stalks and leaves. Then, when the plant dies and decays, the calcium and magnesium are deposited in the surface layer. The remains of plants are rapidly decomposed by the bacteria in the soil, and the organic matter thus returned to the soil each year contains a good supply of plant nutrients. As a result of this decomposition, the content of organic matter increases in the soil profile, and plant nutrients are returned to the upper part.

The products of bacterial decomposition are stable and are relatively insoluble. They are only slightly mobile when they are in a nearly neutral medium in which the colloids have been flocculated by calcium. The result, where plants have decomposed and the organic matter has been mixed into the surface layer, is a very dark colored A1 horizon high in content of organic matter.

The kind of vegetation is influenced by local relief. For example, runoff is rapid in the steep areas occupied by the Buse soils. As a result, the amount of water that enters the soils is reduced. In these areas the dominant vegetation was mid and short grasses, although it also included needleleaf sedge. The kinds of grasses included blue grama, sideoats grama, little bluestem, prairie junegrass, needle-and-thread, and western wheatgrass. The native vegetation on the Barnes soils, which are well drained, was tall and mid grasses. Green needlegrass, western wheatgrass, little bluestem, needle-and-thread, and sideoats grama were the important grasses on those soils.

The native vegetation on the Svea soils, which are moderately well drained, was tall grasses, mainly green needlegrass, big bluestem, switchgrass, and porcupinegrass. The vegetation on the Parnell soils, which are poorly drained, was dominated by prairie cordgrass, mannagrass, rivergrass, and rushes.

Relief.—The content of water in the soil, the temperature of the soil, and the degree of erosion are all related to the microclimate of a given area, as affected by relief. Relief, and therefore the microclimate, also influences the kind and amount of vegetation in a given area. Facts about the relief of the survey area are described in the section "Physiography, Relief, and Drainage" near the front of the report. The components of relief that generally affect the development of soils are elevation, exposure, and slope. Elevation and exposure, however, have had little or no effect on the development of soils in the survey area. This is because the differences in elevation in this area are so slight, only about 200 feet, that they have not noticeably changed the effects of the temperature, precipitation, and evaporation on the development of a soil profile. Also, the effects of exposure, or direction of slope, are insignificant in the survey area. On the north-facing slopes of the valley of the Maple River, for example, woody vegetation grows higher up the slope than on the south-facing slopes. Not enough time has elapsed, however, since formation of the soils has taken place, for the trees and other woody plants to have had observable effects upon the development of the soil profile.

Slope is the one component of relief that has influenced the formation of soils in this area. The degree of slope influences the amount and velocity of runoff and the degree of erosion. The shape of the slope, whether convex, concave, or a nearly level plane, influences whether precipitation runs off, flows across, or accumulates in low or less steep areas.

Soils in which differences in slope have modified the factors of climate and plants and animals are those of the Barnes, Buse, Svea, and Tetonka series. All of these soils, except the Tetonka, developed in loam glacial till of the same age, but all of the soils have slopes of a different gradient or of a different shape. The Tetonka soils, unlike the other soils, developed in a layer of local alluvium of variable thickness over glacial till.

In the Barnes soils, which are well drained, are expressed the maximum effects of the active factors of soil formation, climate and living organisms. The Buse soils are steeper than the Barnes, and water runs off them more rapidly than off the Barnes soils. Also, erosion is more rapid and less water enters the soil. The soil material is removed through erosion almost as soon as it is added to the A1 horizon. Although the Buse soils developed in glacial till, the oldest sediment in the survey area, mainly under mid and short grasses, their steep relief slows the effects of the other factors of soil formation. As a result, the Buse soils exceed the Fairdale soils in degree of profile development only in having a darker A1 horizon. This is true, even though the Fairdale soils formed in the most recently deposited sediments in the survey area and do not have a well-developed profile.

The Svea soils are on gentle, concave slopes, and they receive additional moisture as runoff from the adjacent higher areas. Because of this extra moisture, the native vegetation on the Svea soils was a luxuriant growth of tall grasses. The grasses added organic matter and a large amount of plant nutrients to the soils and made the A1 horizon thicker than that in soils developed under a sparse cover of vegetation. The Svea soils are leached of lime to a greater depth than the Barnes soil because more water percolates through their profile.

The Tetonka soils are in shallow closed depressions in which water is ponded intermittently when runoff water accumulates. The amount of moisture received by these soils far exceeds the amount received through precipitation. The additional water increases percolation, weathering, oxidation and reduction, and the formation of clay. Translocated clay and organic colloids have accumulated in the B horizon. The native vegetation was tall grasses and sedges.

Time.—Time is a passive factor of soil formation. If all other factors are equal, the development of soil characteristics depends upon the length of time the soil material has been exposed to the soil-forming processes. For example, two soils may differ in the degree of expression of soil properties, even though they developed in the same kind of parent material, under a similar climate and similar vegetation, and have the same kind of relief. This is because of differences in the length of time the forces of soil formation have been operative. Soils that have been exposed to the forces of soil development over the longer period of time will have the most strongly developed profile.

The glacial till and sediments deposited in glacial lakes have been exposed to the processes of soil formation for about ten thousand years. The alluvium in the stream valleys is much younger. It has been exposed to the processes of soil formation for only a few tens or hundreds of years.

Classification of Soils

Soils are classified so that we may more easily remember their significant characteristics; assemble knowledge about them; see their relationships to one another and to the whole environment; and develop principles that help us understand their behavior and response to manipulation. First, through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Two systems of natural classification of soils are now in general use in the United States. One of these is the 1938 system, with later revisions (*1*, *6*, *10*, *15*). The other, a completely new system, was placed in general use by the Soil Conservation Service at the beginning of 1965 (*13*, *16*).

The 1938 system, with later revisions, consists of six categories. In the highest of these, soils of the whole country have been placed into three orders. The next two categories, the suborder and family, have not been fully developed. As a consequence, they have not been used much. Attention has been centered on lower categories, the great soil group, the soil series, and the soil type. A further subdivision of the soil type, called the soil phase, has been clearly defined, along with soil type and soil series, in the section "How Soils Are Mapped and Classified" in the front of this report. In this report the 1938 system, with later revisions, is explained more fully than the new system.

In the highest category of the 1938 classification system are the zonal, intrazonal, and azonal orders. The zonal order consists of soils with evident, genetically related horizons that reflect in their formation the dominant influences of climate and living organisms, chiefly vegetation. Typical zonal soils have a thick, black A1 horizon that has weak granular structure. They also have a very dark grayish-brown B horizon that has prismatic structure. In most of the zonal soils of the survey area, a horizon of lime accumulation, the Cca horizon, underlies the B horizon.

In the intrazonal order are soils that have evident, genetically related horizons that reflect the dominant influence of some local factor of relief, drainage, or parent material over the influences of climate and vegetation.

The azonal order consists of soils that lack distinct, genetically related horizons, generally because of youth, resistant parent material, or steep relief.

The classification of the soil series of the Tri-County survey area into orders and great soil groups under the 1938 classification system is shown in the following tabulation:

Order and great soil group	*Series*
Zonal—	
Chernozem	Barnes, Eckman, Egeland, Embden, Fordville, Gardena, Hecla, Maddock (intergrading toward Regosols), Overly, Renshaw, Spottswood, Svea.
Intrazonal—	
Grumusol	Fargo.
Humic Gley	Dimmick, Hamar, Lamoure, Parnell, Perella, Rauville, Tiffany.
Planosol	Tetonka.
Solonchak	Arveson, Bearden, Borup, Divide, Glyndon, Hamerly, Ulen, Vallers.
Solonetz	Aberdeen, Exline, Stirum.
Azonal—	
Alluvial	Fairdale, La Prairie (intergrading toward Chernozems).
Regosol	Buse, Sioux, Zell.

The new system of soil classification recently adopted by the Soil Conservation Service also contains six categories. They are, beginning with the most inclusive, the order, suborder, great group, subgroup, family, and series.

In this system the criteria used as bases for classification are observable or measurable soil properties. The properties are so chosen, however, that soils of similar genesis or mode of origin are grouped together.

In the following paragraphs the great soil groups of the 1938 classification system are defined. Each soil series in the great group has also been tentatively placed in a subgroup of the new comprehensive system.

CHERNOZEMS

Chernozems are the zonal soils of the survey area. Typically, they have a thick, black or nearly black A1 horizon rich in content of organic matter; a brown or very dark grayish-brown transitional B2 horizon that may contain more clay than the A horizon; and a lighter colored C horizon that has an accumulation of lime at a depth of 1½ to 4 feet. Their A1 horizon is slightly acid to neutral, and the soil material above the Cca horizon becomes more alkaline with increasing depth. Base saturation is greater than 85 percent. The Chernozems developed under tall grasses or a mixture of tall and short grasses in a subhumid, temperate to cool temperate climate.

In the survey area the Chernozems are nearly level to sloping and are well drained or moderately well drained. They developed in material of glacial origin—till, outwash, and sediments deposited in glacial lakes. This material is of mixed mineralogy. It ranges from silty clay loam to fine sand in texture.

The Chernozems that developed in loam to silty clay loam (Barnes and Overly) have an A1, B2, Cca, and C sequence of horizons. The A1 horizon is black and has crumb or granular structure. It is slightly acid to neutral and contains 4 to 5 percent organic matter. The B2 horizon is very dark grayish brown to dark grayish brown. In the moderately well drained soils, it has faint mottles of gray and reddish brown, and the color boundaries are less distinct than in well-drained Chernozems. The B2 horizon has weak to moderate prismatic structure. It is neutral in the upper part and mildly to moderately alkaline in the lower part. The Cca horizon is grayish brown to brownish gray and is moderately alkaline and high in content of lime. The calcium carbonate equivalent is between 15 and 25 percent in most places. The C horizons below the Cca horizon are grayish brown and are moderately alkaline. They have a calcium carbonate equivalent, in the lower part, of 10 to 18 percent but most commonly between 12 and 16 percent. In places the C horizon contains gypsum crystals and is slightly saline.

The Chernozems that developed in material of fine sandy loam texture (Egeland and Embden) have weak prismatic structure in the B2 horizon. They have an indistinct Cca horizon.

The Chernozems that developed in material of loamy fine sand texture (Hecla and Maddock) have a B horizon that is primarily a color B horizon because prismatic structure has not developed. They lack a Cca horizon and are commonly noncalcareous to a depth of 5 feet or deeper.

The major processes in the development of Chernozems are (1) the leaching of carbonates and salts from the A and B horizons, (2) the accumulation of organic matter, (3) the development of structure in the A and B horizons, (4) changes in color in the A and B horizons, and (5) the accumulation of lime in the upper C horizon to form a Cca horizon. For the Chernozems in the Tri-County survey area, the length of time the parent material has been affected by the other factors of soil formation has been too short for the formation, removal, and accumulation of a significant amount of clay.

Following are the soil series in the Chernozem great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil Series	*Subgroup in the new comprehensive system*
Barnes	Typic Haploborolls.
Eckman	Typic Haploborolls.
Egeland	Typic Haploborolls.
Embden	Aquic Cumulic Haploborolls.
Fordville	Typic Haploborolls.
Gardena	Aquic Cumulic Haploborolls.
Hecla	Aquic Cumulic Haploborolls.
Maddock	Entic Haploborolls.
Overly	Aquic Cumulic Haploborolls.
Renshaw	Typic Haploborolls.
Spottswood	Cumulic Haploborolls.
Svea	Aquic Cumulic Haploborolls.

GRUMUSOLS

Grumusols are an intrazonal group of soils that have a profile rather high in content of clay, relatively uniform in texture, and marked by signs of local soil movement resulting from shrinking and swelling as the soils wet and dry. Many of these soils have a thick, dark A horizon over a limy C horizon; others are uniform in general appearance, except for the signs of churning. The soils of this great group formed in parent material high in content of clay, or in alkaline soil material, or from rocks that provided abundant clay and alkaline soil material upon weathering. Soils of this group occur mainly in a climate where wet and dry seasons alternate.

The sequence of horizons in the Grumusols is A1, Bg, and Cg. The A1 horizon is black, is neutral to mildly alkaline, and has strong, fine, granular and blocky structure. The Bg horizon is olive gray. It is moderately alkaline and is slightly calcareous in the lower part. The structure of the Bg horizon is strong, fine, blocky. The B2 horizon is discontinuous. It is broken by vertical, wedge-shaped, black tongues of material from the A1 horizon that extend downward into the C horizon at intervals of 12 to 36 inches. The Bg horizon grades to an olive-gray C horizon that has strong blocky structure. It is calcareous and moderately alkaline, and it contains clusters of gypsum crystals in some places. The lower part of the C horizon is slightly saline. When these soils are dry for a long period, cracks develop that are 1 to 3 inches wide and as much as 36 inches deep. Soil material from the surface layer falls or is washed into these shrinkage cracks and develops into block-shaped tongues. Slickensides occur in places in the lower part of the Bg horizon and in the Cg horizon.

The principal processes in the formation of Grumusols are (1) the accumulation of organic matter, (2) the leaching of soluble salts from the A1 and Bg horizons into the C horizons, (3) the development of colors associated with wetness, (4) the leaching of carbonates from the A1 and upper part of the Bg horizon, (5) the development of common deep tongues of material from the A1 horizon that extend downward into the C horizon, and (6) the development of occasional slickensides in the lower part of the Bg horizon and in the C horizon.

In the Tri-County survey area, the only soil series in the Grumusol great soil group is the Fargo. The Fargo are nearly level soils developed in areas of clayey sediments deposited in glacial lakes. These soils have a high content of expanding 2:1 lattice clays. The Fargo series has been classified in the Haplaquoll great group of the new comprehensive system.

HUMIC GLEY SOILS

The Humic Gley soils are in the intrazonal order. They are a group of poorly drained or very poorly drained soils that have a thick, black A horizon, high in content of organic matter, over a gray or mottled B or C horizon. These soils formed in low areas or depressions under marsh plants or swamp forest in a subhumid, cool-temperate to warm-temperate climate. In this survey area the Humic Gley soils developed in material of glacial origin—till, outwash, and lake sediments of mixed mineralogy. The texture of this glacial material ranges from loamy fine sand to clay. In the modal Humic Gley profile, lime has been leached from the A and B horizons but some profiles have free lime throughout.

Except for the Hamar and Dimmick soils, which lack a B horizon, the sequence of horizons in the typical Humic Gley soils is A1, B2g, and Cg. The A1 horizon is black, is slightly acid to moderately alkaline, and contains a large amount, 5 to 10 percent, of organic matter. The B2 horizon is gray or olive gray to dark grayish brown and is gleyed and mottled. The reaction ranges from slightly acid to moderately alkaline. In the Parnell and Perella soils, the B2g horizon is an illuvial horizon that contains accumulated clay; the Cg horizon is neutral to moderately alkaline and is mottled and gleyed. The Hamar soils developed in coarse-textured material. Instead of a B horizon, they have a transitional horizon (AC or Ag) between the A and Cg horizons.

The major processes in the formation of Humic Gley soils are (1) the leaching of soluble salts from the profile, (2) the leaching of carbonates from the A and B horizons, (3) the accumulation of organic matter, (4) the development of colors associated with restricted drainage, that is, mottling and low chroma, (5) the formation of clay, and (6) in the Parnell and Perella soils, the accumulation of clay in the B2 horizon.

Following are the soil series in the Humic Gley great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil series	*Subgroup in the new comprehensive system*
Dimmick	Cumulic Haplaquolls.
Hamar	Typic Haplaquolls.
Lamoure	Cumulic Haplaquolls.
Parnell	Cumulic Argiaquolls.
Perella	Typic Argiaquolls.
Rauville	Cumulic Haplaquolls.
Tiffany	Typic Haplaquolls.

PLANOSOLS

Planosols are in the intrazonal order. They are a group of soils that have an eluviated surface horizon underlain by a B horizon more strongly illuviated, cemented, or compacted than that of associated soils. These soils developed in nearly level upland areas. They are in small, shallow, closed depressions where drainage is somewhat poor or poor or in large depressions that receive only a limited amount of runoff. Deep ponding for prolonged periods seldom occurs in these areas, but the soils are frequently subjected to intermittent ponding. In this survey area the Planosols developed in material of glacial origin—local alluvium over glacial till of mixed mineralogy. The texture of this glacial material ranges from loam to clay loam.

The sequence of horizons in the Planosols is A1, A2, B2, and C. The A1 horizon is black to very dark gray, and it has moderate crumb and granular structure. The A2 horizon is dark gray to gray and has thin platy structure. The B2 horizon is dark grayish brown and has compound weak prismatic and strong blocky structure.

On the basis of depth of leaching, degree of acidity, and the formation and translocation of clay, the Planosols exhibit the greatest degree of profile development of any of the soils in the survey area. The A1 horizon is slightly acid to strongly acid, and the A2 and B2 horizons are medium acid to strongly acid. The C horizon of these soils becomes less acid with increasing depth. Free lime generally occurs within 5 feet of the surface, and the soil material in most areas is mildly alkaline within that depth. Some profiles that are more strongly leached than others, however, are medium acid to a depth of 5 feet.

In the Tri-County survey area, the only soil series in the Planosol great soil group is the Tetonka. The Tetonka series has been tentatively classified in the Aquollic Argialboll subgroup of the new classification system.

SOLONCHAKS

The calcareous Solonchak soils are in the intrazonal order. They developed under grass in nearly level or undulating areas where drainage was moderately good to poor and where there was a seasonal high water table. The material in which they developed has a texture of fine sandy loam to silty clay loam and is of mixed mineralogy. It consists of glacial till, outwash, and sediments deposited in glacial lakes.

The Solonchak soils have an A1, Cca, and C sequence of horizons. Their A1 horizon is black to gray, mildly alkaline to moderately alkaline, and calcareous. It has moderate crumb and granular structure. In places there is a gray transitional A1ca horizon between the A1 and Cca horizon. The Cca horizon is dark gray to light brownish gray. It has weak, coarse, blocky and prismatic structure, is mildly to moderately alkaline, and has a calcium carbonate equivalent of 15 to 40 percent. The C horizon ranges from light olive brown to yellowish brown and has distinct mottles; the poorly drained Solonchak soils have more abundant mottling higher in the C horizon than the moderately well drained to somewhat poorly drained soils of this group. In most places the lower part of the C horizon has a calcium carbonate equivalent of 10 to 12 percent. In the soils developed in loam to silty clay loam, the lower part of the C horizon is slightly to moderately saline.

Except for the Borup and Arveson soils, the Solonchak soils of the survey area have developed in areas similar to those in which the Chernozems developed. Because of the influence of the water table, however, they have a profile that has an A1, Cca, and C sequence of horizons instead of an A1, B2, Cca, and C sequence.

During periods when the water table is high, capillary water can rise to the surface or near the surface. Then, the calcium carbonate carried in solution is precipitated in the upper part of the profile as the volume of water is lowered by plant use, surface evaporation, or both. When the water table is low, the dominant movement of the water that enters the soil from precipitation or other sources is downward. As the water moves downward, it leaches some of the carbonates from the A1 horizon and the upper part of the Cca horizon.

As an example, the Hamerly soils in the Solonchak great soil group and the Barnes soils in the Chernozem great soil group developed in similar material of calcareous loam glacial till. The carbonates have been leached to a greater depth in the Barnes soils than in the Hamerly, however, and only partial leaching of carbonates has taken place in the Hamerly soils. The Barnes soils, although leached to a greater depth, have a Cca horizon that is lower in content of calcium carbonate than that of the Hamerly soils. The lower part of their C horizon contains more calcium carbonate than the lower part of the C horizon in the Hamerly soils. The difference in content of lime in the Cca horizon and the lower C horizon indicates that (1) the Solonchak soils have developed under conditions in which the upward movement of water from the water table exceeded the downward movement of water from precipitation, and (2) the upward movement of water has removed some of the carbonates from the lower C horizon.

The Cca horizon of the Solonchak soils has the highest percentage of clay of any of the horizons in the profile. In most areas more than half of the carbonate particles in that horizon are of clay size, a higher percentage than is present in the Cca horizon of soils in other great groups. The clay-size particles of carbonates do not have the characteristic platelike shape, the stickiness and plasticity, and the cation-exchange capacity of the silicate clay minerals. The cation-exchange capacity in the C horizon, which contains much less clay than the Cca, exceeds that of the Cca horizon in many profiles. Also, in many profiles the percentage of carbonate particles of clay size exceeds that of any silicate clay mineral and may be greater than the combined percentages of all the other clay particles present.

The major processes in the development of the Solonchak soils are (1) accumulation of organic matter, (2) leaching of soluble salts from the A1 and upper C horizons, (3) partial leaching of carbonates from the A1 horizon and the partial removal of carbonates from the lower C horizon, (4) the accumulation of lime below the A1 horizon, and (5) the development in the C horizon of colors associated with restricted drainage, that is, mottling in the moderately well drained or somewhat poorly drained soils and low chroma and mottling in the poorly drained soils.

Following are the soil series in the Solonchak great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil series	*Subgroup in the new comprehensive system*
Arveson	Typic Calciaquolls.
Bearden	Aeric Calciaquolls.
Borup	Typic Calciaquolls.
Divide	Aeric Calciaquolls.
Glyndon	Aeric Calciaquolls.
Hamerly	Aeric Calciaquolls.
Ulen	Aeric Calciaquolls.
Vallers	Typic Calciaquolls.

SOLONETZ SOILS

The Solonetz soils are in the intrazonal order. They have a friable surface horizon of variable thickness, and this surface horizon is underlain by dark, hard soil material, generally of columnar structure. Ordinarily, the Solonetz soils are highly alkaline. In the survey area the Solonetz soils developed in nearly level places where drainage was poor and there was a large amount of sodium. The material in which they developed is glacial lake sediments of fine sandy loam. These sediments are of mixed mineralogy.

The sequence of horizons in the Solonetz soils is A1, B2, and C, but the profile is weakly developed. The A1 horizon is moderately alkaline and calcareous and is 10 to 15 percent exchangeable sodium. The B2 horizon is very dark gray, calcareous, strongly alkaline fine sandy loam that has weak, very coarse, columnar structure. The C horizon is calcareous, strongly alkaline, and saline. Exchangeable sodium in the B and C horizons exceeds 30 percent. The presence of carbonates or salts, or both, in the A and B horizons of the Solonetz soils prevents the high degree of dispersion and the hard crusting that is typical in the horizons of the solodized Solonetz soils that have a high content of exchangeable sodium.

The principal processes in the formation of the Solonetz soils are (1) the accumulation of organic matter, (2) the partial leaching of soluble salts, carbonates, and sodium from the A1 horizon, and (3) the development of weak columnar structure in the B2 horizon.

Solodized Solonetz soils have developed in material of loam to clay texture. The sequence of horizons in their profile is A1, A2, B2, and C. The A1 horizon is black loam to silty clay loam that has crumb and granular structure. It is slightly acid to mildly alkaline. The A2 horizon is slightly acid to neutral and is very dark gray very fine sandy loam to silt loam that has platy structure. The B2 horizon is very dark grayish-brown silty clay loam to silty clay that has strong columnar or prismatic structure. The reaction ranges from mildly alkaline to strongly alkaline. In some soils the lower part of the B2 horizon is saline. The C horizon is saline and is moderately to strongly alkaline.

The ratio of exchangeable calcium to magnesium in the B2 horizon is less than 1. Exchangeable sodium exceeds 15 percent in the B and upper C horizons. Horizons that are high in content of exchangeable sodium disperse when they are wet.

The important processes in the development of these soils are (1) the leaching of salts from the A1, A2, and upper B2 horizons and their accumulation in the lower B and C horizons, (2) the accumulation of organic matter, (3) an increase in the content of exchangeable sodium in the A horizon, (4) dispersion and the translocation of clay from the A horizon to the B horizon, (5) a decrease in the percentage of exchangeable sodium in the A horizon and an increase in percentage of exchangeable sodium in the B horizon, and (6) the development of acidity in the A2 horizon and a low Ca:Mg ratio in the B2 horizon. In this survey area the Exline soils are weakly solodized. The Aberdeen soils are moderately solodized.

Following are the soil series in the Solonetz great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil series	*Subgroup in the new comprehensive system*
Aberdeen	Typic Natriborolls.
Exline	Mazic Natriborolls.
Stirum	Typic Natraquolls.

ALLUVIAL SOILS

Alluvial soils are in the azonal order. They are developing in recently deposited alluvium on flood plains. This alluvium has been exposed for such a short time that it has been but slightly modified by the factors of soil formation.

The sequence of horizons in the Alluvial soils is A-C. The A horizon is slightly darkened by accumulated organic matter and soluble salts, and some of the calcium carbonates have been leached from the A horizon and the upper part of the C horizon. The profile is moderately alkaline and calcareous throughout.

Following are the soil series in the Alluvial great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil series	*Subgroup in the new comprehensive system*
Fairdale	Typic Udifluvents.
La Prairie	Cumulic Haploborolls.

REGOSOLS

Regosols are in the azonal order. They developed in unconsolidated material in areas where drainage was excessive. This excessive drainage was caused either because of the steep slopes and rapid runoff or because of the coarse texture of the parent material. These soils developed in material of glacial origin—till, outwash, and sediments deposited in glacial lakes. Their parent material is of mixed mineralogy, and its texture ranges from loam to fine sandy loam.

Except for the Alluvial soils, the Regosols have the least profile development of any of the soils in the survey area. The sequence of horizons is generally A1-C. In the Buse and Zell soils of the survey area, the A1 horizon is black to dark gray, and it has weak to moderate crumb and granular structure. The A1 horizon grades to the C horizon, and there is a weakly expressed AC, A1ca, or Cca transitional horizon in places. The A1 horizon is mildly alkaline in some areas, but the soils are generally moderately alkaline and calcareous throughout.

In the Sioux soils the profile consists of a noncalcareous, neutral to mildly alkaline A1 horizon of black gravelly sandy loam to gravelly loam that has weak crumb structure. The A1 horizon is less than 10 inches thick and is underlain by a IIC horizon of loose gravelly coarse sand and gravel. The lower sides of the pebbles in the upper part of the IIC horizon are coated with lime.

The major processes in the development of Regosols are (1) the accumulation of organic matter, (2) the leaching of soluble salts from the A horizon, and (3) the removal of part of the calcium carbonate from the A horizon.

Following are the soil series in the Regosol great soil group. Also named are the subgroups in the new comprehensive system into which each series has been tentatively classified:

Soil series	*Subgroup in the new comprehensive system*
Buse	Entic Haploborolls.
Sioux	Entic Haploborolls.
Zell	Entic Haploborolls.

Descriptions of the Soil Series

In the following pages the soil series in the county are described in alphabetic order. For each series a detailed description of a typical profile is given.

Aberdeen Series

The Aberdeen series consists of somewhat poorly drained solodized Solonetz soils developed in glacial lake sediments of silt loam, silty clay loam, and clay. These soils are in nearly level areas or in slight depressions in the lake plain and the eastern edge of the beach area. On the lake plain, they developed in a thin layer of silt loam underlain by lacustrine clay. The fine texture of their B2 horizon is more nearly the result of the fine texture of their parent material than the result of illuviation.

These soils have an A1 horizon of black silt loam and a distinct gray A2 horizon. Their B2 horizon is very dark grayish-brown clay that is very firm when moist and very plastic when wet. It has compound columnar and blocky structure. The C horizon is dark grayish-brown to olive-gray silty clay that is very firm when moist and very sticky when wet. It contains soluble salts and segregations of gypsum.

The Aberdeen soils have a thicker A horizon than the Exline soils. They have compound columnar and blocky structure in the B horizon, unlike the Exline soils, in which a blocky structure has not developed in the B horizon. Also unlike the Exline soils, salts have leached from their B horizon. The Aberdeen soils have developed in finer textured material than the Stirum soils, and they have more distinct A2 and B2 horizons than the Stirum soils. They have an A2 horizon that is lacking in the Gardena and Overly soils, and the structure of their B2 horizon differs from that in the B2 horizon of the Gardena and Overly soils. The columnar structure in the B horizon and the soluble salts and gypsum in the C horizon distinguish the Aberdeen soils from the Tetonka.

Profile of Aberdeen silt loam 500 feet north and 200 feet west of the SE. corner of the NE¼ sec. 22, T. 142 N., R. 52 W.:

Ap—0 to 9 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; compound weak, coarse, blocky and weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; clear, wavy boundary.

A2—9 to 13 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; weak, thick, platy structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt, irregular boundary.

IIB2—13 to 19 inches, very dark grayish-brown (2.5Y 3/2) clay, dark grayish brown (2.5Y 4/2) when dry; the surfaces of the peds are coated with black (10YR 2/1) to very dark brown (10YR 2/2); compound moderate, medium, columnar and strong, fine, blocky structure; prominent clay films; very hard, very firm, very sticky and very plastic; clear, wavy boundary.

IIC1ca—19 to 36 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) when dry; common, medium, distinct, light brownish-gray (2.5Y 6/2) mottles, white (2.5Y 8/1) when dry; moderate, very fine, granular structure; hard, firm, sticky and plastic; strongly calcareous; gradual boundary.

IIC21—36 to 50 inches, dark grayish-brown (2.5Y 4/2) clay, light brownish gray (2.5Y 6/2) when dry; many, fine, distinct, light-gray (2.5Y 7/1) mottles; strong, very fine, blocky structure; few distinct segregations of lime and nests of gypsum crystals; calcareous; gradual boundary.

IIC22—50 to 60 inches, olive-gray (5Y 4/2) clay, light olive gray (5Y 6/2) when dry; common, medium and coarse, prominent, yellowish-brown (10YR 4/4) and light-gray (10YR 7/2) mottles; massive; hard, very firm, very sticky and very plastic; segregations of gypsum crystals; calcareous.

The A horizon ranges from 6 to 15 inches in thickness. The A2 horizon ranges from 2 to 5 inches in thickness and from very fine sandy loam to silt loam in texture. The texture of the B2 horizon ranges from silty clay loam to clay, and the structure of that horizon grades from moderate to strong. In places the clay films in the B2 horizon are distinct. The upper part of the columns in the B2 horizon breaks readily to weak platy structure in some places. The solum ranges from 13 to 30 inches in thickness. Depth to soluble salts ranges from 18 to 36 inches.

Arveson Series

In the Arveson series are poorly drained, calcareous Solonchak soils developed in moderately coarse textured and coarse textured glacial lake sediments. These soils are in low, nearly level areas and in shallow depressions. In most years the water table is at a depth of less than 3 feet during a part of the growing season.

These soils have a weakly developed profile; the sequence of horizons is A1, Cca, and C. The A1 horizon is black (10YR 2/1), friable loam or fine sandy loam. The Cca horizons are light-gray (10YR 6/1) or dark-gray (10YR 4/1) to grayish-brown (2.5Y 5/1 or 5/2), friable fine sandy loam. The Cg horizon is grayish-brown (2.5Y 4/2), loose loamy fine sand to sand distinctly mottled with dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/6).

The Arveson soils occur with the Ulen, Hamar, Tiffany, Hecla, and Embden soils. They have lower chroma to a greater depth than the Ulen soils and have more mottling in the Cg horizon. The Arveson soils have distinct Cca horizons that are lacking in the Hamar and Tiffany soils. They lack the very dark grayish-brown B horizon that is present in the Hecla and Embden soils. The Arveson soils developed in coarser textured glacial lake sediments than the Borup soils.

Profile of Arveson fine sandy loam 600 feet east and 150 feet south of the NW. corner of sec. 15, T. 136 N., R. 53 W.:

A1—0 to 10 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and weak, fine, crumb structure; soft, very friable, and slightly sticky; strongly calcareous; clear boundary.

C11ca—10 to 22 inches, dark-gray (10YR 4/1) fine sandy loam, light gray (10YR 6/1) when dry; compound weak, medium, subangular blocky and weak, coarse, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly calcareous; clear boundary.

C12ca—22 to 34 inches, light brownish-gray (2.5Y 6/2) loamy fine sand, light gray (2.5Y 7/2) when dry; weak, medium, crumb structure; loose; very strongly calcareous; clear, smooth boundary.

C2g—34 to 60 inches, mottled dark grayish-brown (2.5Y 4/2), light olive-brown (2.5Y 5/4), dark grayish-brown (10YR 4/2), and yellowish-brown (10YR 5/6) loamy sand; structureless (single grain); loose; strongly calcareous.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) in color, from loam to fine sandy loam in texture, and from 8 to 24 inches in thickness. The color of the Cca horizons ranges from dark gray or gray to light brownish gray in hues of 10YR and 2.5Y. The texture of those horizons ranges from loam or fine sandy loam to loamy fine sand, and their combined thickness ranges from 10 to 24 inches. In general the texture of the Cg horizon ranges from fine sandy loam to fine sand, but thin layers of silt loam or silty clay loam occur below a depth of 48 inches. The mottles in the Cg horizon are distinct or prominent, and their color ranges from light olive brown (2.5Y 5/4) or olive brown (2.5Y 5/4) to dark grayish brown, dark yellowish brown, and yellowish brown in 10YR hues.

Barnes Series

The Barnes series consists of well-drained Chernozems developed in friable loam glacial till. These soils are in convex areas in the gently undulating till plain.

These soils have a weakly to moderately developed profile; the sequence of horizons is A1, B2, Cca, and C. The A1 horizon is black, friable loam. The B2 horizons are very dark grayish-brown, friable loam, generally with prismatic structure. The Cca horizon is grayish-brown to light-gray, friable loam. The other C horizons are olive-brown to grayish-brown, friable loam glacial till with a few dark-brown mottles. Varible amounts of pebbles and stones, typical of the glacial till in this area, are in all the horizons and in the substratum.

The Barnes soils occur with the Buse, Hamerly, Svea, Tetonka, and Vallers soils. They have a B horizon that is lacking in the Buse and Hamerly soils, and depth to free carbonates is greater than in those soils. They have a thinner A1 horizon than the Svea soils, and they have 10YR instead of 2.5Y hues in the B horizon. The Barnes soils lack the A2 and textural B horizon that are typical in the profile of the Tetonka soils. Unlike the Eckman soils, which developed in medium-textured sediments deposited by glacial melt water, they developed in glacial till.

Profile of Barnes loam 100 feet south and 110 feet east of the NW. corner of the SW¼ of sec. 27, T. 138 N., R. 54 W.:

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; compound weak, medium, blocky and moderate, fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

B21—8 to 11 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; very dark gray (10YR 3/1) coatings on the surfaces of peds; weak, medium, prismatic and subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; clear, smooth boundary.

B22—11 to 20 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; moderate, medium, prismatic and blocky structure; slightly hard, friable, slightly sticky and slightly plastic; clear, smooth boundary.

C1ca—20 to 36 inches, grayish-brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) when dry; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C2—36 to 44 inches, light olive-brown (2.5Y 5/5) loam, pale brown (2.5Y 7/4) when dry; a few, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium and fine, blocky structure; hard, friable, and slightly plastic; calcareous; gradual boundary.

C3—44 to 60 inches, light olive-brown (2.5Y 5/4) loam, pale yellow (2.5Y 8/4) when dry; a few, prominent, dark-brown (7.5YR 4/4) mottles; moderate, medium, blocky structure; hard, friable, slightly sticky and slightly plastic; few gypsum crystals; slightly calcareous.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) in color and from 4 to 8 inches in thickness. The combined thickness of the B horizons ranges from 6 to 18 inches. In places in the B horizons, there are faint clay films that range from patchy to continuous. The color of the C1ca horizon ranges from grayish brown to light brownish gray in hues of 2.5Y. The texture of that horizon ranges from loam to light clay loam. In some places segregations of gypsum crystals are present in the Cca horizon. The color of the C2 and C3 horizons ranges from light olive brown to grayish brown in 2.5Y hues. In many places the mottles in those horizons are few and distinct, but they are prominent in some places, and they range from yellowish brown to reddish brown or dark brown in color. In places the C2 and C3 horizons contain segregations of gypsum and soluble salts. The thickness of the solum ranges from 12 to 22 inches.

Bearden Series

The Bearden series consists of moderately well drained to somewhat poorly drained, calcareous Solonchak soils developed in medium-textured and moderately fine tex-

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tured glacial lake sediments. These soils are nearly level and are on the lake plain.

The horizon sequence in the profile of these soils is A1, Cca, and C. The Bearden soils have an A1 horizon of black, friable silt loam to silty clay loam; a Cca horizon of light-gray to light grayish-brown, friable silt loam to silty clay loam; and a mottled C horizon of olive-gray to light olive-brown silt loam to silty clay loam.

The Bearden soils occur with the Fargo, Glyndon, Borup, Overly, Gardena, and Perella soils. They are coarser textured than the Fargo soils and are finer textured than the Glyndon and Borup soils. The Bearden soils lack the B horizon that is typical in the profile of the Overly and Gardena soils, and they are less gleyed and are less mottled than the Borup soils. Unlike the Perella soils, the Bearden soils have a Cca horizon.

Profile of Bearden silt loam 280 feet south and 200 feet east of the NW. corner of the SW¼ of sec. 10, T. 137 N., R. 54 W.:

Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; compound weak, medium, subangular blocky and moderate, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly calcareous; abrupt, smooth boundary.

C1ca—8 to 14 inches, grayish-brown (2.5Y 5/2) silty clay loam with tongues of black (10YR 2/1) material from the A horizon; light brownish gray (2.5Y 6/2) when dry; compound weak, coarse, prismatic and subangular blocky structure; hard, friable, sticky and plastic; strongly calcareous; clear, wavy boundary.

C2ca—14 to 24 inches, light-gray (2.5Y 7/2) silt loam, white (2.5Y 8/2) when dry; weak, moderate, subangular blocky structure breaking to moderate, fine, crumb structure; hard, friable, slightly sticky and slightly plastic; very strongly calcareous; gradual, wavy boundary.

C3—24 to 40 inches, light olive-brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/3) when dry; weak, medium and fine, blocky structure and moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; calcareous; gradual boundary.

C4—40 to 60 inches, light yellowish-brown (2.5Y 6/3) silt loam, pale yellow (2.5Y 7/4) when dry; many, fine, distinct mottles of light olive brown (2.5Y 6/6) and light gray (N 7/0); hard, friable, slightly sticky and slightly plastic; calcareous; clear boundary.

The color of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and that horizon is friable instead of very friable in some places. The texture of the A horizon ranges from silt loam to silty clay loam, and the thickness of that horizon ranges from 10 to 20 inches. The color of the Cca horizons ranges from grayish brown to light gray in 2.5Y hues. The texture of those horizons ranges from silt loam to silty clay loam, and their thickness ranges from 10 to 20 inches. The color of the C2 and C3 horizons ranges from grayish brown or light olive brown to pale yellow in hues of 2.5Y. The color of the mottles in the C3 horizon ranges from light olive brown to light gray or dark yellowish brown. In places distinct varves occur below a depth of 48 inches.

Borup Series

The Borup series consists of poorly drained, calcareous Solonchak soils developed in medium-textured glacial lake sediments. These soils are in shallow depressions and in low, nearly level areas.

The Borup soils have an A horizon of black, friable very fine sandy loam to silt loam and gray, friable Cca horizons of silt loam to very fine sandy loam. The other C horizons are gray to olive gray and are mottled and gleyed. In most places their texture becomes coarser with increasing depth.

The Borup soils occur with the Hecla, Embden, Ulen, Gardena, and Glyndon soils. They developed in finer textured sediments than the Hecla, Embden, and Ulen soils, and they lack the B2 horizon that is typical in the Gardena profile. The Borup soils have more strongly gleyed horizons than the Glyndon soils.

Profile of Borup silt loam 240 feet east and 140 feet north of the SW. corner of sec. 32, T. 137 N., R. 52 W.:

A1—0 to 18 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; compound weak, medium, subangular blocky and moderate, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; calcareous; clear, wavy boundary.

C1gca—18 to 27 inches, dark-gray (5Y 4/1) silt loam, gray (5Y 6/1) when dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C2gca—27 to 38 inches, gray (5Y 5/1) loam, light gray (5Y 6/1) when dry; moderate, fine, granular structure; hard, friable, slightly sticky and slightly plastic; strongly calcareous, and contains a few, coarse, prominent, white (5Y 8/1) segregations of lime; abrupt, smooth boundary.

IIC3g—38 to 46 inches, olive (5Y 5/3) fine sand, pale yellow (5Y 7/3) when dry; many, coarse, prominent mottles of light olive brown (2.5Y 5/6); single grain; gradual boundary.

IIC4g—46 to 60 inches, mottled dark yellowish-brown (10YR 4/4) and olive (5Y 5/3) fine sand; single grain; loose.

The color of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The texture of that horizon ranges from very fine sandy loam to silt loam, and the thickness ranges from 8 to 20 inches. The color of the Cca horizons ranges from dark gray to light gray in 5Y hues, and the texture of those horizons ranges from very fine sandy loam to silt loam. The color of the Cg horizons ranges from olive (5Y 5/3) to pale yellow (5Y 7/3), and the color of the mottles in those horizons ranges from olive brown (2.5Y 5/6) to dark yellowish brown (10YR 4/4) or light olive brown (2.5Y 5/6). The texture in the Cg horizons becomes coarser with increasing depth and ranges from loam to fine sand. In some areas the texture is fine sandy loam between a depth of 24 and 30 inches.

Buse Series

The Buse series consists of excessively drained, steep Regosols developed in glacial till of friable loam texture. These soils are on the crests of knolls and on the sides of stream valleys entrenched in the till plain.

The texture of the Buse soils is loam throughout the profile. These soils have an A1 horizon of black, friable loam that is slightly calcareous. They also have a weakly defined Cca horizon of dark grayish-brown, friable loam, and olive-brown to light olive-brown C2 and C3 horizons. Variable amounts of pebbles and stones, typical of the glacial till in this area, are in all horizons and in the substratum.

The Buse soils occur with the Barnes, Svea, Hamerly, and Vallers soils. They lack the B horizon that is typical in the profile of the Barnes and Svea soils. They have less lime in the Cca horizon than the Hamerly soils, and they have fewer distinct mottles in the C2 and C3 horizons than those soils. The Buse soils developed in glacial till rather than in glacial lake sediments like the Zell soils.

Profile of Buse loam 1,300 feet west and 200 feet south of the NE. corner of sec. 2, T. 141 N., R. 54 W.:

A1—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and moderate, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly calcareous; clear boundary.

C1ca—7 to 26 inches, dark grayish-brown (2.5Y 4/2) loam, light brownish gray (2.5Y 6/2) when dry; coarse, weak, prismatic breaking to moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C2—26 to 36 inches, light olive-brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; weak, medium, blocky structure; hard, friable, slightly sticky and slightly plastic; calcareous, with a few, fine, white segregations of lime; gradual boundary.

C3—36 to 60 inches, light olive-brown (2.5Y 5/4) loam, light brownish gray (2.5Y 6/2) when dry; a few, fine, distinct mottles of dark yellowish brown (10YR 4/4); hard, friable, sticky and plastic; calcareous with a few fine segregations of lime.

In areas of these soils that have not been disturbed, the color of the A horizon ranges from black (10YR 2/1) to a very dark gray (10YR 3/1) and the thickness of that horizon ranges from 4 to 8 inches. In areas that have been cultivated, the color of the Ap horizon ranges from dark gray in 10YR hues to grayish brown or light brownish gray in 2.5Y hues. The C1ca horizon ranges from 6 to 20 inches in thickness.

Dimmick Series

The Dimmick series consists of very poorly drained Humic Gley soils developed in fine-textured sediments deposited in glacial lakes. These soils are in shallow depressions on the lake plain.

The Dimmick soils have firm, black, clayey A horizons and a strongly gleyed, very firm, dark-gray, clayey AC horizon. Their C horizons are very firm and clayey and are olive gray mottled with dark brown.

The Dimmick soils occur with the Fargo soils, but unlike those soils, they have a neutral black color in the A horizon. They also lack the prominent, deep tonguing of material from the A1 horizon into the B and C horizons.

Profile of Dimmick clay three-tenths of a mile south and 180 feet west of the NE. corner of sec. 23, T. 141 N., R. 52 W.:

A1p—0 to 8 inches, black (N 2/0) clay, dark gray (N 4/0) when dry; compound strong, fine, blocky and granular structure; hard, firm, sticky and plastic; abrupt, smooth boundary.

A12—8 to 14 inches, black (2.5Y 2/1) clay, dark gray (2.5Y 4/1) when dry; compound moderate, medium, blocky and strong, fine, granular structure; hard, firm, sticky and plastic; clear, irregular boundary.

A13g—14 to 18 inches, black (5Y 2/1) clay, dark gray (5Y 4/1) when dry; a few, fine, faint, very dark brown (10YR 2/2) mottles; compound moderate, medium, blocky and strong, fine, granular structure; hard, firm, sticky and very plastic; clear, irregular boundary.

ACg—18 to 36 inches, very dark gray (5Y 3/1) and olive-gray (5Y 4/2) clay, gray (5Y 6/1) when dry; compound moderate, medium and strong, fine and very fine, blocky structure; hard, very firm, very sticky and very plastic; slightly calcareous; gradual boundary.

C1g—36 to 50 inches, olive-gray (5Y 4/2) clay, light olive gray (5Y 6/2) when dry; common, medium, distinct, dark-brown (10YR 3/3) mottles; massive; hard, very firm, very sticky and very plastic; slightly calcareous; clear boundary.

C2gcs—50 to 60 inches, olive-gray (5Y 4/2) clay, light olive gray (5Y 6/2) when dry; common, medium, distinct, dark-brown (10YR 3/3) mottles; massive; hard, very firm, very sticky and very plastic; common nests of segregated gypsum crystals; slightly calcareous; clear boundary.

C3g—60 to 66 inches, dark-gray (5Y 4/1) clay, light gray (5Y 6/1) when dry; common, medium, distinct, brown (10YR 4/3) mottles; massive; hard, very firm, very sticky and very plastic; segregations of gypsum crystals; slightly calcareous.

The texture of the A1 horizon ranges from silty clay to clay, and the thickness of that horizon ranges from 12 to 20 inches. In some places the AC horizon is dark gray (5Y 4/1) mottled with olive gray (5Y 4/2), and that horizon ranges from 18 to 36 inches in thickness. The mottles in the Cg horizons range from few to common in abundance, and their color is 10YR 4/3 instead of 10YR 3/3 in some places. In places segregations of gypsum occur below a depth of 48 inches.

Divide Series

In the Divide series are moderately well drained or somewhat poorly drained, calcareous Solonchak soils. These soils developed in moderately deep, medium-textured glacial lake sediments over gravel and sand.

The sequence of horizons in the Divide soils is A1, Cca, and IIC. In these soils the A1 horizons are slightly calcareous, dark-colored, friable or very friable loam and the Cca horizons are dark-gray to dark grayish-brown, friable loam or heavy sandy loam. The IIC horizons are gravel and coarse sand.

The Divide soils occur with the Sioux, Renshaw, Spottswood, and Fordville soils. Unlike the Sioux soils, they have a Cca horizon above the gravelly substratum, and they lack the B horizon that is present in the profiles of the Renshaw, Spottswood, and Fordville soils. The profile of the Divide soils is somewhat like that of the Glyndon and Ulen soils, but gravel and coarse sand underlie the Cca horizon.

Profile of Divide loam 550 feet south and 100 feet west of the NE. corner of sec. 6, T. 138 N., R. 53 W.:

A1p—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; compound weak, medium, subangular blocky and moderate, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly calcareous; abrupt, smooth boundary.

A12—6 to 17 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; compound weak, coarse, prismatic and weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; slightly calcareous; clear, smooth boundary.

C1ca—17 to 22 inches, dark-gray (10YR 4/1) loam, gray (10YR 6/1) when dry; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly calcareous and contains many distinct, white segregations of lime; clear, smooth boundary.

IIC2ca—22 to 36 inches, dark grayish-brown (2.5Y 4/2) coarse sand and gravel, grayish brown (2.5Y 5/2) when dry; structureless; strongly calcareous; gradual boundary.

IIC3—36 to 50 inches, dark grayish-brown (2.5Y 4/2) coarse sand and gravel, grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) when dry; structureless; calcareous; gradual boundary.

IIC4—50 to 60 inches, dark grayish-brown (2.5Y 4/2) coarse sand and gravel, grayish brown (2.5Y 5/2) when dry; has a large proportion of shale in the sand; structureless; slightly calcareous.

The color of the A1 horizons ranges from black to very dark gray in 10YR hues, and the combined thickness of those horizons ranges from 10 to 17 inches. The combined Cca horizons range from 5 to 20 inches in thickness and from dark gray (10YR 4/1) to dark grayish-brown (2.5Y 4/2) in color. The texture of the Cca horizon ranges from sandy loam to loam. The thickness of the coarse-textured part of the substratum is greater than 5 feet in most places, but it is only about 3 feet in a few places. The coarse-textured material in the substratum ranges from gravel to coarse sand.

Eckman Series

The Eckman series consists of well-drained, nearly level to rolling Chernozems. These soils developed in medium-textured sediments deposited by glacial melt water. The native vegetation was mid and tall grasses.

The A horizon of the Eckman soils is black to very dark gray, friable loam. These soils have a distinct B horizon of dark grayish-brown, friable very fine sandy loam to silt loam.

The Eckman soils occur with the Zell and Gardena soils. They have a B horizon that is lacking in the Zell soils. Their A horizon is thinner and their B horizon is more distinct than that of the Gardena soils. The Eckman soils developed in finer textured material than the Egeland soils. They developed in water-deposited material instead of in glacial till, as did the Barnes soils.

Profile of Eckman loam 950 feet east and 150 feet north of the SW. corner of the SE¼ of sec. 15, T. 142 N., R. 53 W.:

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and moderate, fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

B21—8 to 15 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; compound weak, coarse, prismatic and weak, medium, subangular blocky structure; faint patches of clay films on the vertical surfaces of peds; slightly hard, friable, slightly sticky and slightly plastic; clear boundary.

B22—15 to 25 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; moderate, coarse, prismatic structure; faint patches of clay films on the vertical surfaces of peds; gradual boundary.

B3—25 to 36 inches, light olive-brown (2.5Y 5/5) silt loam, light yellowish brown (2.5Y 6/4) when dry; weak, coarse, blocky structure; hard, friable, slightly sticky and slightly plastic; gradual boundary.

C1ca—36 to 44 inches, light olive-brown (2.5Y 5/4) very fine sandy loam, pale yellow (2.5Y 7/4) when dry; weak, medium, blocky structure; slightly hard, very friable, and slightly sticky; strongly calcareous; gradual boundary.

C2—44 to 60 inches, light olive-brown (2.5Y 5/4) fine sandy loam, pale yellow (2.5Y 7/4) when dry; weak, medium, blocky structure; soft, very friable, and slightly sticky; calcareous.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) in color and from 6 to 8 inches in thickness. The texture of the B2 horizons ranges from very fine sandy loam to silt loam. The B horizons range from 10 to 30 inches in thickness. The color of the Cca horizon ranges from grayish brown to light olive brown in hues of 2.5Y, and the thickness of that horizon ranges from 6 to 14 inches. In places the soil material grades to loamy fine sand between a depth of 36 and 60 inches. In most places, however, the texture is loam throughout the A and B horizons and grades to somewhat coarser textured material below a depth of about 24 inches. Where these soils occur along the western edge of the Sheyenne Delta, they are underlain by friable glacial till at a depth of 24 to 36 inches.

Egeland Series

The Egeland series consists of well-drained Chernozems developed in moderately coarse textured sediments deposited in glacial lakes. These soils are nearly level or undulating and are in convex areas. They are on the Sheyenne Delta and in the beach area.

The A horizon of the Egeland soils is black, friable fine sandy loam. Their B horizon is very dark grayish-brown to yellowish-brown fine sandy loam. The structure of the B horizon is weak prismatic and subangular blocky. In places the profile contains a Cca horizon of light olive-brown, moderately calcareous fine sandy loam. The other C horizons are grayish-brown to yellowish-brown fine sandy loam to loamy fine sand or fine sand.

The Egeland soils occur with the Embden, Hecla, and Maddock soils. They have a thinner A horizon and more distinct B horizons than the Embden soils. They developed in moderately coarse textured material instead of in coarse textured material like that in which the Hecla and Maddock soils developed. The profile of the Egeland soils is somewhat like that of the Eckman soils, but the Egeland soils developed in coarser textured material than the Eckman soils.

Profile of Egeland fine sandy loam 700 feet east and 800 feet south of the NW. corner of the SW¼ of sec. 27, T. 143 N., R. 53 W.:

Ap—0 to 6 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and weak, fine, crumb structure; slightly hard, very friable, and slightly sticky; abrupt, smooth boundary.

B21—6 to 19 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic and weak, medium, subangular blocky structure; slightly hard, very friable, and slightly sticky; clear boundary.

B22—19 to 27 inches, dark-brown (10YR 4/3) fine sandy loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; soft and very friable; clear, smooth boundary.

C1—27 to 42 inches, dark-brown (10YR 4/3) loamy fine sand, yellowish brown (10YR 5/4) when dry; single grain; soft and loose; clear, smooth boundary.

C2—42 to 55 inches, dark-brown (10YR 4/3) and grayish-brown (10YR 5/2) loamy fine sand, yellowish brown (10YR 5/4) when dry; single grain; soft and loose; clear, smooth boundary.

C3—55 to 63 inches, yellowish-brown (10YR 5/4) fine sand, light brownish gray (10YR 6/2) when dry; single grain; soft and loose.

The A horizon of the Egeland soils ranges from 6 to 10 inches in thickness. The color of the B horizons ranges from very dark grayish brown (10YR 3/2) to yellowish brown (10YR 5/4), and the texture of the B horizons is sandy loam instead of fine sandy loam in some places. The thickness of the combined B horizons ranges from 10 to 22 inches. A moderately calcareous Cca horizon of light olive-brown (2.5Y 5/4) fine sandy loam is present in some places. The color of the other C horizons ranges from grayish brown (2.5Y 5/2) or dark brown (10YR 4/3) to yellowish brown (10YR 5/4), and the texture of those horizons ranges from fine sandy loam to fine sand.

Embden Series

The Embden series consists of moderately well drained Chernozems developed in moderately coarse textured glacial lake sediments. These soils are in nearly level or slightly concave areas.

The Embden soils have a thick, black A horizon of very friable fine sandy loam. Their B horizon is weakly defined and is very dark grayish-brown fine sandy loam. They have an olive-brown Cca horizon that is mottled in a few places, and the mottles increase in number with increasing depth. The C horizon is olive-brown, mottled fine sandy loam to sand.

The Embden soils occur with the Gardena, Glyndon, Egeland, Tiffany, and Hecla soils. They developed in coarser textured material than the Gardena and Glyndon soils, have a thicker A horizon than the Egeland soils, and are less mottled than the Tiffany soils. Their profile is finer textured than that of the Hecla soils.

Profile of Embden fine sandy loam 60 feet north of the SW. corner of the SE¼ of sec. 21, T. 137 N., R. 53 W.:

A1p—0 to 8 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 4/1) when dry; compound weak, medium, subangular blocky and fine crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

A12—8 to 14 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; slightly hard, very friable and slightly sticky; clear, smooth boundary.

B1—14 to 20 inches, very dark brown (10YR 2/2) fine sandy loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure; slightly hard and very friable; clear, smooth boundary.

B2—20 to 24 inches, very dark grayish-brown (2.5Y 3/2) fine sandy loam, dark grayish brown (2.5Y 4/2) when dry; weak, fine, subangular blocky structure; slightly hard and very friable; clear, smooth boundary.

C1—24 to 30 inches, very dark grayish-brown (2.5Y 3/2) fine sandy loam, light brownish gray (2.5Y 6/2) when dry; many, medium, distinct mottles of grayish brown (2.5Y 5/2); weak, fine, subangular blocky structure; soft and very friable; slightly calcareous; clear, smooth boundary.

C2ca—30 to 44 inches, olive-brown (2.5Y 4/4) fine sandy loam, light gray (2.5Y 7/2) when dry; a few, fine, prominent mottles of reddish yellow (7.5YR 6/6) and strong brown (7.5YR 5/6); weak, very fine, subangular blocky structure; soft and very friable; calcareous; gradual boundary.

C3—44 to 60 inches, olive-brown (2.5Y 4/4) fine sandy loam, pale yellow (2.5Y 7/3) when dry; common, fine, prominent mottles of reddish brown (2.5YR 4/4) and dark reddish brown (2.5YR 4/3); single grain; soft and loose; slightly calcareous.

The A horizons range from black (10YR 2/1) to very dark gray (10YR 3/1) in color, and their combined thickness ranges from 10 to 22 inches. The color of the B horizons ranges from very dark brown (10YR 2/2) to very dark grayish brown or dark grayish brown in 2.5Y hues. In places the texture of the B horizons is sandy loam instead of fine sandy loam. The thickness of the combined B horizons ranges from 10 to 20 inches. The Cca horizon ranges from 6 to 20 inches in thickness. The Cca horizon is slightly calcareous in some places and moderately calcareous in others. The texture of the underlying C3 horizon ranges from fine sandy loam to fine sand; the coarser textured material is between a depth of 48 and 60 inches. The color of this underlying C3 horizon ranges from olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4). The color of the mottles in that horizon ranges from strong brown (7.5YR 4/4) and dark brown (10YR 3/3) to reddish brown (2.5YR 4/4) or dark reddish brown (2.5YR 4/3).

Exline Series

In the Exline series are poorly drained solodized Solonetz soils developed in medium-textured and moderately fine textured sediments deposited in glacial lakes. These soils are nearly level. They are on the lake plain and in the beach area.

The Exline soils have a thin to moderately thick, black to very dark gray, friable A1 horizon of loam, silt loam, or silty clay loam. They also have a thin, dark gray or very dark gray, friable A2 horizon of loam or silt loam. Their B2 horizon is dark colored and has distinct, strong, columnar structure. Gypsum and soluble salts are present in or immediately below the B2 horizon. The C horizon is mottled olive-gray to light olive-brown silt loam to silty clay.

The Exline soils occur in a complex pattern with the Fargo and Overly soils. Unlike these associated soils, they have a A2 horizon, columnar structure in the B2 horizon, and a concentration of soluble salts in or below the B2 horizon. The Exline soils are finer textured and have more distinct A2 and B2 horizons than the Stirum soils. They have stronger columnar structure than the Aberdeen soils, and salts are higher in their profile than in the profile of the Aberdeen soils.

Profile of Exline loam one-quarter of a mile north of the SE. corner of sec. 13, T. 139 N., R. 54 W.:

A11—0 to 1 inch, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, crumb structure; soft, very friable, slightly sticky and slightly plastic; abrupt boundary.

A12—1 to 9 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; weak, coarse and medium, prismatic structure breaking to moderate, thin, platy structure; soft, friable, slightly sticky and slightly plastic; clear boundary.

A2—9 to 12 inches, very dark gray (10YR 3/1) light loam, gray (10YR 5/1) when dry; a few, fine, faint mottles of dark yellowish brown (10YR 4/4); weak coarse and moderate, thin, platy structure with many fine root channels or pores; slightly hard, very friable, and slightly sticky; abrupt, smooth boundary.

B2—12 to 18 inches, very dark grayish-brown (2.5Y 3/2) clay loam, dark grayish brown (2.5Y 4/2) when dry; strong, medium, columnar structure; very hard, very firm, very sticky and very plastic; prominent clay films on the surfaces of the peds; black and very dark gray stains on the vertical surfaces of the peds; a few roots between the columns and a very few roots penetrating the columns; clear, smooth boundary.

B3sa—18 to 22 inches, light olive-brown (2.5Y 5/3) silty clay loam, light yellowish brown (2.5Y 6/3) when dry; dark grayish-brown (2.5Y 4/2) coatings on the surfaces of the peds; coarse, moderate, prismatic structure; distinct clay films on the surfaces of the prisms; very hard, very firm, very sticky and very plastic; contains threadlike segregations of salts between the aggregates and fine segregations of salts within the aggregates; clear boundary.

C1sacs—22 to 26 inches, light olive-brown (2.5Y 5/4) silty clay loam, light brownish gray (2.5Y 6/2) when dry; weak, very coarse, prismatic structure; very hard, very firm, sticky and plastic; contains segregations of gypsum crystals and salts; clear boundary.

C2sacs—26 to 60 inches, mottled grayish-brown (2.5Y 5/2), light olive-brown (2.5Y 5/4), and light-gray (2.5Y 7/2) silty clay loam; massive; very hard, very firm, sticky and plastic; contains segregations of salts and gypsum crystals; calcareous.

The color of the A1 horizons ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The texture of those horizons ranges from loam to silty clay loam, and their combined thickness ranges from 4 to 10 inches. In some places the A2 horizon is less than 3 inches thick. The texture of the B2 horizon ranges from silty clay loam to silty clay. In some places the clay films on the surfaces of the structural peds in that horizon are distinct instead of prominent. In many places soluble salts and gypsum are present in the lower part of the B2 horizon. The color of the C horizons ranges from light olive brown or grayish brown to olive gray or light olive gray in 2.5Y and 5Y hues. The range of texture in the C horizons is generally from silt loam to silty clay, but soil material of coarser texture occurs below a depth of 36 inches in some places.

Fairdale Series

Moderately well drained soils of the Alluvial great soil group make up the Fairdale series. These soils developed in recent alluvium on natural levees and flood plains, where they receive fresh deposits of alluvium during floods. In this survey area the Fairdale soils are most extensive along the Rush River.

The Fairdale soils have a thin to moderately thick A horizon of very dark grayish-brown or grayish-brown, friable silt loam. The A horizon is underlain by light-colored to dark-colored stratified alluvium that has a texture of silt loam to fine sand.

The Fairdale soils occur with the La Prairie soils, but their profile is lighter colored throughout than that of the La Prairie soils. The Fairdale soils have a lighter colored A horizon than the Zell soils. They have a lighter colored profile than the Gardena soils, and they lack the B horizon that is present in the profile of the Gardena soils.

Profile of Fairdale silt loam 605 feet north and 133 feet west of the SE. corner of the NE¼ of sec. 27, T. 141 N., R. 52 W.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, dark gray (10YR 4/1) when dry; weak, medium, blocky structure breaking to weak, medium, crumb structure; soft, very friable, and slightly sticky; slightly calcareous; abrupt, smooth boundary.

C1—7 to 19 inches, brown (10YR 5/3) very fine sandy loam, pale brown (10YR 6/3) when dry; compound weak, medium, prismatic and subangular blocky structure; slightly hard and very friable; calcareous; clear boundary.

C2—19 to 31 inches, brown (10YR 5/3) very fine sandy loam, pale brown (10YR 6/3) when dry; weak, fine, subangular blocky structure; slightly hard and very friable; calcareous; clear boundary.

C3—31 to 47 inches, dark grayish-brown (10YR 4/2) fine sandy loam, pale brown (10YR 6/3) when dry; weak, fine, crumb structure; soft and very friable; slightly calcareous; abrupt boundary.

IIC—47 to 54 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; common, medium, distinct mottles of dark yellowish brown (10YR 4/4); hard, friable, and slightly plastic; slightly calcareous; clear boundary.

IIIC5—54 to 57 inches, brown (10YR 5/3) very fine sandy loam, light gray (2.5Y 7/2) when dry; common, fine, distinct mottles of dark yellowish brown (10YR 4/4) and brownish yellow (10YR 6/6); hard and very friable; slightly calcareous; clear boundary.

IVC6—57 to 60 inches, brown (10YR 4/3) loamy fine sand, pale brown (10YR 6/3) when dry; a few, fine, faint mottles of dark yellowish brown (10YR 4/4); loose; slightly calcareous.

The A horizon ranges from dark gray to very dark grayish brown or grayish brown in 10YR hues. The stratified material below the A horizon ranges from light brownish gray to olive brown in 2.5Y hues or to brown or dark grayish brown in 10YR hues. The color of the mottles below a depth of 48 inches ranges from very dark grayish brown (2.5Y 3/2) to dark yellowish brown (10YR 4/4). The A horizon of a buried soil is in the profile in some places. The texture throughout the profile ranges from silt loam to fine sand; strata of fine sand occur only below a depth of 30 inches.

Fargo Series

The Fargo series consists of poorly drained Grumusols developed in clayey glaciolacustrine sediments. These soils are on the lake plain. They are nearly level, but there are numerous slight differences in elevation (less than 12 inches) in the areas. Surface drainage is slow.

The Fargo soils have an A horizon of black, friable to firm silt loam to clay. The structure of the A horizon is strong, fine, granular or strong, fine, subangular blocky. The B horizon is olive-gray, very firm clay that has strong, fine, blocky and granular structure. Tongues and wedges of soil material from the A horizon extend downward through the B horizon to the C horizon. The C horizon is olive-gray, very firm, calcareous clay that has moderate, fine, subangular blocky structure or is massive. Dark-brown mottles and segregations of gypsum are common in the C horizon.

The Fargo soils occur with the Overly, Bearden, Dimmick, and Aberdeen soils. They developed in finer textured material than the Overly and Bearden soils. They have a thinner A horizon than the Dimmick soils and are slightly better drained. The Fargo soils lack the A2 horizon and the columnar structure in the B2 horizon that are typical of the Aberdeen and Exline soils.

Profile of Fargo clay 175 feet south and 90 feet west of the NE. corner of the SE¼ of sec. 29, T. 139 N., R. 53 W.:

Ap—0 to 9 inches, black (10YR 2/1) clay, very dark gray (10YR 3/1) when dry; strong, fine, subangular blocky structure; very hard, very firm, very sticky and very plastic; abrupt, smooth boundary.

B2g—9 to 18 inches, olive-gray (5Y 4/2) clay, light olive gray (5Y 6/2) when dry; strong, fine and very fine, blocky and granular structure; very hard, firm, very sticky and very plastic; tongues of soil material from the A horizon extend downward through this horizon; slightly calcareous; clear boundary.

C1gca—18 to 25 inches, olive-gray (5Y 4/2) clay, light gray (5Y 6/1) when dry; moderate, fine, subangular blocky and granular structure; very hard, firm, very sticky and very plastic; strongly calcareous; clear boundary.

C2g—25 to 45 inches, olive-gray (5Y 5/2) clay, light gray (5Y 6/1) when dry; moderate, fine, subangular blocky structure; very hard, firm, very sticky and very plastic; calcareous; clear boundary.

C3—45 to 60 inches, dark grayish-brown (2.5Y 4/1) clay and varves of light brownish-gray (2.5Y 6/2) silt loam with many prominent mottles of dark yellowish brown (10YR 4/4) and dark brown (7.5YR 4/4); stratified; very hard, firm, very sticky and very plastic; strongly calcareous and contains segregations of gypsum crystals.

The texture of the A horizon ranges from silt loam to clay. The thickness of the A horizon ranges from 9 to 20 inches, and the color of that horizon is a neutral black in some places. The thickness of the B2g horizon ranges from 8 to 20 inches. The color of the C horizons ranges from olive gray (5Y 4/2 or 5/2) to dark grayish brown

(2.5Y 4/2). Dark-brown or dark yellowish-brown mottles and segregations of gypsum are common in many places, but they vary in abundance. Varves consisting of alternate layers of silt and clay occur in some places, generally below a depth of 60 inches, but they are at a depth between 42 and 60 inches in some places.

Fordville Series

The Fordville series consists of well-drained Chernozems developed in medium-textured or moderately coarse textured sediments deposited in glacial melt water. These soils are underlain by stratified gravel and coarse sand at a moderate depth. They are most extensive on the beach ridges.

These soils have a black loam or sandy loam A horizon that has moderate granular structure. Their B horizon is very dark brown sandy loam that has prismatic and blocky or subangular blocky structure. It is underlain by stratified gravel and sand.

The Fordville soils occur with the Sioux, Renshaw, and Spottswood soils. Unlike the Sioux soils, they have a B horizon. The Fordville soils have a thicker solum than the Renshaw soils. They have a thinner A horizon and are better drained than the Spottswood soils.

Profile of Fordville loam 250 feet west of the E¼ corner of sec. 1, T. 138 N., R. 54 W.:

Ap—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and granular structure; slightly hard, friable, slightly sticky and slightly plastic; abrupt boundary.

B21—6 to 16 inches, very dark brown (10YR 2/2) heavy sandy loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic and moderate, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; clear boundary.

C1—16 to 24 inches, very dark grayish-brown (2.5Y 3/2) coarse sandy loam, olive brown (2.5Y 4/4) when dry; a few, medium, distinct, dark yellowish-brown (10YR 3/3) mottles; weak, prismatic and subangular blocky structure; slightly hard, very friable, and slightly sticky; clear boundary.

IIC—24 to 60 inches, stratified sand and gravel with many lime-coated pebbles at a depth between 24 and 30 inches.

The A horizon ranges from loam to sandy loam in texture, from black to very dark gray in color, and from 4 to 10 inches in thickness. The B horizon ranges from loam to sandy loam or gravelly loam in texture, from very dark brown to very dark grayish brown in color, and from 10 to 20 inches in thickness. The C1 horizon is absent in some places. Where it is present, it is transitional to the IIC horizon. The thickness of the solum above the sand and gravel substratum is 24 to 30 inches.

Gardena Series

The Gardena series consists of moderately well drained Chernozems developed in medium-textured glacial lake sediments. These soils are in nearly level or slightly concave areas.

These soils have a thick A1 horizon of black, friable loam. Their B horizon is very dark grayish-brown, friable very fine sandy loam to silt loam and has weak prismatic structure. Their C horizon is calcareous, grayish-brown to light olive-brown loam to fine sand.

The Gardena soils occur with the Embden, Eckman, Overly, and Glyndon soils. Unlike the Embden soils, they developed in medium-textured sediments. They have a thicker A horizon than the Eckman soils and are coarser textured than the Overly soils. The Gardena soils have a B horizon that is lacking in the Glyndon soils, and their Cca horizon is at a greater depth than in the Glyndon soils.

Profile of Gardena loam 110 feet north and 70 feet east of the SW. corner of the SE¼ of sec. 14, T. 137 N., R. 54 W.:

A1p—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and fine crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; weak, coarse, prismatic and fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; clear, wavy boundary.

B2—16 to 21 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; weak, medium, prismatic structure; the vertical surfaces of the peds are stained black with organic matter; slightly hard, very friable, slightly sticky and slightly plastic; clear boundary.

B3—21 to 30 inches, dark-brown to brown (10YR 4/3) loam, weak, medium to coarse, subangular blocky structure; the vertical surfaces of the peds are coated with dark grayish brown (10YR 4/2); slightly hard and very friable; abrupt boundary.

C1ca—30 to 33 inches, grayish-brown (2.5Y 5/2) loam; weak, medium, subangular blocky structure; slightly hard and friable; very strongly calcareous; clear boundary.

IICca—33 to 37 inches, light olive-brown (2.5Y 5/4) fine sandy loam, light gray (2.5Y 7/2) when dry; weak, fine, subangular blocky structure; soft and very friable; strongly calcareous; clear boundary.

IIC—37 to 56 inches, light olive-brown (2.5Y 5/4) fine sandy loam, pale yellow (2.5Y 7/3) when dry; few, fine, distinct mottles of light brownish gray (2.5Y 6/2); soft and very friable; calcareous; clear boundary.

IIIC—56 to 64 inches, light olive-brown (2.5Y 5/4) loamy fine sand, pale yellow (2.5Y 7/3) when dry; common, medium, distinct mottles of light brownish gray (2.5Y 6/2); loose; calcareous.

The A1 horizons range from black (10YR 2/1) to very dark gray (10YR 3/1) in color and from 10 to 20 inches in thickness. The B2 horizon ranges from very fine sandy loam to silt loam in texture and from 5 to 16 inches in thickness. The color of the Cca horizons ranges from grayish brown to light olive brown in hues of 2.5Y, and the combined thickness of those horizons ranges from 6 to 12 inches. The texture of the IIC and IIIC horizons ranges from loam to fine sand. In many places light brownish-gray (2.5Y 6/2) mottles are common below a depth of 36 inches.

Glyndon Series

The Glyndon series consists of moderately well drained or somewhat poorly drained calcareous Solonchak soils developed in medium-textured sediments deposited in glacial melt water. These soils are in nearly level or slightly convex areas.

The A1 horizon of these soils is black, friable fine sandy loam to silt loam. Just below the A1 horizon are prominent Cca horizons of grayish-brown or light brownish-gray very fine sandy loam to silt loam. C horizons of light olive-brown to dark yellowish-brown loam to fine sand underlie the Cca horizons.

The Glyndon soils occur with the Hamerly, Borup, Embden, and Gardena soils. Unlike the Hamerly soils, they developed in glacial lake sediments. The Glyndon soils are better drained than the Borup soils, and they have higher chroma in the Cca and C horizons. They lack the B horizon that is present in the Embden soils, and they developed in loam rather than in sandy loam. The Glyndon soils lack the B horizon that is present in the Gardena soils, and they have a Cca horizon immediately beneath the A1 horizon. They lack the weak, coarse, columnar structure, the high content of exchangeable sodium, and the moderately coarse texture that is typical of the Stirum soils, and they are less sticky when wet.

Profile of Glyndon loam 280 feet east of the NW. corner of sec. 15, T. 142 N., R. 52 W.:

A1p—0 to 9 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; very slightly calcareous; abrupt, smooth boundary.

A12ca—9 to 16 inches, very dark gray (10YR 3/1) loam, gray (10YR 6/1) when dry; weak, coarse, prismatic and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; abrupt, smooth boundary.

C1ca—16 to 23 inches, light brownish-gray (2.5Y 6/2) silt loam, white (N 8/0) when dry; has a few, fine, prominent mottles of light olive brown (2.5Y 5/6); weak, coarse, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; numerous fine root channels; very strongly calcareous; clear boundary.

C2ca—23 to 36 inches, grayish-brown (2.5Y 5/2) loam, white (2.5Y 8/2) when dry; has many, fine, distinct mottles of light olive brown (2.5Y 5/4); very weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C3—36 to 44 inches, dark yellowish-brown (10YR 4/4) very fine sandy loam, brownish yellow (10YR 6/5) when dry; soft and very friable; calcareous; gradual boundary.

IIC4—44 to 60 inches, brown (10YR 4/3) loamy fine sand, yellowish brown (10YR 7/2) when dry; loose; slightly calcareous.

The A horizons range from black (10YR 2/1) to very dark gray (10YR 3/1) in color and from fine sandy loam to loam in texture. The thickness of the combined A horizons ranges from 6 to 16 inches. The color of the Cca horizons ranges from grayish brown to light brownish gray in 2.5Y hues. The texture of those horizons ranges from very fine sandy loam to silt loam, and their combined thickness ranges from 8 to 20 inches. The color of the C3 and IIC4 horizons ranges from light olive brown to dark yellowish brown, and the texture of those horizons ranges from loam to fine sand. Mottles commonly occur below a depth of 42 inches.

Hamar Series

The Hamar series consists of somewhat poorly drained or poorly drained Humic Gley soils developed in coarse-textured sediments deposited in glacial melt water. These soils are in nearly level concave areas or in shallow depressions in the Sheyenne Delta.

The A horizon is thick and consists of black, very friable sandy loam to loamy fine sand, faintly mottled with dark brown in the lower part. Below the A horizon is strongly mottled, grayish-brown to light olive-brown loamy fine sand to sand.

The Hamar soils occur with the Hecla, Tiffany, Maddock, and Ulen soils. They are more poorly drained and have a more strongly mottled substratum than the Hecla soils. They developed in coarser textured material than the Tiffany soils, and they have a thicker A1 horizon and more mottling in the substratum than the Maddock soils. The Hamar soils have a more strongly mottled substratum than the Ulen soils, and unlike the Ulen soils, they lack a Cca horizon.

Profile of Hamar loamy fine sand 1,350 feet north and 25 feet west of the SE. corner of the SW¼ of sec. 7, T. 136 N., R. 51 W.:

A11—0 to 8 inches, black (10YR 2/1) loamy fine sand, very dark gray (10YR 3/1) when dry; very weak, medium, subangular blocky and crumb structure; soft and very friable; clear boundary.

A12g—8 to 20 inches, black (2.5Y 2/1) loamy fine sand, very dark gray (2.5Y 3/1) when dry; very weak, medium, subangular blocky structure; soft and very friable; clear boundary.

A13g—20 to 30 inches, black (2.5Y 2/1) loamy fine sand; very dark gray (2.5Y 3/1) when dry; many, fine, faint mottles of dark brown (10YR 4/3) and a few, fine, distinct mottles of dark yellowish brown (10YR 4/4); very weak, coarse, subangular blocky structure; soft and very friable; slightly calcareous.

C1—30 to 38 inches, grayish-brown (2.5Y 5/2) fine sand, light brownish gray (2.5Y 6/2) when dry; common, medium, faint mottles of light olive brown (2.5Y 5/4); single grain; slightly hard and loose; slightly calcareous; abrupt boundary.

C2—38 to 44 inches, grayish-brown (2.5Y 5/2) fine sand; light brownish gray (2.5Y 6/2) when dry; common, coarse, prominent mottles of reddish yellow (7.5YR 6/8); single grain; loose; calcareous; abrupt boundary.

C3—44 to 60 inches, grayish-brown (2.5Y 5/2) fine sand that contains thin layers of silt loam, light brownish gray (2.5Y 6/2) when dry; few, coarse, distinct mottles of dark gray (5Y 4/1); soft and loose; slightly calcareous.

The texture of the A horizons ranges from fine sandy loam to loamy fine sand, and the hues range from 10YR to 2.5Y. The combined thickness of the A horizons ranges from 10 to 30 inches, and depth to the faint dark-brown mottling ranges from 10 to 20 inches. The texture between a depth of 10 and 36 inches ranges from sandy loam to loamy sand. The color of the C horizons ranges from grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4). In general, the texture of those horizons ranges from sandy loam to sand, but thin layers of silt loam and of silty clay loam are only 42 inches from the surface in some places. The color of the prominent mottles in the upper C horizons ranges from strongly contrasting reddish yellow to yellowish brown in hues of 7.5YR and 10YR. In the C3 horizon the color of the mottles ranges from dark gray to olive gray in 5Y hues. In places the mottles in the lower part of the profile are faint instead of distinct.

Hamerly Series

The Hamerly series consists of moderately well drained or somewhat poorly drained, calcareous Solonchak soils developed in medium-textured glacial till. These soils are in nearly level or slightly convex areas adjacent to small depressions and in slightly elevated areas on the till plain.

These soils have an A horizon of black, friable loam. This A horizon is underlain by a prominent Cca horizon of grayish-brown to light brownish-gray, strongly calcareous, friable loam. Below the Cca horizon is a C horizon of light olive-brown, calcareous loam that has a few reddish-brown and yellowish-brown mottles. A variable number of pebbles and stones, typical of the glacial till in this area, occur throughout the profile and in the substratum.

The Hamerly soils occur with the Barnes, Svea, Tetonka, and Vallers soils. Unlike the Barnes and Svea soils, they have a Cca horizon immediately below the A horizon and they lack a B horizon. The Hamerly soils lack the A2 horizon that is typical in the profile of the Tetonka soils, and they are not so poorly drained as the Vallers soils. They developed in glacial till instead of in sediments deposited in melt water like the Glyndon soils.

Profile of Hamerly loam 200 feet north and 20 feet east of the SW. corner of the SE¼ of sec. 19, T. 143 N., R. 53 W.:

Ap—0 to 8 inches, black (10YR 2/1) loam, gray (10YR 5/1) when dry; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; abrupt, smooth boundary.

C1ca—8 to 14 inches, light brownish-gray (2.5Y 6/2) loam, light gray (N 7/0) when dry; horizon broken by thin tongues of black (10YR 2/1) material from the A horizon; coarse, weak, prismatic structure breaking to weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; very strongly calcareous; clear, smooth boundary.

C2ca—14 to 36 inches, light olive-brown (2.5Y 5/4) loam, pale yellow (2.5Y 7/4) when dry; common, medium, faint mottles of light brownish gray (2.5Y 6/2) and a few, medium, distinct mottles of yellowish brown (10YR 5/4); weak, medium, blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C3—36 to 60 inches, light olive-brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) when dry; a few, coarse, prominent mottles of reddish brown (5YR 4/4); weak, medium and fine, blocky structure; calcareous.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) in color and from 6 to 14 inches in thickness. It is slightly calcareous to strongly calcareous. The color of the Cca horizons ranges from grayish brown to light brownish gray or light olive brown in 2.5Y hues. In places the C1ca horizon has a few gray (10YR 4/1) mottles and the C2ca horizon has a few yellowish-brown (10YR 5/4) mottles. The combined thickness of the C1ca and C2ca horizons ranges from 8 to 30 inches. In places the underlying loam till in the C3 horizon has a few prominent mottles that are dark yellowish brown (10YR 4/4) instead of reddish brown (5YR 4/4). In many places the C3 horizon contains gypsum crystals.

Hecla Series

In the Hecla series are moderately well drained Chernozems developed in coarse-textured sediments deposited by glacial melt water. These soils are most extensive on the Sheyenne Delta, but they are also in the northern part of Cass County.

The Hecla soils have a thick, black A horizon of fine sandy loam, loamy fine sand, or fine sand. Their B horizon is weakly defined and is very dark grayish-brown to grayish-brown loamy sand. Their substratum is dark grayish-brown to brown loamy fine sand to sand mottled with dark brown.

The Hecla soils occur with the Embden, Maddock, Ulen, Arveson, Tiffany, and Hamar soils. Their solum is coarser textured than that of the Embden soils. They have a thicker A horizon than the Maddock soils, and unlike the Maddock soils, their substratum is mottled. The Hecla soils lack the distinct Cca horizon that is typical in the profile of the Ulen and Arveson soils, and they are better drained than those soils and than the Tiffany and Hamar soils. They have a coarser textured solum than the Tiffany soils and are less strongly mottled than the Hamar soils.

Profile of Hecla fine sandy loam 75 feet east and 30 feet south of the NW. corner of the SW¼ of sec. 16, T. 143 N., R. 53 W.:

A1p—0 to 6 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky structure; soft and very friable; abrupt, smooth boundary.

A12—6 to 13 inches, very dark brown (10YR 2/2) loamy fine sand, dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; soft and very friable; clear, smooth boundary.

AB—13 to 23 inches, very dark brown (10YR 2/2) loamy fine sand, very dark grayish brown (10YR 3/2) when dry; single grain; soft and loose; gradual boundary.

B—23 to 31 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; common, medium, distinct mottles of very dark brown (10YR 2/2); single grain; loose; gradual boundary.

C1—31 to 46 inches, dark-brown (10YR 3/3) fine sand, brown (10YR 5/3) when dry; many, medium, distinct mottles of very dark grayish brown (10YR 3/2); single grain; loose; clear, wavy boundary.

C2—46 to 64 inches, dark grayish-brown (10YR 4/2) fine sand, brown (10YR 5/3) when dry; many, medium, distinct mottles of dark brown (10YR 3/3); single grain; loose.

The color of the A1p horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The combined thickness of the A horizons ranges from 13 to 40 inches, and the texture of those horizons ranges from fine sandy loam to loamy fine sand or fine sand. Where the texture is fine sandy loam, the thickness of the combined A horizons ranges from 6 to 21 inches but is less than 15 inches in most places. The color of the B horizon ranges from very dark grayish brown to very dark brown in 10YR hues. The texture of that horizon ranges from loamy fine sand to fine sand, and the thickness ranges from 4 to 18 inches. The color of the C horizons ranges from dark brown to dark grayish brown in 10YR hues, and the texture of those horizons ranges from loamy fine sand to sand. The C horizons are slightly calcareous in some places. In other places no free lime occurs above a depth of 60 inches.

Lamoure Series

The Lamoure series consists of somewhat poorly drained Humic Gley soils developed in moderately fine textured alluvium. These soils are on low bottom lands in the valley of the Maple River.

The Lamoure soils have a thick, black to very dark gray A horizon of friable silty clay loam. Their B horizon is olive-brown, friable silty clay loam and is underlain by strata of sandy loam and silt loam. These soils have lime throughout the profile.

The Lamoure soils occur with the Fairdale and La Prairie soils. They are darker colored and more poorly drained than the Fairdale soils and are finer textured and more poorly drained than the La Prairie soils.

Profile of Lamoure silty clay loam 650 feet north and 800 feet east of the SW. corner of the SE¼ of sec. 29, T. 137 N., R. 54 W.:

A1p—0 to 6 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky and moderate, fine, granular structure; hard, friable, slightly sticky and plastic; slightly calcareous; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; hard, friable, slightly sticky and plastic; calcareous; clear, smooth boundary.

A13—10 to 27 inches, very dark gray (10YR 3/1) silty clay loam, light gray (10YR 6/1) when dry; moderate, medium, blocky and fine granular structure; slightly hard, friable, slightly sticky and plastic; snail shells throughout; calcareous; clear, smooth boundary.

Bgca—27 to 40 inches, olive-brown (2.5Y 3/3) silty clay loam, light yellowish brown (2.5Y 6/3) when dry; weak to moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary.

C—40 to 60 inches, olive-brown (2.5Y 4/4) stratified sandy loam and silt loam, light brownish gray (2.5Y 6/2) when dry; hard, friable, slightly sticky and slightly plastic; slightly calcareous.

The color of the A horizons ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the thickness of those horizons ranges from 20 to 30 inches. The color of the Bgca horizon ranges from 2.5Y 3/3 to 2.5Y 4/4, and the thickness of that horizon ranges from 8 to 14 inches.

La Prairie Series

The La Prairie series consists of moderately well drained Alluvial soils intergrading toward Chernozems. These soils developed in recent alluvium. In this county they are most extensive on the bottom lands along the Maple River, but they are also on bottom lands adjacent to the Rush River and Swan Creek.

The La Prairie soils have an A horizon of black, friable silt loam. Their B horizon is very dark grayish-brown, friable silt loam that has weak prismatic structure. The substratum is stratified very fine sandy loam and silt loam, and the strata vary in thickness and color.

The La Prairie soils occur with the Fairdale and Lamoure soils. They are darker colored than the Fairdale soils and are better drained and coarser textured than the Lamoure soils.

Profile of La Prairie silt loam 2,100 feet west and 1,800 feet north of the SE. corner of sec. 18, T. 137 N., R. 53 W.:

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; strong, medium, granular structure; hard, friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

B2—7 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, coarse and medium, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; gradual boundary.

IIA1b1—12 to 16 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak, coarse and medium, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; gradual boundary.

IIB2b11—16 to 32 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; weak, coarse and medium, prismatic structure; hard, friable, slightly sticky and slightly plastic; slightly calcareous; gradual boundary.

IIB2b12—32 to 40 inches, very dark grayish-brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) when dry; hard, friable, slightly sticky and slightly plastic; slightly calcareous; gradual boundary.

IIC1b—40 to 52 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; very hard, friable, slightly sticky and slightly plastic; slightly calcareous; gradual boundary.

IIC2b—52 to 60 inches, dark-brown (10YR 3/3) silt loam, light brownish gray (2.5Y 6/2) when dry; very hard, friable, slightly sticky and slightly plastic; calcareous.

The color of the A horizon ranges from black to very dark gray in hues of 10YR, and the thickness of that horizon ranges from 7 to 20 inches. The color of the B horizon ranges from very dark grayish brown (10YR 3/3) to very dark brown (10YR 2/2) or dark grayish brown (10YR 4/2). The texture of the B horizon ranges from very fine sandy loam to silt loam, and that horizon is slightly calcareous in some places. The color, texture, and thickness of the underlying strata are variable. A buried soil or the A horizon of a buried soil is present in many places but does not occur in all profiles.

Maddock Series

In the Maddock series are well-drained or somewhat excessively drained soils that are moderately coarse textured or coarse textured. Profile development is minimal for classifying these soils as Chernozems, and these soils are intergrading toward the Regosol great soil group. They developed in coarse-textured material deposited in glacial melt water and in windblown sediments. In the survey area, they are most extensive on the Sheyenne Delta, and they occupy convex and slightly higher positions than the surrounding soils.

The A horizon of the Maddock soils is black to very dark brown fine sandy loam to fine sand. Their B horizon is dark grayish-brown to brown loamy fine sand to sand, and their substratum is brown or yellowish-brown loamy fine sand to sand.

The Maddock soils occur with the Hamar, Hecla, and Ulen soils, but they are better drained than those soils. They have a thinner A horizon than the Hamar and Hecla soils and lack the prominent Cca horizon that is typical in the profile of the Ulen soils.

Profile of Maddock loamy fine sand 950 feet east and 30 feet north of the SW. corner of sec. 26, T. 137 N., R. 54 W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) loamy fine sand, dark grayish brown (10YR 4/2) when dry; weak, medium and fine, subangular blocky structure; soft and very friable; abrupt boundary.

B—9 to 16 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; very weak, medium, subangular blocky structure; soft and very friable; gradual boundary.

C1—16 to 30 inches, brown (10YR 5/3) loamy fine sand, pale brown (10YR 6/3) when dry; weak, medium, subangular blocky structure; soft and very friable; gradual boundary.

C2—30 to 52 inches, yellowish-brown (10YR 5/4) loamy fine sand, light yellowish brown (10YR 6/4) when dry; single grain; soft and loose; gradual boundary.

C3—52 to 60 inches, yellowish-brown (10YR 5/4) very fine sandy loam; weak, fine, subangular blocky structure; soft and very friable.

The color of the A horizon ranges from very dark brown to dark grayish brown in hues of 10YR. The texture of that horizon ranges from fine sandy loam to fine sand, and the thickness ranges from 4 to 14 inches. The color of the B horizon ranges from dark grayish brown (10YR 4/2) to yellowish brown (10YR 5/4), and the thickness of that horizon ranges from 6 to 16 inches. The texture of the B horizon ranges from loamy fine sand to fine sand. The color of the C horizons ranges from brown (10YR 5/3) to yellowish brown (10YR 5/4). The texture of the C1 and C2 horizons ranges from loamy fine sand to sand. In places a thin layer of soil material that is finer textured than that in the profile occurs below a depth of 48 inches.

In most areas the profile is noncalcareous, but the substratum is slightly calcareous in some places.

Overly Series

Moderately well drained, nearly level Chernozems make up the Overly series. These soils developed in moderately fine textured sediments deposited in glacial lakes. They are on the lake plain.

The Overly soils have a thick A horizon of black, friable silt loam to silty clay loam, and their A horizon has strong, fine, granular structure. Tongues of dark-colored material from the A horizon extend downward into the B horizon. The B horizon is very dark grayish-brown silty clay loam that has weak prismatic or moderate subangular blocky and strong granular structure. Distinct clay films are on the surfaces of the peds. The Cca horizon is dark grayish-brown to olive-brown silty clay loam, and it is underlain by light olive-brown silty clay loam distinctly mottled with reddish brown.

The Overly soils occur with the Gardena, Fargo, Bearden, and Exline soils. They have a finer textured B horizon than the Gardena soils and are coarser textured than the Fargo soils. Unlike the Bearden soils, they have a B horizon and lack a distinct Cca horizon immediately below the A horizon. They lack the A2 horizon and columnar structure in the B2 horizon that are characteristic of the Exline soils.

Profile of Overly silty clay loam 1,300 feet north of the center of sec. 22, T. 141 N., R. 52 W.:

A1p—0 to 8 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; moderate, coarse, subangular blocky and strong, fine, granular structure; hard, firm, sticky and plastic; abrupt boundary.

A12—8 to 17 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and strong, medium, granular structure; hard, firm, slightly sticky and plastic; clear, irregular boundary.

B2—17 to 22 inches, very dark grayish-brown (2.5Y 3/2) heavy silty clay loam, dark grayish brown (2.5Y 4/2) when dry; moderate, medium and fine, subangular blocky and strong, fine, granular structure; distinct clay films on the surfaces of the peds; hard, firm, sticky and plastic; gradual boundary.

C1ca—22 to 32 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; moderate, medium, subangular blocky structure; faint clay films on the surfaces of the peds; very hard, firm, sticky and plastic; calcareous; gradual boundary.

C2—32 to 50 inches, light olive-brown (2.5Y 5/6) silty clay loam, pale yellow (2.5Y 8/4) when dry; very hard, firm, very sticky and very plastic; calcareous; gradual boundary.

C3—50 to 64 inches, light olive-brown (2.5Y 5/6) silty clay loam, pale yellow (2.5Y 8/4) when dry; a few, fine, distinct mottles of dark brown (7.5YR 4/4); very hard, friable, sticky and plastic; slightly calcareous.

The texture of the A horizons ranges from silt loam to silty clay loam. The combined thickness of those horizons ranges from 10 to 20 inches, but material from those horizons extends deep into the B horizon. The structure of the B horizon ranges from moderate to strong, subangular blocky to strong, fine, granular. The color of the B horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (2.5Y 3/2), and the thickness of that horizon ranges from 4 to 12 inches. The color of the Cca horizon ranges from grayish brown (2.5Y 5/2) to olive brown (2.5Y 4/4) or light olive brown (2.5Y 5/4), and the thickness of that horizon ranges from 8 to 16 inches. In places the texture of the C horizons is silt loam or clay, but the dominant texture is silty clay loam. Stratified silt and clay are below a depth of 42 inches in some places.

Parnell Series

The Parnell series consists of poorly drained Humic Gley soils developed in local alluvium over glacial till. The soils are in deep, closed depressions on the till plain.

These soils have a thick A horizon of black, friable silt loam to silty clay loam and a gray or light-gray B horizon of firm silty clay loam. Their C horizon is olive-gray to dark grayish-brown, firm loam distinctly mottled with dark yellowish brown and light gray.

The Parnell soils occur with the Barnes, Svea, Hamerly, Vallers, and Tetonka soils. Unlike the Barnes and Svea soils, they have a strongly gleyed B horizon and a mottled C horizon. They lack the distinct Cca horizon just beneath the A horizon that is characteristic in the profiles of the Hamerly and Vallers soils, and they lack the A2 horizon that is typical in the profile of the Tetonka soils. The Parnell soils have a profile somewhat similar to that of the Perella soils, but they developed in local alluvium over glacial till instead of in sediments deposited in glacial lakes. They are coarser textured than the Dimmick soils.

Profile of Parnell silt loam 200 feet east and 200 feet south of the center of sec. 25, T. 141 N., R. 53 W.:

A11—0 to 6 inches, black (N 2/0) silt loam, dark gray (5Y 4/1) when dry; moderate, coarse and medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; clear boundary.

A12g—6 to 22 inches, black (N 2/0) silty clay loam, dark gray (5Y 4/1) when dry; many, fine, faint mottles of olive brown (2.5Y 5/4); weak, coarse, prismatic and strong, coarse and medium, subangular blocky structure; hard, friable, sticky and plastic; abrupt boundary.

B2g—22 to 34 inches, gray (5Y 5/1) silty clay loam, light gray (5Y 6/1) when dry; common, medium, faint mottles of light gray (5Y 7/1) and a few, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, coarse, prismatic and moderate, medium, blocky structure; hard, firm, sticky and plastic; clear boundary.

IIC1g—34 to 48 inches, olive-gray (5Y 5/2) loam, gray (5Y 6/1) when dry; many, fine, distinct mottles of dark yellowish brown (10YR 4/4) and light gray (5Y 7/1); hard, firm, sticky and plastic; weakly calcareous; clear boundary.

IIC2g—48 to 60 inches, dark grayish-brown (2.5Y 4/2) loam, light brownish gray (2.5Y 6/2) when dry; common, fine, distinct mottles of light gray (5Y 7/1) and dark yellowish brown (10YR 4/4); hard, friable, sticky and plastic; slightly calcareous.

The texture of the A horizons ranges from silt loam to silty clay loam, and the combined thickness of those horizons ranges from 12 to 24 inches. In places the color of the A horizons is black in 5Y hues.

Perella Series

In the Perella series are poorly drained Humic Gley soils developed in medium-textured and moderately fine textured sediments deposited in glacial lakes. These soils are in shallow depressions on the lake plain.

The Perella soils have a thick A horizon of black, friable to firm silt loam to silty clay loam and a gleyed B horizon of olive-gray to dark-gray silt loam to silty clay loam. Their C horizon is olive-gray silt loam to silty clay loam mottled with yellowish brown and dark brown.

The Perella soils occur with the Overly, Gardena, Bearden, and Glyndon soils. Unlike the Overly and Gardena soils, they have an olive-gray B horizon and a strongly mottled C horizon. They lack the distinct Cca horizon below the A horizon that is present in the Bearden and Glyndon soils. The profile of the Perella soils is somewhat similar to that of the Parnell soils, but the Perella soils developed in sediments deposited in glacial lakes instead of in local alluvium over glacial till. The Perella soils are coarser textured than the Dimmick soils.

Profile of Perella silt loam 0.3 mile north and 0.3 mile west of the SE. corner of sec. 8, T. 142 N., R. 52 W.:

A1p—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt boundary.

A12—8 to 18 inches, black (2.5Y 2/1) silt loam, very dark gray (2.5Y 3/1) when dry; moderate, medium, subangular blocky and granular structure; hard, friable, sticky and plastic; clear boundary.

B2g—18 to 32 inches, olive-gray (5Y 4/2) silty clay loam, gray (5Y 5/1) when dry; a few, fine, faint mottles of light gray (5Y 6/1); moderate, coarse, prismatic and medium, subangular blocky structure; distinct patches of clay films on the vertical surfaces of the peds; very hard, firm, sticky and plastic; gradual boundary.

C1g—32 to 48 inches, olive-gray (5Y 4/2) silty clay loam, light gray (5Y 6/1) when dry; common, medium, distinct mottles of black (2.5Y 2/1) and yellowish brown (10YR 4/4); very hard, firm, sticky and plastic; slightly calcareous and contains a few, fine, white segregations of lime and gypsum crystals; gradual boundary.

C2g—48 to 60 inches, olive-gray (5Y 4/2) silty clay loam, light gray (5Y 6/1) when dry; common, medium, distinct mottles of yellowish brown (10YR 5/4) and a few, medium, prominent mottles of dark brown (7.5YR 4/2); very hard, firm, sticky and plastic; calcareous with common, fine, distinct segregations of white lime.

The texture of the A horizons ranges from silt loam to silty clay loam, and the combined thickness of those horizons ranges from 10 to 20 inches. The color of the B horizon ranges from dark gray (2.5Y 4/1) to olive gray (5Y 4/2), and the texture of that horizon ranges from silt loam to silty clay loam. The B horizon ranges from 10 to 16 inches in thickness. The color of the C horizons ranges from grayish brown (2.5Y 4/2) to olive gray (5Y 4/2) with many mottles of yellowish brown (10YR 5/4), reddish brown (5YR 4/4), and dark brown (7.5YR 4/2). In general, the texture of the C horizons ranges from silt loam to silty clay loam, but thin layers of coarser textured material occur in some places in the C horizons where the Perella soils occur with the Gardena soils.

Rauville Series

The Rauville series consists of very poorly drained Humic Gley soils developed in medium-textured and moderately fine textured alluvium. These soils are in abandoned stream channels, oxbows, and seepage areas along the outer edges of stream valleys.

These soils have a thick A horizon of black, friable silty clay loam to silt loam and a B horizon of black to very dark gray, gleyed silty clay loam. The B horizon has moderate blocky structure and many faint dark brown and very dark brown mottles.

The Rauville soils occur with the Lamoure, Fairdale, and La Prairie soils. They are more poorly drained and have a thicker and darker A horizon than the Lamoure soils, and they also have stronger mottling in the B horizon and substratum. They are more poorly drained and are darker colored than the Fairdale soils, and they are more poorly drained and lack the 10YR hues in the B horizon that are typical in the B horizon of the La Prairie soils.

Profile of Rauville silt loam 1,200 feet north and 200 feet east of the SW. corner of the SE¼ of sec. 29, T. 137 N., R. 54 W.:

A11—0 to 8 inches, black (N 2/0) silt loam, dark gray (N 4/0) when dry; moderate, medium, subangular blocky and granular structure; hard, very friable, and slightly plastic; gradual boundary.

A12g—8 to 18 inches, black (N 2/0) silt loam, dark gray (N 4/0) when dry; weak, coarse, prismatic and moderate, medium, subangular blocky structure; slightly hard, friable, and slightly plastic; weakly calcareous; gradual boundary.

ABg—18 to 32 inches, black (5Y 2/1) silty clay loam, gray (5Y 5/1) when dry; weak, coarse, prismatic to moderate, medium, blocky structure; hard, firm, sticky and plastic; slightly calcareous; clear boundary.

B21g—32 to 40 inches, black (5Y 2/2) silty clay loam, gray (5Y 5/1) when dry; moderate, coarse and medium, blocky structure; hard, firm, sticky and plastic; weakly calcareous; gradual boundary.

B22g—40 to 52 inches, very dark gray (2.5Y 3/1) stratified sandy loam and silty clay loam, dark gray (2.5Y 4/1) when dry; many, fine, faint, very dark brown (10YR 2/2) and very dark grayish-brown (2.5Y 3/2) mottles; hard, firm, sticky and plastic; clear boundary.

A1bg—52 to 60 inches, black (5Y 2/1) stratified sandy loam and silty clay loam, gray (5Y 5/1) when dry; many olive-brown (2.5Y 4/4) and very dark grayish-brown (2.5Y 3/2) mottles; hard, firm, sticky and plastic.

The texture of the A horizons ranges from silt loam to silty clay loam, and the thickness of those horizons ranges from 16 to 30 inches. In places the color of the A horizons is black in 5Y hues. The color of the B horizons ranges from black (5Y 2/1) to very dark gray (2.5Y 3/1) or olive gray (5Y 4/2), and the texture of those horizons ranges from silt loam to silty clay loam. The underlying material is dominantly silt loam to silty clay loam strongly mottled with olive brown (2.5Y 4/4) and very dark grayish brown (2.5Y 3/2), but there are thin layers of sandy loam below a depth of 36 inches in some places. In some places the profile lacks the A horizon of a buried soil.

Renshaw Series

The Renshaw soils are well-drained Chernozems. They developed in medium-textured to moderately coarse textured glacial melt water sediments over gravel and coarse sand. They are most extensive on the beach ridges.

The A horizon of these soils is black to very dark gray, friable loam to sandy loam. Their B horizon is very dark grayish-brown or grayish-brown, friable sandy loam to loam that has moderate prismatic structure. The substratum is gravel and coarse sand.

The Renshaw soils occur with the Sioux and Fordville soils. Unlike the Sioux soils, they have a B horizon. Their profile is similar to that of the Fordville soils, but gravel and sand are immediately below the B horizon.

Profile of Renshaw loam 1,000 feet north and 70 feet west of the SE. corner of the NE¼ of sec. 31, T. 137 N., R. 54 W.:

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium and fine, subangular blocky and moderate, fine, crumb structure; soft, friable, slightly sticky and slightly plastic; abrupt, smooth boundary.

B21—7 to 11 inches, dark grayish-brown (10YR 4/2) light loam, grayish brown (10YR 5/2) when dry; moderate, medium, prismatic and weak, medium and fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt boundary.

B22—11 to 14 inches, dark grayish-brown (10YR 4/2) sandy loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, subangular blocky structure; slightly hard and very friable; clear boundary.

B3—14 to 17 inches, dark grayish-brown (10YR 4/2) gravelly sandy loam, grayish brown (10YR 5/2) when dry; very weak, medium, subangular blocky structure; soft and very friable; lime coatings on the pebbles; abrupt boundary.

IIC1—17 to 36 inches, gravel and sand.

IIC2—36 to 60 inches, stratified sand and gravel.

The texture of the A horizon ranges from loam to sandy loam. The color of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the thickness of that horizon ranges from 4 to 10 inches. The color of the B horizons ranges from very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2), and the texture of those horizons ranges from light loam or sandy loam to gravelly sandy loam. The combined thickness of the B horizons ranges from 4 to 10 inches. The thickness of the solum ranges from 8 to 20 inches, but the dominant thickness is 12 to 18 inches. The substratum is stratified and consists of gravelly sand to coarse gravel.

Sioux Series

The Sioux series consists of excessively drained Regosols. These soils developed in very shallow, medium-textured and moderately coarse textured sediments deposited in glacial melt water. The Sioux soils are most extensive on the beach ridges.

These soils have an A horizon of black to very dark gray, friable sandy loam to loam. The A horizon rests upon the substratum of gravel and coarse sand. The uppermost few inches of the substratum is calcareous and contains many lime-coated pebbles.

The Sioux soils occur with the Renshaw soils. Unlike the Renshaw soils, they lack a B horizon and have a substratum of gravel or gravelly sand immediately below the A horizon. This gravelly substratum distinguishes the Sioux soils from the Buse and Zell soils, which have a substratum of medium-textured glacial till or of sediments deposited in melt water.

Profile of Sioux loam one-fourth of a mile south and 108 feet east of the NW. corner of sec. 6, T. 136 N., R. 54 W.:

A11—0 to 3 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; compound weak, fine, subangular blocky and crumb structure; numerous fine roots; slightly hard, very friable, slightly sticky and slightly plastic; clear, smooth boundary.

A12—3 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; compound weak, medium, prismatic and weak, fine, subangular blocky structure; numerous fine roots; slightly hard, very friable, slightly sticky and slightly plastic; clear, wavy boundary.

IICca—8 to 18 inches, dark grayish-brown (2.5Y 4/2) coarse sand and gravel, light brownish gray (2.5Y 6/2) when dry; few roots; single grain (structureless); loose; strongly calcareous; gradual boundary.

IIC—18 to 60 inches, brown (10YR 4/3) coarse sand and gravel.

The color of the A horizons ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the texture of those horizons ranges from sandy loam to loam. The combined thickness of the A horizons ranges from 4 to 10 inches.

Spottswood Series

In the Spottswood series are moderately well drained Chernozems. These soils developed in medium-textured or moderately coarse textured sediments deposited in glacial melt water, and they are underlain by gravel and coarse sand at a moderate depth. They are most extensive on the lower slopes of the beach ridges.

These soils have a thick A horizon of black, friable sandy loam to loam. Their B horizon is very dark grayish-brown to very dark brown or dark-gray loam, and it has weak to moderate prismatic structure. The upper part of their C horizon is light brownish-gray to grayish-brown, friable sandy loam to loam, and it is underlain by stratified gravel and coarse sand.

The Spottswood soils occur with the Renshaw and Fordville soils, but they have a thicker A horizon than those soils. Also, they have a Cca horizon above the gravel in the substratum that is lacking in the Renshaw soils.

Profile of Spottswood sandy loam 1,100 feet east and 80 feet south of the NW. corner of the NE¼ of sec. 35, T. 141 N., R. 53 W.:

A1p—0 to 8 inches, black (10YR 2/1) sandy loam, dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky structure; slightly hard and very friable; abrupt boundary.

A12—8 to 18 inches, black (10YR 2/1) sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; slightly hard and friable; clear boundary.

B2—18 to 24 inches, very dark brown (10YR 2/2) sandy loam, dark gray (10YR 4/1) when dry; weak, coarse, prismatic and medium, subangular blocky structure; slightly hard and friable; abrupt, wavy boundary.

Cca—24 to 34 inches, grayish-brown (2.5Y 5/2) gravelly loam, light brownish gray (2.5Y 6/2) when dry; weak, coarse, subangular blocky structure; slightly hard and friable; strongly calcareous; clear boundary.

IIC1—34 to 48 inches, dark grayish-brown (2.5Y 4/2) gravel and coarse sand, grayish brown (2.5Y 5/2) when dry; single grain; loose; slightly calcareous; abrupt boundary.

IIIC2—48 to 60 inches, olive-brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; common, coarse, prominent mottles of yellowish red (5YR 4/6); weak, fine, blocky structure; hard, friable, slightly sticky and slightly plastic; calcareous.

The texture of the A horizons ranges from sandy loam to loam, and the combined thickness of those horizons ranges from 10 to 22 inches. The color of the B horizon ranges from very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2) or dark brown (10YR 4/3), and the texture of that horizon ranges from sandy loam to loam. The structure of that horizon is weak to moderate prismatic. The color of the Cca horizon ranges from light brownish gray to grayish brown, and the texture of that horizon ranges from gravelly loam to gravelly sandy loam. The thickness of the solum ranges from 20 to more than 36 inches, but the thickness of the modal solum is between 24 and 36 inches.

Stirum Series

The Stirum series consists of weakly solodized Solonetz soils that are poorly drained. These soils developed in moderately coarse textured sediments deposited in glacial melt water.

The A horizons of these soils range from black to very dark gray in color and from fine sandy loam to silt loam in texture. Their B2 horizon is very dark gray fine sandy loam. It has weak, coarse, columnar or prismatic structure. The surfaces of the peds are coated with gray. Segregations of soluble salts and gypsum crystals are common in the B2 horizon, and that horizon is strongly calcareous and strongly alkaline. The C horizons are grayish-brown to olive-brown fine sandy loam to loamy sand mottled with gray and dark yellowish brown.

The Stirum soils occur with the Glyndon and Ulen soils. They developed in coarser textured sediments than the Glyndon soils. Unlike the Ulen soils, they have a B horizon that has columnar or prismatic structure and contains soluble salts and gypsum.

Profile of Stirum silt loam 200 feet east and 150 feet north of the SW. corner of sec. 13, T. 138 N., R. 54 W.:

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and granular structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly calcareous; abrupt boundary.

A12—7 to 11 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) when dry; weak, coarse and moderate, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; calcareous and contains many very fine, white flecks of salt; moderately alkaline; clear boundary.

B2—11 to 30 inches, very dark gray (2.5Y 3/1) fine sandy loam, dark gray (2.5Y 4/1) when dry; weak, very coarse, columnar and coarse, subangular blocky structure; hard, friable, sticky and plastic; strongly alkaline; strongly calcareous and contains distinct nests of gypsum crystals; clear boundary.

C1ca—30 to 40 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, light gray (2.5Y 7/2) when dry; very hard and very friable; very strongly calcareous and strongly alkaline; contains segregations of gypsum; clear boundary.

C2—40 to 52 inches, grayish-brown (2.5Y 5/2) fine sandy loam, light brownish gray (2.5Y 6/2) when dry; a few, fine, faint, light-gray (5Y 6/1) mottles; very hard and very friable; strongly alkaline; calcareous; gradual boundary.

C3—52 to 60 inches, olive-brown (2.5Y 4/4) fine sandy loam, light yellowish brown (2.5Y 6/4) when dry; a few fine, faint, light-gray (5Y 6/1) and a few, coarse, distinct, very dark brown (10YR 2/2) and dark yellowish-brown (10YR 4/4) mottles; very hard and very friable; slightly calcareous.

The color of the A horizons ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the texture of those horizons ranges from fine sandy loam to silt loam. Flecks of soluble salts occur in some places in the A12 horizon. The combined thickness of the A horizons ranges from 6 to 14 inches. The color of the B2 horizon ranges from very dark gray to light brownish gray in 2.5Y hues. The percentage of exchangeable sodium in that horizon ranges from 30 to 70 percent. The color of the C horizons ranges from grayish brown (2.5Y 5/2) or light brownish gray (2.5Y 6/2) to olive brown (2.5Y 4/4), and those horizons are mottled with light gray (5Y 6/1), very dark brown (10YR 2/2), and dark yellowish brown (10YR 4/4). The percentage of exchangeable sodium in the C horizons exceeds 40 percent.

Svea Series

In the Svea series are moderately well drained Chernozems developed in friable loam glacial till. These soils are in nearly level or slightly concave areas on the till plain.

The Svea soils have a thick A horizon of black loam and a B horizon of very dark grayish-brown, friable loam that has prismatic structure. Their Cca horizon is olive-brown to light brownish-gray loam that has weak blocky structure. The C horizon is olive-brown or light olive-brown, calcareous, friable loam. Variable numbers of pebbles and stones, typical of the glacial till in the survey area, are in all horizons and in the substratum.

The Svea soils occur with the Barnes, Hamerly, Tetonka, Parnell, Buse, and Vallers soils. They have a thicker A horizon and a greater depth to free lime than the Barnes soils, and they lack the distinct Cca horizon that underlies the A horizon in the Hamerly soils. The Svea soils lack the A2 horizon that is typical in the profile of the Tetonka soils, and they are better drained than the Tetonka and Parnell soils. They have a thicker A horizon than the Buse soils, and they have a B horizon that is lacking in the Buse soils. The Svea soils developed in glacial till rather than in glacial melt water sediments like the Gardena soils.

Profile of Svea loam 620 feet north and 150 feet east of the SW. corner of sec. 30, T. 137 N., R. 54 W.:

A1p—0 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky and granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt boundary.

A12—8 to 14 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, coarse, prismatic and moderate, medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; gradual boundary.

AB—14 to 20 inches, very dark brown (10YR 2/2) heavy loam, dark gray (10YR 4/1) when dry; moderate, coarse, prismatic and moderate, coarse and medium, blocky structure; slightly hard, friable, slightly sticky and slightly plastic; clear boundary.

B21—20 to 30 inches, very dark grayish-brown (2.5Y 3/2) light clay loam, dark grayish brown (2.5Y 4/2) when dry; moderate, medium and coarse, prismatic and moderate, medium, blocky structure; faint patches of clay films on the vertical surfaces of the peds; hard, friable, sticky and slightly plastic; numerous pores; gradual boundary.

B22—30 to 36 inches, very dark grayish-brown (2.5Y 3/2) light clay loam, dark grayish brown (2.5Y 4/2) when dry; coarse, weak, prismatic and moderate, medium, blocky structure: faint patches of clay films on the vertical surfaces of the peds; hard, friable, sticky and slightly plastic; clear boundary.

C1ca—36 to 42 inches, olive-brown (2.5Y 4/4) loam, light olive brown (2.5Y 5/4) when dry; a few, fine, distinct mottles of very dark brown (10YR 2/2); coarse, weak, blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; clear boundary.

C2—42 to 60 inches, olive-brown (2.5Y 4/4) loam, light olive brown (2.5Y 5/4) when dry; a few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); slightly hard, friable, slightly sticky and slightly plastic; calcareous.

The combined thickness of the A horizons ranges from 9 to 20 inches. The texture of the B2 horizons ranges from loam to light clay loam, and the structure of those horizons ranges from weak or moderate prismatic to subangular blocky or blocky. In places the faint patches of clay films on the vertical surfaces of the prisms are absent. The combined thickness of the B horizons ranges from 4 to 18 inches. The color of the Cca horizon ranges from olive brown (2.5Y 4/4) to light brownish gray (2.5Y 6/2), and the thickness of the Cca horizon ranges from 6 to 16 inches.

The color of the C2 horizon ranges from olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4) mottled with dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6).

Tetonka Series

The Tetonka series consists of poorly drained Planosols developed in local alluvium over glacial till. These soils are in shallow closed depressions on both the till plain and the lake plain.

These soils have a thick A horizon of black, friable silt loam and a thin to thick A2 horizon of black to very dark gray or gray very fine sandy loam to silt loam. The A2 horizon is mottled with dark yellowish brown and has platy structure. The B2 horizon is firm clay loam to silty clay and has weak prismatic and strong blocky structure.

The Tetonka soils occur with the Barnes, Svea, Hamerly, Vallers, and Parnell soils, but unlike these soils, they have an A2 horizon. The Tetonka soils have a finer textured, darker colored B horizon than the Barnes and Svea soils, and they lack the distinct Cca horizon immediately below the A1 horizon that is typical in the Hamerly and Vallers soils.

Profile of Tetonka silt loam 1,000 feet south of the center of sec. 10, T. 137 N., R. 54 W.:

A1—0 to 15 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; gradual boundary.

A1-A2—15 to 22 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, thin, platy structure; slightly hard, friable, slightly sticky and slightly plastic; clear boundary.

A2—22 to 32 inches, black (2.5Y 2/2) loam, gray (5Y 5/1) when dry; many, medium, distinct mottles of dark yellowish brown (10YR 4/4); strong, thin, platy structure; slightly hard and very friable; abrupt boundary.

B2g—32 to 48 inches, dark grayish-brown (2.5Y 4/2) clay loam, grayish brown (2.5Y 5/2) when dry; common, coarse, distinct mottles of yellowish brown (10YR 5/6) and many, fine, distinct mottles of dark yellowish brown (10YR 3/4); weak, coarse, prismatic and strong, medium and fine, blocky structure; very hard, firm, sticky and plastic; clear boundary.

IIC—48 to 60 inches, dark grayish-brown (2.5Y 4/2) fine sandy ture; slightly hard and very friable; abrupt boundary. medium and fine distinct mottles of pale brown (10YR 6/3), dark brown (10YR 4/3), and very dark brown (10YR 2/2); hard, very friable.

The color of the A1 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the thickness of that horizon ranges from 6 to 24 inches. The color of the A2 horizon ranges from black (2.5Y 2/2) or very dark gray (5Y 3/1) to gray (5Y 5/1), and the texture of that horizon ranges from very fine sandy loam to silt loam. The thickness of the A2 horizon ranges from 2 to 10 inches. The color of the B horizon ranges from very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), and the texture of that horizon ranges from clay loam to silty clay. The structure of the B horizon ranges from weak prismatic to strong, fine, blocky, and the aggregates in the upper part of that horizon are coated with gray soil material from the A2 horizon. The thickness of the B horizon ranges from 14 to 24 inches. The color of the C horizon ranges from dark grayish brown (2.5Y 4/2) to olive (5Y 5/3) with mottles of reddish brown (5YR 4/3) and yellowish brown, dark brown, and very dark brown in 10YR hues. The texture of the C horizon ranges from clay loam or silty clay loam to fine sandy loam. In some places strata of sandy loam occur below a depth of 50 inches.

Tiffany Series

The Tiffany series consists of poorly drained Humic Gley soils developed in moderately coarse textured sediments deposited in glacial lakes. These soils are in shallow depressions and in low concave areas. In most years they have a water table at a depth of less than 5 feet in spring and early in summer.

These soils have a thick A horizon of black, friable fine sandy loam. Their B horizon is dark grayish-brown fine sandy loam mottled with dark brown and dark yellowish brown. The C horizon is light brownish-gray to light-gray fine sandy loam to loamy sand with many dark-brown and yellowish-brown mottles.

The Tiffany soils occur with the Hecla, Embden, Hamar, and Ulen soils. They are finer textured and more poorly drained than the Hecla soils and are more poorly drained and more strongly mottled than the Embden soils. The Tiffany soils are finer textured than the Hamar soils, and they lack the distinct Cca horizon that is present in the Ulen soils.

Profile of Tiffany fine sandy loam 400 feet north and 60 feet west of the SE. corner of the SW¼ of sec. 6, T. 137 N., R. 53 W.:

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and weak, fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; abrupt boundary.

A12—9 to 26 inches, black (10YR 2/1) fine sandy loam, gray (10YR 5/1) when dry; many, fine, faint mottles of very dark brown (10YR 2/2) and dark yellowish brown (10YR 3/4); weak, fine, subangular blocky and crumb structure; slightly hard and very friable; gradual boundary.

B2g—26 to 40 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam, light gray (2.5Y 7/2) when dry; common, medium and fine, distinct mottles of very dark brown (10YR 2/2) and dark yellowish brown (10YR 4/3); very weak, coarse, crumb structure; slightly hard and loose; gradual boundary.

IIC1g—40 to 56 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, white (2.5Y 8/2) when dry; many prominent mottles of dark yellowish brown (10YR 4/6) and a few, medium, prominent mottles of very dark brown (10YR 2/2); hard, friable, and slightly plastic; calcareous; clear boundary.

IIC2g—56 to 62 inches, light-gray (2.5Y 7/2) very fine sandy loam, white (2.5Y 8/2) when dry; many, coarse, prominent mottles of yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4); hard and very friable; calcareous.

The A horizon ranges from 15 to 30 inches in thickness, and the number of mottles in the lower part ranges from common to many. The color of the B horizon ranges from dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 5/3), and the color of the mottles ranges from very dark brown (10YR 2/2) to dark yellowish brown (10YR 4/3). The color of the C horizons ranges from grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) with strong mottling of dark yellowish brown (10YR 4/4) and very dark brown (10YR 2/2). In general, the texture of the C horizons ranges from fine sandy loam or very fine sandy loam to loamy sand, but strata of finer textured material occur below a depth of 48 inches in some places.

Ulen Series

The Ulen series consists of moderately well drained or somewhat poorly drained, calcareous Solonchak soils developed in moderately coarse textured and coarse textured sediments deposited in glacial melt water. These soils are in low, nearly level areas. A water table is at a depth of less than 5 feet in spring and early in summer in most years. These soils are calcareous below a depth of 10 inches, and they are calcareous at the surface in many places.

The A horizon of these soils is black to very dark gray, very friable fine sandy loam to loamy fine sand, and it is underlain by a strongly calcareous Cca horizon of very dark gray to grayish-brown fine sandy loam to loamy fine sand. The C horizon is olive-brown to light olive-brown fine sandy loam to loamy fine sand mottled with brown and very dark grayish brown.

The Ulen soils occur with the Hecla, Embden, Maddock, Egeland, Hamar, and Tiffany soils. They have more mottling in the substratum than the Hecla, Embden, Maddock, and Egeland soils, and unlike those soils, they lack a B horizon. Also, just below the A horizon they have a distinct Cca horizon that is lacking in those soils and is lacking in the Hamar and Tiffany soils. The Ulen soils are coarser textured than the Glyndon soils. They are better drained than the Arveson soils.

Profile of Ulen fine sandy loam 350 feet west and 250 feet north of the center of sec. 3, T. 136 N., R. 52 W.:

Ap—0 to 6 inches, black (10YR 2/1) fine sandy loam, gray (10YR 5/1) when dry; weak, medium, subangular blocky structure; hard, very friable, and slightly sticky; calcareous; abrupt boundary.

C1ca—6 to 18 inches, very dark gray (10YR 3/1) fine sandy loam, light gray (10YR 6.6/1) when dry; weak, medium and fine, subangular blocky and moderate, fine, crumb structure; hard, friable, and slightly sticky; strongly calcareous; gradual boundary.

C2ca—18 to 26 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam, light gray (2.5Y 7/2) when dry; weak, coarse, subangular blocky and fine crumb structure; hard and very friable; strongly calcareous; clear boundary.

C3—26 to 40 inches, light olive-brown (2.5Y 5/4) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; single grain; slightly hard and loose; calcareous; clear boundary.

IIC4—40 to 52 inches, light olive-brown (2.5Y 5/4) light loam, light gray (2.5Y 7/2) when dry; many, medium, distinct, brown (7.5YR 4/4) mottles; hard and friable; calcareous; gradual boundary.

IIC5—52 to 62 inches, light olive-brown (2.5Y 5/4) stratified very fine sandy loam and silt loam (strata of silt loam are very thin), light gray (2.5Y 7/2) when dry; many, medium, distinct, brown (7.5YR 4/4) mottles and a few very dark grayish-brown (10YR 3/2) mottles; hard, friable, and slightly plastic; calcareous.

The color of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the texture of the A horizon ranges from fine sandy loam to loamy fine sand. The thickness of that horizon ranges from 6 to 15 inches. The color of the Cca horizons ranges from very dark gray (2.5Y 3/1) to grayish brown (2.5Y 5/2) or dark grayish brown (2.5Y 4/2). The texture of the Cca horizons ranges from heavy fine sandy loam to loamy fine sand, and the combined thickness of those horizons ranges from 6 to 20 inches. The color of the other C horizons ranges from olive brown to light olive brown in 2.5Y hues, with brown (7.5YR 4/4) mottles. In general, the texture of these other C horizons ranges from fine sandy loam to fine sand, but strata of finer textured material occur in many places below a depth of 42 inches.

Vallers Series

The Vallers series consists of poorly drained calcareous Solonchak soils developed in medium-textured glacial till. These soils are on the till plain adjacent to shallow, closed depressions.

The A horizons of these soils are black to very dark gray, calcareous, friable loam. Their Cca horizons are gray to light olive-gray loam to clay loam. The C horizons below the Cca horizons consist of gray to olive-brown loam mottled with yellowish brown and dark yellowish brown. Variable amounts of pebbles and stones, typical of the glacial till in the survey area, are throughout the profile and in the substratum.

The Vallers soils occur with the Barnes, Svea, Hamerly, and Tetonka soils. They lack the B horizon that is typical in the Barnes and Svea profiles, and they have grayer colors and poorer drainage than the Hamerly soils. The Vallers soils lack the A2 and B horizons that are typical in the Tetonka profile. Unlike the Borup soils, they developed in glacial till. The Vallers soils are finer textured than the Arveson soils.

Profile of Vallers loam 150 feet east and 100 feet north of the center of sec. 25, T. 137 N., R. 54 W.:

A1—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky and granular structure; slightly hard, friable, slightly sticky and slightly plastic; calcareous; clear boundary.

A12ca—7 to 14 inches, very dark gray (2.5Y 3/1) loam, gray (2.5Y 5/1) when dry; weak, coarse, prismatic and medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous; clear boundary.

C1gca—14 to 22 inches, light olive-gray (5Y 6/2) loam, light gray (5Y 7/1) when dry; weak, coarse, prismatic and moderate, medium, subangular blocky structure; hard, friable, sticky and plastic; very strongly calcareous; clear boundary.

C2gca—22 to 34 inches, gray (5Y 5/1) loam, light gray (5Y 6/1) when dry; a few, fine, distinct mottles of light olive brown (2.5Y 5/4); weak, coarse, prismatic and moderate, medium, subangular blocky structure; very hard, friable, sticky and plastic; strongly calcareous; clear boundary.

C3g—34 to 46 inches, gray (5Y 6/1) light loam, light gray (5Y 7/1) when dry; many, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); slightly hard, very friable, slightly sticky and slightly plastic; calcareous; clear boundary.

C4g—46 to 60 inches, olive-brown (2.5Y 4/4) loam, light grayish brown (2.5Y 6/2) and has common, medium, distinct mottles of dark yellowish brown (10YR 4/4) when dry; hard, friable, sticky and plastic; slightly calcareous.

The color of the A horizons ranges from black (10YR 2/1) to very dark gray (10YR 3/1), and the combined thickness of those horizons ranges from 6 to 14 inches. The color of the Cca horizons ranges from gray to light olive gray and light brownish gray in 5Y hues, and the texture of those horizons ranges from loam to clay loam. The combined thickness of the Cca horizons ranges from 10 to 20 inches. The color of the Cg horizons ranges from gray (5Y 6/1) to olive brown (2.5Y 4/4), and the color of the mottles in those horizons ranges from dark yellowish brown (10YR 4/3) to yellowish brown (10YR 5/6). The texture of the Cg horizons ranges from loam to light clay loam, but loam is the dominant texture.

Zell Series

In the Zell series are excessively drained Regosols. These soils developed in medium-textured sediments deposited in glacial lakes. They are on the sides of stream valleys and shallow drainageways that are entrenched in the silty sediments deposited by glacial melt water.

Where these soils have not been cultivated, their A horizon is calcareous, black to very dark gray, friable fine sandy loam to loam. Where the soils have been cultivated, the A horizon is likely to be gray to light brownish gray. The C horizon is mainly brown to light yellowish-brown silt loam, but thin layers of coarser textured material occur in many places below a depth of 24 inches. The profile is calcareous throughout, but in the C horizon the carbonates are more concentrated in the uppermost 12 inches than in the lower part.

The Zell soils occur with the Eckman soils, but they lack the B horizon that is typical in the Eckman profile. Unlike the Buse soils, they developed in sediments deposited in glacial melt water. The Zell soils lack a gravelly substratum like that beneath the Sioux soils.

Profile of Zell loam located 1,200 feet east and 350 feet north of the SW. corner of sec. 16, T. 137 N., R. 54 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky and weak, medium, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; calcareous; abrupt boundary.

C1—8 to 14 inches, brown (10YR 5/3) silt loam, pale brown (10 YR 6/3) when dry; weak, very coarse, subangular blocky structure; slightly hard, friable, and slightly plastic; calcareous; clear, wavy boundary.

C2—14 to 26 inches, light yellowish-brown (10YR 6/4) silt loam, very pale brown (10YR 8/3) when dry; weak, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; calcareous; clear boundary.

C3—26 to 36 inches, yellowish-brown (10YR 5/4) silt loam, very pale brown (10YR 8/4) when dry; moderate, fine and very fine, blocky structure; hard, friable, slightly sticky and slightly plastic; calcareous; gradual boundary.

C4—36 to 60 inches, light yellowish-brown (10YR 6/4) silt loam, very pale brown (10YR 8/4) when dry; hard, friable, and slightly plastic; calcareous.

In areas that have not been cultivated, the color of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). In many places in cultivated fields, the Ap horizon is light gray (10YR 5/1) to light brownish gray (2.5Y 6/2). The texture of the A horizon ranges from fine sandy loam to loam, and the thickness of that horizon ranges from 4 to 10 inches. The color of the C horizons ranges from brown (10YR 5/3) to yellowish brown (10YR 5/4) or light yellowish brown (10YR 6/4). The texture of the C horizons is dominantly silt loam, but thin layers of coarser textured soil material occur below a depth of 24 inches in some places.

Physical and Chemical Analyses of Soils

Data on the physical and chemical properties of a profile from several selected soils in the area are presented in table 8. The data provide information useful in classifying the soils and in making estimates of their response to management. Three of the profiles are described in this section. Typical profiles of Aberdeen silt loam, Egeland fine sandy loam, and Hecla loamy fine sand are described in the section "Descriptions of the Soil Series."

Field and laboratory methods

All samples used to obtain the data in table 8 were collected from carefully selected pits. Profile descriptions were written at the site, and samples were taken from each horizon for analysis. The samples were air dried, crushed by hand, and passed through a 2-millimeter sieve. All laboratory analyses were made on material less than 2 millimeters in diameter, except for the sample used for determining the content of organic carbon, which was ground to pass a 60-mesh sieve. Determinations of bulk density were made by using 3-inch cores (*11*).

Determinations of the percentages of clay were made by using the pipette method (*4*, *5*, *7*). The moisture held at one-tenth atmosphere was 7.28 percent in the AC horizon of Hecla loamy fine sand. That held at one-third atmosphere was 11.4 percent for the A1p horizon of the same soil, 9.49 percent for the A12 horizon, and 11.3 percent for the C1ca horizon. The reaction (pH) of the saturated paste was measured with a glass electrode.

The calcium carbonate equivalent was determined by using the manometric method described by Williams (*19*). The cation-exchange capacity was determined by the sodium acetate method (*11*). Calcium and magnesium were determined by using the versenate procedure of the U.S. Salinity Laboratory (*11*). Sodium and potassium determinations were made using a Perkin-Elmer flame photometer procedure outlined by the U.S. Salinity Laboratory (*11*). The content of organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*9*).

EMBDEN SERIES.—Profile of Embden fine sandy loam, till substratum, 90 feet east and 550 north of the SW. corner of the SE¼ of sec. 25, T. 140 N., R. 54 W.:

Ap—0 to 10 inches, dark-gray (10YR 4/1) fine sandy loam, black (10YR 2/1) when moist; very weak, fine and medium, blocky structure; friable; clear, wavy boundary.

A3—10 to 19 inches, dark-gray (10YR 4.4/1) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, very coarse, blocky structure; very friable; clear, wavy boundary.

IIB—19 to 26 inches, dark grayish-brown (2.5Y 4/2) sandy and gravelly loam, light olive brown (2.5Y 5/4) when moist; single grain and granular structure; friable; calcareous; clear, wavy boundary.

IIIC1ca—26 to 45 inches, mottled white (2.5Y 8/2) loam, light brownish gray (2.5Y 6/2) when moist; has many, fine, prominent mottles that are olive brown (2.5Y 4/4) when moist; weak, medium, granular structure; friable, slightly sticky and slightly plastic; very strongly calcareous; gradual, wavy boundary.

IIIC2—45 to 60 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) when moist; weak, thin to medium, platy structure; moderately firm, slightly sticky and slightly plastic; strongly calcareous.

HECLA SERIES.—Profile of Hecla loamy fine sand 90 feet west and 70 feet north of the SE. corner of SW¼ sec. 14, T. 143 N., R. 53 W.:

A1p—0 to 7 inches, dark-gray (10YR 3.4/1) loamy fine sand, very dark brown (10YR 2.5/2) when moist; a few, fine, faint mottlings that are very dark brown (10YR 2/2) when moist; medium, weak, subangular blocky structure; slightly hard, very friable; abrupt, smooth boundary.

TABLE 8.—*Physical and chemical*

[Analysis by the North Dakota State University Soil Survey

Soil type	Horizon	Depth	Particle-size distribution: Very coarse and coarse sand (2–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.1 mm.)	Very fine sand (0.1–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (<0.002 mm.)	Volume weight[1]	Permeability[1]	Moisture held at 15 atmospheres
		In.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Gm./cc.*	*In./hr.*	
Aberdeen silt loam.	Ap	0–9	0. 2	1. 9	24. 2	37. 0	20. 4	15. 1	1. 54	0. 17	8. 60
	A2	9–13	1. 2	1. 1	28. 1	41. 3	8. 7	8. 8			5. 65
	IIB2	13–19	. 8	. 6	9. 3	23. 5	17. 1	46. 8	1. 42	0	22. 46
	IIC1ca	19–36	2. 0	1. 2	5. 2	7. 3	34. 1	49. 6			18. 28
	IIC21	36–50	3. 5	1. 3	3. 6	4. 7	36. 0	50. 5			21. 01
	IIC22	50–60	3. 0	1. 5	3. 1	5. 3	34. 0	53. 1	1. 30	. 03	23. 96
Egeland fine sandy loam.	Ap	0–6	2. 2	7. 8	45. 9	18. 9	14. 4	9. 8	1. 31	2. 8	11. 4
	B21	6–19	1. 9	7. 1	42. 0	21. 0	16. 5	10. 9	1. 46	3. 4	7. 1
	B22	19–27	5. 2	17. 1	45. 3	9. 3	8. 8	13. 8			5. 0
	C1	27–42	. 2	3. 7	59. 2	20. 6	7. 7	7. 9	1. 42	6. 5	6. 7
	C2	42–55	. 1	1. 1	52. 5	32. 2	8. 0	5. 5			4. 11
	C3	55–63	. 1	2. 3	57. 8	27. 7	7. 1	4. 8			3. 69
Embden fine sandy loam.	Ap	0–10	7. 1	11. 1	39. 1	10. 4	18. 7	12. 6	1. 4	4. 06	10. 9
	A3	10–19	5. 5	11. 4	48. 8	10. 1	13. 7	11. 1	1. 58	2. 22	7. 9
	IIB	19–26	11. 8	12. 4	40. 1	12. 3	12. 8	9. 3			7. 5
	IIIC1ca	26–45	5. 9	4. 0	13. 6	17. 9	36. 1	21. 8	1. 35	. 08	
	IIIC2	45–60	9. 5	4. 3	12. 5	14. 5	40. 2	18. 6	1. 54	. 08	13. 1
Hecla fine sandy loam.	A1p	0–6	4. 2	5. 2	55. 0	14. 0	11. 9	9. 6	1. 45	3. 4	4. 39
	A12	6–13	3. 6	5. 6	65. 0	9. 2	8. 8	7. 6			5. 26
	AB	13–23	3. 3	5. 4	68. 2	9. 2	8. 6	7. 2	1. 40	13. 6	4. 28
	B	23–31	1. 2	4. 0	68. 8	10. 4	7. 1	8. 1	1. 39	12. 6	4. 75
	C1	31–46	3. 1	7. 1	75. 7	5. 0	2. 9	5. 4	1. 44	21. 5	4. 20
	C2	46–64	1. 0	2. 0	77. 4	13. 4	2. 8	3. 1			2. 43
Hecla loamy fine sand.	A1p	0–7	. 3	. 9	35. 8	44. 0	9. 8	8. 5	1. 36	3. 6	6. 18
	A12	7–13	. 2	. 9	38. 6	43. 5	7. 5	7. 5			5. 26
	AC	13–19	. 2	. 9	40. 2	43. 7	7. 5	6. 5	1. 51	4. 5	4. 30
	C1ca	19–33	. 3	. 7	36. 2	42. 0	8. 2	11. 2	1. 45	4. 2	6. 98
	C2	33–40	. 2	. 3	34. 2	49. 1	10. 5	4. 6			4. 1
	C3	40–51	. 1	. 1	22. 9	62. 7	10. 4	2. 7	1. 45	3. 6	3. 38
	C4gca	51–60	. 1	. 1	11. 8	69. 8	13. 5	3. 7			5. 06
Stirum fine sandy loam.	Ap	0–7	2. 9	4. 2	40. 4	26. 7	13. 8	11. 1	1. 4	3. 4	
	B2	7–15	3. 8	4. 5	29. 6	24. 8	18. 8	17. 1	1. 54	0	
	C1ca	15–26	. 2	. 5	14. 1	30. 8	38. 7	16. 8	1. 61	0	
	C2	26–34	. 7	. 4	23. 3	52. 5	20. 3	7. 6	1. 55	. 03	
	IIC3	34–44	3. 9	1. 3	4. 1	18. 0	59. 0	12. 9			
	IIIC4	44–48	. 1	. 7	49. 0	34. 2	9. 3	5. 2			

[1] Data in these columns were obtained by using a 3-inch core for sampling.
[2] Trace.

A12—7 to 13 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, very dark brown (10YR 2.5/2) when moist; a few, fine, faint mottlings that are very dark brown (10YR 2/2) when moist; medium, weak, subangular blocky structure; slightly hard, very friable; clear, wavy boundary.

AC—13 to 19 inches, dark grayish-brown (10YR 4/2) loamy fine sand; very weak, coarse, subangular blocky structure; soft, very friable; clear, wavy boundary.

C1ca—19 to 33 inches, light brownish-gray (10YR 6.4/2) very fine sandy loam; common, fine, faint mottlings that are brown (10YR 5/3) when moist; medium, weak, subangular blocky structure; soft, very friable; very strongly calcareous; gradual boundary.

C2—33 to 40 inches, pale-brown (10YR 6/3) loamy very fine sand, brown (10YR 5/3) when moist; common, medium, distinct mottlings that are light brownish gray (10YR 6/2) when moist; single grain; soft, very friable; strongly calcareous; smooth, gradual boundary.

C3—40 to 51 inches, light yellowish-brown (10YR 6/3) loamy very fine sand, grayish brown (2.5Y 5/2) when moist; many, fine, distinct mottlings that are light olive brown (2.5Y 5/4) when moist; single grain; loose; calcareous; clear, smooth boundary.

C4gca—51 to 60 inches, light-gray (2.5Y 7/2) loamy very fine sand, grayish brown (2.5Y 5/2) when moist; common, coarse, distinct mottlings that are light olive brown (2.5Y 5/4) when moist; single grain; loose, very friable; calcareous.

properties of selected soil profiles

Laboratory. Absence of data indicated by dashed lines]

Available water capacity		Moisture at saturation	pH saturated paste	Electrical conductivity (ECx10³) millimhos per cm. at 25° C.	$CaCO_3$ equivalent	Cation-exchange capacity	Extractable cations				Exchangeable Na	Saturation extract soluble				Organic carbon
							Ca	Mg	Na	K		Ca	Mg	Na	K	
Pct.	In./in. of soil	Pct.				Meq./100 gm.	Meq./100 gm.	Meq./100 gm.	Meq./100 gm.	Meq./100 gm.	Pct.	Meq./l.	Meq./l.	Meq./l.	Meq./l.	
12. 2	0. 188	34. 7	6. 0	0. 41	-------	18. 4	8. 9	5. 5	0. 4	0. 4	2	2. 07	(3)	1. 17	0. 11	1. 75
9. 6	. 148	30. 1	6. 5	. 61	-------	10. 7	4. 1	4. 8	. 6	. 2	5	2. 07	(3)	2. 95	. 06	. 63
18. 3	. 260	82. 8	7. 5	1. 41	-------	35. 2	4. 9	26. 5	4. 3	. 8	10	2. 27	(3)	7. 88	. 07	. 41
16. 3	. 212	64. 0	7. 9	9. 50	19. 5	26. 8	------	28. 7	6. 8	. 7	16	16. 12	71. 24	43. 00	. 77	. 34
15. 8	. 206	70. 1	7. 9	11. 8	15. 8	28. 3	------	22. 8	7. 8	. 9	14	21. 67	102. 96	55. 00	. 83	. 37
17. 4	. 266	90. 2	7. 8	11. 0	14. 1	26. 8	------	[2] 23	8. 1	1. 1	14	22. 65	90. 15	49. 00	1. 18	. 47
4. 2	. 055	38. 3	6. 4	. 41	-------	13. 8	8. 6	2. 3	(2)	. 5	. 1	2. 76	(3)	. 26	. 44	1. 84
3. 9	. 057	30. 4	6. 1	. 29	-------	9. 9	5. 8	2. 4	(2)	. 2	. 2	2. 17	(3)	. 29	. 12	. 68
10. 8	. 156	35. 6	6. 0	. 32	-------	12. 0	6. 6	4. 2	. 1	. 3	. 9	2. 17	(3)	. 37	. 15	. 34
9. 0	. 128	35. 2	6. 2	. 22	-------	9. 1	5. 2	3. 2	------	. 3	------	1. 58	(3)	. 34	. 22	. 20
9. 9	. 141	31. 7	6. 3	. 23	-------	7. 0	4. 1	2. 3	. 2	. 2	2. 1	1. 52	(3)	. 37	. 11	. 09
9. 5	. 135	33. 0	6. 5	. 21	-------	6. 5	4. 1	2. 2	. 2	. 2	2. 2	1. 38	(3)	. 36	. 09	------
7. 9	. 111	35. 3	6. 9	. 50	-------	16. 0	9. 4	4. 9	. 8	. 4	5	2. 40	1. 84	. 31	. 19	1. 79
5. 6	. 089	30. 4	7. 7	. 45	-------	11. 4	4. 8	6. 2	. 1	. 3	1	3. 35	(3)	. 67	. 11	. 62
4. 3	. 058	38. 8	8. 0	. 62	5. 8	10. 3	------	7. 1	. 2	. 3	2	1. 52	3. 31	1. 04	. 13	. 32
------	------	40. 0	7. 9	3. 2	25. 4	13. 8	------	12. 8	1. 2	. 3	6	9. 58	23. 41	8. 80	. 13	. 31
13. 7	. 211	47. 3	7. 6	3. 4	14. 3	17. 9	------	10. 0	1. 2	. 5	4	13. 50	22. 07	8. 35	. 34	. 21
10. 41	. 151	36	7. 4	. 66	-------	13. 3	10. 0	2. 9	. 1	. 4	. 3	3. 48	2. 24	. 34	. 29	1. 53
10. 04	. 104	31	7. 3	. 45	-------	9. 6	6. 6	2. 4	(2)	. 3	. 1	2. 40	1. 74	. 22	. 17	. 66
7. 02	. 098	30	7. 1	. 33	-------	7. 0	4. 5	2. 2	(2)	. 3	. 3	2. 76	(3)	. 28	. 13	. 32
8. 55	. 199	29	6. 3	. 27	-------	7. 5	4. 8	2. 3	(2)	. 3	. 1	2. 17	(3)	. 25	. 15	. 36
5. 15	. 074	28	6. 4	. 21	-------	5. 7	3. 4	1. 7	(2)	. 2	. 4	1. 58	(3)	. 32	. 12	. 19
3. 77	. 054	29	6. 7	. 26	-------	4. 6	2. 8	1. 3	(2)	. 2	. 4	1. 87	(3)	. 26	. 15	. 12
5. 22	. 071	39. 2	7. 6	. 65	-------	12. 6	11. 3	3. 2	(2)	. 2	. 1	3. 92	2. 19	. 40	. 20	1. 29
4. 23	. 058	35. 8	7. 7	. 52	-------	9. 6	8. 3	2. 0	(2)	. 2	. 2	2. 94	1. 89	. 49	. 10	. 72
2. 98	. 045	33. 7	7. 7	. 59	-------	7. 5	6. 4	2. 0	(2)	. 2	. 1	3. 16	1. 77	. 58	. 08	. 27
4. 32	. 062	34. 1	7. 9	. 66	12. 1	5. 8	------	3. 1	. 1	. 1	. 5	3. 38	1. 94	. 66	. 07	. 24
10. 9	. 158	34. 0	8. 1	. 68	8. 7	5. 5	------	2. 8	(2)	. 1	. 2	2. 61	2. 52	. 76	. 09	. 10
11. 6	. 168	35. 9	8. 0	. 70	8. 5	4. 6	------	2. 3	. 1	. 1	. 9	2. 50	2. 33	. 95	. 05	. 12
26. 7	. 387	39. 1	--------	. 70	11. 1	6. 0	------	[2] 3	. 2	. 1	3. 2	2. 40	2. 14	1. 08	. 05	. 16
------	------	32. 1	8. 0	1. 3	2. 4	13. 5	------	2. 6	2. 0	. 4	13	2. 66	(3)	9. 38	. 15	1. 44
------	------	68. 9	8. 8	3. 1	5. 0	16. 9	------	6. 9	11. 2	. 4	56	. 12	(3)	25. 50	. 05	. 68
------	------	72. 3	9. 2	4. 1	18. 6	13. 8	------	6. 1	13. 8	. 3	81	. 06	(3)	37. 0	. 04	. 16
------	------	51. 1	9. 0	6. 1	7. 5	10. 5	------	5. 4	10. 0	. 2	71	. 13	(3)	4. 90	. 07	. 10
------	------	60. 2	8. 9	3. 7	21. 5	14. 8	------	6. 4	11. 8	. 2	68	. 08	(3)	30. 00	. 03	. 16
------	------	37. 1	8. 9	3. 9	4. 9	6. 5	------	2. 6	5. 3	. 1	64	. 10	(3)	31. 5	. 03	. 08

[3] In this horizon the soluble calcium (meq./1.) includes both the calcium and magnesium.

STIRUM SERIES.—Profile of Stirum fine sandy loam, 240 feet east and 350 feet north of the SW. corner of the NW¼ of sec. 24, T. 138 N., R. 54 W.:

Ap—0 to 7 inches, dark-gray (10YR 4/1) fine sandy loam, black (10YR 2/1) when moist; weak, fine and medium, subangular blocky structure; very friable; weakly calcareous; abrupt, smooth boundary.

B2—7 to 15 inches, gray (10YR 5/1) fine sandy loam, dark grayish brown (10YR 4/2) when moist; thick clay films, very dark grayish brown (10YR 3/2) when moist, on the surfaces of the peds; strong, coarse, columnar structure breaking to moderate, fine and medium, angular blocky structure; very hard, firm, plastic, slightly sticky; weakly calcareous; wavy boundary.

C1ca—15 to 26 inches, light-gray (2.5Y 7/2) loam, light brownish gray (2.5Y 6/2) when moist; common, fine, distinct mottlings that are yellowish brown (10YR 5/4) when moist; strong, very coarse, prismatic structure breaking to weak, fine and medium, angular blocky structure; very hard, firm, plastic; moderately calcareous; gradual boundary.

C2—26 to 34 inches, mottled light-gray (5Y 7/2) very fine sandy loam, olive gray (5Y 5/2) when moist; common, medium, distinct mottlings that are yellowish brown (10YR 5/4) when moist, and many, medium, distinct mottlings that are very dark grayish brown (10YR 3/2) when moist; granular structure to single grain; very friable, slightly sticky; weakly calcareous; clear, wavy boundary.

IIC3—34 to 44 inches, mottled light-gray (5Y 7/2) silt loam, light olive gray (5Y 6/2) when moist; many, medium, distinct mottlings that are dark brown (7.5YR 4/4) when moist and many coarse, prominent mottlings that are very dark grayish brown (10YR 3/2) when moist; weak, fine, angular blocky structure; slightly plastic; calcareous; clear, wavy boundary.

IIIC4—44 to 48 inches, mottled light-gray (5Y 7/1) loamy fine sand, gray (5Y 5/1) when moist; many, medium, distinct mottlings that are dark yellowish brown (10YR 4/4) when moist, and a few very dark grayish-brown mottlings; single grain; loose. Too wet to sample below a depth of 48 inches.

Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is reduced (*17*).

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by water. Local alluvium is soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. In this report it includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in a soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension. In this report available moisture capacity is rated as follows:

	Inches		*Inches*
Good	More than 4.5	Low	2 to 3
Fair	3 to 4.5	Very low	Less than 2

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.

Color. See Munsell notation.

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; will 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.

Very firm.—When moist, soil material crushes under strong pressure; barely crushable between thumb and forefinger.

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.

Slightly sticky.—When wet, soil material adheres to both thumb and forefinger after pressure is applied but comes off one or the other cleanly.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Extremely hard.—Extremely resistant to pressure; cannot be broken by hand.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage, soil. Soils are placed in natural drainage classes on the basis of their profile characteristics. The wetness of a particular site may be altered by irrigation or by artificial drainage, but the characteristics of the soil, which indicate soil drainage, remain the same. The soil drainage classes for this report are as follows:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are underlain by coarse-textured material, or have steep slopes, or both.

Somewhat excessively drained.—Water is removed from the soil rapidly. Somewhat excessively drained soils lack well-defined horizons and contain sandy material.

Well drained.—Water is removed from the soil readily but not rapidly. Well-drained soils are free of excess water throughout the growing season. The growth of plant roots is not restricted by wetness.

Moderately well drained.—Water is removed from the soil somewhat slowly. Moderately well drained soils are somewhat wet for a short but significant part of the growing season. In this area their available moisture capacity is most favorable for the growth of the plants.

Somewhat poorly drained.—Water is removed from the soil slowly enough to keep it wet for significant periods but not all the time. Somewhat poorly drained soils are usually wet for a considerable period of time during the growing season, especially in spring or after heavy rains during the growing season. In about half of the years, this wetness does not seriously affect crops.

Poorly drained.—Water is removed from the soil so slowly that the soil is wet during a large part of the growing season. The root zone is commonly restricted by a high water table. Occasionally in dry years, poorly drained soils may be suitable for cultivation.

Very poorly drained.—Water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time. Very poorly drained soils are generally in low, nearly level areas or in depressions.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Mottling may be caused by an accumulation of lime, colloids, organic matter, or iron compounds, or by some process of soil formation. Descriptive terms are as follows: Abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; medium, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

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

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. In this report the relative ratings for content of organic matter are based upon the total content of organic matter in the soil. The terms used are "high," "moderate," and "low."

Parent material. The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Percolation. The downward movement of water through the soil.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows:

	Inches per hour		*Inches per hour*
Very slow	Less than 0.05	Moderately rapid	2.50 to 5.00
Slow	0.05 to 0.20	Rapid	5.00 to 10.00
Moderately slow	0.20 to 0.80	Very rapid	More than 10.00
Moderate	0.80 to 2.50		

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. 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 the growth of crop plants but that does not contain excess exchangeable sodium.

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

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

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

Soil slope. Slope is the number of feet of change in elevation per 100 feet of linear distance expressed as a percentage. The soil slope classes used to describe slope in this survey are as follows:

	Percent		Percent
Nearly level	Less than 3	Strongly rolling	8 to 12
Undulating	3 to 6	Hilly	More than 12
Rolling	6 to 8		

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 parent material. The living roots and other plant and animal life characteristic 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 (1) *single grain* (each grain by itself, as in dune sand) or (2) *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 profile below plow depth.

Substratum. Any layer lying beneath the solum or true soil; the C or R horizon.

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.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

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GUIDE TO MAPPING UNITS AND CAPABILITY UNITS

[Table 3, p. 11, gives the acreage and proportionate extent of the soils mapped, and table 4, p. 52, gives the predicted estimated average acre yields of the principal crops. Management of windbreaks is discussed briefly in the section beginning on p. 55, and management of soils under irrigation is described in the section beginning on p. 57. Facts about use of the soils for engineering is given in the section beginning on p. 63]

Map symbol	Mapping unit	Described on page	Capability unit	
			Symbol	Page
Ad	Aberdeen silt loam	10	IIIs-2	48
Ak	Alluvial land	10	Vw-1	50
An	Arveson fine sandy loam	12	IIIw-1	47
Ar	Arveson fine sandy loam, moderately shallow	12	IIIw-1	47
Av	Arveson fine sandy loam, very wet	12	IIIw-3	47
Aw	Arveson loam	12	IIw-2	44
BaB	Barnes loam, undulating	13	IIe-3	43
BbC	Barnes-Buse loams, rolling	13	IIIe-5	46
BbD	Barnes-Buse loams, strongly rolling	13	IVe-5	50
BdB	Barnes-Svea loams, undulating	14	IIe-3	43
Be	Bearden silt loam	14	IIe-1	43
Bf	Bearden silty clay loam	14	IIe-1	43
Bg	Bearden soils, saline	14	IIIs-6	49
Bh	Bearden-Overly silt loams	15	IIe-1	43
Bo	Borup silt loam	15	IIw-2	44
Bp	Borup silt loam, very wet	15	IIIw-2	47
BuD	Buse loam, hilly	16	VIe-2	51
Dc	Dimmick clay	16	IIIw-2	47
Dv	Divide loam	16	IIIs-4	48
EcA	Eckman loam, nearly level	17	IIe-2	43
EcB	Eckman loam, undulating	17	IIe-3	43
EcC	Eckman loam, rolling	17	IIIe-5	46
EgB	Eckman loam, till substratum, undulating	17	IIe-3	43
EnA	Egeland fine sandy loam, nearly level	18	IIIe-1	45
EnB	Egeland fine sandy loam, undulating	18	IIIe-1	45
Eo	Embden fine sandy loam	18	IIIe-1	45
Ep	Embden-Gardena complex	19	IIIe-1	45
Es	Embden-Glyndon fine sandy loams	19	IIIe-4	46
Et	Embden and Hecla fine sandy loams	19	IIIe-3	46
Ex	Exline complex	20	VIs-1	51
Fa	Fairdale silt loam, levee	20	IIc-1	45
Fc	Fargo clay	20	IIw-1	44
Fg	Fargo silt loam	21	IIw-1	44
Fh	Fargo silty clay loam	21	IIw-1	44
Fk	Fargo silty clay loam, saline	21	IIIs-6	49
Fn	Fargo-Exline silty clay loams	21	IIIs-2	48
Fw	Fresh water marsh	22	(1/)	--
GbA	Gardena loam, very deep, nearly level	23	IIc-1	45
GbB	Gardena loam, very deep, undulating	23	IIe-3	43
GcA	Gardena loam, deep, nearly level	23	IIc-1	45
GdA	Gardena loam, moderately shallow, nearly level	23	IIc-1	45
GdB	Gardena loam, moderately shallow, undulating	23	IIe-3	43
GeA	Gardena loam, till substratum, nearly level	23	IIc-1	45
GfA	Gardena-Eckman loams, till substratum, nearly level	23	IIc-1	45
GgA	Gardena-Glyndon loams, nearly level	23	IIc-1	45
GkA	Gardena-Glyndon loams, till substratum, nearly level	24	IIc-1	45
GmA	Glyndon loam, very deep, nearly level	24	IIe-1	43
GmB	Glyndon loam, very deep, undulating	24	IIe-1	43
GnA	Glyndon loam, deep, nearly level	24	IIe-1	43
GsA	Glyndon-Borup loams, strongly saline, nearly level	25	VIs-1	51

GUIDE TO MAPPING UNITS AND CAPABILITY UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page
GtA	Glyndon and Gardena loams, nearly level	25	IIe-1	43
GuA	Glyndon and Hamerly loams, saline, nearly level	25	IIIs-6	49
Gv	Gravel pits	25	(1/)	--
Ha	Hamar fine sandy loam	26	IIIw-1	47
Hb	Hamar-Ulen fine sandy loams	26	IIIe-4	46
Hc	Hamar-Ulen loamy fine sands	26	IVe-3	50
HdB	Hamerly complex, undulating	27	IIe-1	43
HeA	Hamerly loam, nearly level	27	IIe-1	43
HgB	Hamerly-Barnes loams, undulating	27	IIe-1	43
HkAx	Hecla fine sand, nearly level	27	VIe-1	50
HlAx	Hecla fine sandy loam, nearly level	28	IIIe-1	45
HmA	Hecla fine sandy loam, moderately shallow, nearly level	28	IIIe-3	46
HoAx	Hecla loamy fine sand, loamy substratum, nearly level	28	IVe-1	49
HpAx	Hecla loamy fine sand, moderately shallow, nearly level	28	IVe-1	49
HrA	Hecla sandy loam, loamy substratum, nearly level	28	IIIe-3	46
HsAx	Hecla soils, nearly level	28	IVe-1	49
HtAx	Hecla and Embden fine sandy loams, nearly level	29	IIIe-1	45
HuB2	Hecla-Hamar complex, hummocky, eroded	29	VIe-1	50
HvAx	Hecla and Hamar loamy fine sands, nearly level	29	IVe-1	49
HxAx	Hecla-Ulen fine sandy loams, nearly level	29	IIIe-4	46
HyAx	Hecla-Ulen fine sandy loams, loamy substratum, nearly level	29	IIIe-3	46
La	Lamoure silty clay loam	30	IIw-3	45
Lf	La Prairie and Fairdale soils	30	VIe-2	51
Lp	La Prairie silt loam	30	IIc-1	45
MaAx	Maddock fine sandy loam, nearly level	31	IIIe-2	46
MaBx	Maddock fine sandy loam, undulating	31	IIIe-2	46
MaCx	Maddock fine sandy loam, rolling	31	IIIe-2	46
MdAx	Maddock loamy fine sand, nearly level	31	IVe-2	49
MdBx	Maddock loamy fine sand, undulating	31	IVe-2	49
MhD	Maddock soils, hilly	31	VIe-1	50
MkAx	Maddock loamy fine sand, moderately shallow, nearly level	31	IVe-2	49
Mx3	Maddock-Hamar complex, severely eroded	32	VIe-1	50
OaA	Overly silt loam, nearly level	32	IIc-1	45
ObA	Overly silt loam, saline, nearly level	32	IIIs-6	49
OcA	Overly silty clay loam, nearly level	32	IIc-1	45
OxA	Overly-Exline complex, nearly level	32	IIIs-2	48
OyA	Overly-Gardena loams, nearly level	33	IIc-1	45
Pa	Parnell soils	33	IIIw-2	47
Pe	Perella silt loam	34	IIw-3	45
Pr	Perella silty clay loam	34	IIw-3	45
Ra	Rauville soils	34	Vw-1	50
RnA	Renshaw and Sioux loams, nearly level	35	VIs-2	51
RnB	Renshaw and Sioux loams, undulating	35	VIs-2	51
RsA	Renshaw and Sioux sandy loams, nearly level	35	VIs-2	51
RsC	Renshaw and Sioux sandy loams, rolling	35	VIs-2	51
Sa	Sioux gravelly loam	35	VIs-2	51
SbC	Sioux and Renshaw loams, rolling	35	VIs-2	51
ScA	Spottswood loam, loamy substratum, nearly level	36	IIIs-5	49
SdA	Spottswood sandy loam, loamy substratum, nearly level	36	IIIe-6	47
SmA	Spottswood-Embden sandy loams, nearly level	36	IIIe-6	47
SoA	Spottswood-Gardena loams, nearly level	36	IIIs-5	49
St	Stirum-Glyndon complex	37	IIIs-3	48
Sx	Svea-Barnes loams	37	IIc-1	45

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Nondiscrimination Statement

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquiries

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).