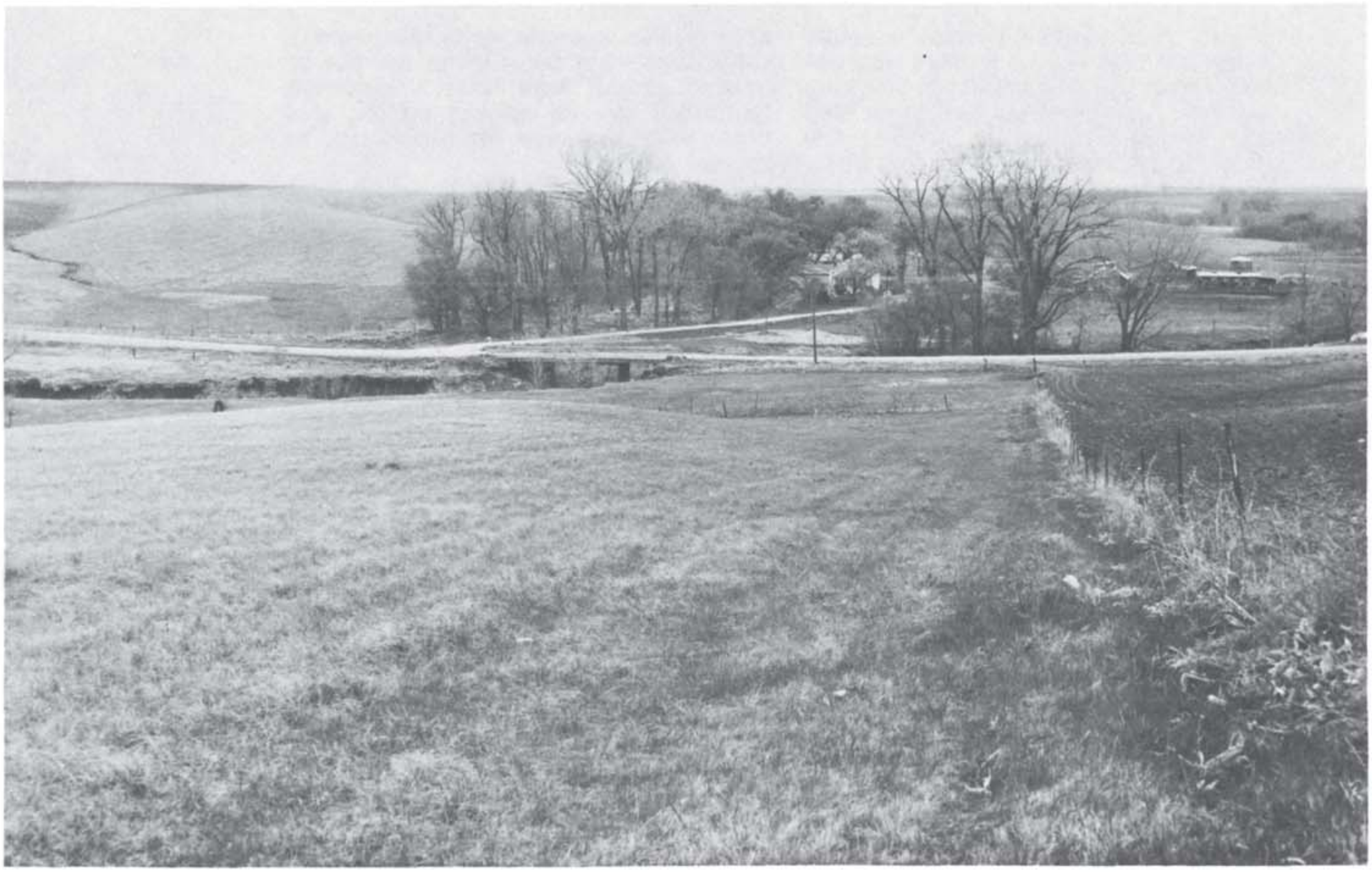
SOIL SURVEY OF

Plymouth County, Iowa



United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa Agriculture and Home Economics Experiment Station and the
Cooperative Extension Service
Iowa State University, and the
Department of Soil Conservation, State of Iowa

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1965–70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service, the Iowa Agriculture and Home Economics Experiment Station and the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Plymouth County Soil Conservation District. Funds appropriated by Plymouth County were used to defray part of the cost of this survey.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

Farmers and those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the capability units.

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

Community planners and others concerned with suburban development can read about the soil properties that affect the choice of homesites, industrial sites, schools, and parks in the sections "Engineering Uses of the Soils" and "Recreation."

Engineers and builders will find, under "Engineering Uses of the Soils," tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

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

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

Newcomers in Plymouth County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Information About the County," which briefly discusses history, drainage and relief, cultural features, trends in farming, and climate.

Cover: Typical landscape in Ida-Monona association. Ida and Monona soils are on the hillsides; Kennebec, McPaul, Napier, and Castana soils are in the valley.

Contents

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SOIL SURVEY OF PLYMOUTH COUNTY, IOWA

BY JOHN R. WORSTER AND ELMER H. HARVEY, SOIL CONSERVATION SERVICE [1]

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION AND THE COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY, AND THE DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

PLYMOUTH COUNTY is in the northwestern part of Iowa (fig. 1). Its total area is about 552,320 acres,

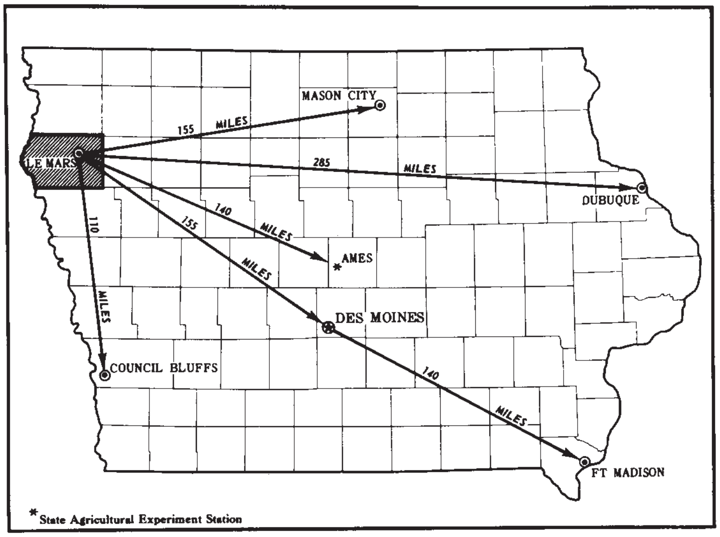

Figure 1.—**Location of Plymouth County in Iowa.**

or 863 square miles. The county seat is Le Mars, which has a population of about 7,800.

Most of the county is in farms. The average farm size is 257 acres. Corn is the major crop, but soybeans, oats, hay, and pasture are also important. Plymouth County is one of the leading counties in the country in the production of hogs and feeder cattle for market.

The climate is subhumid and continental. The growing season is long enough for all commonly grown crops to mature. Inadequate moisture reduces yields in many years, but not to the point that irrigation has become a common practice.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Plymouth County, where they are located, and how they can be used. They went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes, size of streams, kinds of native plants or crops, kinds of rock, and many facts about the soils. They dug or bored 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 to the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are categories of soil classification most used in a local survey (*16*).[2]

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. Galva and Ida, for example, are the names of two soil series. All of the soils in the United States having the same series name are essentially alike in natural characteristics.

Soils of one series vary in texture of the surface layer, slope, degree of erosion, number and size of stones, or some other feature that affects use of the soils by man. On the basis of such differences, soil series are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Galva silty clay loam, 2 to 5 percent slopes, is one of several phases in the Galva series.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photos for their base map because they show buildings, field borders, trees, and similar details that greatly help in drawing boundaries accurately. The soil map at the back of this report was prepared from aerial photographs.

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

[1] Others who participated in the fieldwork of the soil survey were BENNIE CLARKS, JR., ELLIOTT FAISON, JR., LAURENCE T. HANSON, DENNIS SHANNON, ALLEN E. TIARKS, JIMMY L. WASHINGTON, and NEAL D. WILLIAMSON, Soil Conservation Service.

[2] Italic numbers in parentheses refer to Literature Cited, p. 74.

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

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit is shown on the soil map of Plymouth County, the soil complex.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Napier-Castana silt loams, 9 to 14 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Rough broken land is a land type in this county.

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

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

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

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

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, drainage, and other characteristics that affect their management.

The six soil associations in Plymouth County are described in the following pages.

1. *Kennebec-Radford-Colo association*

Nearly level and gently sloping silty soils that are moderately well drained to poorly drained

This association is in the larger valleys of the county. The valleys are about 1/4 to 1 mile wide. The association is made up mainly of nearly level soils on flood plains. It also consists of some nearly level and gently sloping soils on stream benches, mainly in the Big Sioux River Valley. Gently sloping soils on foot slopes along the edges of the valleys are also in this association.

This association occupies about 12 percent of the county. Kennebec soils make up about 28 percent of the association, Radford soils about 20 percent, Colo soils 19 percent, McPaul soils 16 percent, and Calco soils 6 percent. The remaining 11 percent is other minor soils.

Kennebec soils are deep, moderately well drained, and nearly level and gently sloping. The nearly level areas occupy intermediate positions on flood plains, and the gently sloping areas are on foot slopes along the edges of valleys. The surface layer is silt loam or silty clay loam that is slightly acid or neutral. In places calcareous silt loam overwash overlies the surface layer.

Radford soils are nearly level and gently sloping, deep, and somewhat poorly drained. The nearly level areas are on flood plains, and the gently sloping areas are on foot slopes. The surface layer is silty clay loam that is slightly acid or neutral.

Colo soils are nearly level, deep, and poorly drained. They occupy intermediate and low positions on flood plains. The surface layer is silty clay loam that is slightly acid or neutral. In a few places calcareous silt loam overwash overlies the surface layer.

McPaul soils are nearly level to gently sloping, deep, and well drained to moderately well drained. The nearly level areas are on flood plains, and the gently sloping areas are on foot slopes. The surface layer is calcareous silt loam that is mildly alkaline.

Calco soils are nearly level, deep, and poorly drained. They are on flood plains. The surface layer is calcareous silty clay loam that is moderately alkaline.

The minor soils in this association range from sandy, droughty soils on benches to clayey, poorly drained soils on bottom lands.

This association is used mainly for crops. Corn and soybeans are the chief crops. Some areas that are subject to frequent flooding or that are wet are used for pasture. Many large cattle-feeding enterprises are on farms that are partly in this association and partly in

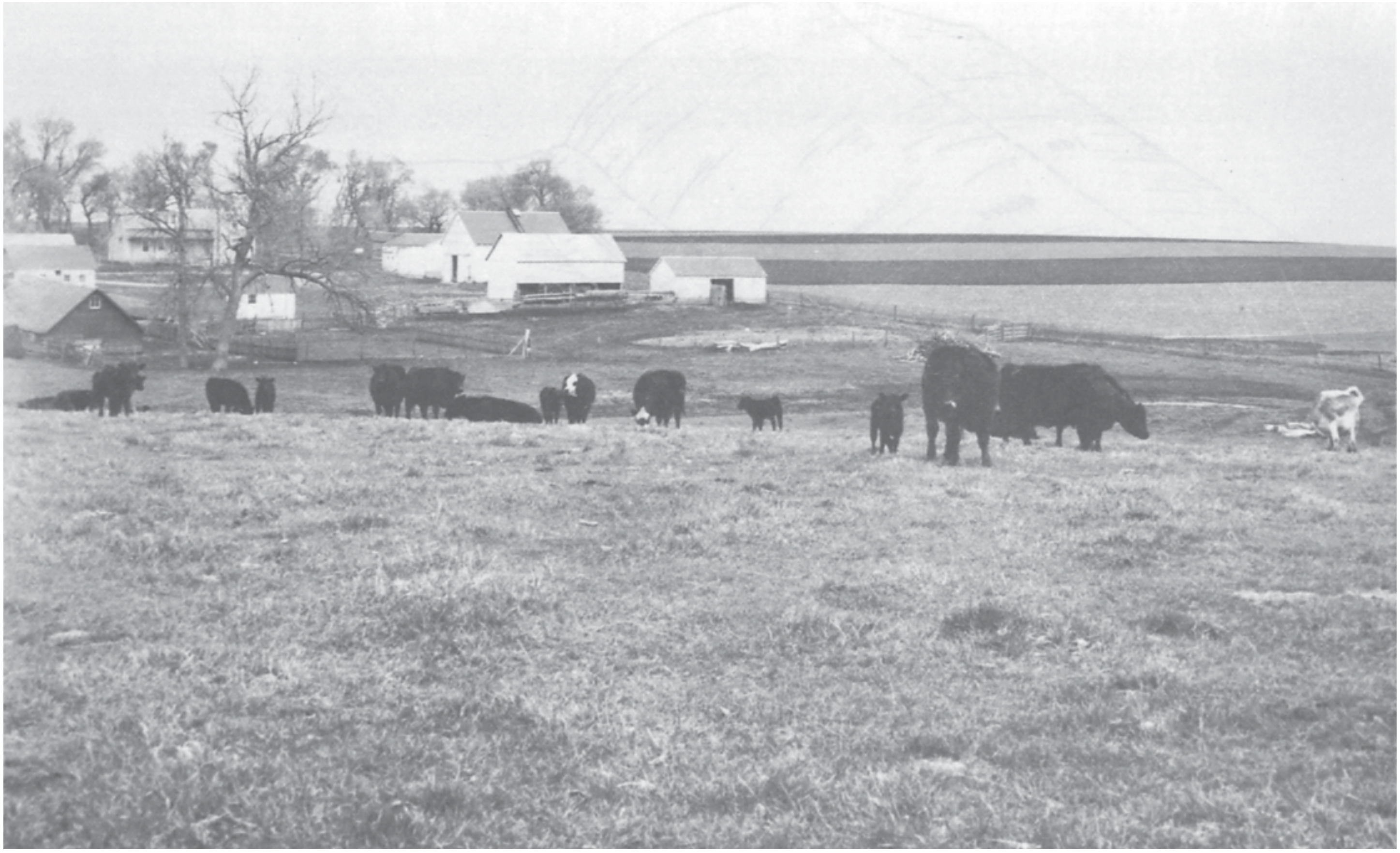

***Figure 2.*—Typical area of Galva-Ida association in eastern part of Plymouth County. Dominant soil is Galva silty clay loam, 5 to 9 percent slopes, moderately eroded.**

other associations that border the stream valleys. Raising hogs is also an important enterprise. Most of the gravel pits in the county are in this association. In places stands of trees grow along the streams.

Other areas in this association have a potential for row crops. The use of large acreages for this purpose, however, would require extensive flood-control and drainage projects. Many of the soils are well suited to irrigation, but this practice is used only to a minor extent. Improved management practices could increase pasture production, especially in bluegrass pastures and in places where trees are in the pastures. Some wooded areas, particularly those in which farm machinery cannot be used, have value for producing commercial wood products.

Most towns are partly in this association. Paved roads follow the streams in the larger valleys. In the smaller valleys the roads follow the regular pattern in the county and are on section lines. Most have a gravel surface.

2. *Ida-Galva association*

Gently sloping to very steep silty soils that are well drained

This association typically has gently sloping or moderately sloping, rounded ridgetops and strongly sloping hillsides. The ridgetops are 300 to 600 feet wide. On the hillsides are numerous drainageways, most of which are crossable with farm machinery. The valleys normally are gently sloping and are about 200 to 300 feet wide. The drainageways in the valleys are generally crossable or are shallow enough that it is practical to work them and to make grass waterways. The association is more sloping in the western part than in the eastern part.

This association occupies about 7 percent of the county. Ida soils make up about 40 percent of the association, and Galva soils about 39 percent. Minor soils on bottom lands and foot slopes make up about 21 percent. Some small areas of soils that formed in glacial drift are on hillsides. Most areas are only an acre or two in size, and the total acreage is less than 1 percent of the association.

Ida soils formed in loess and are deep and well drained. They are on narrow, convex ridgetops and on hillsides. They make up a larger part of the south- and west-facing slopes than of the north- and east-facing slopes. The surface layer is calcareous silt loam that is moderately alkaline.

Galva soils also formed in loess and are deep and well drained. They are on the broader ridgetops and are intermingled with Ida soils on hillsides. The surface layer is silty clay loam that is slightly acid.

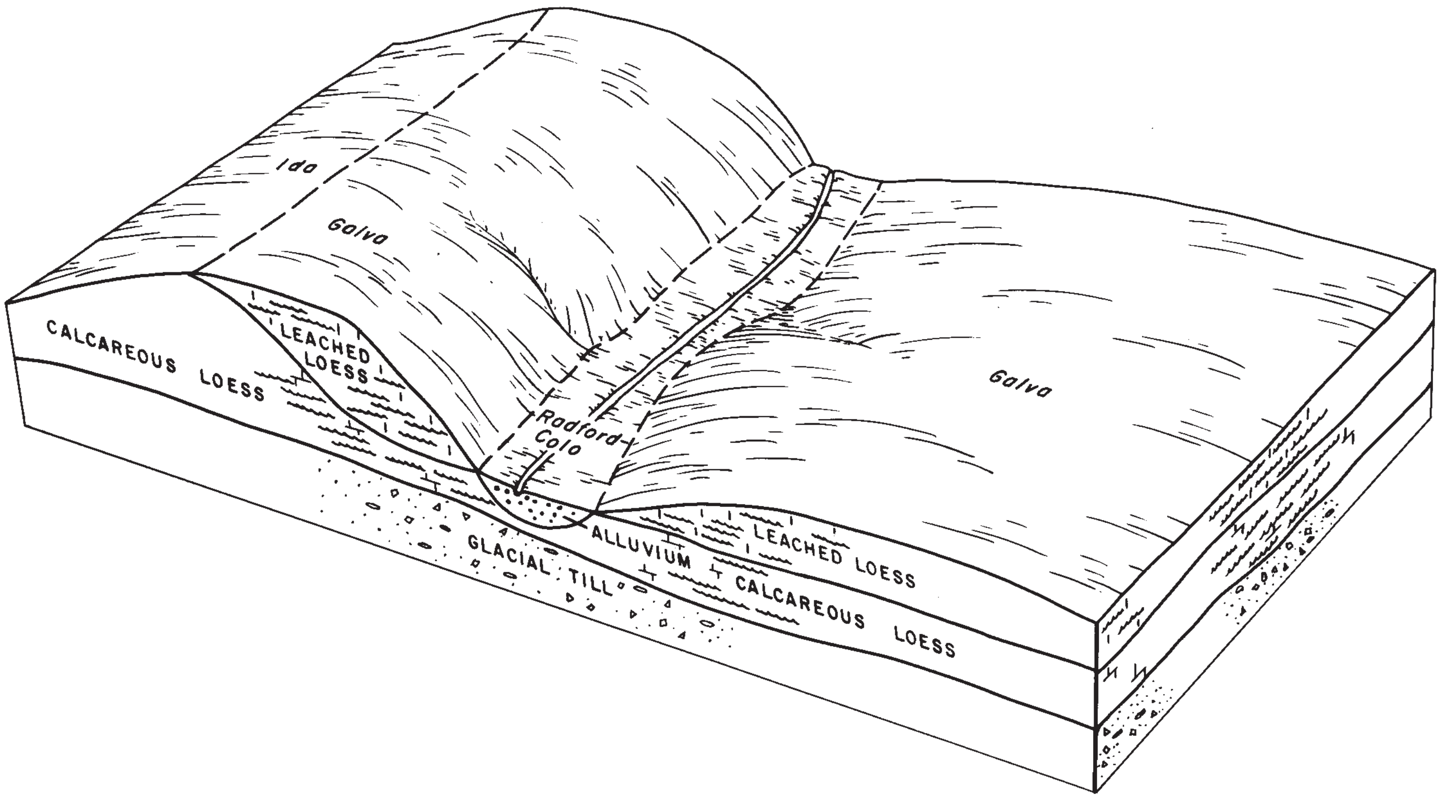

Figure 3.—**Typical pattern of soils and underlying material in Galva-Ida association.**

Among the minor soils in this association are Kennebec, McPaul, and Radford soils. These soils are in valleys. They formed in sediment derived from the loess on hillsides. They are deep and somewhat poorly drained to well drained. The surface layer is silt loam or silty clay loam that is slightly acid, neutral, or mildly alkaline.

This association is used mainly for crops. Corn and soybeans are the chief crops, but a fair amount of oats and hay is also grown. Much of the corn is fed on farms to hogs and cattle being fattened for market.

Erosion is a serious hazard on soils of this association. The soils also tend to be slightly droughty because runoff is more rapid than in much of the rest of the county. In addition, this association is in the western part, where rainfall is less.

This area has potential for more livestock enterprises, especially on farms that are partly in the valleys of association 1 and partly in this association. Most of these soils are well suited to hay and pasture. The soils in the valleys are well suited to row crops.

In this association gravel roads are on most section lines. Some roads that no longer pass farmsteads have been abandoned.

3. *Galva-Ida association*

Nearly level to strongly sloping silty soils that are well drained

This association has gently sloping, rounded ridgetops. The ridgetops typically are about 400 to 500 feet wide, but some are as wide as 1,200 to 1,400 feet. Most hillsides are moderately sloping, but some are strongly sloping. Hillside drainageways are widely spaced and are generally crossable with farm machinery. Most valleys are 200 to 400 feet wide. The upper reaches have waterways where water runs briefly after rains, and they can be crossed with farm machinery. Generally, within about one-half mile of their upper point, the drainageways are not crossable. At this point, they have cut channels, or they are grassed waterways that are too wet most of the time to be crossed with farm machinery. In the widest valleys are nearly level and gently sloping stream benches that are 5 to 15 feet above the flood plain.

This association occupies about 29 percent of the county. Galva soils make up about 77 percent of the association (fig. 2, p. 3), and Ida soils about 14 percent. The remaining 9 percent is minor soils.

Galva soils formed in loess and are deep and well drained. They are on nearly 100 percent of the ridgetops and stream benches, on a very large part of the moderately sloping hillsides, and on about half of the strongly sloping hillsides (fig. 3). The surface layer is silty clay loam that is slightly acid.

Ida soils also formed in loess and are deep and well drained. They are on about half of the strongly sloping hillsides and are on a small proportion of the moderately sloping hillsides. The surface layer is calcareous silt loam that is moderately alkaline.

Among the minor soils in this association are Radford, Primghar, Colo, Kennebec, and Steinauer soils. Radford soils are dominant in valleys. Primghar soils occupy the upper reaches of many valleys and are in

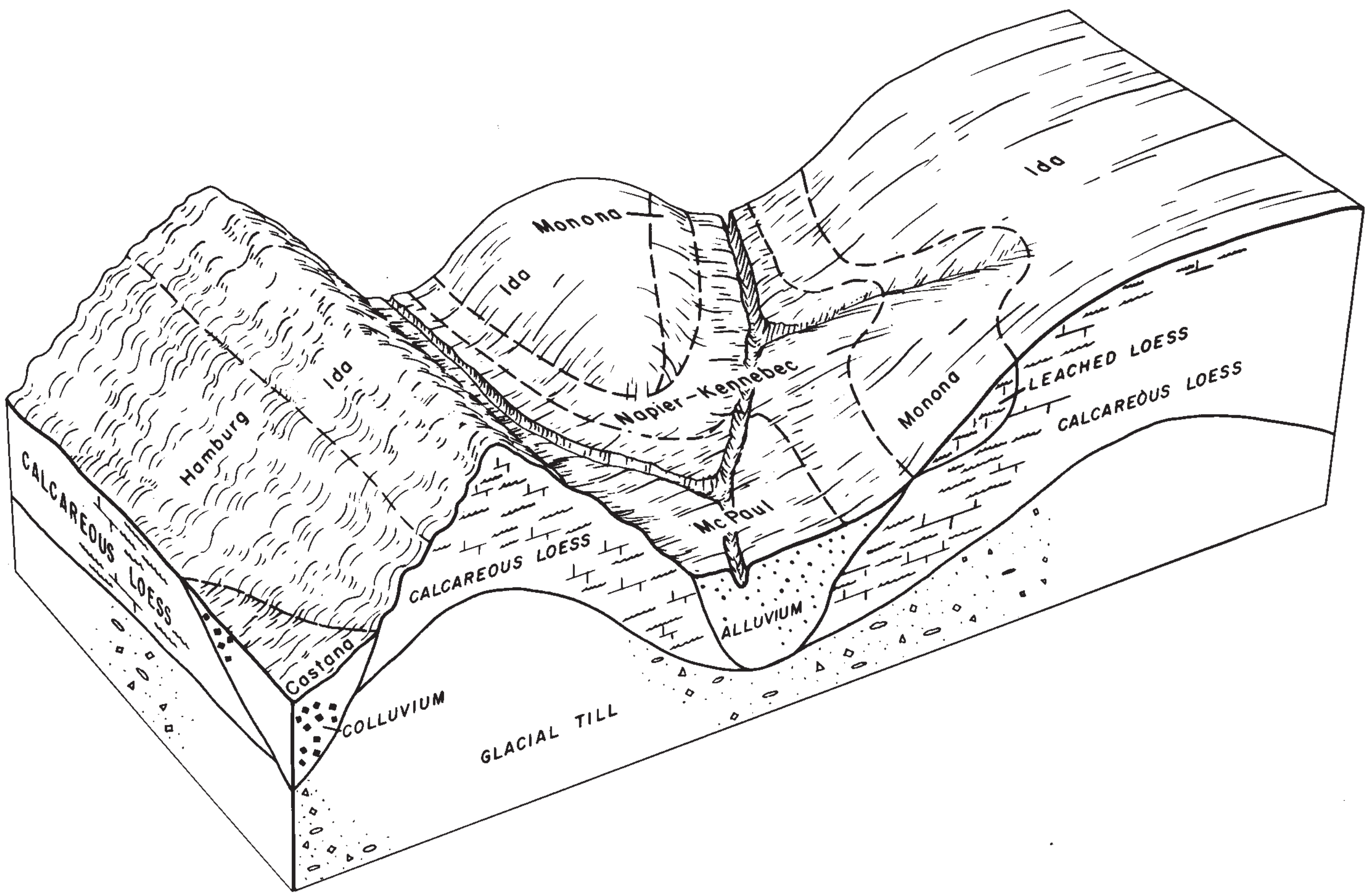

Figure 4.—**Typical pattern of soils and parent material in Ida-Hamburg association.**

slight depressions on some stream benches. Radford and Primghar soils are deep and somewhat poorly drained. The surface layer is silty clay loam that is neutral or slightly acid. Colo and Kennebec soils are also in valleys. Steinauer soils are in a few small areas on hillsides. They formed in glacial till.

This association is used mainly for crops. Corn and soybeans are the chief crops, but oats and hay are also important. Livestock production is a major source of income, and most of the locally grown corn is fed to the livestock. Many, small, narrow bluegrass pastures are in the valleys. Most of the pastures include small parts of the adjoining hillsides.

Galva and Ida soils and some minor soils are subject to erosion. If these soils are used for crops and erosion is controlled, soil and water losses are excessive. In many valleys, a line of tile has been installed to prevent delays in field operations.

The acreage of row crops in this association can be increased if adequate erosion control methods are applied. This association is well suited to livestock production, and a potential exists to increase this enterprise.

This association has a network of gravel roads on most section lines. Several paved roads cross this association on section lines.

4. *Ida-Hamburg association*

Moderately sloping to very steep silty soils that are well drained and somewhat excessively drained

This association has moderately sloping and strongly sloping ridgetops that are about 200 to 300 feet wide. The hillsides are moderately steep to very steep. Typically, in the center of the valleys is a large gully 20 to 40 feet wide and 20 to 40 feet deep that has vertical sides. A small band of gently sloping soils is on each side of the gully. Foot slopes along the edges of the valley are moderately sloping to moderately steep.

This association occupies about 5 percent of the county. Ida soils make up about 55 percent of the association, and Hamburg soils about 12 percent. The other 33 percent of the association is Monona soils on uplands and other soils in valleys. Also included are areas of Steep rock land and Rough broken land.

Ida soils formed in loess and are deep and well drained. They occupy a large part of the ridgetops and the strongly sloping to steep hillsides (fig. 4). The surface layer is calcareous silt loam that is moderately alkaline.

Hamburg soils also formed in loess, and they are deep and somewhat excessively drained. They are on

Figure 5.—**Area of Ida-Hamburg association. Hillsides are mainly Ida soils, and valleys are Kennebec and McPaul soils. Many roads follow valleys or ridgetops in this association.**

very steep hillsides. The surface layer is calcareous silt loam that is moderately alkaline. These soils have a characteristic, stairstep pattern. These "catsteps" are caused by downhill slumping of sections of the soil.

Monona soils formed in loess and are intermingled with Ida soils on the uplands. Other minor soils in this association are Castana, Napier, Kennebec, and McPaul soils. These deep soils are in valleys. The surface layer is silt loam. Steep rock land and Rough broken land include areas of rock outcrop.

This association is used mainly for pasture. The only areas suited to row crops are the wider ridgetops and valleys. A few hillsides are planted to row crops, but they are better suited to hay or pasture. Trees are growing in many places, but few are harvested for commercial products.

The soils in this association are very susceptible to erosion. The soils on uplands are somewhat droughty, because runoff is rapid. The soils in valleys receive a great deal of sediment from the uplands. Runoff from the uplands also adds to the problem of controlling the formation of gullies in most valleys.

Production of hay and pasture can be increased with increased management for that purpose. This association is an excellent area for recreation. Deer and other wildlife are abundant. The watershed approach to conservation enhances the value for recreation as an increasing number of reservoirs are built. Some of the less accessible areas in valleys are suited to trees, such as black walnut.

This association has fewer roads than the other associations in the county. Roads generally follow ridgetops and valleys (fig. 5). Most have a gravel surface.

5. *Ida-Monona association*

Gently sloping to steep silty soils that are well drained

This association has gently sloping or moderately sloping, rounded ridgetops that are about 300 feet wide. The hillsides are strongly sloping to steep. Many have numerous, small drainageways, most of which are crossable with farm machinery. Most of the valleys are about 300 to 500 feet wide and are gently sloping to moderately sloping.

This association occupies about 16 percent of the county. Ida soils make up about 51 percent of the association, and Monona soils about 25 percent. The other 24 percent is mainly soils in the valleys.

Ida soils formed in loess and are deep and well drained. They are intermingled with Monona soils on ridgetops and hillsides (fig. 6). They are in positions where runoff is more rapid than on Monona soils; for example, narrow rounded ridgetops and steep hillsides. The surface layer is calcareous silt loam that is moderately alkaline.

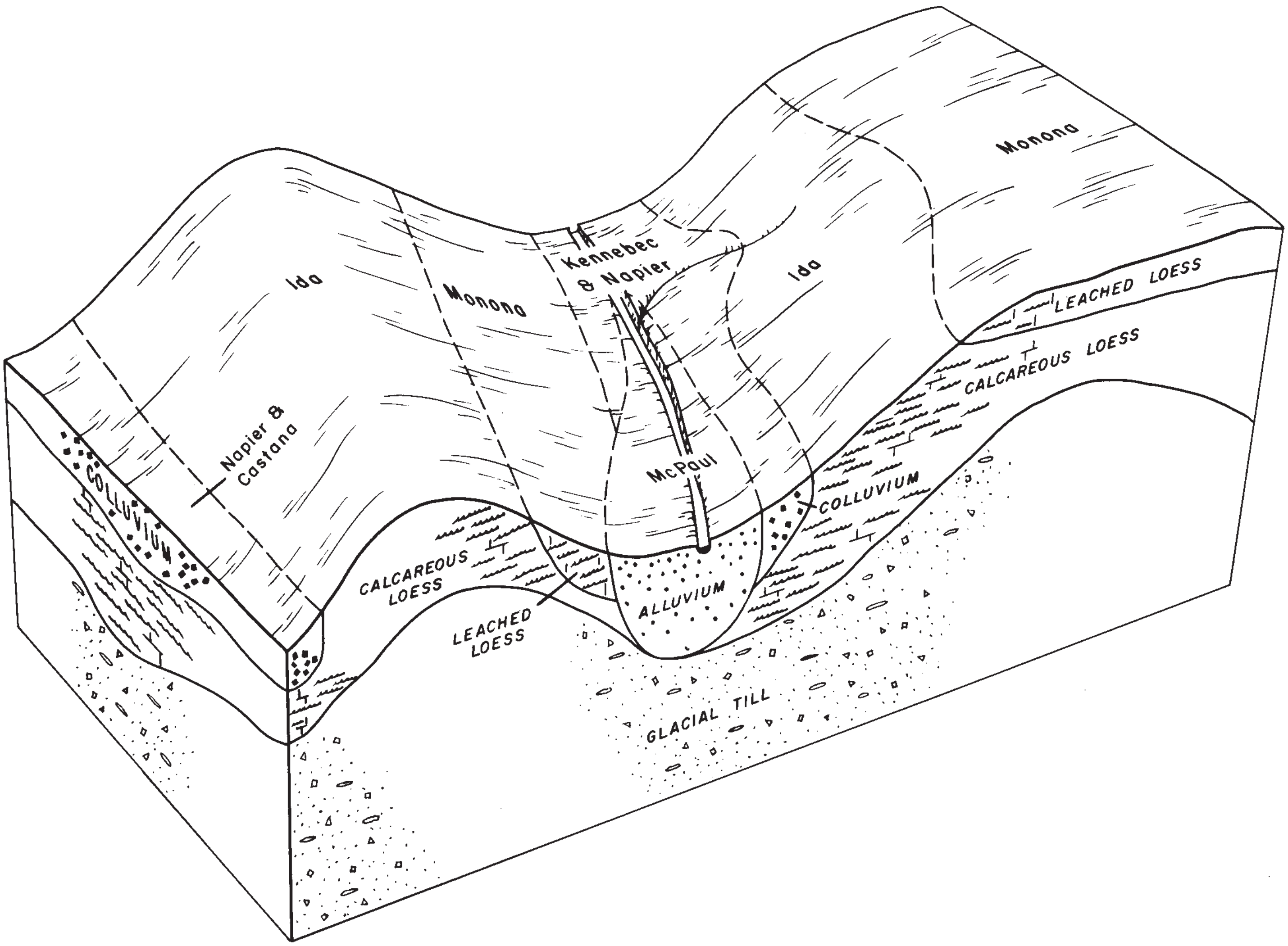

Figure 6.—**Typical pattern of soils and parent material in Ida-Monona association.**

Monona soils also formed in loess and are deep and well drained. They dominate the broad, gently sloping ridgetops and commonly occur on moderately sloping hillsides. Their extent decreases with increasing slope. The surface layer is silt loam that is slightly acid.

Among the minor soils in this association are Kennebec, Steinauer, McPaul, Napier, and Castana soils. A few small areas of Steinauer soils, which formed in glacial till, are on hillsides. The other soils are in valleys and on foot slopes. All are deep. In all but Steinauer soils, the surface layer is silt loam.

This association is used mainly for crops, although some areas too steep for the use of farm machinery are in pasture. Many areas of moderately steep and steep soils are used mainly for hay or pasture and are plowed only at fairly long intervals. Livestock production is an important source of income. Trees are in some valleys and on a few steep hillsides, but little marketable timber is produced.

The soils in this association are very susceptible to erosion. Most are suited to row crops only if substantial erosion-control measures are used. Also, controlling runoff is important in retaining adequate moisture for crop production.

In this association the use of terraces and other erosion-control practices is increasing. These practices enable the inclusion of more row crops in the cropping system. Alternately, more emphasis on high-level management of meadows for hay and pasture will make those uses more competitive with row crops. Thus, the farm operator has more flexibility in his management decisions.

Deer and other wildlife are abundant in this association. Also, the number of small reservoirs is increasing, and recreation activities can be expected to increase. Because Sioux City is near much of this association, some residential subdivisions have been established. More will probably be built in the future.

Roads in this association are on all but 10 percent of the section lines. Some follow ridges and valleys. Most have a gravel surface.

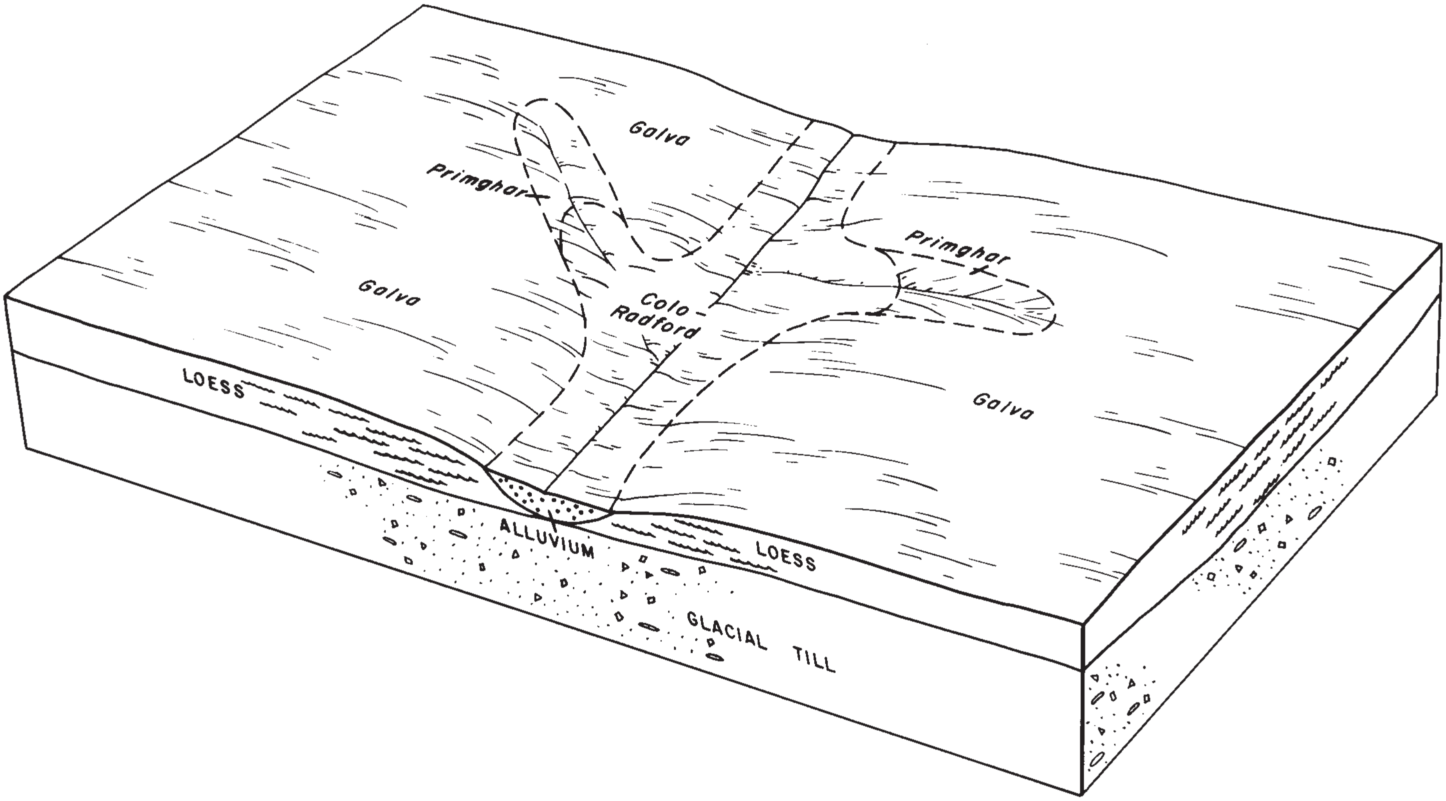

Figure 7.—**Typical pattern of soils and parent material in Galva association.**

6. Galva association

Nearly level to moderately sloping, silty soils that are well drained

This association has broad, nearly straight or slightly rounded, gently sloping ridgetops and generally moderately sloping hillsides. However, part of the association has a gently undulating landscape in which the ridgetops and hillsides are gently sloping and the valleys are nearly level to gently sloping. The valleys typically are 200 to 400 feet wide. A number of stream benches extend along the streams. They are nearly level and gently sloping.

This association occupies about 31 percent of the county. Galva soils make up about 83 percent of the association. The soils in the valleys make up most of the other 17 percent.

Galva soils formed in loess and are deep. They occur on almost all uplands and stream benches (fig. 7). The surface layer is silty clay loam that is slightly acid.

Among the minor soils in this association are Primghar, Steinauer, Wadena, Radford, Colo, and Calco soils. Radford, Colo, and Calco soils formed in alluvium and are the major soils in valleys. All are deep and have a surface layer of silty clay loam. Primghar soils are in the upper reaches of drainageways and in slight depressions on stream benches. They formed in loess, but in most places have sediment on the surface. They are somewhat poorly drained, and the surface layer is slightly acid. Steinauer soils formed in glacial till and are in a few small areas on uplands. Wadena soils formed partly in glacial outwash and are intermingled with Galva soils on escarpments of some stream benches.

This association is used mainly for row crops. Some oats and hay also are grown. A considerable number of livestock are grown and fed for market. Most permanent pasture is in bluegrass. Many pastures are small and narrow and straddle drainageways.

The soils on uplands are subject to erosion, but in most places the erosion hazard is only slight or moderate. The relief is such that conservation practices fit well in the landscape without causing excessive short rows or other undesirable situations. The soils in valleys are somewhat poorly drained or poorly drained. A line of tile generally is installed, especially where these soils are farmed with soils on adjoining hillsides.

This association can be expected to continue as a prime area for row crops. It is very well suited to that use.

This association has almost a complete network of roads on section lines. Almost all are paved or have a gravel surface.

Descriptions of the Soils

This section describes the soil series and mapping units of Plymouth County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure is first to describe the soil series and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to

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

Soil	Acres	Percent
Albaton silty clay, 0 to 1 percent slopes	320	0.1
Calco silty clay loam, 0 to 2 percent slopes	4,720	.9
Castana loam, 9 to 14 percent slopes	275	(1)
Castana silt loam, 14 to 30 percent slopes	1,260	.2
Castana-Gullied land complex, 9 to 14 percent slopes	815	.1
Colo silt loam, calcareous overwash, 0 to 2 percent slopes	885	.2
Colo silty clay loam, 0 to 2 percent slopes	13,180	2.4
Dickman fine sandy loam, 2 to 9 percent slopes	710	.1
Galva silty clay loam, 2 to 5 percent slopes	116,285	21.1
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	124,585	22.6
Galva silty clay loam, 9 to 14 percent slopes, moderately eroded	10,775	2.0
Galva silty clay loam, benches, 0 to 2 percent slopes	5,005	.9
Galva silty clay loam, benches, 2 to 5 percent slopes	23,165	4.2
Galva-Wadena complex, 5 to 14 percent slopes, moderately eroded	1,100	.2
Graceville silt loam, 0 to 2 percent slopes	630	.1
Graceville silt loam, 2 to 5 percent slopes	230	(1)
Hamburg silt loam, 30 to 75 percent slopes	2,945	.5
Ida silt loam, 2 to 5 percent slopes, severely eroded	855	.1
Ida silt loam, 5 to 9 percent slopes, severely eroded	19,745	3.6
Ida silt loam, 9 to 14 percent slopes, severely eroded	40,600	7.4
Ida silt loam, 14 to 20 percent slopes, severely eroded	22,390	4.1
Ida silt loam, 20 to 30 percent slopes, severely eroded	11,060	2.0
Ida silt loam, 30 to 40 percent slopes, severely eroded	2,795	.5
Ida-Wadena complex, 5 to 14 percent slopes, severely eroded	575	.1
Kennebec silt loam, 0 to 2 percent slopes	8,895	1.6
Kennebec silt loam, 2 to 5 percent slopes	905	.2
Kennebec silt loam, channeled, 0 to 2 percent slopes	5,415	1.0
Kennebec silty clay loam, 0 to 2 percent slopes	1,545	.3
Kennebec-McPaul silt loams, 2 to 5 percent slopes	8,015	1.5
Luton silty clay, 0 to 1 percent slopes	980	.2
McPaul silt loam, 0 to 2 percent slopes	9,490	1.7
McPaul-Kennebec silt loams, 2 to 5 percent slopes	16,000	2.9
Modale silt loam, dark subsoil variant, 0 to 2 percent slopes	265	(1)
Monona silt loam, 2 to 5 percent slopes	3,200	.6
Monona silt loam, 5 to 9 percent slopes, moderately eroded	10,175	1.8
Monona silt loam, 9 to 14 percent slopes, moderately eroded	7,470	1.4
Monona silt loam, 14 to 20 percent slopes, moderately eroded	1,005	.2
Monona silt loam, benches, 2 to 5 percent slopes	1,465	.3
Napier silt loam, 5 to 9 percent slopes	5,840	1.1
Napier-Castana silt loams, 9 to 14 percent slopes	4,645	.8
Napier-Gullied land complex, 2 to 10 percent slopes	355	.1
Omadi silt loam, 0 to 2 percent slopes	785	.1
Omadi-Alluvial land complex, 0 to 2 percent slopes	1,765	.3
Primghar silty clay loam, 2 to 5 percent slopes	8,110	1.5
Radford silty clay loam, 0 to 2 percent slopes	8,450	1.5
Radford silty clay loam, 2 to 5 percent slopes	36,140	6.5
Rough broken land	535	.1
Salix silty clay loam, 0 to 2 percent slopes	1,570	.3
Salix silty clay loam, leached subsoil variant, 0 to 2 percent slopes	775	.1
Steep rock land	245	(1)
Steinauer clay loam, 9 to 14 percent slopes, severely eroded	1,075	.2
Steinauer clay loam, 14 to 18 percent slopes, severely eroded	790	.1
Steinauer clay loam, 18 to 30 percent slopes, severely eroded	290	(1)
Wadena loam, 2 to 5 percent slopes	520	.1
Gravel pits and miscellaneous	700	.1
Total	552,320	100.0

1 Less than 0.05 percent.

read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Steep rock land and Rough broken land, for example, are miscellaneous land types that do not belong to a soil series. They are listed, nevertheless, in alphabetic order along with the soil series.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists and others who want detailed information about soils. Unless otherwise indicated, the colors given in the descriptions are those of a moist soil. Some of the terms used to describe the soils are defined in the Glossary at the back of this soil survey.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The pages on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Albaton Series

The Albaton series consists of poorly drained, calcareous, clayey soils that formed in alluvium. These soils are on flood plains. Slope ranges from 0 to 1 percent.

In a representative profile the surface layer is very dark gray, calcareous, firm silty clay about 8 inches thick. Below this is stratified sediment that is dominantly dark grayish-brown and dark-gray, calcareous, firm silty clay. Below a depth of about 42 inches are thin layers of clayey, loamy, and sandy sediment.

These soils have a very slow to slow permeability. They have moderate available water capacity and low organic-matter content. They are low in available nitrogen, very low in available phosphorus, and high in available potassium. The surface layer is neutral or mildly alkaline and is high in lime. These soils have a deep rooting zone, but a seasonal high water table restricts root growth in some years.

Where drainage is adequate, these soils are used for crops. Other areas are used for pasture. Some pastures have not been cleared of trees.

Representative profile of Albaton silty clay, 0 to 1 percent slopes, in an alfalfa field about 1 mile north of the southwest corner of the county; 1,100 feet south and 450 feet west of the northeast corner of SE¼ sec. 27, T. 90 N., R. 48 W.:

Ap—0 to 8 inches, very dark gray (10YR 3/1) silty clay; clods part to moderate, very fine, subangular blocky and angular blocky structure; firm; neutral; slight efferverscence; clear, smooth boundary.

C1—8 to 16 inches, dark grayish-brown (2.5Y 4/2) silty clay; some very dark gray (5Y 3/1) coatings on ped faces; few, fine, prominent, yellowish-red (5YR 5/6) to dark-brown (7.5YR 4/4) mottles; strong, very fine, angular and subangular blocky structure; firm; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—16 to 35 inches, dark grayish-brown (2.5Y 4/2) silty clay; dark-gray (5Y 4/1) and gray (5Y 5/1) coatings on ped faces; common, fine, prominent, yellowish-red (5YR 5/6) to dark-brown (7.5YR 4/4) mottles; dominantly gray (5Y 5/1) below a depth of 24 inches; strong, very fine, angular and subangular blocky structure; firm; moderately alkaline; strong effervescence; clear, smooth boundary.

C3—35 to 42 inches, dark-gray (5Y 4/1) silty clay; upper 3 inches is very dark gray (5Y 3/1); very dark gray (5Y 3/1) coatings on ped faces in rest of horizon; few, fine, prominent, yellowish-red (5YR 5/6) to dark-brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; firm; common small lime concretions; abundant, soft, dark-brown (7.5YR 3/2) iron and manganese accumulations; moderately alkaline; strong effervescence; gradual, smooth boundary.

C4—42 to 48 inches, dark-gray (5Y 4/1) silty clay loam; some very dark gray (5Y 3/1) coatings on ped faces; few, fine, prominent, yellowish-red (5YR 5/6) to dark-brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; firm; common small lime concretions; abundant, soft, dark-brown (7.5YR 3/2) iron and manganese accumulations; moderately alkaline; strong effervescence; clear, smooth boundary.

C5—48 to 60 inches, dominantly stratified, very dark grayish-brown (2.5Y 3/2) and dark grayish-brown (2.5Y 4/2) sandy loam; abundant dark-brown (7.5YR 3/2) accumulations; strong effervescence.

The A horizon ranges from 6 to 10 inches in thickness. It is very dark gray (10YR 3/1 or 5Y 3/1), very dark grayish brown (10YR or 2.5Y 3/2), or dark olive-gray (5Y 3/2) silty clay or clay. It ranges from neutral to moderately alkaline in reaction and from noncalcareous to calcareous.

The C horizon is dominantly silty clay or clay to a depth of 40 inches, but strata of coarser textured material, less than 6 inches thick, are in many places. One or more Ab horizons, less than 6 inches thick, are present in places. They are very dark gray (10YR 3/1 or 5Y 3/1) in color. Strata of coarser textured material are common below a depth of 40 inches. The material ranges from clay to sandy loam.

Albaton soils in this county have more strata of moderately fine textured to moderately coarse textured material than is typical for the series. This difference does not alter the usefulness and behavior of these soils.

Albaton and Luton soils occupy similar positions on the landscape, and they have a somewhat similar profile. Albaton soils have a thinner, lighter colored A horizon than Luton soils, and they are calcareous at or near the surface.

Albaton silty clay, 0 to 1 percent slopes (156).—This soil is on flood plains. Areas are about 40 to 80 acres. Most are in the Big Sioux River Valley in the southern part of the county.

Included with this soil in mapping were small areas of soils that are less clayey and less poorly drained than this soil.

This soil is suited to row crops. It is susceptible to flooding except in areas that are protected by levees. Wetness is a limitation. If this soil is worked when wet, it becomes cloddy. Capability unit IIIw-1.

Calco Series

The Calco series consists of poorly drained, calcareous, silty soils that formed in sediment deposited by streams on flood plains. Slope ranges from 0 to 2 percent.

In a representative profile the surface layer is friable, calcareous silty clay loam about 29 inches thick. It is very dark gray in the upper 8 inches and black in the lower part. The substratum is very dark gray, friable, calcareous silty clay loam.

These soils have moderately slow permeability. They have high to very high available water capacity and high organic-matter content. They are medium or low in available nitrogen, very low in available phosphorus, and low or very low in available potassium. The surface layer is mildly alkaline or moderately alkaline and is high in lime. These soils have a deep rooting zone except where root growth is restricted by a high water table.

Most Calco soils are cultivated. Some areas that are subject to frequent flooding are in pasture.

Representative profile of Calco silty clay loam, 0 to 2 percent slopes, in a cornfield about 4 miles southeast of the town of Hinton; 565 feet south and 75 feet east of the northwest corner of sec. 31, T. 90 N., R. 45 W.:

Ap—0 to 8 inches, very dark gray (10YR 3/1) silty clay loam; clods part to weak, fine, granular and very fine, subangular blocky structure; friable; moderately alkaline; weak effervescence; clear, smooth boundary.

A12—8 to 14 inches, black (N 2/0) silty clay loam; 20 percent mixing of very dark gray (10YR 3/1); weak, fine, granular and very fine, subangular blocky structure; friable; moderately alkaline; weak effervescence; clear, smooth boundary.

A13—14 to 22 inches, black (N 2/0) silty clay loam; weak, fine, granular and very fine, subangular blocky structure; friable; moderately alkaline; weak effervescence; gradual, smooth boundary.

A14—22 to 29 inches, black (N 2/0) silty clay loam; moderate, very fine, subangular blocky structure; friable; moderately alkaline; weak effervescence; diffuse, smooth boundary.

AC1—29 to 36 inches, very dark gray (N 3/0) silty clay loam; weak, very fine and fine, subangular blocky structure; friable; few small lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

AC2—36 to 41 inches, very dark gray (N 3/0) silty clay loam; weak, very fine and fine, subangular blocky structure; friable; common small lime concretions; moderately alkaline; strong effervescence; diffuse, smooth boundary.

C—41 to 60 inches, very dark gray (N 3/0) silty clay loam; weak, very fine and fine, subangular blocky structure; friable; few small lime concretions; moderately alkaline; strong effervescence.

Very dark gray (10YR 3/1) or very dark grayish-brown

(10YR 3/2) overwash up to 15 inches thick is present in many places. It is heavy silt loam to medium silty clay loam.

The A horizon is 24 to 40 inches thick and is light or medium silty clay loam. It is friable or firm.

A Bg horizon is present in places. It is dark gray (N 4/0 or 10YR to 5Y 4/1) or very dark gray (N 3/0 or 10YR to 5Y 3/1) and is mottled in most places.

The C horizon is typically medium silty clay loam, but it ranges from silt loam to silty clay.

Calco soils resemble Colo soils, which are also dark-colored silty clay loams on flood plains. They are calcareous, but Colo soils are not.

Calco silty clay loam, 0 to 2 percent slopes (733).—This soil is on flood plains, typically in valleys that are about 200 to 500 feet wide. Most areas are long and narrow.

Included with this soil in mapping were areas of Colo soils and soils that are calcareous only in the upper 1 or 2 feet of the profile. Also included were soils that are finer textured than this Calco soil. The largest areas of these soils are in the Floyd River Valley between the towns of Merrill and Hinton.

This soil is well suited to row crops. It is susceptible to flooding, and wetness is a limitation. It becomes cloddy if worked when too wet. Capability unit IIw–1.

Castana Series

The Castana series consists of well-drained, calcareous, silty soils. These soils formed in material that washed or slumped from hillsides. They are on foot slopes along the edges of valleys. Slope ranges from 9 to 30 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown, very friable, calcareous silt loam about 18 inches thick. The substratum is brown, very friable, calcareous silt loam.

Castana soils have moderate permeability and very high available water capacity. They have moderate organic-matter content. They are low in available nitrogen, low or very low in available phosphorus, and medium or high in available potassium. They are moderately alkaline and are high in lime. They have a deep rooting zone.

Most areas of Castana soils are used for pasture, but some are farmed with adjoining bottom-land soils and are used for cultivated crops. Stands of trees are in many pastures.

Representative profile of Castana silt loam, 14 to 30 percent slopes, in a pasture about 5 miles southeast of the town of Westfield; 600 feet north and 520 feet east of the southwest corner of NW¼ sec. 17, T. 91 N., R. 48 W.:

A11—0 to 9 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, granular structure; very friable; moderately alkaline; strong effervescence; gradual, smooth boundary.

A12—9 to 14 inches, very dark grayish-brown (10YR 3/2) silt loam, tending to dark grayish brown (10YR 4/2) when crushed; weak, fine, granular structure; very friable; moderately alkaline; strong effervescence; gradual, smooth boundary.

AC—14 to 18 inches, very dark grayish-brown (10YR 3/2) silt loam, tending to dark brown (10YR 3.3) when crushed; weak, fine, granular and weak, very fine, subangular blocky structure; very friable; moderately alkaline; strong effervescence; gradual, smooth boundary.

C1—18 to 28 inches, brown (10YR 4/3) silt loam; weak, fine, granular and weak, very fine, subangular blocky structure; very friable; few small lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—28 to 37 inches, brown (10YR 4/3) silt loam; massive; very friable; lime concretions larger and more abundant than in C1 horizon; moderately alkaline; strong effervescence; gradual, smooth boundary.

C3—37 to 60 inches, brown (10YR 5/3) silt loam, yellowish brown (10YR 5/4) when dry; massive; very friable; common lime concretions; moderately alkaline; strong effervescence.

The A horizon is 10 to 20 inches thick. It is mostly silt loam, but in places it is loam. Some profiles are leached of carbonates to a depth of about 10 inches. The C horizon is yellowish brown (10YR 5/4) in places. Lime concretions are few to common.

Castana loam, 9 to 14 percent slopes, has more sand than is typical for the series. It also contains some limestone fragments. These differences, however, do not significantly affect the use and behavior of the soil.

Castana soils are near Hamburg, Ida, and Napier soils. All are silt loams. Castana soils have a thicker A horizon than Hamburg and Ida soils and a thinner A horizon than Napier soils. They are calcareous higher in the profile than Napier soils.

Castana loam, 9 to 14 percent slopes (14D).—This soil has straight slopes. It is in areas, 100 to 200 feet wide, between very steep rock hillsides and nearly level or gently sloping bottom-land soils. It has a profile similar to the one described as representative of the series, but it has more sand throughout and fragments of limestone, sandstone, or shale are in the upper part of the profile.

Included with this soil in mapping were small areas where rock fragments are common.

This soil is suited to row crops where it is accessible to farm machinery. Pasture is a better use in many places. The soil is susceptible to erosion and receives a great deal of runoff from adjoining soils on uplands. Capability unit IVe–2.

Castana silt loam, 14 to 30 percent slopes (3F).—This soil is along the edges of valleys in the very steep parts of the county. Areas are about 200 to 400 feet wide and ¼ to ½ mile long. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were areas where slopes are steeper than 30 percent. Also included were Napier soils that have slopes of less than 14 percent.

This soil is poorly suited to row crops and generally is managed with the adjacent, very steep and steep soils on hillsides. It is susceptible to erosion. Many areas are not easily accessible by farm machinery. Capability unit VIe–1.

Castana-Gullied land complex, 9 to 14 percent slopes (983D).—This complex is in the upper part of valleys in the very steep parts of the county. Castana soils make up about 75 percent of this complex, and Gullied land and included soils make up the remaining 25 percent. Areas are long and narrow. A large gully is in the center of each area. Some gullies are as deep and as wide as 50 feet and have vertical sides. Small gullies extend from the main ones.

Included with this complex in mapping were areas of Napier soils next to the gullies.

This complex is not suited to row crops. It is susceptible to further gullying and to sheet erosion. Capability unit VIIe–1.

Colo Series

The Colo series consists of poorly drained silty soils. These soils formed in sediment deposited by streams on flood plains. Slope ranges from 0 to 2 percent.

In a representative profile the surface layer is friable silty clay loam about 37 inches thick. Most of this layer is black, but the upper part is very dark grayish brown and very dark gray because the recently deposited sediment is lighter in color. The substratum is very dark gray and dark-gray, friable silty clay loam.

These soils have moderately slow permeability. They have high to very high available water capacity and high organic-matter content. They are generally medium or low in available nitrogen, low or very low in available phosphorus, and medium in available potassium. They are neutral or slightly acid to a depth of 3 feet or more except in areas where overwash that is high in lime is on the surface. They have a deep rooting zone.

Most areas are used for cultivated crops, but a sizable acreage is in pasture.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a bluegrass pasture about 5 miles southeast of the town of Remsen; 120 feet east and 20 feet north of center of NW¼ sec. 35, T. 92 N., R. 43 W.:

A11—0 to 6 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—6 to 14 inches, very dark gray (10YR 3/1) light silty clay loam; weak, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A13—14 to 28 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A14—28 to 37 inches, black (10YR 2/1) silty clay loam; few, fine, faint, dark grayish-brown (10YR 4/2) mottles; moderate, very fine, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

AC—37 to 42 inches, very dark gray (10YR 3/1) silty clay loam, tending to dark gray (10YR 4/1); few, fine, faint, dark grayish-brown (10YR 4/2) mottles; weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C—42 to 60 inches, dark-gray (10YR 4/1) silty clay loam; fine, faint, dark grayish-brown (10YR 4/2) and dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; friable; neutral.

In most places overwash is as much as 15 inches thick. The overwash is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or very dark brown (10YR 2/2). It is light or medium silty clay loam and is neutral or slightly acid. In a few places it is calcareous silt loam or light silty clay loam and is mildly alkaline or moderately alkaline. It is dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2).

The A horizon is 30 to 40 inches thick and, excluding the overwash, is medium acid to neutral. Reddish, brownish, or yellowish mottles are in the lower part of the horizon in many places.

The boundary between the A and C horizons commonly is diffuse and is somewhat arbitrarily established. In places Colo soils are described as having a weak structural B horizon that is very dark gray (10YR 3/1) or dark gray (10YR 4/1). The C horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR or 2.5Y 4/2) below a depth of 40 inches.

Colo soils are on bottom lands near Kennebec, Calco, and Radford soils. They are finer textured than Kennebec soils. In places they have stratified, grayish or brownish overwash, less than 15 inches thick, whereas in Radford soils the stratified material extends to a depth of 18 to 36 inches. Colo soils are noncalcareous, except in a few places that have a thin layer of calcareous overwash, whereas Calco soils are calcareous.

Colo silt loam, calcareous overwash, 0 to 2 percent slopes (133+).—This soil is on flood plains. Areas generally are long and narrow.

This soil has a profile similar to the one described as representative of the series, but it has 6 to 15 inches of calcareous silt loam over black silty clay loam.

This soil is well suited to row crops. It is susceptible to flooding, but floods generally are not common enough to prevent row cropping. Wetness is a limitation. Capability unit IIw–1.

Colo silty clay loam, 0 to 2 percent slopes (133).—This soil is on flood plains. Areas generally are long and narrow and extend along the valley on both sides of the stream. The profile of this soil is the one described as representative of the series. In places the very dark gray or very dark grayish-brown overwash is thinner or is lacking.

Included with this soil in mapping were areas of Calco soils and areas of soils that are more clayey than this Colo soil. Also included, in the Big Sioux River Valley, were some fairly large areas of soils that are slightly more clayey.

This soil is well suited to row crops except in low-lying areas. It is susceptible to flooding, but floods generally are not common enough to prevent row cropping. Wetness is a limitation. If this soil is worked when too wet, it becomes cloddy. Capability unit IIw–1.

Dickman Series

The Dickman series consists of somewhat excessively drained loamy soils that formed in alluvium. Some alluvium has been blown for short distances. These soils are on stream benches. Slope ranges from 2 to 9 percent.

In a representative profile the surface layer is very dark brown, very friable fine sandy loam about 10 inches thick. The subsoil is about 37 inches thick. The upper few inches is dark-brown sandy loam, and the rest is dark yellowish-brown, loose loamy sand. Below this is yellowish-brown, calcareous, loose loamy sand.

These soils have rapid permeability. They have low available water capacity and moderately low organic-matter content. They are low in available nitrogen and phosphorus and high in available potassium. The surface layer is neutral or slightly acid. These soils have a deep rooting zone, but root growth is restricted by lack of moisture in some years.

Most areas of these soils are used for cultivated crops.

Representative profile of Dickman fine sandy loam, 2 to 9 percent slopes, in an alfalfa field about 1 mile from the northwest corner of the county; 450 feet south and 75 feet east of northwest corner of SW¼ sec. 3, T. 93 N., R. 48 W.:

Ap—0 to 6 inches, very dark brown (10YR 2/2) fine sandy loam; weak, coarse, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, very dark brown (10YR 2/2) fine sandy loam, rubs to very dark grayish brown (10YR 3/2); weak, medium and coarse, subangular blocky structure parting to weak, fine, subangular blocky; very friable; slightly acid; clear, smooth boundary.

B1—10 to 14 inches, dark-brown (10YR 3/3) sandy loam; weak, very fine and fine, subangular blocky structure; very friable; slightly acid; clear, smooth boundary.

B2—14 to 21 inches, dark yellowish-brown (10YR 4/4) loamy sand; some dark-brown (10YR 4/3) coatings on ped faces; weak, very fine and fine, subangular blocky structure; loose; slightly acid; gradual, smooth boundary.

B3—21 to 47 inches, dark yellowish-brown (10YR 4/4) loamy sand; single grained; loose; slightly acid; clear, smooth boundary.

C—47 to 60 inches, yellowish-brown (10YR 5/4) loamy sand; single grained; loose; mildly alkaline; strong effervescence.

The A horizon is fine sandy loam or sandy loam 8 to 14 inches thick. It is slightly acid or neutral.

The B1 horizon is lacking in some profiles, but most of those profiles have an A3 horizon instead. The B1, or A3, horizon is 2 to 6 inches thick and is very dark grayish-brown (10YR 3/2) or dark-brown (10YR 3/3) sandy loam or fine sandy loam. It is slightly acid or neutral. The B2 horizon is brown (10YR 4/3) or dark yellowish-brown (10YR 4/4) sandy loam or loamy sand 4 to 8 inches thick. It is slightly acid or neutral. The B3 horizon is loamy sand or sand 10 to 30 inches thick. It is neutral or slightly acid.

The C horizon is calcareous loamy sand or sand that is neutral or mildly alkaline.

The reaction in the solum and the carbonates above a depth of 60 inches are outside the range of the Dickman series. However, these differences have little or no significant affect on the use or behavior of these soils.

Dickman soils are on stream benches near Wadena soils. They are sandier in the upper part of their profile than Wadena soils.

Dickman fine sandy loam, 2 to 9 percent slopes (28B).—This soil is on convex ridges or humps on stream benches in the larger valleys. Areas range from about 10 to 80 acres or more.

Included with this soil in mapping were soils that are not so sandy as Dickman soils. These soils commonly are Wadena soils, which are underlain by gravel in places.

This Dickman soil is suited to row crops. It is commonly farmed with soils that are better suited to this use. It is susceptible to erosion and to soil blowing, and it is droughty. Capability unit IIIe-3.

Galva Series

The Galva series consists of well-drained silty soils that formed in loess on uplands and on high stream benches. Slope ranges from 0 to 14 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown, friable silty clay loam about 12 inches thick. The subsoil is friable silty clay loam about 30 inches thick. It is dark yellowish brown in the upper part and yellowish brown in the lower part. The substratum, extending to a depth of 60 inches, is yellowish-brown, friable light silty clay loam.

These soils have moderate permeability. They have high to very high available water capacity and moderate to high organic-matter content. They are low to medium in available nitrogen, low in available phosphorus, and high in available potassium. The surface layer is medium acid to neutral. These soils have a deep rooting zone.

Almost all areas of these soils are cultivated. A few of the more sloping areas are in pasture.

Representative profile of Galva silty clay loam, 2 to 5 percent slopes, in a meadow about 5 miles north of the town of Kingsley; 66 feet west and 46 feet south of "Witness Post" of Coast and Geodetic Survey, which is near the northwest corner of NE¼NE¼ sec. 30, T. 91 N., R. 43 W.:

Ap1—0 to 3 inches, very dark brown (10YR 2/2) silty clay loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

Ap2—3 to 7 inches, very dark brown (10YR 2/2) silty clay loam; moderate to strong, coarse, angular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A3—7 to 12 inches, very dark grayish-brown (10YR 3/2) silty clay loam; some very dark brown (10YR 2/2) coatings on ped faces, thinning in lower part; very dark grayish brown (10YR 3/2) when crushed and kneaded; moderate, very fine, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

B21—12 to 18 inches, dark yellowish-brown (10YR 4/4) silty clay loam; few very dark grayish-brown (10YR 3/2) coatings on ped faces; dark yellowish brown (10YR 4/4) when kneaded; weak, medium, prismatic structure parting to weak, very fine, subangular blocky; friable; few patchy clay films; slightly acid; gradual, smooth boundary.

B22—18 to 27 inches, dark yellowish-brown (10YR 4/4) silty clay loam; yellowish brown (10YR 5/4) when kneaded; weak, medium, prismatic structure parting to weak, very fine, subangular blocky; friable; few patchy clay films; neutral; gradual, smooth boundary.

B31—27 to 34 inches, yellowish-brown (10YR 5/4) light silty clay loam; weak, medium, prismatic structure parting to weak, fine, subangular blocky; friable; few patchy clay films; neutral; gradual, smooth boundary.

B32—34 to 42 inches, yellowish-brown (10YR 5/4) light silty clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C—42 to 60 inches, yellowish-brown (10YR 5/4) light silty clay loam; common, fine, faint, yellowish-brown (10YR 5/6) mottles and common, fine, distinct, light-gray (10YR 6/1) mottles; massive; friable; neutral, but moderately alkaline and strong effervescence in lower few inches.

The A horizon, in areas where the soil is uneroded or is only slightly eroded, ranges from about 10 to 16 inches in thickness. The maximum clay content in the profile is about 34 to 38 percent. It is most commonly in the A1 horizon within 12 inches of the surface, but in places it is in the A3 or B1 horizon. The A horizon is neutral to medium acid.

The B horizon is about 24 to 30 inches thick. The B2 horizon is brown (10YR 4/3 to 10YR 5/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). In the C horizon and, in places, in the B3 horizon are few to common mottles. The B horizon is commonly neutral or slightly acid.

In places the C horizon is moderately alkaline and calcareous. Calcareous glacial till underlies the loess at a depth of 40 to about 120 inches.

Galva soils resemble Monona soils, which are also well-drained soils that formed in loess. They are finer textured in the upper part of the profile than Monona soils.

Galva silty clay loam, 2 to 5 percent slopes (310B).—This soil occupies many ridgetops in the county. It is also on hillsides in undulating and gently rolling areas. Areas are large; some square-mile sections are made up entirely of this soil, except for narrow strips of other soils in drainageways. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were eroded areas where the plow layer is lighter colored. On many narrow ridgetops the surface layer is very dark grayish brown and is only about 6 inches thick. Also included were small areas of Ida soils, some wetter soils in nar-

***Figure 8.*—Farm buildings on Galva silty clay loam, benches, 0 to 2 percent slopes. Pasture in foreground is on Colo silty clay loam, 0 to 2 percent slopes.**

row drainageways or in depressions, and a few areas, 1 or 2 acres in size, of soils that formed in glacial drift. In the western part of the county, some areas of Galva silty clay loam, benches, 2 to 5 percent slopes, were included.

This soil is well suited to row crops. It is susceptible to erosion, but adequate erosion control can be obtained with reasonable ease. Capability unit IIe–2.

Galva silty clay loam, 5 to 9 percent slopes, moderately eroded (310C2).—This soil is mainly on hillsides. A few areas are on ridgetops in rolling and hilly parts of the county, and some are on escarpments between stream benches and flood plains. Areas typically are large. In many parts of the county this soil makes up almost all hillsides. The hillsides are approximately 400 to 800 feet from ridgetop to valley, and many areas extend for miles along the contour of the landscape.

This soil has a profile similar to the one described as representative of the series, but the surface layer is lighter colored, generally very dark grayish brown.

Included with this soil in mapping were spots of severely eroded Galva and Ida soils on convex knobs between hillside drainageways. Also included were narrow strips of Primghar soils in hillside drainageways. Areas of Steinauer soils, 1 or 2 acres in size, were included and are shown on the soil map by a till symbol. On terrace escarpments small outcrops of sand and gravel are common and are shown on the soil map by a special sand or gravel symbol.

This soil is suited to row crops, but erosion is excessive unless adequate erosion control measures are used. Capability unit IIIe–1.

Galva silty clay loam, 9 to 14 percent slopes, moderately eroded (310D2).—This soil is on convex hillsides and commonly is on uplands near other Galva soils that are less sloping. Most areas are 10 to 20 acres.

This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown.

Included with this soil in mapping were patches of severely eroded Galva and Ida soils on convex knobs between hillside drainageways. Also included were small areas of Steinauer soils and small areas of gravel or sand that are shown on the soil map by special symbols.

This soil is suited to row crops. It also is well suited to hay or pasture. It is very susceptible to erosion. Adequate erosion-control measures are essential, especially for row crops. Capability unit IIIe–2.

Galva silty clay loam, benches, 0 to 2 percent slopes

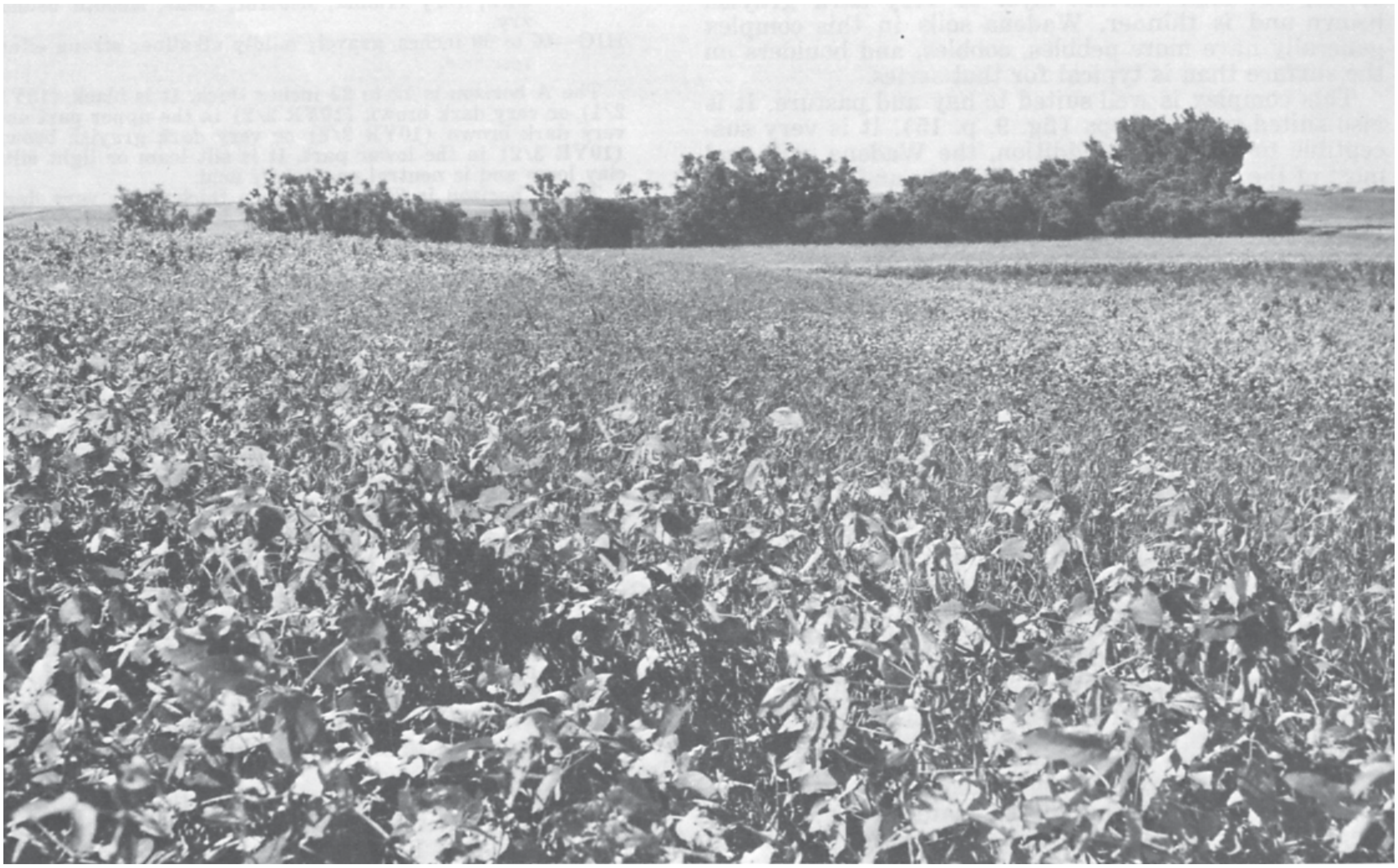

Figure 9.—**Soybeans on Galva-Wadena complex, 5 to 14 percent slopes, moderately eroded.**

(T310).—This soil is on stream benches that are about 5 to 15 feet above the flood plains. Most areas are along the larger streams. Areas are as large as 100 acres (fig. 8).

This soil has a profile similar to the one described as representative of the series, but it is more nearly level and the dark-colored surface layer is 12 to 15 inches thick. In many places sand or gravel is at a depth of 8 to 10 feet, which is not typical of the Galva series.

Included with this soil in mapping were small areas of other Galva soils that have slopes of as much as 5 percent. Also included were areas in depressions, about 1 to 2 acres in size, of soils that are wetter than this Galva soil.

This soil is well suited to row crops. In places it receives runoff from the adjoining hillsides, but this rarely limits its use. In many years the additional moisture is helpful. Capability unit I–1.

Galva silty clay loam, benches, 2 to 5 percent slopes (T310B).—This soil is on stream benches. On some benches, particularly smaller ones, it is the only soil mapped. Typical areas are 10 to 20 acres in size and are 5 to 15 feet above the flood plain. Some areas on the escarpment next to the flood plain are long and narrow.

This soil has a profile similar to the one described as representative of the series, but in many places the dark-colored surface layer is thicker.

Included with this soil in mapping were nearly level Galva soils and areas in depressions, 1 to 2 acres in size, of soils that are wetter than this Galva soil. Also included were gravelly and sandy areas about 1 acre in size. Most of these areas are near the base of the terrace escarpment within a few feet of the flood plain. In many places this soil is underlain at a depth of approximately 8 or 10 feet by sand and gravel.

This soil is well suited to row crops. It is subject to erosion. It receives runoff from adjoining hillsides, which increases the need for erosion control. Capability unit IIe–2.

Galva-Wadena complex, 5 to 14 percent slopes, moderately eroded (317C2).—This complex is on terrace escarpments. Galva soils make up 60 to 80 percent of the complex; Wadena soils, 15 to 30 percent; and included soils, the rest. Areas are 200 to 400 feet wide. They occupy bands between the flood plain and the nearly level or gently sloping stream bench, which is 10 to 15 feet above the flood plain. Wadena soils are in 1- to 5-acre patches on convex knobs that typically are 200 to 400 feet apart.

The Galva and Wadena soils have profiles similar to the ones described as representative of their respective series, but their surface layer is very dark grayish brown and is thinner. Wadena soils in this complex generally have more pebbles, cobbles, and boulders on the surface than is typical for that series.

This complex is well suited to hay and pasture. It is also suited to row crops (fig. 9, p. 15). It is very susceptible to erosion. In addition, the Wadena soils and most of the included soils are droughty and are likely to have pebbles and cobbles on the surface. Capability unit IIIe–3.

Graceville Series

The Graceville series consists of moderately well drained silty soils that formed in alluvium. These soils are on stream benches and are underlain by sand or gravel at a depth of 4 or 5 feet. Slope ranges from 0 to 5 percent.

In a representative profile the surface layer is very dark brown, friable silt loam about 20 inches thick. The subsoil is about 26 inches thick. It is very dark grayish-brown, friable silt loam in the upper 7 inches and grades with increasing depth to dark-brown, friable loam and brown, very friable sandy loam. Below a depth of 46 inches is calcareous gravel.

These soils have moderate permeability. They have high available water capacity and moderate to high organic-matter content. They are low in available nitrogen and phosphorus and medium in available potassium. The surface layer is neutral or slightly acid. In places the rooting zone is restricted by the underlying sand or gravel, but the coarse material generally is deep enough that the influence on plant growth is minor.

These soils commonly are used for cultivated crops.

Representative profile of Graceville silt loam, 0 to 2 percent slopes, in an alfalfa field about 2 miles southwest of the town of Akron; 1,400 feet east and 250 feet south of the northwest corner of sec. 12, T. 92 N., R. 49 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy silt loam; weak, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; neutral; abrupt, smooth boundary.

A12—7 to 13 inches, very dark brown (10YR 2/2) heavy silt loam; less compaction than in Ap horizon; weak, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

A3—13 to 20 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when rubbed; weak, very fine and fine, subangular blocky structure parting to weak to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

B21—20 to 27 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, tending to dark grayish brown (10YR 4/2); brown (10YR 3/3) when rubbed; weak, very fine and fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—27 to 35 inches, dark-brown (10YR 3/3) heavy loam, brown (10YR 4/3) when crushed; weak, very fine and fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

IIB31—35 to 41 inches, brown (10YR 4/3) sandy loam; weak, very fine and fine, subangular blocky structure; very friable; neutral; clear, smooth boundary.

IIB32—41 to 46 inches, brown (10YR 4/3) sandy loam; weak, very fine and fine, subangular blocky structure; very friable; neutral; clear, smooth boundary.

IIIC—46 to 60 inches, gravel; mildly alkaline; strong effervescence.

The A horizon is 12 to 22 inches thick. It is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in the lower part. It is silt loam or light silty clay loam and is neutral or slightly acid.

The B horizon is 26 to 40 inches thick. It is very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) in the upper 6 to 12 inches and brown (10YR 4/3) or dark yellowish brown (10YR 4/4) in the rest of the horizon. The B1 and B2 horizons are light silty clay loam, light clay loam, silt loam, or heavy loam. The B3 horizon ranges from heavy loam to sandy loam. The B horizon is neutral or slightly acid.

The solum commonly extends to the underlying sand or gravel and, in places, extends a few inches into the coarse material. The sand or gravel typically is leached of carbonates to a maximum depth of 6 inches.

In some profiles the B horizon is sandier than is defined as within the range of the Graceville series. This does not, however, significantly affect the use and behavior of these soils.

Graceville soils are near Wadena soils, and their profiles are similar. Depth to sand or gravel is 4 to 5 feet in Graceville soils and is only 2 or 3 feet in Wadena soils.

Graceville silt loam, 0 to 2 percent slopes (116).—This soil is at intermediate elevations on stream benches. Some areas are as large as 200 or 300 acres. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were small areas of Dickman and Wadena soils, which are moderately droughty.

This soil is well suited to row crops. It is susceptible to soil blowing, but this generally is not a serious hazard. Capability unit I–1.

Graceville silt loam, 2 to 5 percent slopes (116B).—This soil is on convex ridges or humps on stream benches. Most areas in the Big Sioux River Valley are long and narrow and are on slightly elevated ridges. Areas in the smaller valleys are on humps, a few feet above the flood plain.

This soil has a profile similar to the one described as representative of the series, but the surface layer is not so thick and, the average depth of the underlying sand and gravel is less.

Included with this soil in mapping were some areas of Wadena and Dickman soils. Some of these soils are droughty.

This soil is well suited to row crops. It is susceptible to erosion. Capability unit IIe–2.

Hamburg Series

The Hamburg series consists of somewhat excessively drained, calcareous, silty soils that formed in loess. These soils have natural terraces, or catsteps, that are caused by slumping of sections of the soil material. Slope ranges from 30 to 75 percent.

In a representative profile the surface layer is dark grayish-brown, calcareous, very friable silt loam about 5 inches thick. Below this, and extending to a depth of 60 inches or more, is brown, calcareous, very friable silt loam that has brownish mottles.

These soils have moderate permeability. They have high to very high available water capacity and low organic-matter content. They are very low in available nitrogen and phosphorus and high in available potassium. The surface layer is mildly alkaline or moderately alkaline and is high in lime. These soils have a deep rooting zone.

Areas of these soils are used for pasture.

Representative profile of Hamburg silt loam, 30 to 75 percent slopes, in a pasture about 11 miles west of the town of Hinton; 360 feet north and 200 feet west of the southeast corner of NE¼ sec. 4, T. 90 N., R. 48 W.:

A1—0 to 5 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, granular and weak, very fine, subangular blocky structure; very friable; moderately alkaline; strong effervescence; clear, irregular boundary.

C1—5 to 19 inches, brown (10YR 4/3 tending to 5/3) silt loam; weak, very fine, subangular blocky structure in upper few inches and massive below; very friable; common light-gray lime concretions and few streaks of lime; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—19 to 31 inches, brown (10YR 5/3) silt loam; massive; very friable; free lime occurs more as streaks and specks than as concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C3—31 to 60 inches, brown (10YR 5/3) silt loam; few, fine, faint, yellowish-brown (10YR 5/6) mottles; massive; very friable; common lime streaks and specks; some evidence of stratification, mainly as yellowish-brown (10YR 5/6) deposits of iron and manganese on horizontal faces; moderately alkaline; strong effervescence.

The A horizon is dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3). It is 6 inches thick where values are less than 3.5 and about 10 inches thick where values are greater than 3.5. It is calcareous and is mildly alkaline or moderately alkaline. Carbonate concretions are on the surface in places.

The C horizon is brown (10YR 4/3 or 5/3) or yellowish brown (10YR 5/4). It is dominantly silt loam, but in a few places it is silt. Mottles are few to many and are commonly strong brown, reddish brown, or gray.

Hamburg and Ida soils occupy similar positions on the landscape, and they have a similar profile. Hamburg soils, however, have less clay than Ida soils.

Hamburg silt loam, 30 to 75 percent slopes (2G).—This soil is on hillsides and is high on the landscape.

Included with this soil in mapping were areas of moderately sloping or strongly sloping soils on ridgetops 50 to 100 feet wide. Also included were areas of Hamburg soils where slopes are more than 75 percent. In places a few areas of glacial till or bedrock outcrop are near the base of hills. The outcrop is shown on the soil map by a special symbol.

This soil is suited to pasture, but steepness of slope severely limits its use. It is extremely susceptible to erosion. It is too steep to permit use of regular farm machinery; consequently, pastures are in native grasses. If pastures are overgrazed, little can be done to speed renovation. Runoff is rapid because slopes are steep. This soil tends to be droughty. Yucca and other plants that are common to dry climates grow in places. Few if any trees are on this Hamburg soil, but trees are common on adjacent soils. Capability unit VIIe–1.

Ida Series

The Ida series consists of well-drained, calcareous, silty soils that formed in loess. Most areas of Ida soils are on convex hillsides, and slopes typically face south or west, where runoff is rapid. The less sloping areas of Ida soils are on narrow convex ridgetops. Slope ranges from 2 to 40 percent.

In a representative profile the surface layer is dark grayish-brown, very friable, calcareous silt loam about 8 inches thick. The substratum is dark yellowish-brown and yellowish-brown, very friable, calcareous silt loam. Lime nodules are on the surface in places.

Ida soils have moderate permeability and very high available water capacity. They have moderately low to low organic-matter content, depending on the amount of erosion that has taken place. They are generally very low in available nitrogen and phosphorus and medium to high in available potassium. The surface layer typically is moderately alkaline and is high in lime. These soils have a deep rooting zone.

The less sloping Ida soils are generally used for crops, and the steeper soils are used for pasture. In places young trees grow in pastures.

Representative profile of Ida silt loam, 9 to 14 percent slopes, severely eroded, in a meadow about 7 miles west of the town of Hinton; 170 feet west and 432 feet north of the southeast corner of NE¼ sec. 32 T. 91 N, R. 47 W.:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 4/3) when crushed; weak, fine, granular structure; very friable; many lime concretions; moderately alkaline; strong effervescence; clear, smooth boundary.

C1—8 to 13 inches, dark yellowish-brown (10YR 4/4) silt loam, yellowish brown (10YR 5/4) when crushed; weak, fine, granular structure; very friable; many lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—13 to 26 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, faint, yellowish-brown (10YR 5/6) to strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; very friable; few lime concretions and a few dark-colored iron and manganese concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C3—26 to 60 inches, yellowish-brown (10YR 5/4) silt loam, light yellowish brown (10YR 6/4) when crushed; common, fine, faint, yellowish-brown (10YR 5/6) to strong-brown (7.5YR 5/8) mottles and common, fine, distinct, light-gray (10YR 6/1) mottles; massive; very friable; few lime concretions and few dark-colored iron and manganese concretions; moderately alkaline; strong effervescence.

The A1 or Ap horizon is very dark grayish brown (10YR 3/2) in slightly eroded places. In undisturbed areas the A1 horizon is 3 to 6 inches thick. In severely eroded places the Ap horizon is brown (10YR 4/3 to 10YR 5/3) or dark yellowish brown (10YR 4/4) and many lime nodules are on the surface. The A horizon ranges from neutral to moderately alkaline.

The C horizon is brown (10YR 4/3 or 10YR 5/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). Depth to mottles ranges from about 10 to 30 inches. Vertical cleavage or prismatic structure occurs in the upper part of the C horizon in some profiles.

Ida soils are near Monona and Hamburg soils. They are calcareous, and Monona soils are not. In addition, they lack a distinct, brownish B horizon that is characteristic of Monona soils, and they have lower organic-matter content and natural fertility than those soils. They have a profile similar to that of Hamburg soils, but they contain more clay and less sand.

Ida silt loam, 2 to 5 percent slopes, severely eroded (1B3).—This soil is on ridgetops. Most areas are less than 10 acres and occur as patches surrounded by Galva or Monona soils. On a few ridgetops, however, long, narrow strips of this soil are as large as 20 acres. Many

Figure 10.—**Light-colored areas of Ida silt loam, 5 to 9 percent slopes, severely eroded, intermingled with darker colored areas of Galva silty clay loam, 5 to 9 percent slopes, moderately eroded.**

very small areas are shown on the soil map by a special symbol.

This soil has a profile similar to the one described as representative of the series, but where erosion is less severe, the surface layer is very dark grayish brown. These areas lack the lime concretions on the surface that are in the representative profile.

This soil is well suited to row crops, but it is susceptible to erosion. Fertility is low, but crops respond well to fertilizer. Capability unit IIe–2.

Ida silt loam, 5 to 9 percent slopes, severely eroded (IC3).—This soil is on many ridgetops and on hillsides. Some areas on ridgetops are 400 to 500 feet wide and more than ½ mile long. Areas on hillsides generally are about 5 to 20 acres (fig. 10).

This soil has a profile similar to the one described as representative of the series, but in less eroded places the surface layer is very dark grayish brown.

Included with this soil in mapping were areas, 1 or 2 acres in size, of sandy or gravelly soils or soils that formed in glacial till. These areas are shown on the soil map by a special symbol.

This soil is suited to row crops, but erosion is a severe hazard. The steeper areas are commonly used for pasture or hay along with adjoining soils. This soil is well suited to this use. Capability unit IIIe–1.

Ida silt loam, 9 to 14 percent slopes, severely eroded (ID3).—This soil is on ridgetops and hillsides. The areas generally are large. Some hillsides are made up entirely of this soil. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were small areas of Steinauer soils. These areas are shown on the soil map by a symbol for till. Also included were patches of soils that formed in glacial outwash or sand. They are shown on the soil map by a special symbol for gravel or sand. A grayish soil that has reddish and brownish mottles and iron concretions was also included. This soil is in narrow strips along the contour of hillsides.

This Ida soil is well suited to hay or pasture. It is suitable for row crops if measures are used to help control erosion. It is very susceptible to erosion. Excessive runoff reduces the amount of water available to crops, and crops are likely to be damaged in years when moisture is limited. Capability unit IIIe–2.

Ida silt loam, 14 to 20 percent slopes, severely eroded (IE3).—This soil is on hillsides. Areas commonly form entire hillsides and extend for a mile or more along the contour of the land.

Included with this soil in mapping were narrow strips of a grayish soil that has brownish and reddish mottles and iron concretions. Also included were small areas of Steinauer soils and areas, 1 or 2 acres in size, of gravelly and sandy soils. These areas are shown on the soil map by special symbols. Included in the western part of the county were areas of bedrock outcrop and areas of soils, less than 5 acres in size, that are moderately deep over bedrock. These areas are shown on the soil map by special symbols. In places bedrock is not at the surface, but the soil is so shallow that bedrock hinders cultivation. Springs or seepy spots are in some of these places.

This soil is well suited to hay or pasture. Slope does not prevent the use of farm machinery. Row crops can be grown, but this soil is very susceptible to erosion. Practices that adequately control erosion are difficult to establish, because slopes are steep. Capability unit IVe–1.

Ida silt loam, 20 to 30 percent slopes, severely eroded (1F3).—This soil is on hillsides. Areas range from about 10 to 100 acres.

This soil has a profile similar to the one described as representative of the series, but in areas of native vegetation, the surface layer is very dark grayish brown, and in many places it is neutral in reaction.

Included with this soil in mapping were areas of bedrock outcrop. These areas are in the western part of the county. The bedrock outcrop is shown on the soil map by a symbol for rock outcrop.

This soil is suited to pasture or hay. Much of it can be worked with farm machinery, although a risk is involved because slopes are steep. Row crops are planted occasionally, but this soil is not suited to row crops. The erosion hazard is very severe. A few areas have stands of trees. Bur oak is the dominant tree, and the stands are of poor quality. Little merchantable timber is produced. A lack of moisture, partly because runoff is rapid, is a limitation to use of this soil for timber or pasture. Capability unit VIe–1.

Ida silt loam, 30 to 40 percent slopes, severely eroded (1G3).—This soil is intermingled with other very steep and steep soils on hillsides. Areas are as much as 80 acres. Most slopes face north or east.

This soil has a profile similar to the one described as representative of the series, but in many places the surface layer is darker and thicker. In these places the surface layer is neutral or mildly alkaline.

Included with this soil in mapping were bowllike areas around hillside drainageways. These areas are not so steep or so dry as others, and trees commonly grow in these places. Also included were areas of bedrock outcrop, which are shown on the soil map by a special symbol.

This soil is suited to pasture or to recreational uses. Use of this soil is limited by very steep slopes. Regular farm machinery cannot be used. This soil tends to be droughty because runoff is rapid. Erosion is a severe hazard. Capability unit VIIe–1.

Ida-Wadena complex, 5 to 14 percent slopes, severely eroded (114D3).—This complex is on terrace escarpments. Ida soils make up 50 to 75 percent of the complex; Wadena soils, 15 to 30 percent; and minor soils, the rest. Areas typically are 150 to 300 feet wide and extend to as much as ½ mile between the flood plain and the nearly level or gently sloping stream bench. Wadena soils are in 1- to 5-acre patches on convex knobs. The patches typically are about 200 to 400 feet apart.

The Ida soil has a profile similar to the one described as representative of the Ida series, but sand and gravel are at a shallower depth. The Wadena soil has a profile similar to the one described as representative of the Wadena series, but the surface layer is thinner and lighter colored. It also has more pebbles and cobbles on the surface than is typical.

Included with these soils in mapping was a soil similar to Galva soils. It is underlain at a depth of 2 to 3 feet by sand or gravel and occurs as a narrow belt at the base of slopes.

This complex is well suited to hay or pasture and is suited to row crops. It is subject to erosion and is droughty in places. Rocks on the surface hinder farm operations, and some rocky areas are left in meadow when the rest of the complex is plowed. Capability unit IIIe–3.

Kennebec Series

The Kennebec series consists of moderately well drained silty soils that formed in alluvium. These soils are on flood plains and gently sloping foot slopes. Slope is 0 to 5 percent.

In a representative profile the surface layer is very dark brown, friable silt loam and light silty clay loam about 32 inches thick. It grades to very dark grayish brown in the lower part. Below this is dark grayish-brown, friable light silty clay loam.

These soils have moderate permeability. They have very high available water capacity and high organic-matter content. They are medium to low in available nitrogen and medium in available phosphorus and potassium. The surface layer generally is neutral in reaction. These soils have a deep rooting zone.

Kennebec soils generally are used for cultivated crops. In places less accessible areas and areas that are subject to flooding are used for pasture. Stands of trees are in some pastures.

Representative profile of Kennebec silt loam, 0 to 2 percent slopes, in an oatfield near the northwest corner of the county; 50 feet south of the northeast corner of NW¼NE¼ sec. 5, T. 93 N., R. 48 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; weak, medium, subangular blocky structure parting to moderate, very fine and fine, subangular blocky; friable; natural; abrupt, smooth boundary.

A12—7 to 15 inches, very dark brown (10YR 2/2) light silty clay loam; weak, medium, subangular blocky structure parting to moderate, very fine and fine, subangular blocky; stronger structure than in Ap horizon; friable; slightly acid; gradual, smooth boundary.

A13—15 to 21 inches, very dark brown (10YR 2/2) light silty clay loam; moderate, medium, subangular blocky structure parting to moderate, very fine and fine, subangular blocky; friable; neutral; gradual, smooth boundary.

A14—21 to 32 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) light silty clay loam; moderate, medium, subangular blocky structure parting to moderate, very fine and fine, subangular blocky; friable; neutral; gradual, smooth boundary.

AC—32 to 44 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, very dark grayish brown

(10YR 3/2) when kneaded; weak, medium, prismatic structure parting to moderate, very fine and fine, subangular blocky; friable; neutral; diffuse, smooth boundary.

C2—44 to 60 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; weak, medium, prismatic structure in upper part, massive in lower part; friable; neutral to a depth of 47 inches, mildly alkaline below.

The A horizon is 30 to 40 inches thick. It is black (10YR 2/1) or very dark brown (10YR 2/2). In most profiles it grades to very dark grayish brown (10YR 3/2) in the lower part, and in a few places to very dark gray (10YR 3/1). In places the color of the upper 6 to 15 inches is about one value or one chroma higher than that of the underlying part. This results from more recent sediment being deposited on the original A horizon. The A horizon is silt loam or light silty clay loam and is 25 to 30 percent clay.

The boundary to the C horizon is indistinct, and an AC horizon, 6 to 12 inches thick, is described in most profiles. The AC horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2).

The C horizon is generally very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2), but it is darker in a few places. It is silt loam or light silty clay loam. It generally is about 5 percent sand but is as much as 15 percent in a few places.

Kennebec silty clay loam, 0 to 2 percent slopes, is slightly finer textured than is defined for the range of the Kennebec series. This does not, however, significantly affect the use and behavior of this soil.

Kennebec soils have a profile somewhat similar to that of Colo and Salix soils, and they occupy similar positions on the landscape. They are about 28 percent clay throughout, whereas Colo soils are about 34 percent clay. They have better natural drainage than Colo soils. They lack the alkaline, calcareous C horizon above a depth of 40 inches that is typical of Salix soils.

Kennebec silt loam, 0 to 2 percent slopes (212).—This soil is on flood plains. Most areas are in the larger stream valleys. Some areas are more than 100 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were places where overwash is 6 to 12 inches thick and ranges from calcareous silt loam to noncalcareous sandy loam. Many of the overwashed soils are in low-lying areas that are frequently flooded.

This soil is well suited to row crops. The main limitation is the flood hazard, and this generally is only a slight problem. Levees have been built in places. Capability unit I–1.

Kennebec silt loam, 2 to 5 percent slopes (212B).—This soil commonly occurs as long strips 200 to 400 feet wide. Some strips are along the edges of larger valleys, between steep soils on hillsides and nearly level bottomland soils. Others occupy narrow valleys.

This soil has a profile similar to the one described as representative of the series, but it is browner and has better natural drainage. Recent deposits of light-colored, calcareous silt loam overwash are common. The overwash is up to 15 inches thick.

Included with this soil in mapping were areas where the overwash is thicker. Also included were many areas that are frequently flooded.

This soil is well suited to row crops, but many areas are small and must be managed with adjoining soils on hillsides, particularly where an active gully is in the center of the Kennebec soil area. Pasture, hay, or trees are suitable crops in those places. This soil receives runoff from soils upslope. Rill erosion and siltation are hazards unless erosion-control measures are used. Capability unit IIe–1.

Kennebec silt loam, channeled, 0 to 2 percent slopes (C212).—This soil is on flood plains next to the stream channel. Areas consist of parts of the flood plain that are cut by former channels and are most subject to flooding.

This soil has a profile similar to the one described as representative of the series, but it is slightly sandier.

Included with this soil in mapping were small patches of soils too sandy to be classified as Kennebec soils. Also included in most places were areas where recent overwash is 10 to 15 inches thick. This overwash commonly has thin layers of sand. In a few places, mostly close to the stream, it is 2 to 4 feet thick. These areas are especially common along the Floyd River in the southern part of the county.

Use of this soil is limited by flooding and by former stream channels. Some of the old channels are deep and contain water most of the time; others are almost completely filled and do not seriously hinder farm operations. Levees have been built on some farms, but most are away from the stream and some areas are unprotected. This soil is well suited to pasture. Row crops can be grown if the limitations can be overcome. Capability unit Vw–1.

Kennebec silty clay loam, 0 to 2 percent slopes (26).—This soil is at intermediate elevations on flood plains. Areas range from 40 acres to about 200 acres.

This soil has a profile similar to the one described as representative of the series, but it is slightly finer textured throughout. Natural drainage is not quite so good as in other Kennebec soils.

Included with this soil in mapping were small areas of Colo soils that are more poorly drained.

This soil is well suited to row crops. It is susceptible to flooding, but most floods come early in spring before planting time. Many areas are protected by levees. Capability unit I–1.

Kennebec-McPaul silt loams, 2 to 5 percent slopes (19B).—This complex is along the edges of the larger valleys and is in narrow valleys, where it makes up the entire valley. Kennebec silt loam, 2 to 5 percent slopes, makes up about 50 percent of the complex; Kennebec silt loam, 0 to 2 percent slopes, 25 percent; and McPaul silt loam, 0 to 5 percent slopes, 25 percent. Areas generally are 100 to 400 feet wide and ½ mile or more long. The McPaul soil is most common in places where silt is deposited, such as behind fences or along roads.

The Kennebec soils have a profile similar to the one described as representative of the Kennebec series, but they typically have up to 15 inches of light-colored, calcareous silt loam overwash on the surface. The McPaul soil has a profile similar to the one described as representative of the McPaul series, but it commonly has a buried soil of dark-colored, noncalcareous light silty clay loam at a depth of 2 to 3 feet. The buried soil is shallower and slightly finer textured than is typical of the McPaul series.

These soils are well suited to row crops. They generally are farmed, however, with soils on adjoining hillsides that are less well suited. They are susceptible to erosion and siltation. Some areas have an active gully in the center. Low-lying areas are subject to flooding or are wet. Capability unit IIe–1.

Luton Series

The Luton series consists of poorly drained clayey soils that formed in alluvium. These soils are on flood plains. Slope ranges from 0 to 1 percent.

In a representative profile the surface layer is black, firm silty clay about 14 inches thick. The subsoil is firm silty clay that extends to a depth of about 44 inches. It is very dark gray in the upper few inches; the rest is olive gray and dark gray and has yellowish-red and yellowish-brown mottles. The substratum is mottled, olive-gray, firm silty clay.

These soils have very slow to slow permeability. They have moderate available water capacity and high organic-matter content. They are medium to low in available nitrogen, very low in available phosphorus, and high in available potassium. The surface layer generally is neutral in reaction. These soils have a deep rooting zone, but root growth is sometimes restricted by a seasonal high water table.

These soils generally are used for cultivated crops.

Representative profile of Luton silty clay, 0 to 1 percent slopes, in a soybean field near the southwest corner of the county; 75 feet north and 50 feet west of the southeast corner of SW¼SE¼ sec. 34, T. 90 N., R. 48 W.:

Ap—0 to 6 inches, black (10YR 2/1) light silty clay, tending to very dark gray (10YR 3/1); weak clods parting to weak, very fine and fine, subangular blocky structure; firm; neutral; clear, smooth boundary.

A12—6 to 14 inches, black (10YR 2/1) silty clay, tending to very dark gray (10YR 3/1); moderate, very fine, subangular blocky structure; firm; neutral; gradual, smooth boundary.

B1—14 to 19 inches, very dark gray (10YR 3/1 to 5Y 3/1) silty clay, mixed with 10 percent olive-gray (5Y 5/2) peds; moderate, very fine, subangular blocky structure; firm; neutral; gradual, smooth boundary.

B2g—19 to 29 inches, olive-gray (5Y 5/2) silty clay; olive-gray (5Y 4/2) and dark-gray (5Y 4/1) ped faces; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, very fine, subangular blocky and angular blocky structures; firm; very dark gray (10YR 3/1) coatings on a few channels; common pores; shiny ped coatings; neutral; smooth boundary.

B3g—29 to 44 inches, olive-gray (5Y 5/2) silty clay; olive-gray (5Y 5/2) and gray (5Y 5/1) ped faces; common, fine, prominent, yellowish-red (5YR 4/6) and yellowish-brown (10YR 5/6) mottles; moderate, very fine, subangular blocky and angular blocky structure; firm; oriented slickensides have very dark gray (5Y 3/1) faces; neutral; gradual, smooth boundary.

Cg—44 to 60 inches, olive-gray (5Y 5/2) silty clay; common, prominent, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; massive; firm; mildly alkaline.

In places the A horizon grades to very dark gray (10YR 3/1 or 5Y 3/1) in the lower part. It is light silty clay or clay.

The B1 horizon is lacking in many places, but most of these places have an A3 horizon instead. The B horizon is light silty clay or clay. It is neutral or mildly alkaline. Depth to mottles corresponds fairly closely to depth to the B2 horizon.

The C horizon is dominantly silty clay or clay, but in places it has strata of coarser texture.

Depth to colors with value of 3.5 or lighter ranges from 10 to 35 inches, which is outside the range defined for the Luton series. This difference does not alter the use or behavior of these soils.

Luton and Albaton soils formed in clayey alluvium in similar positions on the landscape. Luton soils have a thicker, darker colored A horizon than Albaton soils and are noncalcareous to a greater depth than those soils.

Luton silty clay, 0 to 1 percent slopes (66).—This soil is on flood plains. A few areas are as large as 300 acres.

Included with this soil in mapping were small areas of less clayey soils and places where silty sediment as much as about 15 inches thick overlies the original surface layer.

This soil is suited to row crops, which generally are grown intensively. It is quite wet, and maintaining good tilth is difficult because the texture is clayey. Capability unit IIIw–1.

McPaul Series

The McPaul series consists of well drained to moderately well drained, calcareous, silty soils that formed in alluvium. These soils are on flood plains and foot slopes. Slope ranges from 0 to 5 percent.

In a representative profile the surface layer is dark grayish-brown, very friable, calcareous silt loam about 7 inches thick. Below this is stratified, very friable, calcareous silt loam that is dominantly dark grayish brown and very dark grayish brown. At a depth of about 43 inches is black, friable, calcareous silt loam, which was the surface layer before it was buried by more recent sediment.

These soils have moderate permeability. They have very high available water capacity and low organic-matter content. They are very low in available nitrogen, low in available phosphorus, and high in available potassium. The surface layer generally is mildly alkaline or moderately alkaline and is high in lime. These soils have a deep rooting zone.

Most areas of these soils are used for cultivated crops. The rest, especially those that are subject to frequent flooding, are used for pasture. Stands of trees are in some pastures.

Representative profile of McPaul silt loam, 0 to 2 percent slopes, in a meadow about 7 miles southwest of the town of Westfield; 450 feet west and 625 feet south of northeast corner of SW¼ sec. 27, T. 91 N., R. 48 W.:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam; some mixing of very dark grayish-brown (10YR 3/2) peds; clods part to weak, fine, granular structure; very friable; mildly alkaline; strong effervescence; abrupt, smooth boundary.

C—7 to 43 inches, stratified, dark grayish-brown (10YR 4/2) and very dark grayish-brown (10YR 3/2) silt loam; few strata of brown (10YR 5/3), yellowish brown (10YR 5/4), and grayish brown (10YR 5/2); few fine, distinct, brown (7.5YR 4/4) and strong-brown (7.5YR 5/6) mottles on horizontal cleavage faces in the lower part; massive but has horizontal cleavage; very friable; moderately alkaline; strong effervescence; clear, smooth boundary.

Ab—43 to 60 inches, black (10YR 2/1) silt loam; weak, very fine, subangular blocky structure; friable, mildly alkaline; weak effervescence.

In places the Ap horizon is very dark grayish brown (10YR 3/2). It ranges from neutral to moderately alkaline and is noncalcareous in a few places.

The C horizon is stratified. Most strata are silt loam, but they differ in color. In a few profiles, thin strata of silty clay loam or of material coarser than silt loam occur. The C horizon commonly is mildly alkaline or moderately alkaline, but in a few profiles it has thin strata that are neutral.

An Ab horizon of black silt loam or light silty clay loam is in most profiles. The upper boundary generally is between depths of 30 and 48 inches.

McPaul soils have a profile somewhat similar to that of Omadi and Radford soils, and they are in similar positions on the landscape. They are calcareous silt loam, whereas Radford soils are noncalcareous silty clay loam. They generally lack the sandy strata that are typical in Omadi soils, and they are also higher colored than those soils.

McPaul silt loam, 0 to 2 percent slopes (70).—This soil is on flood plains. The largest areas are along streams, such as Perry Creek, Broken Kettle Creek, and Westfield Creek. These areas are about one-fourth mile wide, and they extend for miles along the valleys. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were many low-lying areas that are flooded frequently.

This soil is well suited to row crops, which are generally grown intensively. Flooding is a hazard, but some areas are rarely flooded. Most areas are flooded only occasionally. Capability unit I–1.

McPaul-Kennebec silt loams, 2 to 5 percent slopes (18B).—This complex is in narrow valleys. Nearly level McPaul soils, in the centers of valleys, make up about 33 percent of the complex; gently sloping McPaul soils, about 33 percent; and gently sloping Kennebec soils, the rest. Many areas occupy the entire width of the valley and extend for a mile or more. A few areas are on foot slopes along the edges of larger valleys.

The McPaul soils have a profile similar to the one described as representative of the McPaul series. The Kennebec soils have a profile similar to the one described as representative of the Kennebec series, but up to 15 inches of light-colored, calcareous silt loam overwash is present in many places.

Included with these soils in mapping were severely gullied places in the centers of valleys and places that are subject to frequent flooding. Also included were areas of moderately sloping and strongly sloping soils along the edges and in the upper reaches of valleys.

Accessible areas of these soils are commonly planted to row crops and are well suited to this use. Areas in small valleys and in inaccessible places generally are managed with adjoining soils on uplands. Such areas are most commonly in pasture. Sheet and rill erosion, siltation, and growth of existing gullies are hazards in areas that receive runoff from adjacent hills. Capability unit IIe–1.

Modale Series, Dark Subsoil Variant

The Modale series, dark subsoil variant, consists of moderately well drained to somewhat poorly drained, calcareous, silty soils that are underlain at a depth of about 2 or 3 feet by clayey sediment. These soils formed in alluvium on flood plains. Slope ranges from 0 to 2 percent.

In a representative profile the surface layer is very dark grayish-brown, calcareous, friable silt loam about 8 inches thick. It is underlain by stratified sediment that is dominantly very dark grayish-brown, calcareous, friable silt loam. At a depth of 26 inches is a layer of very dark gray, calcareous, firm silty clay 5 inches thick. Below this is dark grayish-brown, calcareous, firm silty clay.

These soils have moderate permeability in the upper part and very slow to slow permeability in the clayey substratum. They have high available water capacity and low organic-matter content. They are very low in available nitrogen and phosphorus and high in available potassium. The surface layer generally is mildly alkaline and high in lime. Root growth is restricted to some extent by the clayey sediment, especially where there is a seasonal high water table.

Most areas of these soils are used for cultivated crops.

Representative profile of Modale silt loam, dark subsoil variant, 0 to 2 percent slopes, in an alfalfa field about 5 miles north of the southwest corner of the county; 400 feet west and 530 feet north of the southeast corner of SW¼SE¼ sec. 4, T. 90 N., R. 48 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; stratification is evident, and dark grayish-brown coatings are on some horizontal cleavage faces; clods part to weak, fine, granular and very fine, subangular blocky structure; friable; mildly alkaline; slight effervescence; abrupt, smooth boundary.

C—8 to 26 inches, stratified, very dark grayish-brown (10YR 3/2) silt loam; dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) coatings on horizontal faces and thin strata; massive; friable; charred stems and roots at a depth of 24 to 26 inches; moderately alkaline; strong effervescence; clear, smooth boundary.

IIAb—26 to 31 inches, very dark gray (10YR 3/1) silty clay; strong, fine, granular structure; firm; moderately alkaline; strong effervescence; gradual, smooth boundary.

IIB1bg—31 to 41 inches, dark grayish-brown (2.5Y 4/2) silty clay; few dark-gray (10YR 4/1) coatings on ped faces; few, fine, prominent, strong-brown (7.5YR 5/6) mottles; strong, very fine, subangular blocky and angular blocky structure; firm; mildly alkaline; strong effervescence; gradual, smooth boundary.

IIB2bg—41 to 60 inches, dark grayish-brown (2.5Y 4/2) silty clay; few dark-gray (10YR 4/1) coatings on ped faces; common, fine, prominent, yellowish-red (5YR 5/6) and strong-brown (7.5YR 5/6) mottles; strong, very fine, subangular and angular blocky structure; firm; moderately alkaline; strong effervescence.

The A horizon is 6 to 10 inches thick and is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). It is neutral and noncalcareous or mildly alkaline and calcareous.

The C horizon is stratified silt loam 8 to 24 inches thick. It is dominantly very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) and is mildly alkaline or moderately alkaline.

Depth to the upper boundary of the clayey substratum is 18 to 30 inches. The IIAb horizon is very dark gray (10YR 3/1) or very dark grayish-brown (10YR 3/2) silty clay or clay that is mildly alkaline or moderately alkaline. The IIBb horizon is dark grayish-brown (2.5Y 4/2), olive-gray (5Y 5/2), or grayish-brown (2.5Y 5/2) silty clay or clay.

Modale soils, dark subsoil variant; McPaul soils; and Omadi soils formed in stratified, calcareous silt loam alluvium. Modale soils, dark subsoil variant, have a clayey substratum, which McPaul and Omadi soils lack.

Modale silt loam, dark subsoil variant, 0 to 2 percent slopes (149).—This soil is on flood plains. Typical areas are 30 to 40 acres in size.

Included with this soil in mapping were places where the silty layer is only 10 to 18 inches deep over the clayey substratum. Also included were low-lying areas that are subject to frequent flooding.

This soil is subject to flooding, but only the lowest elevations are seriously affected. It is well suited to row crops, which generally are grown intensively. Capability unit I–1.

Monona Series

The Monona series consists of well-drained silty soils that formed in loess. Most of these soils are on ridgetops and hillsides, but some are on stream benches. Slope ranges from 0 to 20 percent.

In a representative profile the surface layer is very dark brown, friable silt loam about 11 inches thick. The subsoil is dark-brown to brown, friable silt loam that extends to a depth of 40 inches. The substratum is calcareous, yellowish-brown, friable silt loam that has common grayish mottles.

Monona soils have moderate permeability and very high available water capacity. They are typically moderately low or moderate in organic-matter content, but the amount is variable and depends on the degree of erosion. These soils are low in available nitrogen and phosphorus and high in available potassium. The surface layer and upper part of the subsoil generally are neutral or slightly acid. These soils have a deep rooting zone.

These soils are used mainly for cultivated crops. Some of the more sloping areas are in pasture.

Representative profile of Monona silt loam, 2 to 5 percent slopes, in a meadow about 7 miles west of the town of Hinton; 45 feet south and 560 feet west of the northeast corner of SE¼NE¼ sec. 32; T. 91 N., R. 47 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, granular structure; friable, many roots; slightly acid; clear, smooth boundary.

A3—7 to 11 inches, very dark brown (10YR 2/2) heavy silt loam, tending to very dark grayish brown (10YR 3/2) when crushed; weak, fine, subangular blocky structure; friable; many roots; neutral; gradual, smooth boundary.

B1—11 to 17 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 4/3) when crushed; a few very dark grayish-brown (10YR 3/2) coatings on ped faces in the upper part; weak, fine, subangular blocky structure; friable; few, fine, fibrous roots; neutral; gradual, smooth boundary.

B21—17 to 23 inches, brown (10YR 4/3) silt loam, dark yellowish brown (10YR 4/4) when crushed; weak, fine, subangular blocky structure; friable; many very fine pores; neutral; gradual, smooth boundary.

B22—23 to 33 inches, brown (10YR 4/3) silt loam, dark yellowish brown (10YR 4/4) when crushed; weak, fine and medium, subangular blocky structure; very friable; many fine pores; neutral; gradual, smooth boundary.

B3—33 to 40 inches, brown (10YR 4/3) silt loam, dark yellowish brown (10YR 4/4) when crushed; weak, fine and medium, subangular blocky structure; very friable; many fine pores; neutral; gradual, smooth boundary.

C1—40 to 55 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, distinct, light-gray (N 6/0) mottles; massive; very friable; many fine pores; few white lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—55 to 60 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, distinct, light-gray (N 6/0) mottles increasing to common with increasing depth; massive; very friable; many, fine, prominent, very dusky red (2.5YR 2/2), soft accumulations; moderately alkaline; strong effervescence.

In uneroded or slightly eroded areas, the A horizon is 10 to 18 inches thick. The Ap horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Some profiles have both an A1 and an A3 horizon under the Ap horizon, but the Ap horizon is commonly underlain by the B horizon.

The B horizon ranges from about 12 to 40 inches in thickness. Some profiles are dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4) in the lower part of the B horizon. Mottles are in the B3 horizon in places.

The C horizon generally has brownish and grayish mottles. In places the upper part is noncalcareous and neutral or mildly alkaline. Lime concretions are common.

In places, Monona soils on uplands have a thinner, lighter colored surface layer than is defined as within the range for the series. This does not significantly affect the use or behavior of these soils.

Monona and Galva soils formed in loess and have somewhat similar profiles. Monona soils are not so fine textured in the upper part of the profile as Galva soils. They are near Ida soils. They are noncalcareous and have a B horizon, whereas Ida soils are calcareous and lack a B horizon.

Monona silt loam, 2 to 5 percent slopes (10B).—This soil occupies ridgetops in undulating to rolling landscapes. The largest areas are 600 to 800 feet wide, but most areas are 200 to 400 feet wide. Some extend for ½ to 1 mile. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were areas where the surface layer is very dark grayish brown and 5 to 8 inches thick. Also included were nearly level areas of Monona soils that have a dark-colored, thicker surface layer and areas of wetter soils in small depressions.

This soil is well suited to row crops. Erosion is a hazard. If maximum row cropping is planned, erosion-control measures are needed to prevent excessive loss of soil and water. Capability unit IIe–2.

Monona silt loam, 5 to 9 percent slopes, moderately eroded (10C2).—This soil is on ridgetops in rolling and hilly landscapes. On many ridgetops it is in north- and east-facing areas and Ida soils occupy the other areas. This soil also occurs on hillsides in rolling areas. Most areas are on north- and east-facing slopes.

This soil has a profile similar to the one described as representative of the series, but in many places plowing has mixed the very dark brown surface layer with the dark-brown subsoil. Also, the subsoil is thinner, and the soil is calcareous at a depth of only 2 or 3 feet.

Included with this soil in mapping were 1- to 5-acre areas of Ida soils and areas of Monona soils where most of the original dark-colored surface layer has eroded away. These areas are shown on the soil map by special symbols. A few areas of gravel, sand, and glacial till also were included.

This soil is suited to row crops, but it is susceptible to erosion. Adequate erosion-control measures are important in areas of intensive row cropping. Capability unit IIIe–1.

Monona silt loam, 9 to 14 percent slopes, moderately eroded (10D2).—This soil is on hillsides, commonly on north- or east-facing slopes. It is in slightly concave positions along the lower third of the hillsides or around the heads of hillside drainageways. Areas are about 5 to 30 acres.

This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown and about 7 inches thick. Also, the subsoil is thinner and is calcareous at a shallower depth.

Included with this soil in mapping were small patches of severely eroded Monona soils where the plow layer is mostly subsoil material. Some 1- or 2-acre areas of Ida soils were also included. A few patches of sand, gravel, and glacial till were included and are shown on the soil map by special symbols.

This soil is well suited to hay or pasture. It can also be used for row crops, but it is very susceptible to erosion. Capability unit IIIe–2.

Monona silt loam, 14 to 20 percent slopes, moderately eroded (10E2).—This soil is generally on north- and east-facing hillsides. Many areas are along the base of hills next to the valley. Others are in concave positions around drainageways on hillsides.

In inaccessible areas that have not been plowed, this soil has a profile similar to the one described as representative of the series, but the subsoil is thinner and calcareous material is closer to the surface. In most cultivated areas, the surface layer is very dark grayish brown and is only 6 or 8 inches thick.

Included with this soil in mapping were small, severely eroded areas of Monona or Ida soils. Small areas of sand, gravel, and glacial till also were included and are shown on the soil map by a special symbol.

This soil is suited to hay or pasture. Row crops can be grown occasionally, but this soil is very susceptible to erosion. Capability unit IVe–1.

Monona silt loam, benches, 2 to 5 percent slopes (T10B).—This soil is on stream benches, most of which are 5 to 10 feet above the flood plain. Areas range from about 10 to 30 acres. Slopes are dominantly 2 or 3 percent.

This soil has a profile similar to the one described as representative of the series, but the dark-colored surface layer and the subsoil are thicker. Also, lime is leached to a greater depth.

Included with this soil in mapping were areas of nearly level Monona soils. Along the edges of some benches are areas of moderately sloping Monona soils that have a very dark grayish-brown surface layer only 6 or 8 inches thick. Also included were depressions, 1 to 5 acres in size, that are shown on the soil map by special symbols. The soils in the depressions are wetter than this Monona soil.

This soil is well suited to row crops, which generally are grown often. Erosion is a hazard, especially in areas that receive runoff from adjoining hillsides. Adequate erosion control, on the hillsides and on this soil, can be obtained without a great deal of difficulty. Capability unit IIe–2.

Napier Series

The Napier series consists of well-drained, silty soils that formed in material washed from nearby hillsides. These soils are on foot slopes along the edges of valleys. Slope ranges from 2 to 14 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown, friable silt loam about 30 inches thick. The subsoil is friable silt loam that extends to a depth of about 60 inches. It is very dark grayish brown in the upper part and brown in the lower part.

These soils have moderate permeability. They have high organic-matter content and very high available water capacity. They are generally medium to low in available nitrogen, low in available phosphorus, and high in available potassium. The surface layer generally is neutral, but overwash that is moderately alkaline and high in lime is common.

Most areas of Napier soils are cultivated, but a number of small inaccessible areas are in pasture or woodland.

Representative profile of Napier silt loam, 5 to 9 percent slopes, in an alfalfa field about 10 miles west of the town of Hinton; 140 feet north and 100 feet east of the center of SE¼ sec. 19, T. 90 N., R. 47 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; moderate, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A12—8 to 15 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, very fine, subangular blocky and weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

A13—15 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, very fine, subangular blocky and weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

A3—22 to 30 inches, very dark grayish-brown (10YR 3/2) silt loam, tending to dark brown (10YR 3/3) when crushed; weak, very fine, subangular blocky and weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

B1—30 to 39 inches, very dark grayish-brown (10YR 3/2) silt loam, tending to dark brown (10YR 3/3); weak, very fine, subangular blocky and weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

B2—39 to 48 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 4/3) when crushed; weak, very fine, subangular blocky and weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

B3—48 to 60 inches, brown (10YR 4/3) silt loam; weak, very fine, subangular blocky and weak, fine, granular structure; friable; mildly alkaline.

The A horizon ranges from 24 to 36 inches in thickness. The upper part is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2), but calcareous, brown (10YR 4/3) or dark yellowish-brown (10YR 4/4) overwash is common.

The B horizon extends to a depth of 36 to 60 inches. It is dark brown (10YR 3/3) or brown (10YR 4/3), but darker coatings on ped faces mask the brownish color in many places.

The C horizon, where present, is neutral to moderately alkaline.

Napier soils are near Kennebec and Castana soils, and their profiles are similar. Napier soils have a brownish B horizon that Kennebec and Castana soils lack. They are noncalcareous above a depth of about 36 inches, whereas Castana soils are calcareous.

Napier silt loam, 5 to 9 percent slopes (12C).—This soil has concave or straight slopes. Areas are long and narrow. The profile of this soil is the one described as representative of the series.

Included in places with this soil in mapping were areas of gently sloping or nearly level soils in the centers of valleys. Many areas have a deep, wide gully.

This soil is suited to row crops. It is susceptible to

Figure 11.—**Corn and hay on Napier-Castana silt loams, 9 to 14 percent slopes. Native grass is on steep hillsides.**

erosion. Runoff from steeper soils upslope is a hazard. In places this soil is managed with soils on adjoining hillsides and is used for pasture or hay. Capability unit IIIe–1.

Napier-Castana silt loams, 9 to 14 percent slopes (170D).—This complex is in narrow valleys below steep and very steep hillsides. Napier soils make up about 70 percent of the complex; Castana soils, about 20 percent; and other soils, the rest. Areas are long and narrow, and many have fingers that extend up side valleys. Castana soils are in narrow bands along the upslope side of mapped areas.

Included with these soils in mapping were areas of other soils in the centers of valleys. Also included were areas of less sloping Napier soils.

This complex is suited to row crops, but many areas are not readily accessible with farm machinery (fig. 11). The soils are susceptible to erosion and receive considerable runoff from adjoining soils on uplands. Capability unit IIIe–2.

Napier-Gullied land complex, 2 to 10 percent slopes (717C).—This complex has concave or straight slopes. Napier soils make up about 75 or 80 percent of the complex, and Gullied land makes up the rest. Areas are long and narrow. In the Gullied land part, gullies are as deep and as wide as 40 feet and generally have vertical sides.

Included with these soils in mapping were areas of Napier soils that are accessible with farm machinery. These areas can be used for cultivated crops, and some are cultivated.

This complex is better suited to pasture or trees than to most other uses. It is susceptible to erosion. Gullies are a hazard to livestock. Capability unit VIIe–1.

Omadi Series

The Omadi series consists of well drained to moderately well drained, calcareous, silty soils that formed in alluvium. These soils are on flood plains. Slope ranges from 0 to 2 percent.

In a representative profile the surface layer is very dark brown, calcareous, friable silt loam about 8 inches thick. The next layer is very dark brown, calcareous, friable light silty clay loam about 5 inches thick. Below this is stratified sediment that is dominantly very dark brown and very dark grayish-brown, calcareous, friable silt loam, but thin layers of sand are common.

These soils have moderate permeability. They have very high available water capacity and moderately low or low organic-matter content. They are very low in available nitrogen, low in available phosphorus, and high in available potassium. The surface layer is neutral or mildly alkaline to moderately alkaline. These soils generally are high in lime. They have a deep rooting zone.

These soils are commonly used for cultivated crops, but many areas are in pasture. Many pastures have not been cleared of trees.

Representative profile of Omadi silt loam, 0 to 2 percent slopes, in a soybean field about 2 miles south of the northwest corner of the county; 750 feet west and 650 feet north of the southeast corner of SW¼ SW¼ sec. 8, T. 93 N., R. 48 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) heavy silt loam, tending to very dark grayish brown (10YR 3/2) when crushed; grayish brown (10YR 5/2) when dry; weak, very fine and fine, subangular blocky structure; friable; mildly alkaline; weak effervescence; abrupt, smooth boundary.

C1—8 to 13 inches, very dark brown (10YR 2/2) light silty clay loam, tending to very dark grayish brown (10YR 3/2) when crushed; few, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, fine and medium, subangular blocky structure; friable; moderately alkaline; strong effervescence; clear, smooth boundary.

C2—13 to 60 inches, stratified, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) silt loam; thin strata of silty clay loam and dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) sand; common, fine, prominent, yellowish-red (5YR 4/6) mottles; massive but has horizontal cleavage caused by bedding; friable; moderately alkaline; strong effervescence.

The A horizon is 6 to 10 inches thick and is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). It is silt loam or light silty clay loam that ranges from neutral and noncalcareous to moderately alkaline and calcareous.

The C horizon is stratified and is dominantly very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) silt loam. Thin strata ranging from silty clay loam to sand are common. Some are dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). The sand content between depths of 10 and 40 inches is 10 to 25 percent. More than half of the sand is very fine. The C horizon is moderately alkaline and calcareous, but in some of the thin strata reaction ranges to neutral.

Omadi, McPaul, and Radford soils are on bottom lands and formed in stratified sediment. Omadi soils have more strata of texture other than silt loam and are darker colored throughout than McPaul soils. They are calcareous silt loam rather than noncalcareous silty clay loam, as are Radford soils.

Omadi silt loam, 0 to 2 percent slopes (189).—This soil is on low-lying parts of the Big Sioux River flood plain. Areas are 40 acres or larger. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were areas of other soils that formed in alluvium and that are more sandy or more clayey than Omadi soils.

This soil is well suited to row crops. It is susceptible to flooding, but many floods come before planting time in spring. Many areas are protected by levees. Capability unit I–1.

Omadi-Alluvial land complex, 0 to 2 percent slopes (609).—This complex is in low-lying areas of the Big Sioux River flood plain. Omadi silt loam makes up about 70 percent of this complex, and Alluvial land makes up the rest. Areas extend along the river and are as wide as one-half mile and as long as a mile or more. The Omadi soil is at intermediate elevations. Generally, the soils at higher elevations are sandier than Omadi soils, and the soils in the swales are more clayey.

These soils are suited to pasture or trees. They are susceptible to flooding. Most areas are not protected by levees. Capability unit Vw–1.

Primghar Series

The Primghar series consists of somewhat poorly drained silty soils that formed in loess on uplands and on stream benches. Slope ranges from 2 to 5 percent.

In a representative profile the surface layer is about 19 inches thick. It is black, friable silty clay loam that grades to very dark gray in the lower few inches. The subsoil is dark grayish-brown and grayish-brown, friable silty clay loam about 21 inches thick. It is underlain by grayish-brown, friable, calcareous light silty clay loam and silt loam.

Primghar soils have moderately slow permeability. They have high to very high available water capacity and high organic-matter content. They are medium to low in available nitrogen and medium in available phosphorus and potassium. The surface layer is medium acid to neutral. These soils have a deep rooting zone.

These soils generally are used for cultivated crops. In a few places they are used with wetter soils as pasture.

Representative profile of Primghar silty clay loam, 2 to 5 percent slopes, in a meadow about 4 miles east of the town of Remsen; 400 feet north and 150 feet east of the southwest corner of NW¼ sec. 2, T. 92 N., R. 43 W.:

Ap1—0 to 5 inches, black (10YR 2/1) silty clay loam; weak, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; slightly acid; abrupt, smooth boundary.

Ap2—5 to 8 inches, black (10YR 2/1) silty clay loam; moderate, very fine and medium, angular blocky structure parting to moderate, fine, granular; friable; medium acid; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure parting to moderate, very fine, subangular blocky; friable; medium acid; gradual, smooth boundary.

A3—15 to 19 inches, very dark gray (10YR 3/1 to 5Y 3/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when crushed; weak, medium, subangular blocky structure parting to moderate, very fine, subangular blocky; friable; neutral; gradual, smooth boundary.

B1—19 to 27 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark gray (10YR 3/1 to 5Y 3/1) coatings on ped faces; some mixing of very dark gray (10YR 3/1 to 5Y 3/1) peds from above; common, fine, prominent, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure parting to moderate, fine, granular and weak, very fine, subangular blocky; friable; neutral; gradual, smooth boundary.

B2—27 to 40 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) coatings on ped faces; common, fine, prominent, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; few black (10YR 2/1) and very dark gray (10YR 3/1) peds and worm casts; weak, medium, subangular blocky structure parting to weak, very fine, subangular blocky; friable; common soft oxides; neutral; clear, smooth boundary.

C1—40 to 52 inches, grayish-brown (2.5Y 5/2) light silty clay loam; common, fine, prominent, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; few black (10YR 2/1) and very dark gray (10YR 3/1) peds and worm casts; weak, medium, subangular blocky structure parting to weak, very fine, subangular blocky (structure is weaker than in B2); friable; mildly alkaline; strong effervescence; clear, smooth boundary.

C2—52 to 60 inches, grayish-brown (2.5Y 5/2) silt loam; strong-brown (7.5YR 5/6) mottles are more abundant than in overlying horizons; massive; friable; common lime concretions; moderately alkaline; strong effervescence.

The A horizon is 16 to 22 inches thick. It is black (10YR 2/1 or N 2/0) in most places, but in a few places it is very dark brown (10YR 2/2). It is medium or heavy silty clay loam that ranges from neutral to medium acid.

The B horizon is 15 to 30 inches thick. It ranges from heavy to light silty clay loam in the upper part and from medium silty clay loam to silt loam in the lower part. Colors typically are 2.5Y in hue, but they are 10YR in places. They range from 10YR or 2.5Y 4/2 to 5/4. Mottles are both high and low in chroma. The upper part of the horizon is neutral or slightly acid. The lower part ranges to moderately alkaline and is calcareous in places.

The C horizon is light silty clay loam, silt loam, or, in a few places, clay loam.

Primghar soils are near Galva soils. They have a thicker A horizon and more restricted natural drainage than Galva soils.

Primghar silty clay loam, 2 to 5 percent slopes (91B).—This soil occupies the upper reaches of many small valleys in undulating to gently rolling landscapes. A few areas are on stream benches. Typical areas are 200 to 400 feet wide and about $\frac{1}{8}$ to $\frac{1}{2}$ mile long.

Included with this soil in mapping were some poorly drained soils in the centers of valleys or in small depressions. Some nearly level Primghar soils were also included.

This soil is well suited to row crops. It receives runoff from adjoining soils. This runoff causes erosion, siltation, and wetness. Capability unit IIe–1.

Radford Series

The Radford series consists of somewhat poorly drained silty soils that formed in alluvium. These soils are on flood plains and foot slopes. Slope ranges from 0 to 5 percent.

In a representative profile the surface layer is very dark brown, friable silty clay loam about 9 inches thick. It is underlain by stratified, very dark brown and very dark grayish-brown, friable silty clay loam that is mixed with dark grayish brown. Below this, at a depth of 24 inches, is black, friable silty clay loam that extends to a depth of 60 inches or more (fig. 12).

These soils have moderately slow permeability. They have very high available water capacity and moderate to high organic-matter content. They are low or medium in available nitrogen, low in available phosphorus, and medium in available potassium. They are neutral or slightly acid. They have a deep rooting zone.

These soils generally are used for cultivated crops. A few areas are used for pasture.

Representative profile of Radford silty clay loam, 0 to 2 percent slopes, in a plowed field about 10 miles northeast of the town of Kingsley; 260 feet east and 65 feet north of the center of NW$\frac{1}{4}$ sec. 14, T. 91 N., R. 43 W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) light silty clay loam; tending to and rubbing to very dark grayish brown (10YR 3/2); moderate, fine, granular and moderate, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

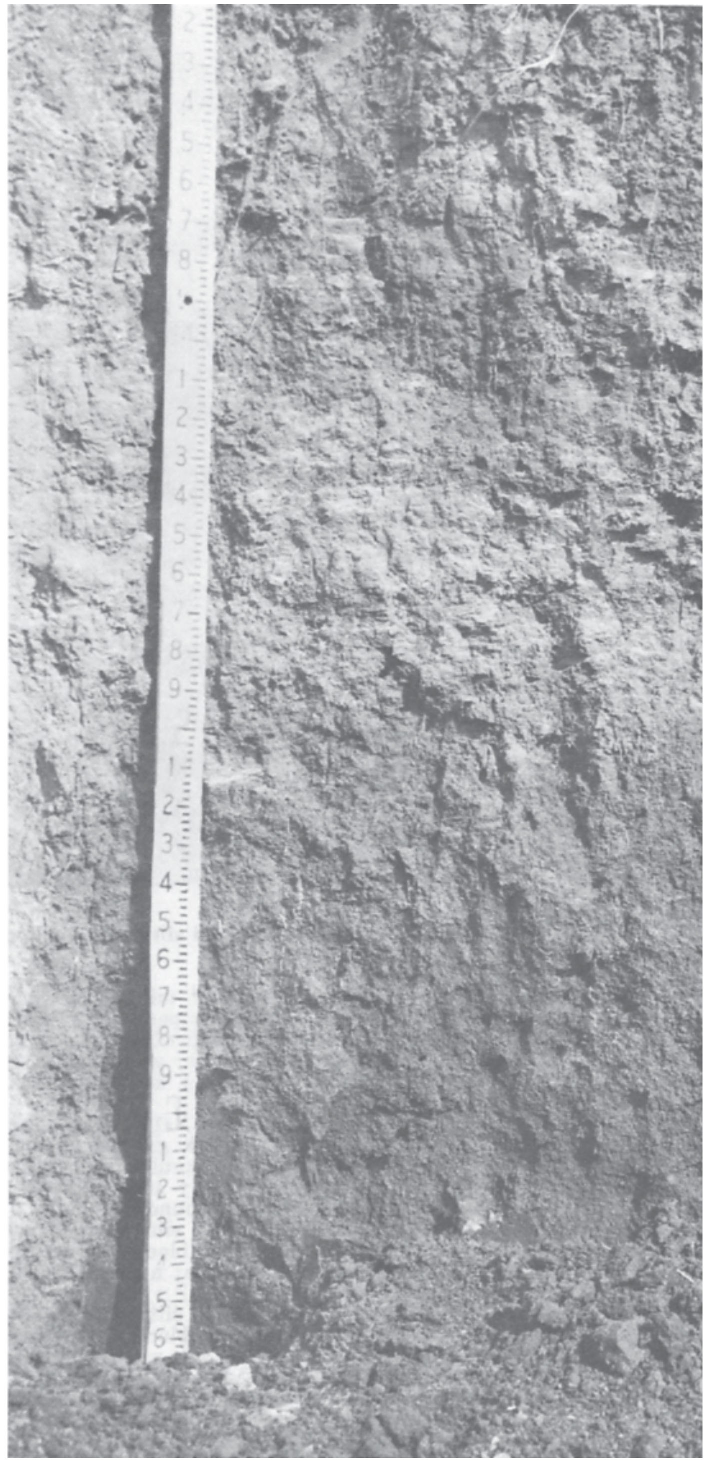

Figure 12.—**Profile of Radford silty clay loam, 0 to 2 percent slopes. The black layer at a depth of about 2 feet is typical.**

C1—9 to 16 inches, very dark brown (10YR 2/2) light silty clay loam; tending to and rubbing to very dark grayish brown (10YR 3/2); weak, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C2—16 to 24 inches, very dark grayish-brown (10YR 3/2)

Figure 13.—**Grassed waterway on Radford silty clay loam, 2 to 5 percent slopes. Adjoining Galva soils have been plowed.**

light silty clay loam; 25 percent mixing of very dark brown (10YR 2/2) and 10 percent of dark grayish brown (10YR 4/2), much of which is silt on horizontal faces of some plates; weak, fine and medium, platy structure; friable; neutral; clear, smooth boundary.

A11b—24 to 28 inches, black (10YR 2/1) silty clay loam; 10 percent mixing of dark grayish brown (10YR 4/2); moderate, fine, granular and moderate, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A12b—28 to 38 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure has some vertical cleavage; friable; neutral; gradual, smooth boundary.

A13b—38 to 48 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure has some vertical cleavage; friable; neutral; gradual, smooth boundary.

A14b—48 to 60 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure has some vertical cleavage; friable; neutral.

The Ap horizon is 6 to 10 inches thick and is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). In some profiles it has dark grayish-brown (10YR 4/2) peds. It is light or medium silty clay loam and ranges from neutral to medium acid.

The C horizon typically is stratified. Very dark grayish brown (10YR 3/2) is the dominant color, but very dark brown (10YR 2/2) is also common. Thin strata of black (10YR 2/1), very dark gray (10YR 3/1), or dark grayish brown (10YR 4/2) are in many profiles. The C horizon is light or medium silty clay loam and is neutral or slightly acid. It extends to a depth of 18 to 36 inches.

The Ab horizon is 24 to 40 inches thick. In places it grades from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1) with increasing depth. It is light or medium silty clay loam and is neutral or slightly acid.

The texture of the Ap and C horizons is finer than is defined as within the range for the Radford series, but this does not significantly affect the use and behavior of these soils.

Radford soils resemble McPaul and Omadi soils, which also formed in recent stratified alluvium. The upper 18 to 36 inches of Radford soils is silty clay loam that is neutral to medium acid and noncalcareous. In contrast, these horizons in McPaul and Omadi soils are silt loam that is mildly alkaline or moderately alkaline and calcareous.

Radford silty clay loam, 0 to 2 percent slopes (467).—This soil is on flood plains, generally on alluvial fans where tributaries enter the flood plain of larger streams in areas next to the main stream. Most areas are large. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were areas of Colo soils that have as much as 15 inches of stratified overwash.

This soil is well suited to row crops. The flood hazard varies from place to place, and the soil has somewhat poor internal drainage. Some areas that are wet and subject to flooding are in pasture. Capability unit I–1.

Radford silty clay loam, 2 to 5 percent slopes (467B).—This soil is generally in valleys 200 to 400 feet wide, but it is also on foot slopes along the edges of larger valleys.

Included with this soil in mapping were areas of Colo soils that have up to 15 inches of overwash. Also included were areas of Primghar soils in the upper reaches of some valleys.

This soil is well suited to row crops. It receives runoff from adjoining hillsides; therefore, wetness and the hazards of erosion and siltation are limitations. Some areas are used as grassed waterways (fig. 13). Capability unit IIe–1.

Rough Broken Land

Rough broken land (378) consists of very steep areas that are between the valley floor and areas of very steep Ida and Hamburg soils near the tops of hills. Most areas have outcrop of bedrock on the lower parts of slopes. The dominant parent material of the soils is silt loam loess or loesslike material that has slumped or washed from higher areas. Other soils in these areas formed in material weathered from limestone, sandstone, shale, and glacial drift.

Rough broken land is not suitable for crops. It is used mainly for pasture. The very steep areas make the use of farm machinery impractical. The soils are very susceptible to erosion. Capability unit VIIe–1.

Salix Series

The Salix series consists of moderately well drained silty soils that formed in alluvium. These soils are on flood plains. Slope ranges from 0 to 2 percent.

In a representative profile the surface layer is friable light silty clay loam about 18 inches thick. It is black in the upper 7 inches and very dark brown below. The subsoil is very dark grayish-brown, friable light silty clay loam about 11 inches thick. Underlying this is very dark grayish-brown and dark grayish-brown, calcareous, friable silty clay loam.

Salix soils have moderate permeability. They have high to very high available water capacity and high organic-matter content. They are medium to low in available nitrogen, medium in available phosphorus, and high in available potassium. The surface layer is neutral or mildly alkaline. These soils have a deep rooting zone.

Almost all areas of these soils are used for crops.

Representative profile of Salix silty clay loam, 0 to 2 percent slopes, 3 miles north of the town of Akron; 440 feet west and 75 feet north of the center of sec. 17, T. 93 N., R. 48 W.:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when rubbed and dark gray (10YR 4/1) with a gray (10YR 5/1) crust when dry; clods part to weak and moderate, very fine and fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A3—7 to 18 inches, very dark brown (10YR 2/2) light silty clay loam, tending to very dark grayish brown (10YR 3/2) when kneaded; vertical cleavage and weak, medium, subangular blocky structure parting to moderate, very fine and fine, subangular blocky; friable; neutral; gradual, smooth boundary.

B2—18 to 22 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; very dark brown (10YR 2/2) coatings on ped faces; very dark grayish brown (10YR 3/2) when kneaded; vertical cleavage and moderate, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B3—22 to 29 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; vertical cleavage and moderate, very fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

C1—29 to 40 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish brown (10YR 3/2) coatings on ped faces; moderate, very fine, subangular blocky structure; moderately alkaline; strong effervescence; clear, smooth boundary.

C2—40 to 60 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark gray (10YR 3/1) coatings on ped faces; dark grayish-brown (10YR 4/2) when kneaded, but slightly darker than overlying horizon; moderate, very fine and fine, subangular blocky structure and a few angular blocky peds; friable; some lime flecks, but no concretions; possibly an incipient Ab horizon; moderately alkaline; strong effervescence.

The A horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in the lower part. It is neutral or mildly alkaline. It is 10 to 20 inches thick.

The B horizon is light silty clay loam or heavy silt loam. It is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) in the upper part. The lower part generally is dark grayish brown (10YR 4/2). In most places very dark grayish-brown (10YR 3/2) coatings are on ped faces. Thickness of the B horizon is 10 to 15 inches, and reaction is neutral or mildly alkaline.

The C horizon is silty clay loam or silt loam. In many places it does not have the darker organic coatings on ped faces.

Salix soils are similar to Kennebec soils and to Salix soils, leached subsoil variant, and are near these soils on the landscape. They are calcareous within a depth of 40 inches, and Kennebec soils and Salix soils, leached subsoil variant, are not.

Salix silty clay loam, 0 to 2 percent slopes (36).—This soil is on flood plains and low stream benches. Areas are about 10 to 60 acres. Most are in the Big Sioux River Valley. This soil is at slightly higher elevations than most other soils in the valley.

Included with this soil in mapping were areas that have 6 to 15 inches of calcareous silt loam overwash.

This soil is well suited to row crops. It is susceptible to flooding, but flooding is not a serious hazard. Capability unit I–1.

Salix Series, Leached Subsoil Variant

The Salix series, leached subsoil variant, consists of well-drained silty soils that formed in alluvium. These soils are on high second bottoms and low stream benches. Slope is 0 to 2 percent.

In a representative profile the surface layer is very dark brown, friable light silty clay loam about 17 inches thick. The subsoil is dark brown and brown, friable light silty clay loam and silt loam about 26 inches thick. The underlying material is brown, very friable, calcareous silt loam.

These soils have moderate permeability and high to very high available water capacity. Typically, they are high in organic-matter content, medium to low in available nitrogen, medium in available phosphorus, and high in available potassium. The surface layer is generally slightly acid or neutral. These soils have a deep rooting zone.

Most areas of these soils are used for cultivated crops.

Representative profile of Salix silty clay loam, leached subsoil variant, 0 to 2 percent slopes, in an alfalfa field about 3 miles north of the town of Akron; 25 feet south of the northeast corner of sec. 17, T. 93 N., R. 48 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam; moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—8 to 17 inches, very dark brown (10YR 2/2) light silty clay loam, tending to very dark grayish brown (10YR 3/2) when rubbed; moderate, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B1—17 to 24 inches, dark brown (10YR 3/3) light silty clay loam; common very dark brown (10YR 2/2) coatings on ped faces; some very dark brown (10YR 2/2) worm casts and peds and a few brown (10YR 4/3) peds; weak to moderate, very fine, subangular blocky and moderate, fine, granular structure; friable; neutral; gradual, smooth boundary.

B21—24 to 35 inches, brown (10YR 4/3) silt loam; some very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) coatings on ped faces; weak to moderate, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—35 to 43 inches, brown (10YR 4/3) silt loam; few very dark brown (10YR 2/2) peds; weak to moderate, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C1—43 to 48 inches, brown (10YR 4/3) silt loam, tending to brown (10YR 5/3); massive; very friable; common lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—48 to 96 inches, brown (10YR 4/3) silt loam, tending to brown (10YR 5/3) and to hue of 2.5Y; massive; very friable; some lime concretions; moderately alkaline; strong effervescence.

The A horizon is 12 to 20 inches thick. The upper part is black (10YR 2/1) or very dark brown (10YR 2/2). The lower part is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). Reaction is slightly acid or neutral.

The B horizon is 20 to 30 inches thick. The lower part is mildly alkaline in places. The C horizon is commonly silt loam, but the upper part is light silty clay loam in places. In places it has strata or sandy loam or loamy sand.

Salix soils, leached subsoil variant, are similar to Salix soils. They are noncalcareous to a depth of 40 inches or more, whereas Salix soils are calcareous within that depth.

Salix silty clay loam, leached subsoil variant, 0 to 2 percent slopes (607).—This soil is on low stream benches and is intermingled with other nearly level soils. Areas range from about 10 to 60 acres in size.

Included with this soil in mapping were places that have light-colored, calcareous overwash. Also included were some soils that are calcareous within a depth of 1 or 2 feet.

This soil is well suited to row crops. Some areas are subject to flooding, but the hazard is slight. Capability unit I–1.

Steep Rock Land

Steep rock land (478) has very steep slopes. It is in long, narrow areas along the lower parts of hillsides. It adjoins nearly level to moderately sloping soils at lower elevations.

Included with this land type in mapping were small areas of soils in concave positions in drainageways and along the base of hillsides. These soils are less sloping and are deeper over bedrock than Steep rock land.

Steep rock land is poorly suited to crops, grasses, and trees. It is susceptible to erosion. It is so steep and rocky that it generally is better suited to wildlife and recreation than to most other uses. Capability unit VIIe–1.

Steinauer Series

The Steinauer series consists of well-drained, calcareous, loamy soils that formed in glacial till on uplands. Slope ranges from 5 to 40 percent.

In a representative profile the surface layer is dark-brown, calcareous, friable clay loam about 6 inches thick. Below this, and extending to a depth of 60 inches or more, is yellowish-brown, calcareous, firm clay loam.

These soils have moderately slow permeability. They have high available water capacity and low organic-matter content. They are very low in available nitrogen and phosphorus and medium in available potassium. They are moderately alkaline and high in lime. They have a deep rooting zone.

Most areas of these soils are used for pasture. Some of the less sloping areas are used for crops.

Representative profile of Steinauer clay loam, 14 to 18 percent slopes, severely eroded, in a meadow about 3 miles northeast of the town of Craig; 300 feet east of southwest corner of NW¼NW¼ sec. 1, T. 93 N., R. 46 W.:

Ap—0 to 6 inches, dark-brown (10YR 3/3) light clay loam; weak, fine, granular and weak, very fine, subangular blocky structure; friable; moderately alkaline; strong effervescence; clear, smooth boundary.

AC—6 to 11 inches, yellowish-brown (10YR 5/4) light clay loam; almost 50 percent dark brown (10YR 3/3) and brown (10YR 4/3); vertical cleavage and weak, fine, granular and weak, very fine, subangular blocky structure; firm; moderately alkaline; strong effervescence; gradual, smooth boundary.

C1—11 to 18 inches, yellowish-brown (10YR 5/4) light clay loam; few very dark grayish-brown (10YR 3/2) peds and coatings on ped faces; light yellowish brown (10YR 6/4) when kneaded; weak, very fine, subangular blocky structure; firm; few small lime concretions; moderately alkaline; strong effervescence; gradual, smooth boundary.

C2—18 to 36 inches, yellowish-brown (10YR 5/4) light clay loam; few, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, very fine and fine, subangular blocky structure; firm; common lime concretions up to 1/2 inch in diameter; moderately alkaline; strong effervescence; gradual, smooth boundary.

C3—36 to 60 inches, yellowish-brown (10YR 5/4) light clay loam; common, fine, prominent, strong-brown (7.5YR 5/8) mottles and few, fine, prominent, yellowish-red (5YR 4/6) mottles; massive; firm; some segregated lime; moderately alkaline; strong effervescence.

In most places the Ap or A1 horizon is dark brown (10YR 3/3), brown (10YR 4/3 or 5/3), or yellowish brown (10YR 5/4). In the least eroded areas, it is very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The darker and lighter colors commonly are mixed in an Ap horizon. The texture generally is light clay loam, but it ranges from medium clay loam to loam. Gravel and cobbles are common in some profiles. This horizon typically is moderately alkaline and calcareous, but it ranges to neutral and noncalcareous.

The C horizon is yellowish brown (10YR 5/4 or 5/6), pale brown (10YR 6/3), or light yellowish brown (10YR

***Figure 14.*—Cattle in pasture on Steinauer clay loam, 9 to 14 percent slopes, severely eroded.**

6/4). Mottles are few or common in most profiles. They are commonly yellowish brown, grayish brown, reddish brown, or strong brown. This horizon is light or medium clay loam. Pockets or lenses of sand occur in places.

Steinauer and Ida soils are both calcareous soils that lack a B horizon, and they occupy similar positions on the landscape. Steinauer soils formed in glacial till and have a higher content of sand than Ida soils, which formed in loess. They also contain pebbles and stones, which Ida soils lack.

Steinauer clay loam, 9 to 14 percent slopes, severely eroded (33D3).—This soil is on hillsides. Most areas are 5 to 15 acres in size.

Included with this soil in mapping were areas of moderately sloping Steinauer soils that generally have a darker colored surface layer than the profile described as representative of the series. Most of these included soils are on humps or at the edge of ridgetops.

This soil is well suited to hay or pasture (fig. 14). Row crops can be grown occasionally, but soil and water losses are excessive unless adequate erosion-control measures are used. Capability unit IVe–2.

Steinauer clay loam, 14 to 18 percent slopes, severely eroded (33E3).—This soil is on hillsides. Most areas are on the lower parts of slopes and are about 20 to 40 acres in size. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were less eroded areas where the surface layer is very dark grayish brown. Also included were areas of soils that have more gravel and sand and less clay than this Steinauer soil. Special symbols for sand or gravel are used to show these areas on the soil map.

This soil is suited to pasture or hay. Farm machinery can be used in most areas, and row crops can be grown occasionally. This soil, however, is very susceptible to erosion. Capability unit VIe–1.

Steinauer clay loam, 18 to 30 percent slopes, severely eroded (33F3).—This soil is on hillsides, generally on the lower parts of slopes. Areas are about 5 to 30 acres in size.

Included with this soil in mapping were places that are less eroded, where the surface layer is very dark grayish brown. Also included were areas of soils that have more sand and gravel and less clay than this Steinauer soil. These areas are shown by special symbols on the soil map.

This soil is suited to pasture. Farm machinery can be used in some areas, and in those areas hay is a suitable crop. Erosion is a serious hazard. Capability unit VIIe–1.

Wadena Series

The Wadena series consists of well-drained loamy soils that formed in alluvium. These soils are underlain at a depth of about 2 or 3 feet by sand or gravel. They are on stream benches, mainly along the major streams. Slope ranges from 2 to 14 percent.

In a representative profile the surface layer is black, friable loam that grades to very dark grayish brown in the lower part. It is about 15 inches thick. The subsoil is brown, friable to very friable loam and sandy loam about 16 inches thick. The underlying material is loamy sand and sand that is calcareous except in the upper few inches.

Wadena soils have moderately rapid permeability in the upper part and very rapid permeability in the underlying material. They have low to moderate available water capacity and moderate organic-matter content. They are low in available nitrogen and phosphorus and medium in available potassium. The surface layer is neutral or slightly acid. The gravel or sand in the substratum restricts root growth.

Most areas of these soils are used for crops. A few areas are in pasture.

Representative profile of Wadena loam, 2 to 5 percent slopes, in a pasture about 2 miles south of the town of Akron; 760 feet west and 360 feet north of the southeast corner of NE¼NW¼ sec. 13, T. 92 N., R. 49 W.:

A1—0 to 9 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when crushed; weak, fine, subangular blocky structure parting to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

A3—9 to 15 inches, very dark grayish-brown (10YR 3/2) loam; many very dark brown (10YR 2/2) coatings on ped faces; weak, fine, subangular blocky structure parting to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

B2—15 to 24 inches, brown (10YR 4/3) loam; few very dark grayish-brown (10YR 3/2) coatings on ped faces; weak, fine and medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

I&IIB3—24 to 31 inches, brown (10YR 4/3) light sandy loam; weak, medium and coarse, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

IIC1—31 to 36 inches, dark yellowish-brown (10YR 4/4) loamy medium sand; single grained; loose; mildly alkaline; gradual, smooth boundary.

IIC2—36 to 60 inches, yellowish-brown (10YR 5/4) medium sand; single grained; loose; moderately alkaline; strong effervescence.

The A horizon is 10 to 16 inches thick except in eroded places. It is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It ranges from loam to silt loam or light silty clay loam and has a high content of sand. It is neutral or slightly acid.

The B horizon is 10 to 24 inches thick. It is brown (10YR 4/3 or 5/3) or dark yellowish-brown (10YR 4/4) loam or light clay loam. In the lower part, it is sandy loam in places. It is neutral or slightly acid.

Depth to the upper boundary of the IIC horizon is between 20 and 36 inches. The IIC horizon ranges from medium sand and no gravel to gravel and very little sand. In many profiles it is a mixture of sand and gravel. In the upper few inches it is commonly leached, but in some profiles it is calcareous just below the I&IIB horizon.

In places, especially in mapping units 114D3 and 317C2, the A horizon is thinner than is defined as within the range for the Wadena series. This does not significantly affect the use or behavior of these soils. In places the sandy loam layer in the B horizon is thicker than is defined as within the range for the series, but this does not alter the use or behavior of the soils.

Wadena soils are on the stream benches near Graceville and Dickman soils. They are shallower to sand or gravel than Graceville soils. They are finer textured in the upper 2 or 3 feet than Dickman soils.

Wadena loam, 2 to 5 percent slopes (108B).—This soil is in areas that have a maximum width of about 600 feet. Many areas are ¼ to 1 mile in length.

Included with these soils in mapping were nearly level Wadena soils in which depth to underlying coarse-textured material varies from place to place. In these soils the substratum is gravelly rather than sandy in places. Also included were areas that are sandy or gravelly throughout.

This soil is well suited to row crops. It is subject to soil blowing and water erosion and is slightly droughty. Use of crop residue and other practices that conserve moisture are especially helpful. Capability unit IIe-2.

Use and Management of the Soils

This section discusses the use and management of the soils of Plymouth County for crops, pasture, and trees; for wildlife; for engineering uses; and for recreation.

Management for Crops, Pasture, and Trees

This section discusses the management of the soils for crops, pasture, and trees. It explains the capability classification used by the Soil Conservation Service and describes the use and management of the soils by capability units. It also gives predicted yields for crops commonly grown in the county.

Crops

About 78 percent of Plymouth County is used for cultivated crops. Corn and soybeans are the major row crops. In general, the value of a soil is measured by its suitability for growing these two crops. Oats and alfalfa-bromegrass hay are also important. Sorghum, popcorn, and other kinds of hay and crops are grown to a lesser extent.

On about 84 percent of the cultivated soils, erosion is the most serious hazard. On about 12 percent, wetness is a major hazard. The other 4 percent is nearly level soils that have no serious limitations.

Among the erosion-control methods used in the county are contour tillage, diversions and terraces, rotations that include grass and legumes, minimum tillage, grassed waterways, use of crop residue, and fertility management. Generally, a combination of several practices is used.

The percolation rate in the soils of Plymouth County is high enough that terraces can be built with level, rather than graded, channels. Fertility management is important on all soils. Without it, plant cover is often sparse and erosion is harder to control. Chemical fertilizer is widely used. Also, because numerous livestock is raised in the county, manure is readily available and is used on most farms. Legumes are commonly grown as a green-manure crop.

Soil blowing is a hazard on all cultivated soils, especially in fields that are plowed in fall after soybeans are harvested. In this county plowing generally is done in fall for better distribution of labor. For maintaining tilth, however, plowing in fall has little or no ad-

Figure 15.—**Trees on Castana and Napier soils in valleys and native grass on Ida and Hamburg soils on hillsides.**

vantage over plowing in spring, except on a few soils in drainageways or on bottom lands.

The soils that are subject to wetness are in drainageways or on bottom lands. Tile can be used in most soils, but surface drainage normally is more practical in Luton and Albaton soils because they are clayey.

In most years, rainfall plus stored soil moisture is adequate for the crops commonly grown in the county. However, where fertility management is good, insufficient moisture is commonly a limitation. This limitation is normally not serious, and therefore, very few irrigation systems have been installed. An increase in irrigation is probable.

Pasture

About 13.5 percent of the county is in pasture. In the uplands near the Big Sioux River Valley, many of the pastures are too steep for the use of farm machinery. Other pastures are on moderately steep to steep soils that can be worked with machinery. Pastures are also on flood plains or in drainageways.

Control of grazing is important on the very steep soils. Any renovation or reseeding must be done by hand. These pastures have native grasses such as big bluestem, little bluestem, and side-oats grama. Thin stands of trees occur, mostly on Steep rock land.

Pastures on soils where farm machinery can be used commonly are in bromegrass or bromegrass and alfalfa. These pastures can be plowed and reseeded where necessary. Generally, corn is planted the first year, and then the land is reseeded. Other practices that can be used are topdressing with fertilizer or disking and reseeding the old sod.

Pastures on flood plains and in drainageways are in bluegrass. If flood-control or drainage practices are installed, these pastures are used for crops. In areas that are subject to flooding and wetness, bluegrass pasture is a good use. Practices that can be used are controlled grazing, fertilization, and renovation where needed. Weed control is especially important because weed seed is carried by floodwaters.

Trees

Only about 12,000 acres, or 2 percent of the county, is woodland. Almost all the woodland is grazed and is managed mainly as pasture.

A very small demand exists for timber products of the quality and volume produced in the county. Trees and shrubs are used mainly for windbreaks or for wildlife and recreation. In a few places, however, woodland competes with alternate uses.

Sizable stands of trees are in low-lying areas along the larger streams. The biggest areas are along the Big Sioux River and along the lower reaches of the Floyd River. The stands in these areas consist mainly of eastern cottonwood, silver maple, and elm, but willow, green ash, black walnut, and other trees are also common.

The acreage of trees on bottom lands is decreasing as areas are cleared for farming. In most places where levees are built, stands of trees are left between the levee and the river. Also, along some of the streams, patches of woodland, a few acres in size, are isolated between the channel and the steep adjoining hillsides. These stands can be managed to provide wood products for on-farm use. They can possibly provide some marketable timber also, black walnut in particular.

The steep and very steep soils in the county are poorly suited to trees. Available water is limited because runoff is rapid. North- and east-facing slopes are slightly more favorable than other slopes. Bur oak is the dominant tree on hillsides. It has little commercial value.

Castana, Napier, and other soils on foot slopes support stands that include black walnut, elm, and green ash (fig. 15, p. 33). Many of these woodlands are between a steep hillside and a deep, active gully. These areas are not suitable for cultivated crops, because they are inaccessible, but soil characteristics are favorable. Managing these stands for production of hardwoods can be considered. Planting evergreens for Christmas trees is another alternative.

Good woodland management requires restricted grazing and elimination of competition from weeds and undesirable trees. Professional help can be secured by contacting a State forester or the local representative of the Soil Conservation Service or Extension Service.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment (*18*). The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, woodland, or engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (None in Plymouth County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage) ; *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in some parts of the United States, but not in Plymouth County, shows that the chief limitation is climate that is too cold or too dry.

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

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants; to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–4 or IIIe–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management by capability units

In the pages that follow, each of the capability units in Plymouth County is described, and suggestions for use and management of the soils are given. The names of soil series represented in a capability unit are mentioned in the description of each capability unit, but this does not mean that all the soils of a given series are in the unit. To find the names of the soils in any given unit, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This unit consists of level or nearly level silty soils that are well drained to somewhat poorly drained. The soils are on bottom lands or stream benches.

These soils have a friable surface layer of silt loam or silty clay loam. Permeability is generally moderate or moderately slow, but it is very slow to slow in the soils that have a clayey substratum. The content of organic matter ranges from low to high. Available water capacity is high or very high. The surface layer ranges from slightly acid to mildly alkaline. It is generally calcareous where the reaction is mildly alkaline.

Most of the soils have a deep rooting zone. During periods of heavy rain in spring, root growth is somewhat restricted by a seasonal high water table in the soils that have a clayey substratum. In places root growth is restricted in the soils that are underlain by sand and gravel, but generally the sand and gravel are at a depth of 4 feet or more and the effect on plant roots is slight.

The soils of this unit have no serious limitations for intensive row cropping. The soils on bottom lands are subject to overflow, but only the soils in low-lying areas of bottom lands are not suited to crops. Floods generally occur early in spring before planting time. Controlling weeds is a concern where weed seeds are deposited by floodwaters. The soils in low-lying areas and those that receive runoff from adjoining soils are likely to pond.

These soils are well suited to irrigation and to row crops. If adequate water is available, crops respond to large applications of fertilizer. The soils are used mainly for corn and soybeans, but a few other crops are also grown. A few areas, especially on bottom lands, are used for pasture, and some pastured areas have stands of trees.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping silty soils that are well drained to somewhat poorly drained. The soils generally are in narrow drainageways, but they also occur on foot slopes along the edges of larger valleys.

These soils have a surface layer of friable silt loam or silty clay loam. Permeability is moderate or moderately slow. Content of organic matter is generally moderate to high, but in some soils it is low. Available water capacity is high or very high in all the soils. The surface layer is mildly alkaline and calcareous to slightly acid, and noncalcareous.

These soils receive runoff from adjoining soils. Sheet and rill erosion are hazards, and a large, actively cutting gully is in the center of some valleys. Runoff also causes siltation and wetness in places (fig. 16). The somewhat poorly drained soils, in particular, are excessively wet during periods of heavy rainfall. They have a seasonal high water table, and a line of tile has been installed in many of the valleys. Siltation, however, is a more severe hazard on some soils in this unit than wetness.

Figure 16.—Silt eroded from Galva soils and deposited on soils of capability unit IIe-1.

Contour tillage, terraces, and other conservation practices help to reduce excess wetness in the soils of this unit. Large gullies can be filled and a grassed waterway established after runoff is controlled.

These soils are well suited to row crops. However, most areas are long and narrow and are managed with adjoining steeper soils. Row cropping generally is not so intensive that control of erosion is a concern. Some areas are in pasture along with adjacent steep soils. These soils are suited to pasture.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping silty or loamy soils that are moderately well drained or well drained. The soils are on uplands and stream benches.

These soils have a friable silty clay loam, silt loam, or loam surface layer. Most have moderate permeability, but some soils have moderately rapid permeability in the upper part and very rapid permeability in the underlying sand or gravel. The organic-matter content ranges from low to high and depends to a great extent on the amount of erosion that has taken place. The available water capacity is high or very high in most of the soils, but in some soils it is low to moderate. The surface layer is generally neutral or slightly acid, but in some soils it is moderately alkaline and calcareous.

These soils are subject to erosion. They are commonly farmed with soils in capability unit IIIe-1, which are sloping and are more susceptible to erosion than the soils of this unit. Erosion-control measures suitable for the more sloping soils are normally more than adequate for the soils of this unit. In places soils of this unit are farmed alone or with class I soils. Most of these areas are used for intensive row cropping. Control of erosion is a concern in cultivated areas.

These soils are well suited to row crops, and corn and soybeans commonly are grown intensively. In a

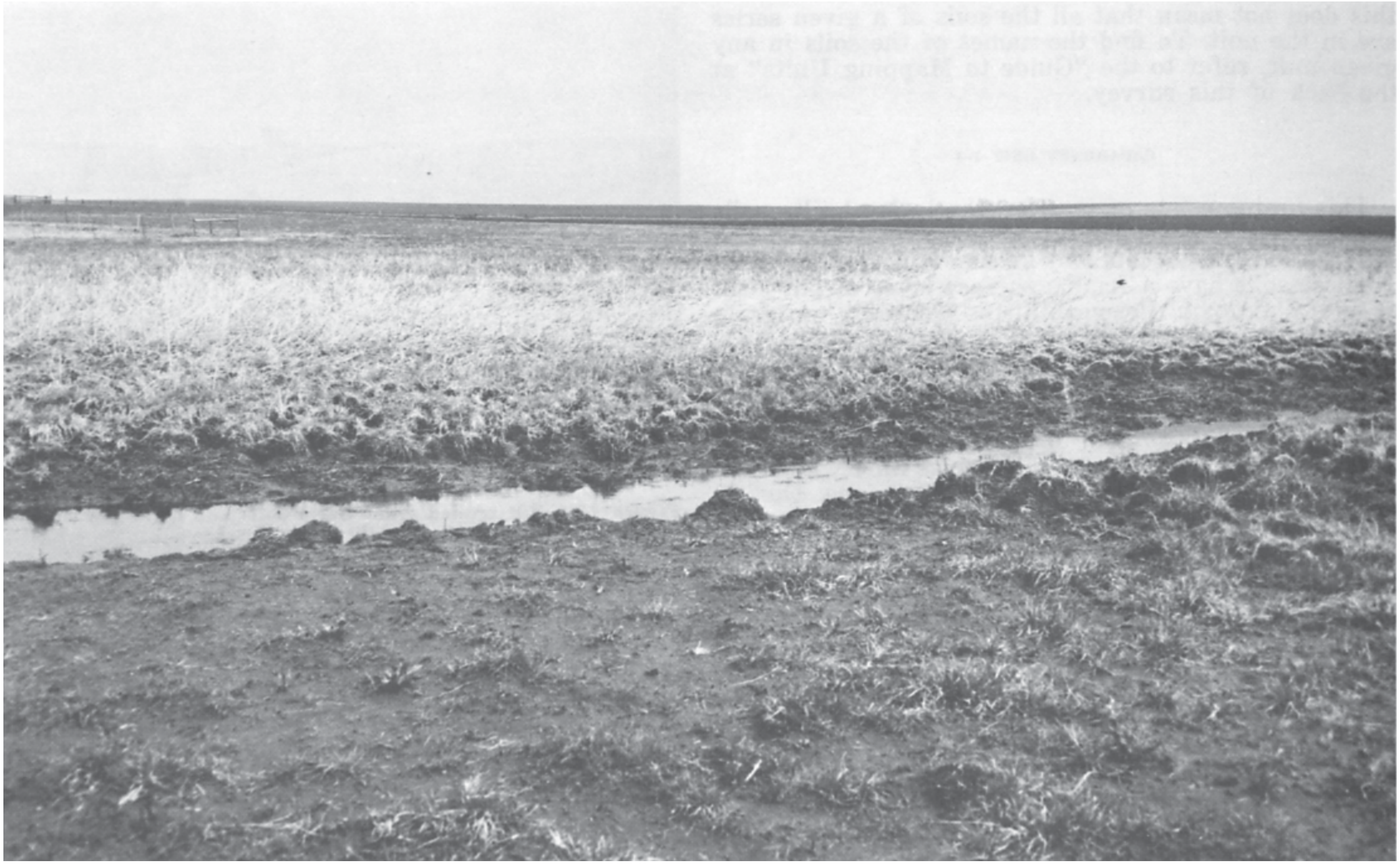

Figure 17.—**Colo silty clay loam, 0 to 2 percent slopes, in capability unit IIw–1.**

few areas the soils are near steeper soils, and these areas are used for pasture or hay.

CAPABILITY UNIT IIw–1

This unit consists of level or nearly level silty soils that are poorly drained. The soils are on bottom lands.

These soils have a friable silty clay loam or silt loam surface layer. They have moderately slow permeability. The organic-matter content is high, and the available water capacity is high or very high. The surface layer ranges from slightly acid to moderately alkaline and calcareous.

These soils are subject to overflow, but the hazard is slight or moderate in most areas. Slow runoff and inadequate internal drainage are more severe limitations (fig. 17). A seasonal high water table restricts root growth in some seasons. Wetness generally can be overcome by using tile or surface drains. Suitable outlets can be obtained in most places. It is hard to maintain good tilth without adequate drainage.

Typically these soils are used for intensive row cropping, which is a suitable use. Bluegrass pastures are fairly common in areas subject to more than average flooding. In some of these areas, flood control and drainage are practiced and row crops are planted. Most of these soils, however, are in farms where all or most of the soils are well suited to row crops. Other soils generally can be prepared for intensive row cropping with less difficulty than the soils of this unit (fig. 18).

CAPABILITY UNIT IIIe–1

This unit consists of moderately sloping silty soils that are well drained. The soils are on uplands, stream benches, and foot slopes.

These soils have a friable or very friable silt loam or silty clay loam surface layer. They have moderate permeability. The organic-matter content ranges from low to high and depends to a great extent on the amount of erosion that has taken place. The available water capacity is high or very high. Typically the surface layer is neutral or mildly acid, but in some soils it is moderately alkaline and calcareous.

These soils are subject to erosion. They are commonly farmed with the less sloping soils in capability unit IIe–1 or with the more sloping soils in capability unit IIIe–2. In places where they are farmed with less sloping soils, row crops commonly are planted. Soil loss is greater on the soils of this unit than on the less sloping soils if management is the same. In places where the soils of this unit are farmed with more sloping soils, the opposite is true.

These soils are suited to intensive row cropping if adequate erosion control measures are used. Cropping

Figure 18.—**Colo silty clay loam, 0 to 2 percent slopes, in capability unit IIw–1. This area has no artificial drainage and has been left in pasture.**

systems vary. In general row crops are grown more commonly on the Galva soils than on the other soils of this unit. The other soils typically are included on farms that have strongly sloping and moderately steep soils.

CAPABILITY UNIT IIIe–2

This unit consists of strongly sloping silty soils that are well drained. The soils are on foot slopes, uplands, or stream benches.

These soils have a friable or very friable silt loam or silty clay loam surface layer. They have moderate permeability. The organic-matter content ranges from low to high and depends to a great extent on the amount of erosion that has taken place. The available water capacity is high or very high. The surface layer is slightly acid to moderately alkaline and calcareous.

These soils are very susceptible to erosion. Row crops are commonly grown, but soil loss is severe unless adequate erosion-control measures are used. Generally, meadows are used in the cropping system to help prevent excessive soil loss.

These soils are suited to growing row crops fairly often if erosion is controlled. They are well suited to hay (fig. 19). Some areas that are intermingled with moderately steep to very steep soils are used for pasture, which is a suitable use.

CAPABILITY UNIT IIIe–3

This unit consists of gently sloping to strongly sloping loamy and silty soils that are well drained or somewhat excessively drained. The soils are on stream benches and on escarpments between the benches and the flood plain.

These soils have a friable and very friable surface layer that ranges from fine sandy loam to silty clay loam. Commonly included on the soil maps are small areas that have a gravelly sandy loam surface layer and some that have pebbles and cobbles on the surface. Permeability is moderate, moderately rapid, or rapid. The organic-matter content is low to moderate. The available water capacity is low in some soils, but in soil complexes it ranges from low to very high in some areas. Typically the surface layer is neutral, mildly alkaline, or moderately alkaline. In a few places it is slightly acid.

These soils are subject to erosion. They are commonly farmed with nearly level and gently sloping soils, and row crops are commonly planted. Soil loss generally is greater on these soils than on other soils in the same fields. Soil blowing is a problem, especially on the soils that have a fine sandy loam surface layer, and it often damages young plants. Yields are commonly limited by the lack of adequate available water.

These soils are suited to row crops if erosion and

***Figure 19.*—Field of hay on Napier and Castana soils in capability unit IIIe–2. Native grass on steeper soils in background.**

soil blowing are controlled. The amount of water available in the soil at planting time has an influence on the choice of crops. If a source of water is available, irrigation is a good possibility, particularly on the gently sloping soils. Practices that help conserve moisture and prevent soil blowing, such as crop residue management, are especially helpful on these soils.

CAPABILITY UNIT IIIw–1

This unit consists of nearly level to level, poorly drained clayey soils. The soils are on bottom lands.

These soils have a firm silty clay surface layer. They have very slow to slow permeability. The organic-matter content ranges from low to high. The available water capacity is moderate. The surface layer is slightly acid to mildly alkaline and calcareous.

Wetness is a limitation. Stream overflow is a hazard, but it is not a serious one in most areas. It is hard to get timely field operations and to maintain good tilth on these soils. Surface drains and land grading can be used to help overcome these problems. Some farmers use a lister to plant row crops on these soils. This makes it easier to avoid working the soil when it is too wet, because fewer field operations are needed (fig. 20).

These soils commonly are used for intensive row cropping. They are well suited to this use if drainage is adequate.

CAPABILITY UNIT IVe–1

This unit consists of moderately steep silty soils that are well drained. The soils are on hillsides in the uplands.

These soils have a very friable or friable silt loam surface layer. They have moderate permeability. The organic-matter content is low to moderately high, depending on previous erosion. The available water capacity is very high. The surface layer ranges from slightly acid to moderately alkaline and calcareous.

These soils are very susceptible to erosion. Row crops can be grown occasionally without excessive soil loss if erosion-control practices are used. Erosion-control practices are more difficult to build and to maintain on these soils than on less sloping soils. Using a large proportion of meadow in the cropping system is an easy, effective method to help keep soil losses at a minimum.

These soils are well suited to hay. They are suited to growing row crops occasionally if adequate erosion-control measures are used. In places these soils are next to steep or very steep soils and are used for pasture. They are well suited to this use. In most places

Figure 20.—Lister used to plant corn on Luton silty clay, 0 to 1 percent slopes, which is in capability unit IIIw–1.

farm machinery can be used to apply fertilizer, to mow weeds, and to perform other measures needed to improve pastures.

CAPABILITY UNIT IVe–2

This unit consists of strongly sloping loamy and silty soils that are well drained. The soils are on uplands or on foot slopes at the base of steep slopes.

These soils have a friable loam or clay loam surface layer. They have moderately slow or moderate permeability. The organic-matter content is low to moderate, and the available water capacity is high or very high. The surface layer is moderately alkaline and calcareous.

These soils are very susceptible to erosion. The soils on foot slopes receive runoff and sediment from the steep hillsides. A good erosion-control system is important, especially if these soils are used for row crops. A diversion or basin terrace at the upslope edge of the soils on foot slopes reduces siltation and runoff.

These soils are well suited to hay or pasture. Slopes are not too steep for the use of farm machinery, although adjacent slopes are too steep in many places. These soils are suited to growing row crops occasionally. Row crops commonly are grown next to fairly large areas of less sloping soils. Another possible use is for timber production, especially in areas that are not accessible with farm machinery.

CAPABILITY UNIT Vw–1

This unit consists of nearly level or level, dominantly silty soils that are moderately well drained or well drained. Also included are some poorly drained to somewhat excessively drained sandy, loamy, or clayey soils. These soils have a wide range of soil properties. They are on bottom lands.

These soils are subject to frequent flooding and in places are cut by numerous meandering channels (fig. 21). Major projects, such as building levees, are necessary to reduce these hazards. Other soil properties generally are favorable for row crops.

These soils are well suited to pasture or timber production. Generally, excellent stands of trees or pasture plants can be obtained, but the flood hazard needs to be considered in all management decisions. Row crops can be grown in places where limitations are less severe.

CAPABILITY UNIT VIe–1

This unit consists of moderately steep and steep soils that are well drained. The soils are on hillsides in the uplands or on moderately steep foot slopes at the base of steep to very steep hillsides.

Figure 21.—**Bottom land in capability unit Vw–1 that is subject to frequent flooding and is cut up by meandering streams. Area has been left in pasture.**

These soils have a friable or very friable silt loam or clay loam surface layer. Permeability is moderate or moderately slow. The organic-matter content is moderate to low and depends somewhat on the amount of erosion that has taken place. The available water capacity is high or very high. The surface layer is moderately alkaline and calcareous.

These soils are very susceptible to erosion. Some receive runoff and sediment from hillsides. Soils of this unit generally are used for pasture. Farm machinery can be used on many of the soils to improve pastures.

These soils are well suited to pasture. Some of the less sloping areas are also suited to hay. In those areas an occasional row crop can be planted as a first step in reseeding the grass or grass and legume. These soils, particularly those on foot slopes, also are suited to trees.

CAPABILITY UNIT VIIe–1

This unit consists of gently sloping to very steep soils that are well drained or somewhat excessively drained. The soils have a wide range of soil properties. They are on moderately steep to very steep hillsides or in valleys that have large, actively cutting gullies.

These soils have a very friable or friable silt loam or clay loam surface layer. They have moderate or moderately slow permeability. The organic-matter content ranges from low to high, depending mainly on past erosion. The available water capacity is high or very high. The surface layer is generally moderately alkaline and calcareous, but in some soils it is neutral and noncalcareous.

These soils are very susceptible to sheet and gully erosion. In addition, many of the soils on hillsides are somewhat droughty, because runoff is too rapid for adequate infiltration. Soils of this unit generally are used for pasture, even where stands of trees exist. Grazing needs to be controlled. Reseeding and renovation are difficult because many places are too steep for the use of farm machinery.

These soils are suited to pasture or trees. The soil complexes in this unit can be used for row crops if the gullies are controlled and filled, but this would be a major reclamation project.

Predicted yields

In table 2 the average yields per acre of principal crops are predicted under a high level of management. The yields are those to be expected under a management system that controls erosion; maintains organic-matter content and tilth; provides for the level of fertility needed for each crop (as indicated by soil tests and field trials); controls the water level in wet

TABLE 2.—*Predicted average yields per acre of principal crops under high-level management*

[Absence of data indicates that the crop is not ordinarily grown on the soil]

Soil	Corn	Soybeans	Oats	Hay [1]	Pasture [2]
	Bu	*Bu*	*Bu*	*Ton*	*AUD* [3]
Albaton silty clay, 0 to 1 percent slopes	71	27	50	2.8	140
Calco silty clay loam, 0 to 2 percent slopes	87	33	74	3.5	175
Castana loam, 9 to 14 percent slopes	47	18	33	1.9	90
Castana silt loam, 14 to 30 percent slopes				1.7	85
Castana-Gullied land complex, 9 to 14 percent slopes					45
Colo silt loam, calcareous overwash, 0 to 2 percent slopes	78	30	66	3.1	155
Colo silty clay loam, 0 to 2 percent slopes	92	35	78	3.7	185
Dickman fine sandy loam, 2 to 9 percent slopes	39	15	33	1.6	80
Galva silty clay loam, 2 to 5 percent slopes	90	34	77	3.6	180
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	84	32	71	3.4	170
Galva silty clay loam, 9 to 14 percent slopes, moderately eroded	76	29	65	3.0	150
Galva silty clay loam, benches, 0 to 2 percent slopes	94	36	80	3.8	190
Galva silty clay loam, benches, 2 to 5 percent slopes	92	35	78	3.7	185
Galva-Wadena complex, 5 to 14 percent slopes, moderately eroded	67	25	56	2.7	135
Graceville silt loam, 0 to 2 percent slopes	89	34	76	3.6	180
Graceville silt loam, 2 to 5 percent slopes	87	33	74	3.5	175
Hamburg silt loam, 30 to 75 percent slopes					
Ida silt loam, 2 to 5 percent slopes, severely eroded	72	27	50	2.9	145
Ida silt loam, 5 to 9 percent slopes, severely eroded	68	26	48	2.7	135
Ida silt loam, 9 to 14 percent slopes, severely eroded	60	23	42	2.4	120
Ida silt loam, 14 to 20 percent slopes, severely eroded	46	17	32	1.8	90
Ida silt loam, 20 to 30 percent slopes, severely eroded				1.3	70
Ida silt loam, 30 to 40 percent slopes, severely eroded					
Ida-Wadena complex, 5 to 14 percent slopes, severely eroded	55	21	39	2.2	110
Kennebec silt loam, 0 to 2 percent slopes	104	40	73	4.2	210
Kennebec silt loam, 2 to 5 percent slopes	92	35	64	3.7	185
Kennebec silt loam, channeled, 0 to 2 percent slopes					
Kennebec silty clay loam, 0 to 2 percent slopes	106	40	74	4.2	210
Kennebec-McPaul silt loams, 2 to 5 percent slopes	94	36	66	3.8	190
Luton silty clay, 0 to 1 percent slopes	65	25	45	2.5	125
McPaul silt loam, 0 to 2 percent slopes	94	36	66	3.8	190
McPaul-Kennebec silt loams, 2 to 5 percent slopes	90	34	63	3.6	180
Modale silt loam, dark subsoil variant, 0 to 2 percent slopes	81	31	57	3.2	160
Monona silt loam, 2 to 5 percent slopes	85	32	60	3.4	170
Monona silt loam, 5 to 9 percent slopes, moderately eroded	79	30	55	3.2	160
Monona silt loam, 9 to 14 percent slopes, moderately eroded	72	27	50	2.9	145
Monona silt loam, 14 to 20 percent slopes, moderately eroded	58	22	41	2.3	120
Monona silt loam, benches, 2 to 5 percent slopes	89	34	62	3.6	180
Napier silt loam, 5 to 9 percent slopes	89	34	62	3.6	180
Napier-Castana silt loams, 9 to 14 percent slopes	79	30	55	3.2	160
Napier-Gullied land complex, 2 to 10 percent slopes					55
Omadi silt loam, 0 to 2 percent slopes	82	31	57	3.4	170
Omadi-Alluvial land complex, 0 to 2 percent slopes					
Primghar silty clay loam, 2 to 5 percent slopes	95	36	81	3.8	190
Radford silty clay loam, 0 to 2 percent slopes	94	36	80	3.8	190
Radford silty clay loam, 2 to 5 percent slopes	96	36	82	3.8	190
Rough broken land					
Salix silty clay loam, 0 to 2 percent slopes	103	39	72	4.1	205
Salix silty clay loam, leached subsoil variant, 0 to 2 percent slopes	103	39	72	4.1	205
Steep rock land					
Steinauer clay loam, 9 to 14 percent slopes, severely eroded	68	26	48	2.7	135
Steinauer clay loam, 14 to 18 percent slopes, severely eroded			26	1.8	90
Steinauer clay loam, 18 to 30 percent slopes, severely eroded				1.3	70
Wadena loam, 2 to 5 percent slopes	67	25	47	2.7	135

[1] Alfalfa-bromegrass hay.
[2] Bromegrass pasture.
[3] Animal-unit-day is the number of days that 1 acre will provide grazing for 1 animal-unit, or 1,000 pounds of animal weight, without damage to the pasture.

soils; and provides for timely operations. A relatively small percentage of farmers now provide this level of management.

All available sources of yield information were used to make these estimates, including data from the Federal Census, Iowa Farm Census, experimental farms, cooperative experiments with farmers, and on-farm experience by soil scientists, extension workers, and others.

The yield estimates are designed to serve as guides. They are approximations only and should be so considered. Of more value than actual yield figures to many users are the comparative yields between soils. These relations should remain fairly consistent over a period of years. On the other hand, actual yields have been increasing in past years. If they continue to increase as expected, predicted yields in this table will soon be too low.

Wildlife [3]

Proper plant cover, determined mainly by soil characteristics, is a basic requirement of all wildlife populations. Other soil characteristics, such as slope, permeability, and drainage, determine the potential of natural wet areas for waterfowl habitat or for construction of ponds for fish. This combination of plant cover and specific soil characteristics allows identification of three general types of wildlife habitat in Plymouth County: woodland, wetland, and open-land. Other factors such as disease, extreme weather conditions, predation, and hunting pressure affect wildlife populations; therefore, good wildlife habitat is not a guarantee of an abundant wildlife population.

Table 3 describes the potential of soils in Plymouth County to produce seven elements of wildlife habitat and three kinds of wildlife.

The occurrence of kinds of wildlife can generally be described according to soil associations, which are shown on the general soil map. The Ida-Hamburg association in the southwestern part of the county is the most productive of white-tailed deer. Deer are also produced on the Kennebec-Radford-Colo association where the timber has not been removed. An estimated 294 deer are present in the county. Pheasant are not abundant in the county; however, most are produced on the Galva and the Kennebec-Radford-Colo associations, which are the most intensively farmed. Waterfowl are abundant in the county, mainly along the Big Sioux River in the Kennebec-Radford-Colo association. Plymouth County is within the Missouri River waterfowl flyway; farm ponds in the county provide rest areas during spring and fall migrations. Fox squirrels are common but not abundant in the timbered areas of the Ida-Hamburg and Ida-Monona associations. Cottontail rabbits are found throughout the county in grass or weed cover as found along road ditches and fences. Hay land, especially in the Ida-Galva and Galva-Ida associations, provides important nesting cover. Farm ponds stocked with largemouth bass, channel catfish, or both, provide good fish production if fish are harvested regularly.

Engineering Uses of the Soils [4]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 4, 5, and 6, which show, respectively, several estimated soil properties significant to engineering, interpretations for various engineering uses, and results of laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations and other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 5 feet. Also, inspection of sites is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The "Glossary" defines many of these terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system, used by the SCS engineers. The Department of Defense (*19*), and others, and the AASHO system, adopted by the American Association of State Highway Officials (*1*).

The Unified system classifies soils according to engineering uses for building material or for the support of structures other than highways. Soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-

[3] By BILL D. WELKER, biologist, Soil Conservation Service.
[4] VOLNEY H. SMITH, assistant State conservation engineer, Soil Conservation Service, assisted in the preparation of this section.

grained soils that are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of content of organic-matter and nonplastic fines. They are CL, CH, ML, OL, MH, and OH. There is one class of highly organic soils, Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example CL–ML.

The AASHO system classifies soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups, ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6.

As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 6; the estimated classification, without group index numbers, is given in table 4 for all soils mapped in the survey area.

Soil properties significant in engineering

Estimates of several soil properties significant in engineering are given in table 4. These estimates are made by layers that have significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 4.

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

Soil texture is described in table 4 in the standard terms used by the Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in soil material smaller than 2 millimeters. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the "Glossary" of this soil survey.

The percentage passing sieves, shown on table 4, is the normal range of soil particles passing the respective screen sizes.

Liquid limit and plasticity index are water contents obtained by specified operations. As the water content of a clayey soil from which the particles coarser than 0.4 millimeter have been removed is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; and the liquid limit from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 4, but in table 6 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability, as used here, is an estimate of the rate at which saturated soil would transmit water in a vertical direction under a unit head of pressure. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or much transient soil features as plowpans and surface crusts are not considered.

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

Reaction refers to the acidity or alkalinity of a soil, expressed as pH for a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the "Glossary."

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils may damage building foundations, roads, and other structures. Soil that have a *high* shrink-swell potential are the most hazardous.

Depth to bedrock is omitted from table 4. In most places in the county the bedrock is buried by many feet of unconsolidated soil material. The only exception is along the edge of the Big Sioux River Valley, where there are outcrops of limestone, sandstone, and shale of Cretaceous age. Almost all of the outcrops are in areas of Steep rock land or Rough broken land. A few outcrops are present in the Ida, Hamburg, and Steinauer soils in that area.

Engineering interpretations of the soils

The interpretation in table 5 are based on the engineering properties of soils shown in table 4, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Plymouth County. In table 5, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for ponds and reservoirs, embankments, drainage for crops and pasture, irrigation, and terraces and diversions. For these particular uses, table 5 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight*, *moderate*, and *severe*. *Slight* means soil properties gen-

TABLE 3.—*Suitability of the soils for elements*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees and shrubs
Albaton: 156	Fair	Fair	Fair	Fair
Calco: 733	Good to fair	Good to fair	Good to fair	Fair
Castana:				
3F	Poor	Fair	Good	Good
14D	Fair	Fair	Good	Good
983D	Poor	Poor	Good	Good
Colo: 133, 133+	Good to fair	Good to fair	Good to fair	Fair
Dickman: 28B	Fair	Good to fair	Good to fair	Fair
Galva:				
310B, T310, T310B	Good	Good	Good	Good
310C2, 310D2	Fair	Good	Good	Good
317C2	Fair	Good	Good	Fair
Graceville: 116, 116B	Good	Good	Good	Good
Hamburg: 2G	Very poor	Poor	Fair	Poor
Ida:				
1B3	Good	Good	Good	Good
1C3, 1D3	Fair	Good to fair	Good	Fair
1E3	Poor	Fair	Good	Fair to poor
1F3	Poor	Fair	Good	Poor
1G3	Very poor	Fair to poor	Good	Poor
114D3	Fair	Fair	Good	Fair
Kennebec:				
19B, 26, 212, 212B	Good	Good	Good	Good
C212	Poor	Poor	Fair	Good
Luton: 66	Fair	Fair	Fair	Fair
McPaul:				
18B	Good	Good	Good	Good
70	Good	Good	Good	Good
Modale, dark subsoil variant: 149	Good	Good	Good	Good
Monona:				
10B, T10B	Good	Good	Good	Good
10C2, 10D2	Fair	Good	Good	Fair
10E2	Poor	Fair	Good	Fair
Napier:				
12C	Fair	Good	Good	Good
170D	Fair	Good	Good	Good
717C	Poor	Poor	Good	Good
Omadi:				
189	Good	Good	Good	Good
609	Poor	Poor	Fair	Good
Primghar: 91B	Good	Good	Good	Good
Radford: 467, 467B	Good	Good	Good	Good
Rough broken land: 378	Very poor	Very poor	Fair	Fair
Salix: 36	Good	Good	Good	Good
Salix, leached subsoil variant: 607	Good	Good	Good	Good
Steep rock land: 478	Very poor	Very poor	Fair	Fair
Steinauer:				
33D3	Fair	Good	Good	Good
33E3	Poor	Fair	Good	Good
33F3	Very poor	Poor	Good	Good
Wadena: 108B	Good	Good	Good	Good

of wildlife habitat and kinds of wildlife

Elements of wildlife habitat—Continued			Kinds of wildlife		
Coniferous plants and shrubs	Wetland plants	Shallow water areas	Open-land	Woodland	Wetland
Poor	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Good to fair	Fair	Good.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Poor	Fair	Good	Poor.
Poor	Good	Good to fair	Good to fair	Fair	Good.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Very poor	Very poor	Very poor	Poor	Poor	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Poor	Very poor	Very poor	Fair	Fair	Very poor.
Very poor	Very poor	Very poor	Fair	Fair to poor	Very poor.
Very poor	Very poor	Very poor	Poor	Poor	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Fair	Fair	Fair	Poor	Fair	Fair.
Poor	Good	Good	Fair	Fair	Good.
Good	Poor	Poor	Good	Good	Poor.
Good	Fair	Fair	Good	Good	Fair.
Good	Fair	Fair	Good	Good	Fair.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Good to fair	Fair	Very poor.
Poor	Very poor	Very poor	Fair to poor	Fair	Very poor.
Good	Fair	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Poor	Fair	Good	Poor.
Good	Fair	Fair	Good	Good	Fair.
Fair	Fair	Fair	Poor	Fair	Fair.
Good	Fair to poor	Poor	Good	Good	Poor.
Good	Fair to poor	Poor	Good	Good	Poor.
Poor	Very poor	Very poor	Poor	Fair	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Poor	Good	Good	Poor.
Poor	Very poor	Very poor	Poor	Fair	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Poor	Good to fair	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.

TABLE 4.—*Estimated soil properties*

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

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHO
	Feet	*Inches*			
Albaton: 156	[1] 1–3	0–42 42–60	Silty clay or clay ([2])	CH ([2])	A–7–6 or A–7–5 ([2])
Alluvial land Mapped only in a complex with Omadi soils.	[1] 1–3	0–60	([2])	([2])	([2])
Calco: 733	[1] 1–3	0–60	Silty clay loam	CL, CH or OH	A–7–5 or A–7–6
Castana:					
14D	[1] 5	0–15 15–60	Loam Silt loam	CL–ML, ML, or CL CL–ML, ML, or CL	A–4 or A–6 A–4 or A–6
3F, 983D Gullied land part of 983D is too variable to rate.	> 5	0–60	Silt loam	CL–ML, ML, or CL	A–4 or A–6
Colo:					
133	[1] 1–3	0–60	Silty clay loam	CL, CH or OH	A–7–5 or A–7–6
133+	[1] 1–3	0–10 10–60	Silt loam Silty clay loam	CL–ML, ML, or CL OH, CH, or CL	A–4 or A–6 A–7–6 or A–7–5
Dickman: 28B	> 5	0–14 14–60	Sandy loam or fine sandy loam. Loamy sand	SM, SM–SC, or SC SP–SM	A–2–4 or A–4 A–1 or A–3
*Galva: 310B, 310C2, 310D2, T310, T310B, 317C2. For Wadena part of 317C2, see Wadena series.	> 5	0–12 12–27 27–60	Medium or heavy silty clay loam. Silty clay loam Light silty clay loam or silt loam.	CH, MH, CL, or ML CL or CH ML or CL	A–7–6 A–7–6 A–6 or A–7–6
Graceville: 116, 116B	> 5	0–27 27–46 46–60	Heavy silt loam or light silty clay loam. Loam or sandy loam Gravel	ML or CL CL SM–SP	A–7–6 A–6 A–1–a, A–1–b, or A–2–4
Gullied land. Mapped only in complexes with Castana and Napier soils. Material is too variable to rate.					
Hamburg: 2G	>10	0–60	Silt loam	ML or ML–CL	A–4
*Ida: 1B3, 1C3, 1D3, 1E3, 1F3, 1G3, 114D3. For Wadena part of 114D3, see Wadena series.	>10	0–60	Silt loam	ML or CL	A–4 or A–6
*Kennebec: 19B, 26, 212, 212B, C212. For McPaul part of 19B, see McPaul series.	[1] 3–5	0–60	Silt loam or light silty clay loam.	CL or ML	A–6 or A–7–6
Luton: 66	[1] 1–3	0–19 19–60	Silty clay or clay Silty clay or clay	CH or OH CH	A–7–5 or A–7–6 A–7–5 or A–7–6
*McPaul: 18B, 70 For Kennebec part of 18B, see Kennebec series.	[1] 3–5	0–60	Silt loam	CL or ML	A–4 or A–6

significant to engineering

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

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	
100	100	95–100	95–100	60–85	30–55	0.2	0.11–0.13	7.4–8.4	High.
100	100	90–100	([2])	([2])	([2])	([2])	([2])	7.4–8.4	([2]).
100	100	80–100	([2])	([2])	([2])	([2])	([2])	6.6–8.4	([2]).
100	100	95–100	90–100	41–60	15–30	0.2–0.6	0.19–0.22	7.4–8.4	High.
90–100	85–95	75–85	50–75	25–40	5–20	0.6–2.0	0.20–0.22	7.4–8.4	Low to moderate.
95–100	90–95	85–90	80–90	25–40	5–20	0.6–2.0	0.20–0.22	7.9–8.4	Low to moderate.
100	100	95–100	95–100	25–40	5–20	0.6–2.0	0.21–0.23	7.4–8.4	Low to moderate.
100	100	95–100	95–100	41–60	15–30	0.2–0.6	0.19–0.22	6.1–7.3	High.
100	100	98–100	95–100	25–40	5–20	0.6–2.0	0.21–0.23	7.4–8.4	Moderate.
100	100	98–100	96–100	41–60	15–30	0.2–0.6	0.19–0.22	6.1–7.3	High.
95–100	90–100	55–75	20–40	20–30	2–10	2.0–6.0	0.14–0.16	6.1–7.3	Low.
95–100	90–100	30–60	5–10	[3] NP	[3] NP	6.0–20.0	0.07–0.09	6.1–8.4	Low.
100	100	95–100	90–100	41–55	15–25	0.6–2.0	0.21–0.23	5.6–7.3	Moderate to high.
100	100	95–100	90–100	41–55	15–30	0.6–2.0	0.18–0.20	6.1–7.3	Moderate to high.
100	100	95–100	90–100	35–45	15–25	0.6–2.0	0.20–0.22	6.6–8.4	Moderate.
95–100	90–100	85–95	80–90	41–50	11–20	0.6–2.0	0.21–0.23	6.1–7.3	Moderate to high.
95–100	90–100	75–85	55–70	25–40	11–20	0.6–2.0	0.15–0.17	6.1–7.3	Moderate.
50–60	20–40	10–30	2–8	NP	NP	>20.0	0.02–0.04	7.4–8.4	Very low.
100	100	95–100	90–100	25–35	5–10	0.6–2.0	0.20–0.22	7.4–8.4	Low.
100	100	95–100	90–100	30–40	5–15	0.6–2.0	0.20–0.22	7.4–8.4	Low.
100	100	95–100	90–100	30–50	11–25	0.6–2.0	0.21–0.23	6.1–7.8	Moderate.
100	100	95–100	90–100	60–85	35–60	<0.2	0.12–0.14	6.6–7.3	High.
100	100	95–100	90–100	60–85	35–60	<0.2	0.11–0.13	6.6–8.4	High.
100	100	95–100	90–100	30–40	5–15	0.6–2.0	0.21–0.23	7.4–8.4	Moderate.

TABLE 4.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHO
	Feet	*Inches*			
Modale, dark subsoil variant: 149.	[1] 1-3	0-26	Silt loam	ML or CL	A-6 or A-7-6
		26-60	Silty clay or clay	CH	A-7-5 or A-7-6
Monona: 10B, 10C2, 10D2, 10E2, T10B.	>10	0-40	Silt loam	ML or CL	A-7-6
		40-60	Silt loam	ML or CL	A-6 or A-7-6
*Napier: 12C, 170D, 717C. For Castana part of 170D, see Castana series. Gullied land part of 717C is too variable to rate.	[1] > 5	0-60	Silt loam	ML or CL	A-7-6 or A-6
*Omadi: 189, 609. For Alluvial land part of 609, see Alluvial land.	[1] 3-5	0-60	Stratified; dominantly silt loam.	ML or CL	A-4 or A-6
Primghar: 91B	[1] 2-4	0-19	Silty clay loam	OH, MH, or OL	A-7-5 or A-7-6
		19-60	Silty clay loam or silt loam	CL	A-6 or A-7-6
Radford: 467, 467B	[1] 1-3	0-60	Silty clay loam	CL or ML	A-6 or A-7-6
Rough broken land: 378	>10	0-60	(2)	(2)	(2)
Salix: 36	[1] 3-5	0-29	Light silty clay loam	CL	A-6 or A-7-6
		29-60	Silty clay loam	CL or ML	A-6 or A-7-6
Salix, leached subsoil variant: 607.	[1] 3-5	0-17	Light silty clay loam	CL	A-6 or A-7-6
		17-43	Silty clay loam	CL or ML	A-6 or A-7-6
		43-60	Silt loam	CL or ML	A-6
Steep rock land: 478	>10	0-60	(2)	(2)	(2)
Steinauer: 33D3, 33E3, 33F3	>10	0-60	Clay loam	CL	A-6 or A-7
Wadena: 108B	> 5	0-24	Loam	ML-CL, CL, or ML	A-4 or A-6
		24-60	Light sandy loam to sand and gravel.	SP-SM, SM, or SP	A-1-6 or A-3

[1] Susceptible to flooding or to runoff from upslope.
[2] Too variable to be estimated.
[3] Nonplastic.

erally are favorable for the rated use, or in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special design, or intensive maintenance.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of the columns in table 5:

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 5 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope; and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the em-

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	
100	100	95–100	90–100	30–50	11–20	0.6–2.0	0.21–0.23	6.6–7.8	Moderate.
100	100	95–100	90–100	60–85	40–60	<0.2	0.11–0.13	7.4–8.4	High.
100	100	95–100	90–100	41–50	15–30	0.6–2.0	0.20–0.23	6.1–8.4	Moderate.
100	100	95–100	90–100	35–45	11–20	0.6–2.0	0.20–0.23	7.4–8.4	Moderate.
100	100	95–100	90–100	30–50	11–25	0.6–2.0	0.21–0.23	6.1–7.8	Moderate.
100	100	95–100	90–100	30–40	5–15	0.6–2.0	0.21–0.23	7.4–8.4	Low to moderate.
100	100	95–100	90–100	45–60	20–35	0.2–0.6	0.21–0.23	6.1–7.3	High.
100	100	95–100	90–100	35–50	15–30	0.2–0.6	0.19–0.21	6.6–8.4	Moderate to high.
100	100	95–100	96–100	35–50	15–30	0.2–0.6	0.19–0.21	6.1–7.3	High.
([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	6.6–8.4	([2])
100	100	95–100	90–100	35–50	20–30	0.6–2.0	0.19–0.22	6.6–7.8	Moderate to high.
100	100	95–100	90–100	35–50	15–25	0.6–2.0	0.18–0.20	7.4–8.4	Moderate to high.
100	100	95–100	90–100	35–50	20–30	0.6–2.0	0.21–0.23	6.1–7.4	Moderate to high.
100	100	95–100	90–100	35–50	15–25	0.6–2.0	0.18–0.20	6.6–7.8	Moderate to high.
100	100	95–100	90–100	25–40	11–25	0.6–2.0	0.20–0.22	7.9–8.4	Low to moderate.
([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	6.6–8.4	([2])
95–100	85–95	80–95	55–75	30–45	15–25	0.2–0.6	0.16–0.18	7.4–8.4	Moderate.
95–100	95–100	65–85	55–70	25–40	5–15	2.0–6.0	0.19–0.21	6.1–7.3	Low to moderate.
50–90	40–60	35–55	3–10	NP	NP	>20.0	0.05–0.07	7.4–8.4	Low.

bankment material as interpreted from the Unified soil classification and the amount of stones, if any, which influences the ease of excavation and compaction of the embankment material.

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

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 5 apply only to a depth of about 6 feet, and therefore a limitation rating of *slight* or *moderate* may not be valid for deeper trenches. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless, every site should be investigated before it is selected.

Local roads and streets, as rated in table 5, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly of asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity

TABLE 5.—*Interpretations of*

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

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
Albaton: 156	Severe: very slow to slow permeability; unsatisfactory percolation rate; seasonal high water table; subject to flooding where not protected.	Generally slight: seasonal high water table but more than 2 feet of very slowly to slowly permeable material in upper part. Severe where subject to flooding.	Severe: poorly drained; seasonal high water table; clayey surface layer.	Severe: seasonal high water table; poorly drained; subject to flooding unless protected; clayey.	Severe: poorly drained; subject to flooding if not protected; high shrink-swell potential.	Poor: high shrink-swell potential; poorly drained.
Alluvial land: Mapped only in a complex with Omadi soils.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Poor to good: varies from place to place.
Calco: 733	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; high organic-matter content; subject to flooding.	Severe: poorly drained; seasonal high water table; subject to flooding.	Severe: seasonal high water table; poorly drained; subject to flooding.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; poorly drained.
*Castana: 3F, 14D, 983D. For Gullied land part of 983D, see Gullied land.	Severe: slopes of 9 to 30 percent.	Severe: moderate permeability; slopes of 9 to 30 percent.	Moderate where slopes are less than 14 percent, severe where slopes are more than 14 percent.	Moderate to severe: subject to runoff from high-lying areas; slopes of 9 to 30 percent.	Moderate to severe: slopes of 9 to 30 percent; low to moderate shrink-swell potential.	Fair: low to moderate shrink-swell potential; slopes of 9 to 30 percent.

engineering properties of the soils

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the that appear in the first column of the table]

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Poor: high clay content; low organic-matter content; poorly drained.	Slopes of 0 to 1 percent; very slow to slow permeability; seasonal high water table.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility; high shrink-swell potential.	Very slow to slow permeability; clayey; seasonal high water table; subject to flooding in places.	Slopes of 0 to 1 percent; poorly drained; seasonal high water table; moderate available water capacity; intake rate of 0.10 acre-inch per hour.[1]	Slopes of 0 to 1 percent.
Poor: possibility of small areas of sand.	Fair to poor: low organic-matter content.	Slopes of 0 to 2 percent.	Varies from place to place but dominantly fair stability; fair compaction characteristics; moderate permeability when compacted; medium to high compressibility; piping hazard.	Natural drainage adequate in most places; subject to flooding.	Slopes of 0 to 2 percent; characteristics vary from place to place; dominantly well drained; high available water capacity; intake rate of 0.30 acre-inch per hour.	Slopes of 0 to 2 percent.
Unsuitable	Poor: moderately high clay count; poorly drained.	Slopes of 0 to 2 percent; moderately slow permeability; seasonal high water table.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility; high shrink-swell potential; high organic-matter content.	Moderately slow permeability; seasonal high water table; subject to flooding.	Slopes of 0 to 2 percent; poorly drained; seasonal high water table; high to very high available water capacity; intake of 0.20 acre-inch per hour.	Slopes of 0 to 2 percent.
Unsuitable	Fair: slopes of 9 to 30 percent.	Slopes of 9 to 30 percent; moderate permeability.	Fair stability; fair compaction characteristics; low to moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 9 to 30 percent; hazard of erosion; very high available water capacity; intake rate of 0.35 acre-inch per hour.	Short, straight slopes of 9 percent; moderate permeability makes level terraces feasible; hazard of erosion and siltation; low fertility in disturbed areas.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
Colo: 133, 133+	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; high organic-matter content; subject to flooding.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; subject to flooding.	Severe: seasonal high water table; poorly drained; subject to flooding.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; poorly drained.
Dickman: 28B	Slight [2]	Severe: rapid permeability.	Severe: dominantly loamy sand.	Severe: rapid permeability; sandy.	Slight	Good
*Galva: 310B, 310C2, 310D2, T310, T310B, 317C2. For Wadena part of 317C2, see Wadena series.	Slight to moderate: moderate permeability; slopes of 0 to 14 percent.	Moderate to severe: moderate permeability; slopes of 0 to 14 percent; moderate to high organic-matter content.	Slight where slopes are less than 9 percent, moderate where slopes are more than 9 percent.	Slight to moderate: slopes of 0 to 14 percent.	Moderate: slopes of 0 to 14 percent; moderate to high shrink-swell potential.	Fair: moderate to high shrink-swell potential; slopes of 0 to 14 percent; fair to poor bearing capacity.
Graceville: 116, 116B.	Slight [2]	Severe: very rapid permeability in substratum below a depth of about 4 feet; moderate to high organic-matter content.	Slight to moderate; gravel at a depth of about 4 feet.	Moderate: very rapid permeability in substratum below a depth of about 4 feet; sandy or gravelly substratum.	Moderate: moderate to high shrink-swell potential.	Fair: moderate to high shrink-swell potential.
Gullied land. Mapped only in complexes with Castana and Napier soils.	([3])	([3])	([3])	([3])	([3])	([3])

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Poor: moderately high clay content; poorly drained.	Slopes of 0 to 2 percent; moderately slow permeability; seasonal high water table.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility; high shrink-swell potential; high organic-matter content.	Moderately slow permeability; seasonal high water table; subject to flooding.	Slopes of 0 to 2 percent; poorly drained; seasonal high water table; high to very high available water capacity; intake rate of 0.20 acre-inch per hour.	Slopes of 0 to 2 percent.
Poor to fair for sand.	Poor: high sand content; moderately low organic-matter content.	Slopes of 2 to 9 percent; rapid permeability.	Good stability; fair to good compaction characteristics; moderate to high permeability when compacted; slight compressibility; piping hazard.	Natural drainage adequate.	Slopes of 2 to 9 percent; hazard of soil blowing; low available water capacity; intake rate of 0.50 acre-inch per hour.	Short, irregular slopes of 2 to 9 percent; sandy material; hazard of erosion and siltation; low fertility in disturbed areas.
Unsuitable	Fair: moderately high clay content; slopes of 0 to 14 percent.	Slopes of 0 to 14 percent; moderate permeability.	Fair to poor stability; fair to poor compaction characteristics; low to moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 0 to 14 percent; erosion hazard; high to very high available water capacity; intake rate of 0.30 acre-inch per hour.	Long, regular convex slopes of 0 to 14 percent; moderate permeability makes level terraces feasible; hazard of erosion and siltation.
Good: sand or gravel at a depth of about 4 feet.	Good	Slopes of 0 to 5 percent; moderate permeability; gravel or sand at a depth of about 4 feet.	Fair stability; fair compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 0 to 5 percent; high available water capacity; intake rate of 0.30 acre-inch per hour; sand or gravel at a depth of about 4 feet.	Slopes of 0 to 5 percent; convex slightly elevated positions on stream benches; gravel or sand at a depth of about 4 feet.
Unsuitable	(3)	(3)	(3)	Natural drainage adequate.	(3)	(3).

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
Hamburg: 2G	Severe: slopes of 30 to 75 percent.	Severe: moderate permeability; slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.	Poor: slopes of 30 to 75 percent.
*Ida: 1B3, 1C3, 1D3, 1E3, 1F3, 1G3, 114D3. For Wadena part of 114D3, see Wadena series.	Slight to severe: slopes of 2 to 10 percent; satisfactory percolation rate.	Severe: moderate permeability; slopes of 2 to 40 percent.	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent.	Slight to severe: slopes of 2 to 40 percent.	Slight to severe: slopes of 2 to 40 percent.	Good to poor: slopes of 2 to 40 percent; fair to poor bearing capacity; medium compressibility; low shrink-swell potential.
*Kennebec: 19B, 26, 212, 212B, C212. For McPaul part of 19B, see McPaul series.	Severe: moderate permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; moderate permeability; high organic-matter content; subject to flooding.	Moderate to severe: seasonal water table at a depth of 3 to 5 feet; subject to flooding.	Severe: seasonal high water table; subject to flooding or to runoff from high-lying areas.	Severe: subject to flooding; moderate shrink-swell potential.	Fair: moderate shrink-swell potential.
Luton: 66	Severe: very slow to slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; high organic-matter content; subject to flooding.	Severe: poorly drained to very poorly drained; water table at a depth of 1 to 3 feet; clayey.	Severe: seasonal high water table; poorly drained; subject to flooding; clayey.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; poorly drained.

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Poor: low organic-matter content; slopes of 30 to 75 percent.	Slopes of 30 to 75 percent; moderate permeability but approaches moderately rapid.	Poor stability; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 30 to 75 percent; hazard of erosion; high to very high available water capacity; intake rate of 0.35 acre-inch per hour.[4]	Short, irregular, convex slopes of 30 to 75 percent; moderate permeability makes level terraces feasible; hazard of erosion and siltation; low fertility in disturbed areas; generally, construction feasible only at base of slope.
Unsuitable	Poor: low organic-matter content; slopes of 2 to 40 percent.	Slopes of 2 to 40 percent; moderate permeability.	Poor stability; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 2 to 40 percent; hazard of erosion; very high available water capacity; intake rate of 0.35 acre-inch per hour.[4]	Short, irregular, convex slopes of 2 to 40 percent; moderate permeability makes level terraces feasible; hazard of erosion and siltation; low fertility in disturbed areas.
Unsuitable	Good	Slopes of 0 to 5 percent; moderate permeability; seasonal high water table.	Fair stability; fair compaction characteristics; moderate permeability when compacted; medium to high compressibility; piping hazard; high organic-matter content.	Natural drainage adequate; seasonal high water table; subject to flooding.	Slopes of 0 to 5 percent; very high available water capacity; intake rate of 0.30 acre-inch per hour.	Slopes of 0 to 5 percent; gently sloping soils are on foot slopes at base of steeper soils; moderate permeability makes level terraces feasible; hazard of erosion and siltation.
Unsuitable	Poor: high clay content; poorly drained.	Slopes of 0 to 1 percent; very slow permeability; seasonal high water table.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility; high shrink-swell potential; high organic-matter content.	Very slow to slow permeability; clayey; seasonal high water table; subject to flooding.	Slopes of 0 to 1 percent; poorly drained; seasonal high water table; moderate available water capacity; intake rate of 0.10 acre-inch per hour.	Slopes of 0 to 1 percent.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
*McPaul: 18B, 70. For Kennebec part of 18B, see Kennebec series.	Severe: subject to flooding.	Severe: moderate permeability; subject to flooding.	Slight where protected from flooding; slopes of 0 to 5 percent; silt loam.	Severe: subject to flooding or to run-off from high-lying areas.	Severe: subject to flooding; moderate shrink-swell potential.	Fair: moderate shrink-swell potential.
Modale, dark subsoil variant: 149.	Severe: very slow to slow permeability below a depth of about 2 feet; seasonal high water table; subject to flooding.	Severe: seasonal high water table; subject to flooding.	Severe: moderately well drained to somewhat poorly drained; some areas subject to flooding; seasonal water table at a depth of 1 to 3 feet.	Severe: seasonal high water table; moderately well drained to somewhat poorly drained; subject to flooding; clayey below a depth of about 2 feet.	Severe: moderately well drained to somewhat poorly drained; subject to flooding; moderate shrink-swell potential in upper 2 feet, high below that depth.	Poor: high shrink-swell potential in material below a depth of about 2 feet; moderately well drained to somewhat poorly drained.
Monona: 10B, 10C2, 10D2, 10E2, T10B.	Slight to severe: slopes of 0 to 20 percent.	Moderate to severe: moderate permeability; slopes of 0 to 20 percent; moderately low or moderate organic-matter content.	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent.	Slight to severe: slopes of 0 to 20 percent.	Moderate to severe: slopes of 0 to 20 percent; moderate shrink-swell potential.	Fair: moderate shrink-swell potential; slopes of 0 to 20 percent.
*Napier: 12C, 170D, 717C. For Castana part of 170D and for Gullied land part of 717C, see Castana series and Gullied land, respectively.	Slight to moderate: slopes of 2 to 14 percent.	Moderate to severe: moderate permeability; slopes of 2 to 14 percent; high organic-matter content.	Slight where slopes are less than 9 percent, moderate where slopes are more than 9 percent.	Slight to moderate: subject to run-off from high-lying areas; slopes of 2 to 14 percent.	Moderate: slopes of 2 to 14 percent; moderate shrink-swell potential.	Fair: moderate shrink-swell potential.

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Fair: low organic-matter content.	Slopes of 0 to 5 percent; moderate permeability.	Poor stability; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate; subject to draining.	Slopes of 0 to 5 percent; very high available water capacity; intake rate of 0.35 acre-inch per hour.[4]	Slopes of 0 to 5 percent; gently sloping soils are on foot slopes at base of steeper soils; moderate permeability makes level terraces feasible; low fertility in disturbed areas.
Unsuitable	Fair: low organic-matter content.	Slopes of 0 to 2 percent; moderate permeability in upper part, very slow to slow below a depth of about 2 feet; seasonal high water table.	Fair stability; fair compaction characteristics; low permeability when compacted; medium to high compressibility.	Natural drainage adequate; seasonal high water table; subject to flooding.	Slopes of 0 to 2 percent; moderately well drained to somewhat poorly drained; seasonal high water table; intake rate of 0.35 acre-inch per hour.[4]	Slopes of 0 to 2 percent.
Unsuitable	Good to fair: moderately low to moderate organic-matter content; slopes of 0 to 20 percent.	Slopes of 0 to 20 percent; moderate permeability.	Poor stability; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate.	Slopes of 0 to 20 percent; hazard of erosion; very high available water water capacity intake rate of 0.35 acre-inch per hour.	Short, irregular, convex slopes of 0 to 20 percent; moderate permeability makes level terraces feasible; hazard of erosion and siltation; low fertility in disturbed areas.
Unsuitable	Fair: slopes of 2 to 14 percent.	Slopes of 2 to 14 percent; moderate permeability.	Fair stability; fair compaction characteristics; moderate permeability when compacted; medium to high compressibility; piping hazard; high organic-matter content.	Natural drainage adequate.	Slopes of 2 to 14 percent; hazard of erosion; very high available water capacity; intake rate of 0.35 acre-inch per hour.	Short, straight slopes of 2 to 14 percent on foot slopes make level terraces feasible; hazard of erosion and siltation.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
*Omadi: 189, 609. For Alluvial land part of 609, see Alluvial land.	Severe: subject to flooding.	Severe: moderate permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; moderate shrink-swell potential.	Fair: moderate shrink-swell potential.
Primghar: 91B	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; high organic-matter content; subject to flooding.	Severe: somewhat poorly drained; seasonal water table at a depth of 2 to 4 feet.	Severe: seasonal high water table; somewhat poorly drained; subject to flooding or to runoff from high-lying areas.	Severe: somewhat poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; somewhat poorly drained.
Radford: 467, 467B.	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; moderate to high organic-matter content; subject to flooding.	Severe: somewhat poorly drained; seasonal water table at a depth of 1 to 3 feet; subject to flooding.	Severe: seasonal high water table; somewhat poorly drained; subject to flooding or to runoff from high-lying areas.	Severe: somewhat poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; somewhat poorly drained.
Rough broken land: 378.	Severe: slopes of 25 to 50 percent.	Severe: slopes of 25 to 50 percent.	Severe: slopes of 25 to 50 percent.	Severe: seasonal high water table; somewhat poorly drained; subject to flooding or to runoff from high-lying areas.	Severe: somewhat poorly drained; subject to flooding; high shrink-swell potential.	Poor: high shrink-swell potential; somewhat poorly drained.

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Fair: moderately low or low organic-matter content.	Slopes of 0 to 2 percent; moderate permeability.	Poor stability; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard.	Natural drainage adequate; subject to flooding.	Slopes of 0 to 2 percent; very high available water capacity; intake rate of 0.35 acre-inch per hour.	Slopes of 0 to 2 percent.
Unsuitable	Fair: moderately high clay content.	Slopes of 2 to 5 percent; moderately slow permeability; seasonal high water table.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility.	Moderately slow permeability; seasonal high water table; subject to flooding or runoff from high-lying areas.	Slopes of 2 to 5 percent; somewhat poorly drained; seasonal high water table; high to very high available water capacity; intake rate of 0.30 acre-inch per hour.	Short, concave slopes of 2 to 5 percent; most areas in waterways; hazard of wetness in channels.
Unsuitable	Fair: moderately high clay content.	Slopes of 0 to 5 percent; moderately slow permeability; seasonal high water table; difficult to compact.	Fair to poor stability; fair to poor compaction characteristics; low permeability when compacted; high compressibility; high shrink-swell potential.	Moderately slow permeability; seasonal high water table; subject to flooding or to runoff from high-lying areas.	Slopes of 0 to 5 percent; somewhat poorly drained; seasonal high water table; very high available water capacity; intake rate of 0.30 acre-inch per hour.	Slopes of 0 to 5 percent; gently sloping soils in waterways; hazard of wetness in channels.
Unsuitable	Poor: slopes of 25 to 50 percent.	Slopes of 25 to 50 percent; dominantly moderate permeability; bedrock outcrops in places.	Dominantly poor stability, but varies from place to place; poor compaction characteristics; moderate permeability when compacted; medium compressibility; piping hazard; bedrock outcrops in places.	Natural drainage adequate.	Slopes of 25 to 50 percent; bedrock outcrops in places; hazard of erosion.	Slopes of 25 to 50 percent; irregular; bedrock outcrops in places.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for— Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets	Road fill
Salix: 36	Severe: subject to flooding; seasonal water table at a depth of 3 to 5 feet.	Severe: moderate permeability; high organic-matter content; subject to flooding.	Moderate: moderately well drained; seasonal water table at a depth of 3 to 5 feet.	Severe: subject to flooding.	Severe: subject to flooding; moderate shrink-swell potential.	Fair: moderate shrink-swell potential; fair to poor bearing capacity; fair to poor compaction characteristics.
Salix, leached subsoil variant: 607.	Slight unless subject to flooding; seasonal water table at a depth of 3 to 5 feet.	Moderate where protected from flooding; moderate permeability.	Moderate: seasonal water table at a depth of 3 to 5 feet; subject to infrequent flooding.	Slight to moderate: seasonal water table at a depth of 3 to 5 feet.	Severe: moderate or high shrink-swell potential; high susceptibility to frost action.	Poor: moderate to high shrink-swell potential; fair to poor bearing capacity; fair to poor compaction characteristics.
Steep rock land: 478.	Severe: steep and very steep slopes.	Severe: steep and very steep slopes.	Severe: slopes of 30 to 75 percent.	Severe: steep and very steep slopes; bedrock at a depth of less than 40 inches.	Severe: steep and very steep slopes.	Poor: steep and very steep slopes.
Steinauer: 33D3, 33E3, 33F3.	Severe: moderately slow permeability; slopes of 5 to 40 percent.	Severe: slopes of 5 to 40 percent.	Moderate where slopes are less than 14 percent, severe where slopes are more than 14 percent; clay loam; some stones.	Moderate to severe: slopes of 5 to 40 percent.	Moderate to severe: slopes of 5 to 40 percent; moderate shrink-swell potential.	Fair to poor: moderate shrink-swell potential; slopes of 5 to 40 percent; good bearing capacity; fair to good compaction characteristics.
Wadena: 108B	Slight [2]	Severe: moderately rapid permeability in upper part, very rapid below a depth of about 2 or 3 feet; moderate organic-matter content; sand and gravel in substratum too porous to hold water.	Severe: sand and gravel below a depth of about 2 feet.	Severe: moderately rapid permeability to a depth of about 2 feet, very rapid below that depth; sandy or gravelly substratum.	Slight to moderate: moderate shrink-swell potential in upper 2 feet, low below that depth.	Good: good bearing capacity and shear strength.

[1] Cracks develop in this soil as it dries, and intake rate is much greater until the cracks close.
[2] In places where permeability of the underlying material is rapid or very rapid, pollution is a hazard.

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuitable	Fair to good: friable silty clay loam.	Slopes of 0 to 2 percent; moderate permeability.	Fair stability; fair compaction characteristics; moderate permeability when compacted; medium to high compressibility; piping hazard; high organic-matter content.	Natural drainage adequate; subject to flooding.	Slopes of 0 to 2 percent; moderately well drained; high to very high available water capacity; intake rate of 0.30 acre-inch per hour.	Slopes of 0 to 2 percent.
Unsuitable	Fair to good: friable silty clay loam.	Slopes of 0 to 2 percent; moderate permeability; seasonal water table at a depth of 3 to 5 feet.	Fair stability; fair compaction characteristics; moderate permeability when compacted; medium to high compressibility; piping hazard; high organic-matter content.	Natural drainage adequate; subject to infrequent flooding.	Slopes of 0 to 2 percent; well drained; high to very high available water capacity; intake rate of 0.30 acre-inch per hour.	Slopes of 0 to 2 percent.
Unsuitable	Poor: steep and very steep slopes.	Steep and very steep slopes; bedrock at a depth of less than 40 inches.	Bedrock at a depth of less than 40 inches.	Natural drainage adequate.	Steep and very steep slopes; bedrock at a depth of less than 40 inches; hazard of erosion.	Steep and very steep slopes; bedrock at a depth of less than 40 inches.
Poor: possibility of small pockets of sand or gravel in places.	Fair to poor: moderately high clay content; some rocks low in organic-matter content; slopes of 5 to 40 percent.	Slopes of 5 to 40 percent; moderately slow permeability; possibility of sand or gravel pockets in places.	Fair to good stability; fair to good compaction characteristics; low permeability when compacted; medium to high compressibility.	Natural drainage adequate.	Slopes of 5 to 40 percent; hazard of erosion; high available water capacity; intake rate of 0.15 acre-inch per hour.	Convex slopes of 5 to 40 percent; level terraces sometimes pond water; hazard of erosion and siltation; low fertility in disturbed areas.
Good: overburden about 2 feet deep over sand and gravel.	Good	Slopes of 2 to 5 percent; moderately rapid permeability to a depth of about 2 feet; very rapid below that depth; gravel or sand below a depth of about 2 feet.	Good stability; fair to good compaction characteristics; high permeability when compacted; slight compressibility.	Natural drainage adequate.	Slopes of 2 to 5 percent; hazard of erosion; low to moderate available water capacity; intake rate of 0.35 acre-inch per hour; sand or gravel at a depth of about 2 feet.	Slopes of 2 to 5 percent; convex elevations on stream benches; sand or gravel at a depth of about 2 feet.

[3] For interpretations for Gullied land, see Castana and Napier series.
[4] Surface tends to seal which reduces intake rate.

TABLE 6.—*Engineering*

[Tests performed by the Iowa

Soil and location	Parent material	Report No. AAD6	Depth from surface	Horizon	Moisture-density[1]		Mechanical analysis[2]		
					Maximum dry density	Optimum moisture content	Percentage passing sieve—		
							No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)
			In.			*Pct.*			
Galva silty clay loam: NE¼NE¼, 30–91N–43a 66 feet W. and 46 feet S. of Coast and Geodetic Survey witness post. (Modal)	Wisconsin loess.	445	0–7	Ap	88	26	100	100	99
		446	12–27	B2t	93	24			100
		447	27–42	B3	94	21			100

[1] Based on AASHO Designation: T 99 (*1*).
[2] Mechanical analyses according to AASHO Designation: T 88 (*1*).

and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

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

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 5 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the material nor do they indicate quality of the deposit.

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

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

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

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

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

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

Test data

Table 6 contains engineering test data for a Galva soil in Plymouth County. These tests were made to help evaluate the soil for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

test data

State Highway Commission]

Mechanical analysis [2]—Continued							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued		Percentage smaller than—							AASHO [3]	Unified [4]
No. 100 (0.15 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm	0.001 mm				
							Pct			
99	98	91	64	41	34	29	44	20	A-7-6(13)	CL
100	99	93	66	43	37	31	48	24	A-7-6(15)	CL
100	100	90	58	37	31	27	42	22	A-7-6(13)	CL

[3] Based on AASHO Designation M 145-49 (*1*).
[4] Based on MIL-STD-619B (*19*).

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density.* As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Recreation

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 7 the soils of Plymouth County are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails.

In table 7 the soils are rated as having *slight, moderate,* or *severe* limitations for the specified uses. For all these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they can easily be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these, is required.

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

Picnic areas are attractive natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and do not have slopes or stoniness that greatly increases cost of leveling sites or of building access roads.

Playgrounds are used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or by horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded no more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Formation and Classification of the Soils

In this section the factors that affect the formation of the soils in Plymouth County are discussed, and the soil series are placed in the higher categories of the classification system.

TABLE 7.—*Use of the soils for recreational developments*

Soil series and map symbols	Degree of limitation and major features affecting use for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Albaton: 156	Severe: poorly drained; very slow to slow permeability; clayey surface layer; seasonal water table at a depth of 1 to 3 feet.	Severe: poorly drained; very slow to slow permeability; clayey surface layer; seasonal water table at a depth of 1 to 3 feet.	Severe: poorly drained; very slow to slow permeability; clayey surface layer; seasonal water table at a depth of 1 to 3 feet.	Severe: poorly drained; very slow to slow permeability; clayey surface layer; seasonal water table at a depth of 1 to 3 feet.
Calco: 733	Severe: poorly drained; subject to flooding; moderately slow permeability.	Severe: poorly drained; subject to flooding.	Severe: poorly drained; subject to flooding; moderately slow permeability.	Severe: poorly drained; subject to flooding; moderately slow permeability.
Castana:				
3F, 14D	Moderate where slopes are less than 14 percent, severe where slopes are more than 14 percent; well drained; moderate permeability.	Moderate where slopes are less than 14 percent, severe where slopes are more than 14 percent.	Severe: slopes of 5 to 30 percent.	Slight where slopes are less than 14 percent, moderate where slopes are more than 14 percent; well drained; silt loam surface layer.
983D. Ratings are for both parts of unit.	Severe: gullies dangerous.	Severe: gullies dangerous.	Severe: gullies dangerous.	Moderate: gullies dangerous.
Colo: 133, 133+	Severe: poorly drained; subject to flooding; moderately slow permeability.	Severe: poorly drained; subject to flooding.	Severe: poorly drained; subject to flooding; moderately slow permeability.	Severe: poorly drained; subject to flooding.
Dickman: 28B	Slight	Slight	Moderate: slopes of 2 to 9 percent.	Slight.
Galva:				
310B, 310C2, 310D2, T310, T310B.	Slight where slopes are less than 9 percent, moderate where slopes are more than 9 percent; well drained; moderate permeability; silty clay loam surface layer.	Slight where slopes are less than 9 percent, moderate where slopes are more than 9 percent; well drained; silty clay loam surface layer.	Slight where slopes are less than 2 percent, moderate where slopes are 2 to 5 percent, severe where slopes are more than 5 percent; well drained; moderate permeability; silty clay loam surface layer.	Slight: well drained; slopes of less than 14 percent; silty clay loam surface layer.
317C2. Ratings are for both parts of unit.	Moderate: slopes of 5 to 14 percent.	Moderate: slopes of 5 to 14 percent.	Severe: slopes of 5 to 14 percent.	Slight.
Graceville: 116, 116B	Slight	Slight	Slight where slopes are 0 to 2 percent; moderate where slopes are 2 to 5 percent.	Slight.
Hamburg: 2G	Severe: slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.	Severe: slopes of 30 to 75 percent.

TABLE 7.—*Use of the soils for recreational developments*—Continued

Soil series and map symbols	Degree of limitation and major features affecting use for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Ida: 1B3, 1C3, 1D3, 1E3, 1F3, 1G3	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent; well drained; moderate permeability; silt loam surface layer.	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent; well drained; silt loam surface layer.	Slight where slopes are less than 5 percent; severe where slopes are more than 5 percent; well drained; moderate permeability; silt loam surface layer.	Slight where slopes are less than 14 percent, moderate where slopes are 14 to 24 percent, severe where slopes are more than 24 percent; well drained; silt loam surface layer.
114D3. Ratings are for both parts of unit.	Moderate: slopes of 5 to 14 percent.	Moderate: slopes of 5 to 14 percent.	Severe: slopes of 5 to 14 percent.	Slight.
Kennebec: 26, 212, 212B, C212, 19B	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: subject to flooding.	Slight.
Ratings are for both parts of unit.	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: slopes of 2 to 5 percent; subject to flooding.	Moderate: subject to flooding.
Luton: 66	Severe: seasonal high water table; wet for long periods; very muddy and slippery when wet.	Severe: seasonal high water table; wet for long periods; very muddy and slippery when wet.	Severe: very muddy and slippery when wet; seasonal high water table; wet for long periods.	Severe: very muddy and slippery when wet; wet for long periods.
McPaul: 70	Slight if protected from flooding; well drained to moderately well drained; nearly level or gently sloping.	Slight if protected from flooding; well drained to moderately well drained; nearly level or gently sloping.	Slight if protected from flooding; well drained to moderately well drained; nearly level or gently sloping.	Slight if protected from flooding; well drained to moderately well drained; nearly level or gently sloping.
18B. Ratings are for both parts of unit.	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: slopes of 2 to 5 percent; subject to flooding.	Slight.
Modale, dark subsoil variant: 149.	Slight to moderate if protected from flooding; seasonal high water table.	Slight to moderate: seasonal high water table.	Slight to moderate: seasonal high water table.	Slight: seasonal high water table.
Monona: 10B, 10C2, 10D2, 10E2, T10B.	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent; well drained; moderate permeability; silt loam surface layer.	Slight where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent, severe where slopes are more than 14 percent; well drained; moderate permeability; silt loam surface layer.	Slight where slopes are 0 to 2 percent, moderate where slopes are 2 to 5 percent, severe where slopes are more than 5 percent; well drained; moderate permeability; silt loam surface layer.	Slight where slopes are less than 14 percent, moderate where slopes are more than 14 percent; well drained; silt loam surface layer.
Napier: 12C	Moderate to severe: subject to local runoff and short-duration flooding.	Slight to moderate where slopes are less than 9 percent, moderate where slopes are 9 to 14 percent; subject to local runoff and short-duration flooding.	Moderate where slopes are less than 5 percent, severe where slopes are more than 5 percent; wet for short periods; subject to local runoff and short-duration flooding.	Slight: wet for short periods.

TABLE 7.—*Use of the soils for recreational developments*—Continued

Soil series and map symbols	Degree of limitation and major features affecting use for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
170D. Ratings are for both parts of unit.	Moderate where slopes are 9 to 14 percent.	Moderate where slopes are 9 to 14 percent.	Severe where slopes are 9 to 14 percent.	Slight.
717C. Ratings are for both parts of unit.	Severe: gullies dangerous.	Severe: gullies dangerous.	Severe: gullies dangerous.	Moderate: gullies dangerous.
Omadi: 189, 609. Ratings are for both parts of unit 609.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.
Primghar: 91B	Moderate: somewhat poorly drained; seasonal water table at a depth of 2 to 4 feet; silty clay loam surface layer.	Moderate: somewhat poorly drained; seasonal water table at a depth of 2 to 4 feet; silty clay loam surface layer.	Moderate: somewhat poorly drained; seasonal water table at a depth of 2 to 4 feet; silty clay loam surface layer.	Moderate: somewhat poorly drained; seasonal water table at a depth of 2 to 4 feet; silty clay loam surface layer.
Radford: 467, 467B	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained; silty clay loam surface layer.
Rough broken land: 378	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.
Salix: 36	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate: possible flooding in some areas; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.
Salix, leached subsoil variant: 607.	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate if protected from flooding; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.	Slight to moderate: possible flooding in some areas; moderately well drained; moderate permeability; nearly level; silty clay loam surface layer.
Steep rock land: 478	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.	Severe: slopes of more than 25 percent.
Steinauer: 33D3, 33E3, 33F3	Moderate where slopes are 9 to 14 percent, severe where slopes are 14 to 30 percent.	Moderate where slopes are 9 to 14 percent, severe where slopes are 14 to 30 percent.	Severe where slopes are 9 to 30 percent.	Slight where slopes are 9 to 14 percent, moderate where slopes are 14 to 30 percent.
Wadena: 108B	Slight	Slight	Moderate: slopes of 2 to 5 percent.	Slight.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil formation have acted on the material.

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

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

Parent material

The soils of Plymouth County formed in loess, in alluvium, and in glacial drift. In addition, in the southwestern part of the county there are some outcrops of sandstone, limestone, and shale of Cretaceous age. However, no soils are mapped that formed in this bedrock. These outcrops are included in Steep rock land or Rough broken land. Small bedrock outcrops are included with other mapping units and are shown on the soil map by a special symbol.

Small areas of eolian sand are intermingled with the loess, particularly in the northwestern part of the county. These areas are also shown on the soil map by a special symbol.

In the following paragraphs these different parent materials are discussed briefly (*2, 3, 4*).

Loess is the most extensive parent material in the county. It is yellowish-brown, wind-deposited material which is composed primarily of silt-sized particles. It normally contains about 25 percent clay-sized particles and less than 10 percent sand. There are no pebbles or stones, although there are numerous lime concretions, formed after the loess was deposited.

Most of the uplands of Plymouth County are covered by soils that formed in loess. These soils make up about 75 percent of the county. Galva soils are the most extensive, but Ida and Monona soils are dominant in the southwestern part of the county. Hamburg and Primghar soils also formed in loess.

The loess is thickest in the southwestern part of the county, where it is as thick as 60 to 70 feet in places. It thins to the northeast and is 7 to 8 feet thick on uneroded ridgetops near the northeastern corner of the county. In places geological erosion has removed most of the loess, exposing bedrock or glacial drift.

The soils that formed in loess have a deep rooting zone and high or very high available water capacity. If slope is suitable, loessal soils are excellent for cultivation. Crops respond quite well to fertilization because tilth is favorable. The physical properties are also favorable for construction that involves earthmoving. This is especially true in the areas of thick loess.

Alluvium is the second most extensive parent material in the county. It consists of sediment deposited along major streams and narrow upland drainageways and on low stream benches. Silty clay loam and silt loam are the dominant textures of the alluvium. A few fairly sizable areas of silty clay and clay alluvium are in the major valleys, especially in Big Sioux River Valley. Sand to sandy loam and loam alluvium is also confined mainly to the major stream valleys; their total acreage is very small.

Most alluvium is derived from loess that washed from the uplands. Some is transported just a short distance and is called "local" alluvium. Some is moved primarily by gravity rather than water. This material is properly called "colluvium," but it is included with alluvium in this discussion.

Along major streams, alluvium and the soils that formed in it vary widely in texture and other properties. Texture differs from place to place mainly because sorting of different sized soil particles occurred during transport. The amount of organic matter is variable because differences occur in the frequency of flooding and in the source of material. The gravel and sand that underlies some stream benches is thought to be derived from melting glaciers.

Soils that formed in alluvium make up about 24 percent of Plymouth County. Sixteen soil series in the county formed in this material. Two of the major series, Radford and McPaul, formed entirely or partly in sediment presumed to have been deposited since farming began in the county. Two of the other extensive soil series, Kennebec and Colo, normally have lighter colored sediment over the original dark-colored surface layer. These soils were buried by the most recent sediment in the formation of the Radford and McPaul soils.

About 97 percent of the alluvial soils in the county are silt loam or silty clay loam. The remaining 3 percent is more clayey or more sandy soils, mostly in the Big Sioux River Valley.

The medium-textured soils that occupy almost all of the alluvial areas have a deep rooting zone and high or very high available water capacity. Most of the soils are excellent for cultivation because they have favorable physical properties. Crops respond well to fertilizer and to artificial drainage if it is needed. Frequent flooding is a hazard in places. Siltation and erosion are hazards on some soils, such as Napier, that are on foot slopes next to uplands.

Glacial drift is the parent material for only one soil series in Plymouth County, and it is of small extent. Glacial till is drift that has not been sorted by water and shows little evidence of sorting or stratification. It contains pebbles, boulders, and sand, as well as silt and clay. The mineral composition is heterogeneous.

Drift that has been sorted is glacial outwash. The outwash normally is gravelly or sandy, and most of the fine soil particles have been washed out by water.

At least two ice sheets covered what is now Plymouth County. The first was the Nebraskan; and the second was the Kansan. Both left thick deposits of glacial till. It had been thought that a third glacier, the Iowan stage of the Wisconsin, covered the northern and eastern parts of the county. Recent investigations indicate that the "Iowan" landscape may have been produced by an erosion cycle on the Kansan till rather than by an Iowan ice sheet (*12, 15*). The gravel and sand that underlies the stream benches is assumed to be of Wisconsin age.

Most of the glacial material is covered by loess. Less than 1 percent of Plymouth County consists of soils that formed in glacial drift. Only the Steinauer series formed in till. Most individual areas are small, and many are so small that they are shown only by a special map symbol. Small areas of glacial outwash also are exposed in places in the uplands, especially in the northwestern part of the county. The areas are shown only by special map symbol. This outwash is presumed to be of Kansan age.

Glacial outwash underlies many of the stream benches. In Wadena and Graceville soils, this sand and gravel is shallow enough to affect crop production.

A small number of gravel pits have been dug on the stream benches. The largest are in the Big Sioux River Valley. Also, gravel pits are in some outcrops of glacial outwash in the uplands. Most of these upland pits are small and are mainly for on-farm use.

Erosion is a hazard on Steinauer soils, and cobblestones and boulders hinder farm operations in places. The outcrops of outwash are droughty and infertile.

Eolian sand is a very minor parent material in the county. No soils that formed in eolian sand are mapped in the county, but small individual areas are shown on the soil map by a special sand symbol. The sand was deposited by wind during the same period as the loess, and it is intermingled with loess. Most spots are south or east of a major stream valley and are within a mile or two of the valley. This indicates that there was a local source of sand, probably on the flood plain.

Bedrock outcrops occur mostly in the southwestern part of the county. Most are included in Steep rock land or Rough broken land. Others are shown on the soil map by a special symbol. The bedrock includes shale, sandstone, and limestone. A number of different kinds of soil formed on material weathered from the bedrock or on thin deposits of loess or till over the bedrock. However, they are all shallow to bedrock, are steep or very steep, and are intermingled in such a complex pattern that no attempt was made to map them.

Climate

Plymouth County soils, according to recent evidence, formed under variable climatic conditions. In the Post-Cary glaciation period between about 13,000 and 10,500 years ago, the climate was cool and the vegetation was dominated by conifers (*20*). Between 10,500 and 8,000 years ago, a warming trend changed the vegetation from conifers to mixed forest, with hardwood species prominent. Beginning about 8,000 years ago, the climate became warmer and drier. Prairie vegetation became dominant and has continued to dominate to the present time. A late change in postglacial climate from relatively dry prairie to more mesic conditions has taken place (*9*). This change may have begun about 3,000 years ago. The present climate is midcontinental and subhumid.

Nearly uniform climate prevails throughout the county, although there is some variation in rainfall from west to east. This difference in rainfall has resulted in slight differences in the Galva soils in the county. Some previous investigators have considered the soils on uplands in the northwestern part of the county to be in the Moody series (*7*). This is a major series in the drier climates to the west. The transition zone between Galva and Moody soils is along the northwestern edge of Iowa, where the average precipitation is about 25 inches per year. Galva soils in northwestern Plymouth County have many similarities to Moody soils.

The influence of the general climate is modified by local conditions. For example, on the very steep bluffs occupied by Hamburg soils, most of the water runs off or percolates rapidly through the soil. This results in a warmer and drier microclimate, and the vegetation is not like that elsewhere in the county. Plants such as cacti and yucca (Spanish bayonet), common to drier portions of the Great Plains, can be found in many places on the bluffs. North- and east-facing slopes tend to be cooler and more moist than south-facing slopes, and in this climate natural stands of trees are more likely to grow. The general climate has had an important overall influence on the characteristics of the soils, but has not caused major differences among them. The local climate differences influence the characteristics of the soils and account for some of the differences in soils within the same climatic region.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by physical and chemical action take place. Rainfall has influenced the formation of the soils through its effects on the amount of leaching in soils and on the kinds of plants that grow. Some variations in plant and animal life are caused by variations in temperature or by the action of other climatic forces on the soil material. To that extent, climate indirectly influences changes in soils that are brought about by the direct influence of plants and animals.

Plant and animal life

A number of kinds of living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. But differences in the kind of vegetation commonly cause the most marked differences between soils.

In Plymouth County tall grasses were the dominant vegetation at the time of settlement. Only a few acres were in trees. Therefore, trees have had only slight influence on soil development. Stands of trees in this county are most common in steep areas near the Big Sioux River Valley. Some stands have been in place long enough to cause slight, but noticeable, changes in the soils.

Trees, especially willow and cottonwood, are common near the larger streams. The soils in these areas are recent alluvium, and not enough time has elapsed for the trees to influence soil development, other than to drop a thin litter of leaves and twigs on the soil surface.

Man changes soil most obviously by causing accelerated erosion. Less obvious are chemical changes brought about by additions of lime and fertilizer and changes in microbial activity and organic-matter content as a result of removing the native vegetation and substituting crops.

Two soil series in the county result from man's activities. In McPaul and Radford, two bottom-land series, the original dark-colored soil has been covered by new parent material that is lighter colored. This material has been eroded from the uplands, largely through man's farming operations.

Relief

Relief refers to the lay of the land. It ranges from nearly level to very steep in Plymouth County. It is an important factor in soil formation through its effect on drainage, runoff, depth to the water table, and erosion. A difference in relief is the basic reason for differing soil properties in the soils of the county.

Even though soils have formed from the same parent material, the influence of relief is seen in the color, thickness of solum, and horizonation of the soils. Galva, Primghar, and Ida soils, for instance, formed in similar parent material but differ in characteristics mainly through the effect of relief.

Primghar soils typically are in concave positions. Runoff is medium to slow, and many areas get additional water from runoff. Galva soils are well drained and occur mostly in areas where runoff is medium to rapid. Ida soils are in positions where most of the water runs off and where erosion has occurred at such a rate that little soil formation has taken place.

Extra water produces more luxuriant vegetation, and where runoff is less more organic matter accumulates. Primghar soils have a thicker, darker surface layer than Galva soils, and Galva soils have a thicker, darker surface layer than Ida soils. Water percolating through the soil carries lime and other minerals deeper into the profile. Ida soils have carbonates at or near the surface because less water infiltrates into the soil. Galva and Primghar soils are leached of carbonates to a depth of about 3 feet or more.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage is generally grayish and mottled. Primghar and Galva soils are examples. The subsoil of Primghar soils has grayish-brown colors and is mottled; that of Galva soils is yellowish brown and dark yellowish brown and is not mottled.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Very similar kinds of soils are produced from widely different kinds of parent material if other factors continue to operate over long periods, but soil development is generally interrupted by geologic events that expose new parent material.

At least three times new parent material has been added to the uplands (*13, 15*). The bedrock has been covered by glacial drift from at least two different glaciers. Then the present surface material, the loess, was deposited. As a result, soils have been buried, and further development of those soils has stopped.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating soils that formed in Wisconsin Loess (*10*). The upper part of the Wisconsin Loess on uneroded uplands is of early Wisconsin age (*11*). Based on this data, the age of nearly level loess soils on stable divides is about 14,000 years. Galva and Monona soils on ridgetops are examples in Plymouth County.

In much of Iowa, including Plymouth County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediment downslope. The surfaces of nearly level upland divides are older than the slopes that are beveled and ascend to the divides. Thus, the side slopes are less than 14,000 years old. The base of the local alluvium in some stream valleys is less than 1,800 years old (*5*). Because the sediment from the side slopes accumulated to form the alluvium, the side-slope surfaces in these areas are also less than 1,800 years old. Some soils that formed in these and similar areas of alluvium are Napier, Kennebec, Colo, and Salix soils.

The percentages of land surfaces that are about 14,000 years old and younger can be obtained by extrapolating soil data by landscapes in counties with completed soil surveys (*6*). In Plymouth County it is probable that less than 5 percent of the soils are as old or older than 14,000 years.

Processes of Soil Horizon Differentiation

Horizon differentiation is considered the result of four basic kinds of changes. These are additions, removals, transfers, and transformations in the soil system (*14*). Each of these affects many substances in soil. For example, there may be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals.

In general these processes tend to promote horizon differentiation, but some tend to offset or retard it. These processes and the changes brought about proceed simultaneously in soils, and the ultimate nature of the profile is governed by the balance of these changes within the profile.

Addition of organic matter is an early step in the process of horizon differentiation in most soils. Generally, the soils on flood plains are divided into two broad groups based mainly on this feature. The soils that have a dark-colored surface layer, as a result of additions of organic matter, are separated from those that do not. The dark color, or lack of it, is the most obvious difference between Luton and Albaton soils.

In some soils on uplands the darkened surface layer is the only soil feature that reflects these basic processes. Ida and Steinauer soils are examples.

The process of removal of substances from parts of the profile is very important in the differentiation of horizons in Plymouth County. This process accounts for some of the most obvious differences between a number of soils in the county. The movement of calcium carbonate downward in the soil as a result of leaching is an example. In such soils as Ida and Steinauer, little calcium carbonate has been removed, so they are calcareous at or near the surface. No B horizon has developed in these soils. In Monona and Galva soils calcium carbonate has been removed from the upper part of the profile by leaching. This removal, along with other processes, has resulted in the differentiation of a B horizon in these soils. Monona and Galva soils formed in calcareous loess, as did Ida soils. Steinauer soils formed in glacial till.

A transfer of substances from one horizon to another is evident in the soils of Plymouth County. Phosphorus is removed from the subsoil by plant roots and transferred to parts of the plant growing above the ground. Then it is added to the surface layer in the plant residue.

The translocation of silicate clay minerals is an important process in horizon differentiation. Clay minerals from the A horizon are carried downward suspended in percolating water. They accumulate in the B horizon in pores and root channels and as clay films on ped faces. Many soils in Iowa have a profile that shows strong evidence of this process, but none are mapped in Plymouth County. However, in the county are some depressions, a few acres in size, that have soils similar to the Corley soils mapped in other counties. The accumulation of clay in the B horizon of those soils is quite evident. Because these areas are small, they are shown on the soil map by a special symbol.

Another kind of transfer that is minimal in most soils but occurs to some extent in very clayey soils, is caused by shrinking and swelling. This causes cracks to form and transfers some materials from the surface layer to lower parts of the profile. Luton and Albaton soils, for instance, have potential for this kind of physical transfer.

Transformations are physical and chemical. One example of transformation is the weathering of soil particles to smaller sizes. The reduction of iron is another example of transformation. This process is called "gleying" and involves the saturation of the soil with water for long periods of time in the presence of organic matter. It is characterized by the presence of ferrous iron and gray colors. Gleying is associated with poorly drained and very poorly drained soils, such as Luton soils.

Still another kind of transformation is the weathering of the primary apatite mineral in parent material to secondary phosphorus compounds. According to theory, the soil pH must decline to about 7 before an appreciable amount of this weathering takes place (*8*). This is important in Plymouth County because it helps to explain the difference in available phosphorus levels between soils formed in similar calcareous parent materials. For example, Ida soils, which are calcareous, are very low in available phosphorus. In Monona soils, which have been leached and are about neutral, the available phosphorus, although low, is in better supply than in Ida soils.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification and then through use of the soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The classification system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The system is under continual study (*17*). Therefore, readers interested in developments of this system should search the latest literature available. In table 8 some of the classes in the current system are given for each soil series. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

Table 8 shows the two orders in Plymouth County: Entisols and Mollisols. Entisols are recent soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols have a thick surface layer that is darkened by organic matter.

SUBORDER: Each order is divided into suborders, primarily on the basis of those characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging, or soil differences resulting from climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Udolls (*Ud,* meaning humid, and *oll,* from Mollisol).

GREAT GROUP: Soil suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated, or those that have pans that interfere with growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The names of great groups have three or four syllables and are made

TABLE 8.—*Classification of soil series*

Series	Family	Subgroup	Order
Albaton	Fine, montmorillonitic (calcareous), mesic.	Vertic Fluvaquents	Entisols.
Calco	Fine-silty, mixed (calcareous), mesic.	Cumulic Haplaquolls	Mollisols.
Castana	Fine-silty, mixed, mesic	Entic Hapludolls	Mollisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Dickman	Sandy, mixed, mesic	Typic Hapludolls	Mollisols.
Galva	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Graceville [1]	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Hamburg	Coarse-silty, mixed (calcareous), mesic.	Typic Udorthents	Entisols.
Ida	Fine-silty, mixed (calcareous), mesic.	Typic Udorthents	Entisols.
Kennebec [1]	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Luton [1]	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
McPaul	Coarse-silty, mixed (calcareous), mesic.	Typic Udifluvents	Entisols.
Modale, dark subsoil variant.	Coarse-silty over clayey, mixed (calcareous), mesic.	Aquic Udifluvents	Entisols.
Monona	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Napier	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Omadi	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Primghar	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Radford [1,2]	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Salix	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Salix, leached subsoil variant.	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Steinauer	Fine-loamy, mixed (calcareous), mesic.	Typic Udorthents	Entisols.
Wadena [1]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic (coarse-loamy).	Typic Hapludolls	Mollisols.

[1] All or part of these soils are taxadjuncts to the series. Reasons for differences in classification are given in the descriptions of the soil series.
[2] The classification of these soils is provisional.

by adding a prefix to the name of the suborder. An example is Hapludoll (*hapl* meaning simple, *ud* for humid, and *oll* from Mollisol).

SUBGROUP: Great groups are divided into subgroups, one representing the central (typic) segment of the group and the others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is *Typic Hapludoll.*

FAMILY: Subgroups are divided into families primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. The family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, etc. that are used as family differentiae. An example is the *fine-silty, mixed, mesic family of Typic Hapludolls.*

SERIES: The series consists of a group of soils that formed from a particular kind of parent material and have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

New soil series must be established, and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review at State, regional, and national levels of responsibility for soil classification results in a judgment that the new series should be established. All of the soil series described in this survey have been established. They are given the name of a geographic location near the place where that series was first observed and mapped. An example is the Galva series.

Additional Information About the County

This section discusses the history, drainage and relief, cultural features, trends in farming, and climate of Plymouth County.

History

The area that is now Plymouth is part of the large prairie that covers the north-central part of the United States. Trees are limited mainly to the stream valleys and some adjoining steep hillsides.

Plymouth County was established in 1851. The first settlers came in 1856. The population had grown to over 22,000 by 1900.

Wheat, oats, and flax were the first crops. Corn soon became the major crop, and livestock raising also grew rapidly.

Drainage and Relief

Plymouth County is in the drainage basin of the Missouri River, which passes within a few miles of the southwest corner of the county. The major streams flow to the south and southwest and enter the Missouri River south of the county line.

The Big Sioux River is the largest stream. Its source is in South Dakota, about 100 miles north of Plymouth County. The Big Sioux River forms the western boundary of the county, and it drains the western part. The Floyd River flows through the center of Plymouth County and drains about one-third of the county. Its source is in northern Iowa, 30 to 35 miles north of Plymouth County. The West Fork of the Little Sioux River drains most of the southeastern part. Its source is a few miles northeast of where it enters the county. Smaller streams, which have sources within the county, drain some of the southern part.

No large tracts of bottom land occur in Plymouth County. The largest valleys have a maximum width of a mile or two. Drainageways, however, extend into all parts of the uplands, and nearly level or gently sloping soils on bottom lands and stream benches make up about 28 percent of the total acreage in the county. Some of these soils have restricted drainage, and artificial drainage is used in places. Tile has been installed in the upper reaches of many of the drainageways in the northeastern two-thirds of the county.

Elevation in the county ranges from about 1,100 to about 1,500 feet above sea level. More than 70 percent of the uplands is gently undulating or gently rolling; about 15 percent is rolling; and the rest, which is mostly in the western and southwestern parts of the county, is hilly to very steep. Natural drainage is good, and no artificial drainage is needed on the soils of the uplands.

Cultural Features

The population of Plymouth County is approximately 24,000. The largest town is Le Mars, the county seat; it has a population of about 7,800. Other towns that have populations of 500 to 1,500 are Akron, Kingsley, Remsen, Merrill, and Hinton. There are also a number of smaller communities in the county. In addition, Sioux City, which has a population of about 85,000, adjoins the southwest corner of Plymouth County.

One federal and three State highways cross Plymouth County. Interstate Highway 29 and another federal highway go through Sioux City and run within a few miles of Plymouth County. Surfaced county roads are 1 mile apart throughout much of the county.

Four railway companies and three bus companies provide service to the county. Le Mars has a municipal airport where charter flights are available. Other transportation facilities available at Sioux City include scheduled airline flights and barge transportation on the Missouri River.

Agriculture, including farming and related activities, is the principal industry in the county. Food processing is an important source of income in and near the county. Several very large beef- and pork-packing plants operate in the area. Poultry, milk, popcorn, and honey are also processed in the area. Many of the other industries, such as tile-manufacturing plants, are part of the larger agricultural industry.

A 4-year college is at Le Mars, and five other colleges or universities are within 50 miles of the county. Eight high schools are in Plymouth County.

Trends in Farming

The total acreage in farms in Plymouth County has been fairly constant, but the number of people living on farms has been decreasing. In 1969 there were 8,432 people living on 2,079 farms, a decrease of 1,275 people and 321 farms since 1964. An average farm in 1969 was 257 acres in size, and about 47 percent of the farmland was owned by the operators. This compares to a State average of 247 acres per farm and 52.5 percent operator-owned.

For years corn has been the most important crop by a wide margin. It retains this position, but soybeans are increasing rapidly in importance. The acreage of soybeans tripled between 1959 and 1969. The acreages of crops in 1969 were as follows: corn, 199,960; pasture, 87,660; soybeans, 59,077; oats, 49,926; hay, 33,401; popcorn, 1,075; sorghum, 590; wheat, 102; barley, 97; red clover for seed, 66; and rye, 13.

Plymouth County is one of the leading counties in the country in the marketing of beef cattle and hogs. Their numbers have been increasing. Poultry and other livestock are less important, and their numbers are declining. Livestock population for 1969 was as follows: grain-fed cattle sold, 133,236; grain-fed sheep and lambs sold, 6,537; lambs born, 3,451; sows farrowed, 57,794; hogs marketed, 368,787; milk cows, 4,332; beef cows, 14,618; hens and pullets of laying age, 110,199; turkeys raised, 60,013; and commercial broilers raised, 9,300.

Climate [5]

The climatic data available from centrally located Le Mars are quite representative of Plymouth County. The variability of showers within short distances and of minimum temperatures on calm, clear mornings are often noticeable.

About three-fourths of the total annual precipitation, or some 21 inches, falls during the warm part of the year, from April through September (table 9). During an average year, a trace or more of precipitation falls on 170 days, of which 95 have at least 0.01 inch; 50, at least 0.10 inch; and 17, 0.50 inch or more. In 24 hours, precipitation will be 3.7 inches once in 5 years and 6.2 inches once in 100 years. During the warm part of the year, heavier showers are more frequent, and an average of about 13 days have 0.50 inch or more of pre-

[5] By PAUL J. WAITE, climatologist and director, Iowa Weather Service.

TABLE 9.—*Temperature and precipitation data*

[Data from Le Mars]

Month	Temperature				Precipitation				
	Average daily high	Average daily low	Average monthly highest	Average monthly lowest	Average total	One year in 10 will have— Less than—	One year in 10 will have— More than—	Average number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°F	°F	°F	°F	In	In	In		In
January	28	9	49	−20	0.6	0.1	1.3	18	5
February	32	12	51	−13	.8	.1	1.8	15	4
March	45	24	67	0	1.4	.4	3.4	11	6
April	61	36	84	20	2.6	.5	3.9	(1)	2
May	72	48	91	29	3.9	1.4	6.1	0	0
June	81	58	95	42	4.4	1.2	6.5	0	0
July	87	62	98	48	3.5	1.0	5.9	0	0
August	85	60	96	45	3.1	.7	5.4	0	0
September	72	51	91	31	3.2	.6	7.1	0	0
October	64	39	84	20	1.8	.2	3.0	(1)	(1)
November	46	25	67	4	1.1	(2)	2.1	3	3
December	33	14	53	−11	.8	.2	2.1	11	4
Year	59	37	99	−23	27.2	16.3	33.0	58	5

[1] Less than one-half. [2] Trace.

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

[Data from Le Mars]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 11	April 21	April 28	May 11	May 19
2 years in 10 later than	April 5	April 15	April 23	May 6	May 14
5 years in 10 later than	March 26	April 4	April 12	April 26	May 4
Fall:					
1 year in 10 earlier than	October 21	October 15	October 7	September 30	September 16
2 years in 10 earlier than	October 26	October 20	October 12	October 5	September 21
5 years in 10 earlier than	November 6	October 31	October 23	October 16	October 1

cipitation. This is the time when soil tillage is at a maximum and the potential for soil erosion is high.

The average number of days per year that have an inch or more of snow cover totals 58. The first such snow cover generally occurs late in November, but has occurred as early as late in September. Some 10 percent of the annual precipitation falls as snow, commonly about 32 inches per year.

Ideally, during crop planting, the topsoil is dry and the subsoil contains ample moisture. However, variations from the optimum are frequent. Without adequate subsoil moisture at the beginning of the season, rainfall is rarely sufficient to provide the inch of moisture per week that corn needs. The chances of receiving an inch or more of precipitation per week are about 2 in 5 in June, diminishing to about 1 in 4 late in July and in August.

The temperature at Le Mars has ranged from 111° F on July 17, 1936, to −37° on January 12, 1912. In about half of the years, the temperature reaches −26° or lower and 99° or higher.

The threshold temperature of 90°, which is too hot for optimum corn growth, is equalled or exceeded on an average of 33 days per year. Freezing temperature occurs about 159 days per year. The growing season averages 120 days per season (table 10).

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Glossary

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

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

Bench, stream. See Terrace (geological).

Bottom land. Land formed by alluvial deposit along a stream or in a lake basin; a flood plain.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Catch crop. 1. A quick-growing crop, planted and harvested between two regular crops in consecutive seasons, or between two patches of regular crops in the same season. 2. Such a crop planted after another has failed, or when the season is too late for the usual crops.

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.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Eolian soil material. Earthly parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Crossbedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

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

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

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

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.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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GUIDE TO MAPPING UNITS

For a complete description of a mapping unit, read both the description of the mapping unit and that of the soil series to which it belongs. Management for crops, pasture, and trees is discussed by capability units on pages 34 to 40. Other information is in tables as follows:

Acreage and extent, table 1, page 9.
Predicted yields, table 2, page 41.
Wildlife interpretations, table 3, page 44.
Engineering data and interpretations, tables 4, 5, and 6, pages 46 through 63.
Recreational interpretations, table 7, page 64.

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page
1B3	Ida silt loam, 2 to 5 percent slopes, severely eroded	17	IIe-2	35
1C3	Ida silt loam, 5 to 9 percent slopes, severely eroded	18	IIIe-1	36
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	18	IIIe-2	37
1E3	Ida silt loam, 14 to 20 percent slopes, severely eroded	18	IVe-1	38
1F3	Ida silt loam, 20 to 30 percent slopes, severely eroded	19	VIe-1	39
1G3	Ida silt loam, 30 to 40 percent slopes, severely eroded	19	VIIe-1	40
2G	Hamburg silt loam, 30 to 75 percent slopes	17	VIIe-1	40
3F	Castana silt loam, 14 to 30 percent slopes	11	VIe-1	39
10B	Monona silt loam, 2 to 5 percent slopes	23	IIe-2	35
10C2	Monona silt loam, 5 to 9 percent slopes, moderately eroded	23	IIIe-1	36
10D2	Monona silt loam, 9 to 14 percent slopes, moderately eroded	23	IIIe-2	37
10E2	Monona silt loam, 14 to 20 percent slopes, moderately eroded	24	IVe-1	38
T10B	Monona silt loam, benches, 2 to 5 percent slopes	24	IIe-2	35
12C	Napier silt loam, 5 to 9 percent slopes	24	IIIe-1	36
14D	Castana loam, 9 to 14 percent slopes	11	IVe-2	39
18B	McPaul-Kennebec silt loams, 2 to 5 percent slopes	22	IIe-1	35
19B	Kennebec-McPaul silt loams, 2 to 5 percent slopes	20	IIe-1	35
26	Kennebec silty clay loam, 0 to 2 percent slopes	20	I-1	35
28B	Dickman fine sandy loam, 2 to 9 percent slopes	13	IIIe-3	37
33D3	Steinauer clay loam, 9 to 14 percent slopes, severely eroded	31	IVe-2	39
33E3	Steinauer clay loam, 14 to 18 percent slopes, severely eroded	31	VIe-1	39
33F3	Steinauer clay loam, 18 to 30 percent slopes, severely eroded	31	VIIe-1	40
36	Salix silty clay loam, 0 to 2 percent slopes	29	I-1	35
66	Luton silty clay, 0 to 1 percent slopes	21	IIIw-1	38
70	McPaul silt loam, 0 to 2 percent slopes	22	I-1	35
91B	Primghar silty clay loam, 2 to 5 percent slopes	27	IIe-1	35
108B	Wadena loam, 2 to 5 percent slopes	32	IIe-2	35
114D3	Ida-Wadena complex, 5 to 14 percent slopes, severely eroded	19	IIIe-3	37
116	Graceville silt loam, 0 to 2 percent slopes	16	I-1	35
116B	Graceville silt loam, 2 to 5 percent slopes	16	IIe-2	35
133	Colo silty clay loam, 0 to 2 percent slopes	12	IIw-1	36
133+	Colo silt loam, calcareous overwash, 0 to 2 percent slopes	12	IIw-1	36
149	Modale silt loam, dark subsoil variant, 0 to 2 percent slopes	22	I-1	35
156	Albaton silty clay, 0 to 1 percent slopes	10	IIIw-1	38
170D	Napier-Castana silt loams, 9 to 14 percent slopes	25	IIIe-2	37
189	Omadi silt loam, 0 to 2 percent slopes	26	I-1	35
212	Kennebec silt loam, 0 to 2 percent slopes	20	I-1	35
212B	Kennebec silt loam, 2 to 5 percent slopes	20	IIe-1	35
C212	Kennebec silt loam, channeled, 0 to 2 percent slopes	20	Vw-1	39
310B	Galva silty clay loam, 2 to 5 percent slopes	13	IIe-2	35
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	14	IIIe-1	36
310D2	Galva silty clay loam, 9 to 14 percent slopes, moderately eroded	14	IIIe-2	37
T310	Galva silty clay loam, benches, 0 to 2 percent slopes	14	I-1	35
T310B	Galva silty clay loam, benches, 2 to 5 percent slopes	15	IIe-2	35
317C2	Galva-Wadena complex, 5 to 14 percent slopes, moderately eroded	15	IIIe-3	37
378	Rough broken land	29	VIIe-1	40
467	Radford silty clay loam, 0 to 2 percent slopes	28	I-1	35
467B	Radford silty clay loam, 2 to 5 percent slopes	28	IIe-1	35
478	Steep rock land	30	VIIe-1	40
607	Salix silty clay loam, leached subsoil variant, 0 to 2 percent slopes	30	I-1	35
609	Omadi-Alluvial land complex, 0 to 2 percent slopes	26	Vw-1	39

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page
717C	Napier-Gullied land complex, 2 to 10 percent slopes	25	VIIe-1	40
733	Calco silty clay loam, 0 to 2 percent slopes	11	IIw-1	36
983D	Castana-Gullied land complex, 9 to 14 percent slopes	11	VIIe-1	40

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