

SOIL SURVEY OF  
**Fremont County, Iowa**



**United States Department of Agriculture  
Soil Conservation Service**

**In cooperation with**

**Iowa Agriculture and Home Economics  
Experiment Station**

**Cooperative Extension Service, Iowa State University  
and the**

**Department of Soil Conservation, State of Iowa**

Major fieldwork for this soil survey was done in the period 1960-66. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station, 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 Fremont County Soil and Water Conservation District.

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

## HOW TO USE THIS SOIL SURVEY

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

### Locating Soils

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

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

### Finding and Using Information

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

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent

material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

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

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

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

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

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

*Newcomers in Fremont 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 information about the county given at the beginning of the publication and in the section "General Nature of the County."

Cover picture: Area of the Monona association about 2 miles east of the town of Hamburg.

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# SOIL SURVEY OF FREMONT COUNTY, IOWA

BY LEWIS A. CLARK AND JOHN R. NIXON, SOIL CONSERVATION SERVICE<sup>1</sup>

FIELDWORK BY LEWIS A. CLARK, RAYMOND I. DIDERIKSEN, JOHN R. NIXON, AND WILEY MANGRUM, SOIL CONSERVATION SERVICE

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

**F**REMONT COUNTY is in the extreme southwest corner of Iowa (fig. 1). It is bounded on the west by the Missouri River and on the south by the State of Missouri. It has a total area of 335,232 acres. Sidney, the county seat, is about 40 miles south of Council Bluffs, Iowa.

Farming is the main enterprise in the county. The principal crops are corn, soybeans, hay, and pasture. Several thousand acres are in nursery crops and orchards. Both cash-grain and general farming are common. The principal livestock are beef cattle and hogs.

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

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have 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. Monona and Ida, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Ida silt loam, 9 to 14 percent slopes, is one of several phases within the Ida series.

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

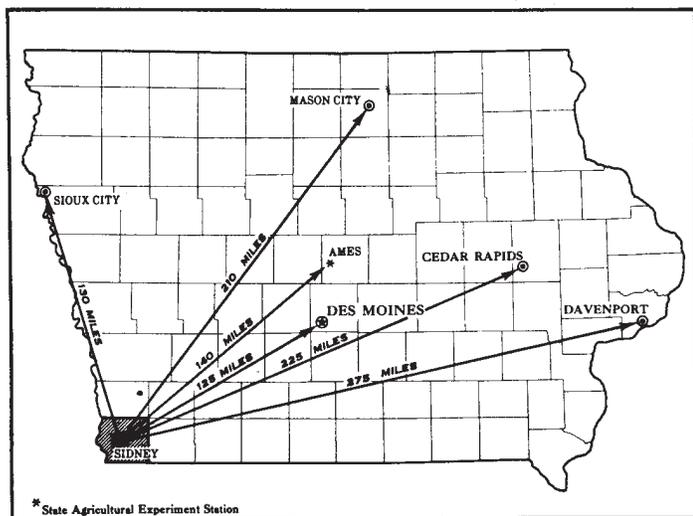


Figure 1.—Location of Fremont County in Iowa.

## How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Fremont County, where they are located, and

<sup>1</sup> The soils were surveyed and the survey manuscript prepared under the general direction of LACY I. HARMON, Soil Conservation Service, and F. F. RIECKEN, Iowa Agriculture and Home Economics Experiment Station.

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

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

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Napier-Gullied land complex, 2 to 10 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils or of two or more. Malvern soils, 9 to 14 percent slopes, severely eroded, is an undifferentiated soil group in this county.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Riverwash 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 kinds 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 kinds 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 soils 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 Fremont County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

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

The soil associations in Fremont County are discussed in the following pages. The terms for texture used in the descriptive headings of the associations apply to the surface layer of the major soils.

### 1. Marshall association

*Well-drained, nearly level to strongly sloping, silty soils on uplands*

This association (fig. 2) is along the eastern county line and extends from the northern part of the county to the southern part. It is about 10 miles wide in the northern part and about 6 miles wide in the southern part. Soils and topography along Highway 59 south of Shenandoah are typical of this association.

This association makes up about 29 percent of the county. It is about 62 percent Marshall soils and 38 percent minor soils.

The Marshall soils formed in thick loess. They have a surface layer of black or very dark brown silty clay loam and a subsoil of brown to yellowish-brown silty clay loam. They are nearly level to moderately sloping on ridgetops and moderately to strongly sloping on side slopes.

Minor soils in this association are the Colo, Judson, Malvern, Adair, Shelby, and Steinauer soils. Colo and Judson silty clay loams are along the numerous drainageways in the area. Colo soils are along the center of the drainageways, and Judson soils are on the sides of the drainageways at the base of upland slopes. Malvern soils are in small, irregularly shaped areas on the lower part of slopes. The Adair and Shelby soils are most frequently on the lower part of slopes in the southern part of this association. The steep Steinauer soils are mainly on side slopes on the north side of the East Nishnabotna River valley from Shenandoah to Riverton.

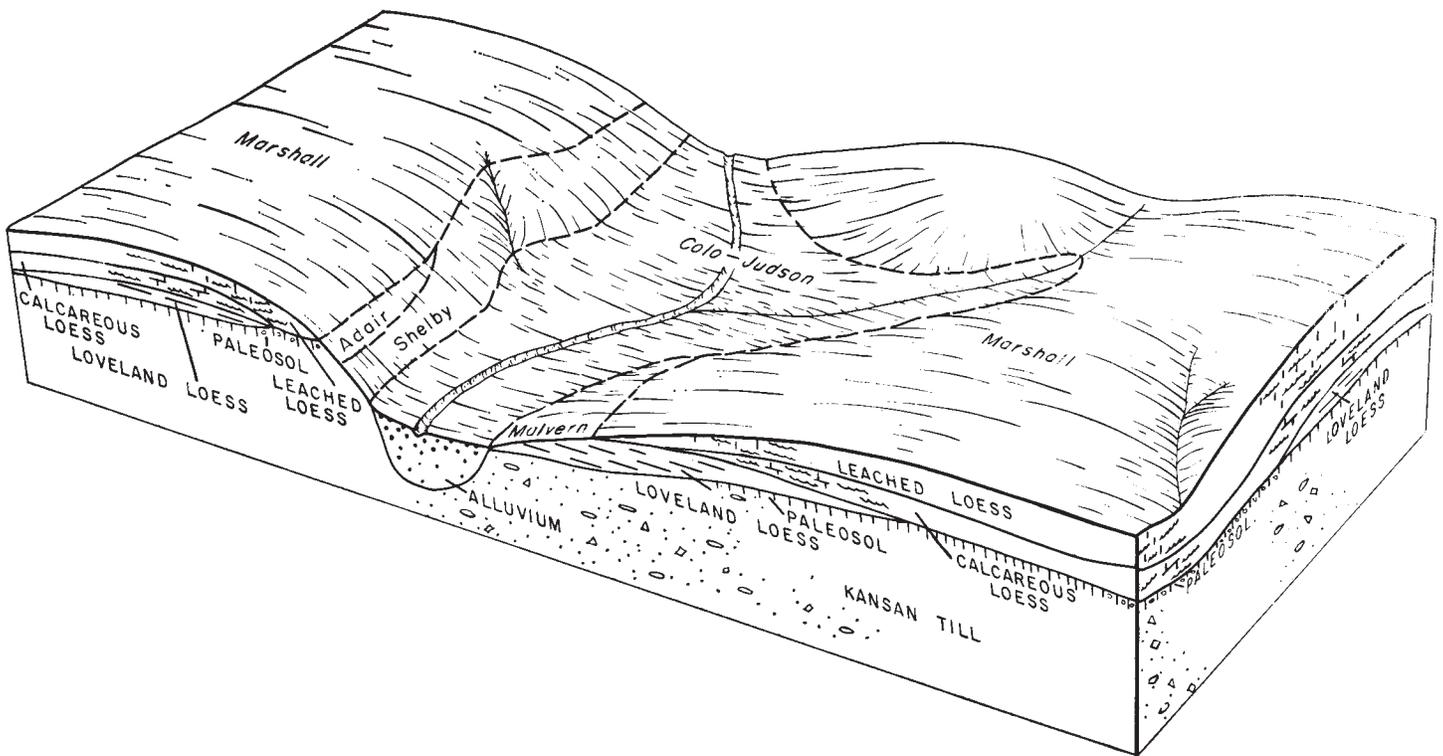


Figure 2.—Relationship of soils in the Marshall association to relief and underlying material.

Most of the soils of this association are used for crops. Corn, soybeans, small grain, and hay crops are commonly grown. General livestock farming, mostly raising hogs and feeding beef cattle, is the main enterprise.

Controlling runoff and erosion and maintaining fertility are considerations in managing the soils in this association. Wet areas in the drainageways are of minor importance. Roads follow section lines in most places. Farm size is about average for the county.

## 2. Marshall-Nevin association

*Well-drained and somewhat poorly drained, nearly level to gently sloping, silty soils on benches*

This association is in long, narrow areas along the East and West Nishnabotna Rivers. It is mainly on the east side of the valleys. Most of the soils are nearly level, but some are gently sloping or moderately sloping (fig. 3). The towns of Farragut and Randolph are in this association.

This association makes up about 4 percent of the county. It is 58 percent Marshall soils and 15 percent Nevin soils. The remaining 27 percent is minor soils.

The Marshall soils formed in loess on uplands and are well drained. They have a surface layer of black or very dark brown silty clay loam and a subsoil of brown to yellowish-brown silty clay loam. Nevin soils formed in silty alluvium and are somewhat poorly drained. They have a thick surface layer of black silty clay loam and a subsoil of dark grayish-brown silty clay loam.

Minor soils in this association are the Minden, Monona, Corley, Judson, Colo, and Zook soils. Minden soils are nearly level. Monona soils are only in a small area near the

town of Hamburg. Corley soils are in depressions. Judson soils are at the base of upland slopes. Some of the benches in this association are large enough to have developed drainage systems, and small areas of Colo and Zook soils are in some of the drainageways.

Soils of this association are well suited to crops. Corn and soybeans are the principal crops, but some small grains and meadow plants are also grown. The growing of nursery stock is an important local enterprise, and most of the stock produced in the county is grown in this association.

Maintaining fertility is the major management need on most soils in this association, but drainage is a concern in managing the minor Corley soils. The sloping soils are subject to erosion. Roads are mainly along section lines, but because the rivers are so close together and because their tributary streams cross this association, roads are not along every section line.

## 3. Nodaway-Kennebec-Colo association

*Moderately well drained and poorly drained, nearly level, silty soils on bottom lands of the Nishnabotna Rivers and Walnut Creek*

This association is along the main streams in the county other than the Missouri River. The streams are the East and West Nishnabotna Rivers and Walnut Creek. The soils are nearly level.

This association makes up about 12 percent of the county (see fig. 4). It is about 40 percent Nodaway soils, 20 percent Kennebec soils, and 18 percent Colo soils. The remaining 22 percent is minor soils.

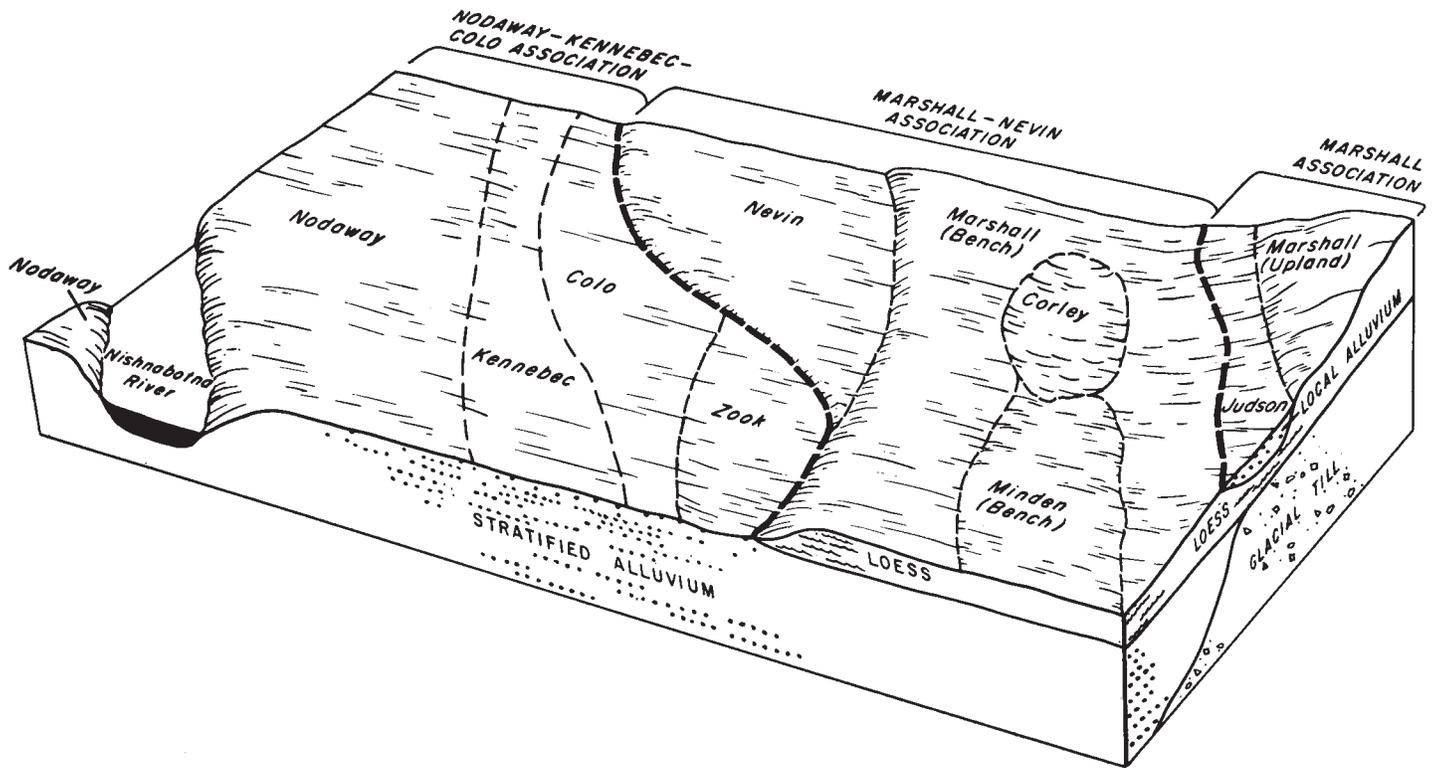


Figure 3.—Relationship of soils in the Marshall-Nevin association, Nodaway-Kennebec-Colo association, and Marshall association to relief and underlying material.



Figure 4.—Corn growing on Kennebec and Colo soils in the Nodaway-Kennebec-Colo association.

The Nodaway soils are adjacent to the main stream channels and are moderately well drained. They have a surface layer of very dark grayish-brown silt loam about 7 inches thick and a substratum of dark grayish-brown, grayish-brown, and very dark grayish-brown, stratified silt loam. Kennebec soils are at somewhat higher elevations nearer the uplands and are moderately well drained. They have a thick surface layer of black to very dark grayish-brown silt loam. Beneath the surface layer is black to very dark grayish-brown silt loam or light silty clay loam. Colo soils are some distance from the stream channels nearer the uplands and are poorly drained. They typically have a thick, black to very dark gray surface layer and very dark gray or dark-gray substratum. They are silty clay loam throughout, except where silt loam overwash is on the surface.

Minor soils in this association are the Dockery, Zook, and Nishna soils. Areas of Marsh are also in this association. Dockery soils are near the stream channels. Zook soils are nearly level or are in slight depressions at some distance from the streams. Nishna soils are similar to Zook soils but are calcareous throughout and have numerous snail shells and lime concretions. These soils are in similar positions on the landscape. Natural marsh and marsh created by man are near Riverton.

Most of these soils are cultivated and are used intensively for row crops (fig. 4). Corn and soybeans are the major crops. Small grain and meadow plants are minor

crops. Farming enterprises are generally of the cash-grain type.

There are several management concerns. Maintaining fertility is a management need on all of the soils. At lower elevations, drainage is a concern. In many places surface drains and tile systems are difficult to install because of inadequate outlets. Flooding occurs occasionally along the Nishnabotna Rivers, particularly at the junction of Walnut Creek and the West Nishnabotna Rivers. Private dikes have been built for protection in some areas. Farms are larger in size than the average for the county. Roads are adequate but are not so common as in other associations, but river crossings are numerous. Residences in this association are few. In many places farms are partly in this association and partly in the adjacent associations on uplands.

**4. Monona-Marshall association**

*Well-drained, gently sloping to steep, silty soils on uplands*

This association is between the Monona and the Marshall associations. Typical areas are north of Sidney along Highway 275 and south of Riverton along County blacktop "U". The soils formed in thick loess (fig. 5). They are gently sloping to moderately sloping on ridgetops and moderately sloping to steep on side slopes. Numerous small streams dissect this association.

This association makes up about 16 percent of the county. It is about 53 percent Monona soils and 24 per-

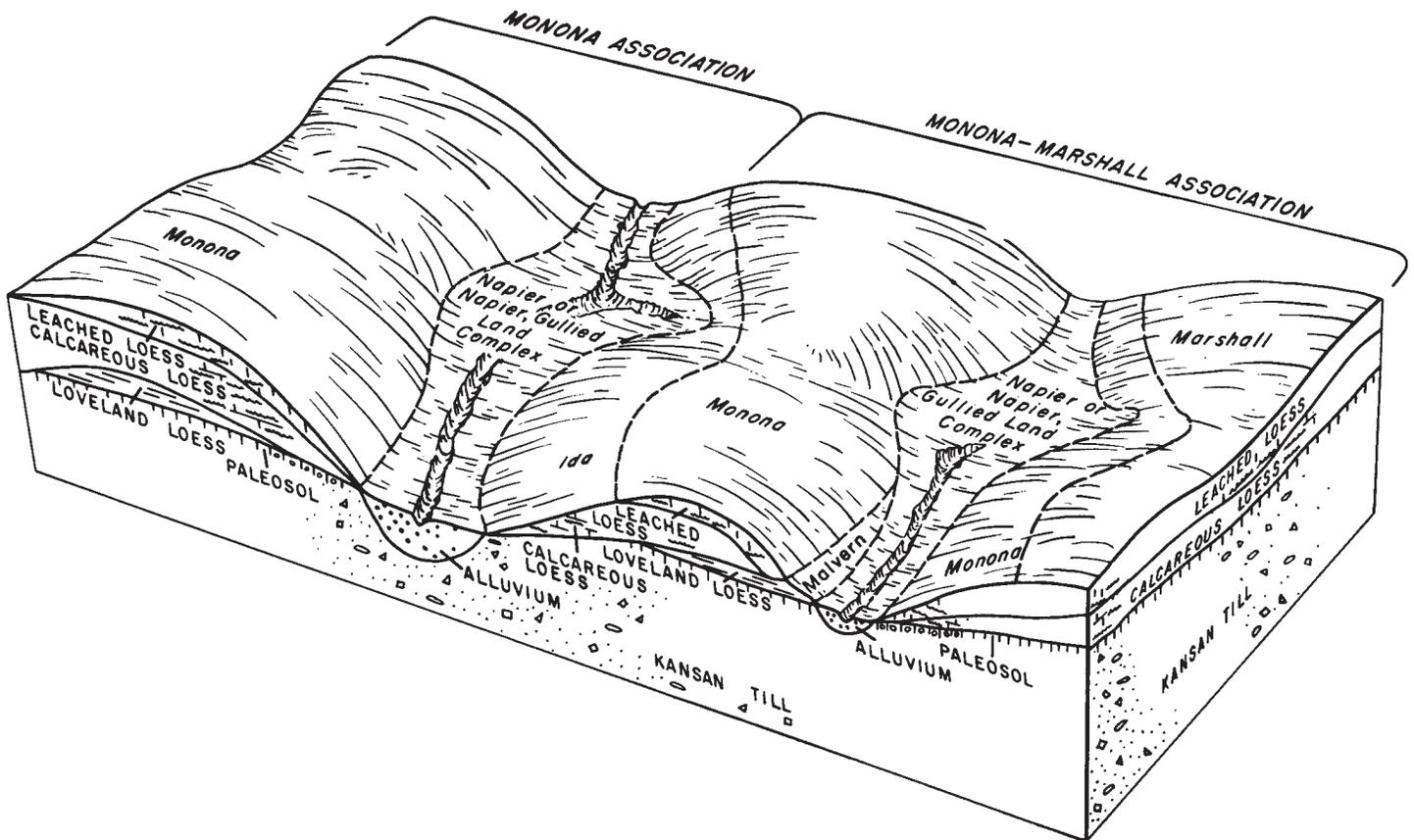


Figure 5.—Relationship of soils in the Monona-Marshall association and Monona association to relief and underlying material.

cent Marshall soils. The remaining 23 percent is minor soils.

The Monona soils are on the ridgetops and the steeper side slopes of the association and are well drained. These soils typically have a surface layer of very dark brown or very dark grayish-brown silt loam and a subsoil of brown silt loam. Marshall soils are mostly gently sloping to moderately sloping and are on ridgetops. They are well-drained silty clay loam throughout. They typically have a very dark brown surface layer and a brown subsoil.

Minor soils in this association are the Colo, Judson, Ida, Malvern, Adair, and Shelby soils. There are Colo and Judson soils in the smaller drainageways east of the West Nishnabotna River and Napier soils on the west side of the river. Malvern, Adair, and Shelby are generally on the lower part of side slopes.

Most farms are of the general type where some livestock is kept. Raising hogs and fattening beef cattle are the most common livestock enterprises. Corn, soybeans, small grain, and hay are the main crops grown in the association.

Controlling sheet and gully erosion is a major management need. Maintaining fertility is also important. Farms are about the average size for the county. Roads are in a square pattern, generally on section lines; however, some are on half-mile lines or in other places. Many sections do not have roads completely around them.

### 5. Monona association

*Well-drained, moderately sloping to steep, silty soils on uplands*

This association parallels the Ida-Monona-Hamburg association to the west. One area is along Highway 275 from Sidney to Hamburg. The soils in this association formed in thick loess. This association is characterized by moderately sloping ridgetops and strongly sloping to steep side slopes. Small drainageways with larger gullies are common.

This association makes up about 9 percent of the county. It is 65 percent Monona soils and 35 percent minor soils.

The Monona soils are on ridgetops and side slopes. Typically they have a surface layer of very dark brown or very dark grayish-brown silt loam and a subsoil of brown silt loam.

Minor soils in this association are the Napier, Ida, Malvern, Adair, and Shelby soils. Napier soils are in drainageways. Ida soils most frequently are on severely eroded slopes that face south. Malvern, Adair, and Shelby soils are generally on the lower part of slopes.

Soils of this association are more commonly used for general farms that produce livestock and grain than for other farm uses. Many soils of this association are suited to crops. Where the soils are not too steep, corn and soybeans are grown in rotation with small grain, hay, and pasture plants. Much of the grain and hay is used for livestock raised for market. Some of the steeper areas are in meadow or permanent pasture. Some small areas are in timber.

The main management needs are controlling erosion and maintaining fertility. Farms are about the average size for the county. Roads are mainly on section lines,

but some are on half-mile lines or in other places. In many places the roads are not completely around a section.

### 6. Ida-Monona-Hamburg association

*Well drained and somewhat excessively drained, moderately sloping to very steep, silty soils on uplands*

This association extends from Hamburg north to the county line and is about 1 to 3 miles wide. It consists of soils that formed in thick loess under prairie grass in the bluffs area east of the flood plain (fig. 6) along the Missouri River. It is characterized by narrow, rounded ridgetops; long, steep to very steep side slopes; and very deep, raw gullies.

This association makes up about 7 percent of the county. It is 45 percent Ida soils, 25 percent Monona soils, and 8 percent Hamburg soils. The remaining 22 percent is minor soils.

The Ida soils typically have a thin surface layer that is dark grayish-brown or brown, and beneath it, they are yellowish brown. They are silt loam throughout, high in content of lime, and well drained. They are generally steep. Monona soils are on ridgetops and steep side slopes and are well drained. Typically they have a surface layer of very dark brown or very dark grayish-brown silt loam and a subsoil of silt loam. Hamburg soils are near the flood plain of the Missouri River and are somewhat excessively drained. They are very steep. They are brown or yellowish-brown silt loam. These soils are characterized by the "catsteps" formed by small earth slips on the very steep slopes.

Minor soils in this association are the Napier and Castana soils. Also in this association are areas of Gullied land. Napier soils are along small drainageways. The Napier soils and Gullied land are in narrow drainageways that have deep, uncrossable gullies. Castana soils are only in areas downslope from the Hamburg bluffs.

Some ridgetops and side slopes and small areas along drainageways are cultivated and used for row crops, hay, and rotation pasture. Most of the steeper areas are in permanent pasture or timber. Stands of timber began growing here recently. It appears that timber encroachment is continuing on the steeper areas. General livestock farming is more common than other kinds of farming. Because there is a higher proportion of pasture in this association than in other associations, herds of beef cattle are more common.

Farms in this area are smaller than is average in the county. Roads tend to follow the ridgetops or drainageways and are fewer than in other associations.

### 7. McPaul-Napier association

*Well drained and moderately well drained, nearly level to gently sloping, silty soils on bottom lands, on alluvial fans, and on foot slopes along bottom lands of the Missouri River*

This association is at the base of the bluffs in a band about 1/2 mile to 3 miles wide, extending from Hamburg north to the Mills County line. It consists of nearly level to gently sloping soils that formed in alluvium on bottom lands, alluvial fans, and foot slopes.

This association makes up about 4 percent of the county. It is 50 percent McPaul soils and 32 percent Napier soils. The remaining 18 percent is minor soils.

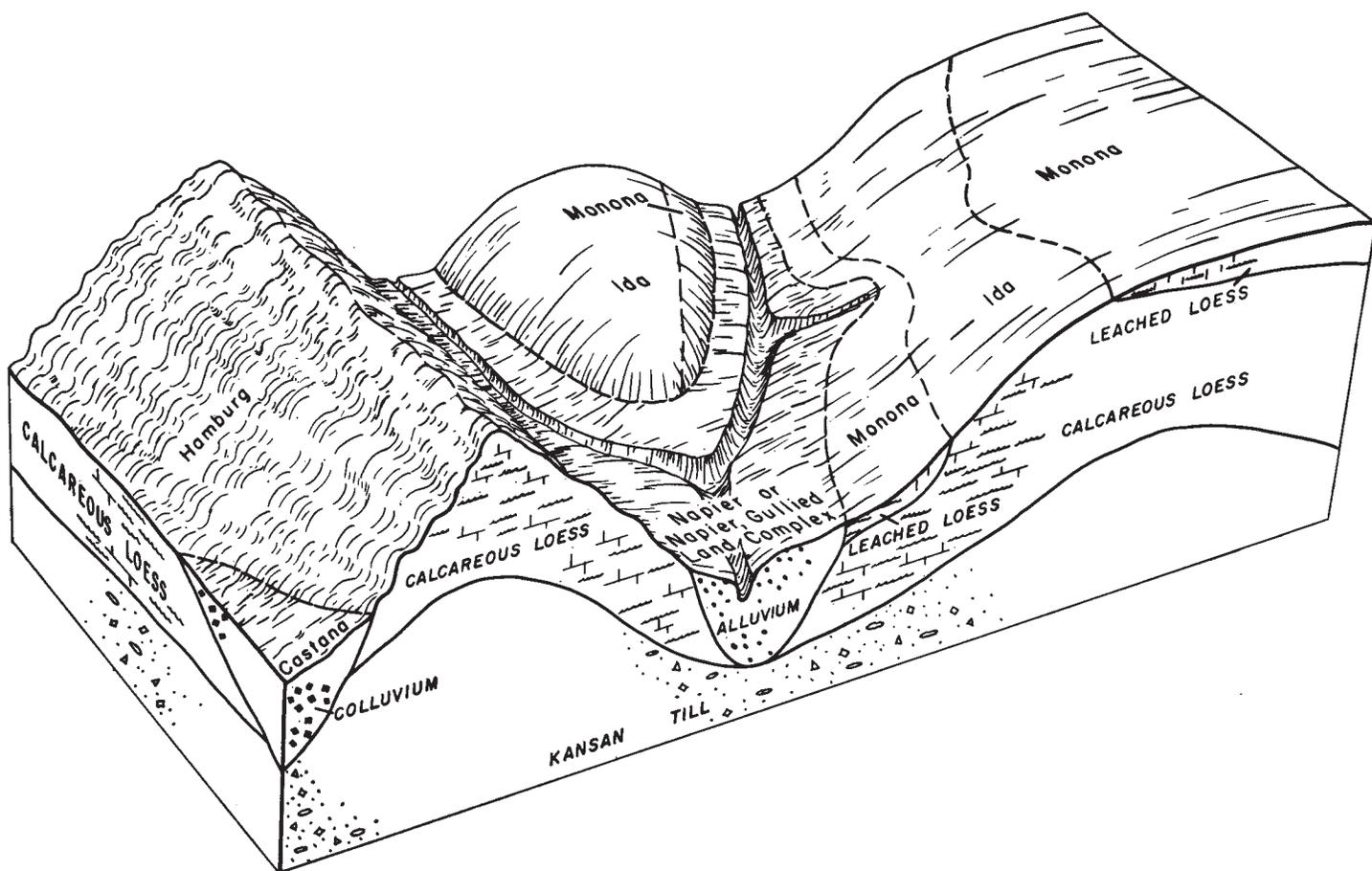


Figure 6.—Relationship of soils in the Ida-Monona-Hamburg soil association to relief and underlying material.

The McPaul soils formed in alluvium deposited by small streams flowing from the adjacent uplands. This deposition generally is confined to diked areas or desilting basins. These soils are well drained or moderately well drained. McPaul soils have a thin surface layer that is very dark grayish brown and brown, and beneath the surface layer they are dark grayish brown to brown. They are stratified, have silt loam texture, and are calcareous. Napier soils are at the base of the bluffs on foot slopes and alluvial fans. They are well drained. They have a thick surface layer that is very dark brown and a subsoil that is dark brown to brown.

Minor soils in this association are the Kennebec and Merville soils. Kennebec soils are nearly level and are on bottom lands. Merville soils are similar to McPaul soils in the upper part of the profile but are underlain by silty clay at a depth of about 2 feet. They occupy positions similar to McPaul soils.

Desilting basins have been used in this association to protect drainage ditches from siltation. One of the first of these was constructed in 1909, and since that time other basins have been built. At present there are five active desilting basins in this association. In recent years terracing of the soils on uplands and of the structures for county roads has greatly reduced the silt load of the small streams.

Soils of this association are well suited to crops and are generally cropped intensively for corn and soybeans. Most farming is of the cash-grain type. Few livestock are kept.

Maintaining fertility is the major management need. Farms are larger than is average in the county. Many farmsteads are at the base of the bluffs and are partly or wholly on Napier soils. In many places some soils of the uplands are farmed with these soils. Most roads are on section lines, but some are on half-mile lines or are in other places. In many places roads are not entirely around a section.

#### 8. Luton-Lakeport-Salix-Keg association

*Very poorly drained to well-drained, nearly level, clayey and silty soils on bottom lands of the Missouri River*

This association extends approximately from the Burlington Northern Railroad tracks east to the eastern edge of the Missouri River valley. The soils formed in alluvium ranging from silt loam to clay (fig. 7) in texture. These sediments have been in place long enough for the formation of a soil profile that has a dark-colored surface layer.

This association makes up about 10 percent of the county. It is 25 percent Luton soils, 15 percent Lakeport soils, 15 percent Salix soils, and 15 percent Keg soils. The remaining 30 percent is minor soils.

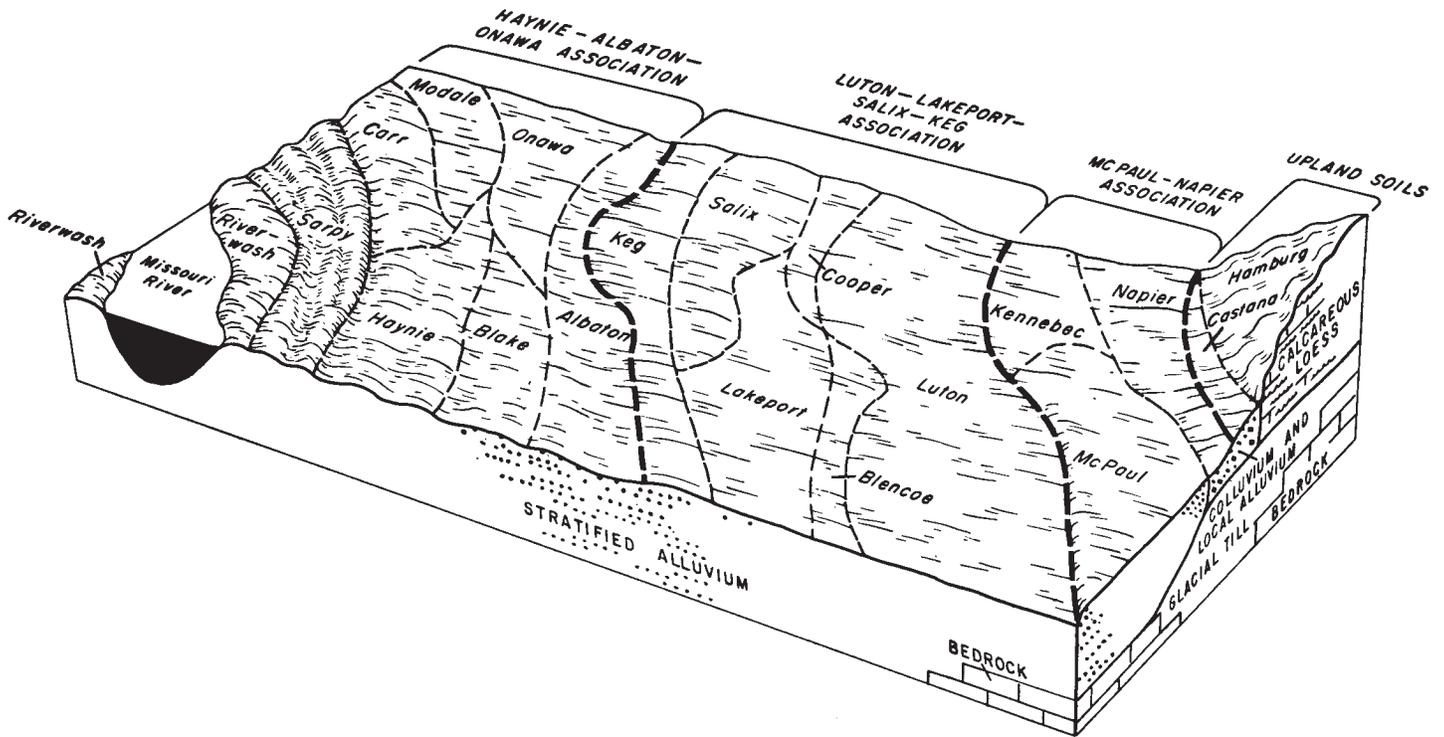


Figure 7.—Relationship of soils on bottom lands along the Missouri River to relief and underlying material.

The Luton soils are poorly drained to very poorly drained. They have a thick surface layer of black to very dark gray silty clay and a subsoil of dark-gray and gray, firm silty clay. Lakeport soils are at slightly higher elevations than Luton soils and at slightly lower elevations than Salix soils. They are somewhat poorly drained. These soils are silty clay loam throughout, and they have a thick surface layer that is black to very dark gray and a subsoil that is dark grayish brown. Salix soils are at slightly lower elevations than Keg soils and are moderately well drained. They are silty clay loam in the upper part and silt loam in the substratum. They have a surface layer that is black and a subsoil that is dark grayish brown. Keg soils are at the higher elevations on bottom lands and are moderately well drained or well drained. They are silt loam throughout, and they have a surface layer that is black to very dark brown and a subsoil that is yellowish brown.

Among the minor soils in this association are the nearly level Cott, Buckney, Cooper, Luton, Blencoe, Blend, and Woodbury soils and the Solomon soils, which are in the lowest areas of this association. Marsh areas, both man-made and natural, are in this association. The Forney Lake game refuge area is quite marshy, and several of the desilting basins on the border of this association are also quite marshy. The position of minor soils on the landscape with respect to elevation is related to texture. The sandier soils are at the higher elevations, and the finer textured soils are at the lower elevations.

All of the soils in this association are used intensively for crops. Corn, soybeans, and wheat are more commonly grown than other crops. Wheat and soybeans are grown on the poorly drained or very poorly drained, fine-textured soils, such as Luton, Solomon, or Blend soils, more fre-

quently than on other soils. Most farms are of the cash-grain type. Few livestock are kept.

The major management concern is drainage. Drainage ditches and surface drains are common. In wet seasons these drains are not adequate and some crops are drowned out. The delay of field operations and replanting of crops are common. Some land leveling is needed to improve drainage. If spring is dry and windy, soil blowing is a hazard. Maintaining fertility is important because the cropping systems are intensive. Farms are larger than average in the county. Roads are generally on section lines or half-mile lines, but many sections do not have roads completely around them. Farmsteads are most often on Salix or Keg soils and seldom on such soils as Luton or Solomon soils that are more poorly drained than most other soils in this association.

### 9. Haynie-Albaton-Onawa association

*Well-drained to poorly drained, nearly level, silty and clayey soils on bottom lands of the Missouri River*

This association is along the Missouri River channel in an area that is wider than 3 miles in only a few places. The soils formed in recently deposited alluvium. Most of this association is nearly level, but in places swales and undulating areas occur.

This association makes up about 9 percent of the county. It is about 20 percent Haynie soils, 14 percent Albaton soils, and 13 percent Onawa soils. The remaining 53 percent is minor soils.

Haynie soils are at the higher elevations and are well drained or moderately well drained. They are silt loam throughout and are stratified and grayish brown in color. The Albaton soils are mainly in slight depressions and

are poorly drained. They are silty clay throughout. The surface layer is typically very dark gray, but beneath the surface layer the soil is dark grayish brown and olive gray.

Onawa soils are in nearly level areas and slight depressions at slightly higher elevations than the Albaton soils. They are somewhat poorly drained or poorly drained. They are silty clay to a depth of about 2 feet and silt loam or very fine sandy loam below this depth. They are mainly dark grayish brown, but in most places the surface layer is darker colored.

Minor soils in this association are the Sarpy, Carr, Grable, Modale, Waubonsie, Vore, Blake, and Percival soils. Riverwash and Alluvial land are near the river channel. Sarpy soils tend to be hummocky or undulating, but the rest of the minor soils are nearly level.

A levee constructed by the U.S. Army Corps of Engineers protects about 85 percent of the association from flooding. Riverwash, Alluvial land, and some areas of soils, such as those of the Haynie and Albaton series, are in the unprotected area that is flooded almost every spring.

Cash-grain farming is the major enterprise. Most of the soils are cropped rather intensively, and corn, soybeans, and wheat are the major crops. Few livestock are kept. In areas not protected by the levee, there are small tracts of timber.

In some of the lower areas, wetness is a hazard, and in areas not protected by the levee, flooding is a hazard. Soil blowing is a hazard. Sandy soils are quite often left in pasture and timber to protect them from soil blowing, and in dry seasons, these soils and some of the soils that have a sandy substratum are droughty. Maintaining fertility is important. Farms are larger than the average for the county, but farmsteads are not common. The roads are along section lines and in other places, but they are less plentiful than in other associations. In the unprotected area between the levee and the river, there are only lanes.

## ***Descriptions of the Soils***

This section describes the soil series and mapping units in Fremont County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

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

mapping unit. Color terms are for moist soil, unless otherwise stated.

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

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 and woodland group in which the mapping unit has been placed. The page for the description of each capability unit and woodland group can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (14).<sup>2</sup>

## **Adair Series**

The Adair series consists of dark-colored, moderately well drained or somewhat poorly drained soils on uplands. These soils generally are on points of ridges and on the lower part of side slopes. Slopes are 5 to 14 percent. Areas generally are small. Areas of the Adair soils that are less than 1 acre in size and within areas of other soils are shown on the soil map by a spot symbol for red clay.

These soils formed in areas of an old, reddish, clayey soil that formed during an earlier geologic period. The old soil formed in clay loam glacial till under forest vegetation but later was buried by loess. In time, the loess was removed by geologic erosion and a new soil began to form. The remaining old, reddish, clayey layers became the subsoil of the newly formed Adair soils. Beneath the clayey subsoil is glacial till. The native vegetation of the new Adair soils was prairie grasses.

In a representative profile the surface layer is very dark brown clay loam about 11 inches thick. The subsoil, to a depth of about 21 inches, is brown, firm clay loam that has reddish-brown mottles. The next layer, to a depth of about 30 inches, is brown, very firm clay that has reddish-brown mottles. The lower part of the subsoil, to a depth of 50 inches, is dark yellowish brown and has brown, grayish-brown, and brownish-gray mottles. It is very firm light clay that grades to firm clay loam at a depth of about 40 inches.

The Adair soils are low or very low in available nitrogen, very low or low in available phosphorus, and low or medium in available potassium. The organic-matter content generally is low. The surface layer generally is slightly or medium acid, unless the soil has been limed. Available water capacity is high, and permeability is slow. These soils are subject to sheet erosion and gullying. In places, during periods of high rainfall, a seepy area is at the border between Adair soils and the soils upslope.

Most areas of Adair soils are cultivated along with adjacent soils, but some are in pasture.

<sup>2</sup> Italic numbers in parentheses refer to Literature Cited, p. 102.

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

Soil	Area	Extent	Soil	Area	Extent
	<i>Acres</i>	<i>Percent</i>		<i>Acres</i>	<i>Percent</i>
Adair clay loam, 5 to 9 percent slopes, moderately eroded.....	220	0.1	Marshall silty clay loam, benches, 2 to 5 percent slopes.....	2,580	0.8
Adair clay loam, 9 to 14 percent slopes.....	280	.1	Marshall silty clay loam, 5 to 9 percent slopes.....	6,470	1.9
Adair clay loam, 9 to 14 percent slopes, moderately eroded.....	1,800	.5	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded.....	13,870	4.1
Adair soils, 9 to 14 percent slopes, severely eroded.....	150	( <sup>1</sup> )	Marshall silty clay loam, 9 to 14 percent slopes.....	2,600	.8
Albaton silt loam.....	660	.2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded.....	25,620	7.7
Albaton silty clay.....	2,940	.9	Marshall silty clay loam, 9 to 14 percent slopes, severely eroded.....	1,690	.5
Alluvial land.....	740	.2	McPaul silt loam.....	7,500	2.2
Blake silt loam.....	320	.1	Minden silty clay loam, benches.....	1,350	.4
Blake silty clay loam.....	2,930	.9	Modale silt loam.....	1,550	.5
Blencoe silty clay.....	1,230	.4	Monona silt loam, 0 to 2 percent slopes.....	340	.1
Blend silty clay.....	650	.2	Monona silt loam, 2 to 5 percent slopes.....	2,400	.7
Buckney fine sandy loam, 1 to 3 percent slopes.....	2,000	.6	Monona silt loam, 5 to 9 percent slopes.....	4,900	1.5
Carr fine sandy loam, 1 to 3 percent slopes.....	1,200	.4	Monona silt loam, 5 to 9 percent slopes, moderately eroded.....	7,700	2.3
Castana silt loam, 9 to 20 percent slopes.....	200	( <sup>1</sup> )	Monona silt loam, 5 to 9 percent slopes, severely eroded.....	320	.1
Colo silt loam, overwash.....	3,790	1.1	Monona silt loam, 9 to 14 percent slopes.....	1,140	.3
Colo silty clay loam.....	3,430	1.0	Monona silt loam, 9 to 14 percent slopes, moderately eroded.....	25,720	7.7
Colo-Judson silty clay loams, 2 to 5 percent slopes.....	27,172	8.1	Monona silt loam, 9 to 14 percent slopes, severely eroded.....	2,370	.7
Cooper loam.....	1,270	.4	Monona silt loam, 14 to 20 percent slopes.....	540	.2
Cooper silty clay loam.....	1,230	.4	Monona silt loam, 14 to 20 percent slopes, moderately eroded.....	4,640	1.4
Corley silt loam.....	160	( <sup>1</sup> )	Monona silt loam, 14 to 20 percent slopes, severely eroded.....	930	.3
Cott loam.....	330	.1	Monona silt loam, 20 to 30 percent slopes, moderately eroded.....	1,140	.3
Cott clay loam.....	910	.3	Moville silt loam.....	1,380	.4
Dockery silt loam.....	690	.2	Napier silt loam, 2 to 5 percent slopes.....	16,730	5.0
Dockery silty clay loam.....	4,370	1.3	Napier silt loam, 5 to 9 percent slopes.....	870	.3
Dow silt loam, 9 to 14 percent slopes.....	270	.1	Napier-Gullied land complex, 2 to 10 percent slopes.....	4,340	1.3
Grable silt loam.....	2,410	.7	Nevin silty clay loam.....	2,490	.7
Hamburg silt loam, 40 to 75 percent slopes.....	1,910	.6	Nishna silt loam, overwash.....	340	.1
Haynie silt loam.....	6,100	1.8	Nishna silty clay.....	850	.2
Ida silt loam, 9 to 14 percent slopes.....	250	.1	Nodaway silt loam.....	16,730	5.0
Ida silt loam, 9 to 14 percent slopes, severely eroded.....	890	.3	Onawa silt loam.....	380	.1
Ida silt loam, 14 to 20 percent slopes.....	1,030	.3	Onawa silty clay.....	3,320	1.0
Ida silt loam, 14 to 20 percent slopes, severely eroded.....	1,620	.5	Percival silty clay.....	720	.2
Ida silt loam, 20 to 30 percent slopes.....	2,230	.7	Riverwash.....	1,010	.3
Ida silt loam, 20 to 30 percent slopes, severely eroded.....	1,560	.5	Salix silty clay loam.....	4,840	1.4
Ida silt loam, 30 to 40 percent slopes.....	3,400	1.0	Sarpy loamy fine sand, 1 to 3 percent slopes.....	1,250	.4
Judson silty clay loam, 2 to 5 percent slopes.....	5,390	1.6	Sarpy loamy fine sand, 3 to 7 percent slopes.....	620	.2
Keg silt loam.....	4,840	1.5	Shelby loam, 9 to 14 percent slopes, moderately eroded.....	780	.2
Kennebec silt loam.....	7,850	2.3	Shelby loam, 14 to 18 percent slopes, moderately eroded.....	520	.2
Kennebec silt loam, overwash.....	2,200	.7	Shelby loam, 18 to 25 percent slopes, moderately eroded.....	140	( <sup>1</sup> )
Knox silt loam, 5 to 14 percent slopes.....	330	.1	Solomon clay.....	1,390	.4
Knox silt loam, 14 to 20 percent slopes.....	110	( <sup>1</sup> )	Steinauer loam, 18 to 25 percent slopes.....	250	.1
Lakeport silt loam, overwash.....	420	.1	Terril loam, 3 to 8 percent slopes.....	220	.1
Lakeport silty clay loam.....	4,860	1.4	Vore silty clay loam.....	850	.2
Luton silt loam, overwash.....	780	.2	Waubonsie fine sandy loam.....	920	.3
Luton silty clay loam.....	2,100	.6	Waubonsie silty clay loam.....	380	.1
Luton silty clay.....	8,480	2.5	Woodbury silty clay.....	1,070	.3
Malvern silty clay loam, 5 to 9 percent slopes, moderately eroded.....	220	.1	Zook silt loam, overwash.....	740	.2
Malvern silty clay loam, 9 to 14 percent slopes.....	260	.1	Zook silty clay loam.....	1,760	.5
Malvern silty clay loam, 9 to 14 percent slopes, moderately eroded.....	1,380	.4	Zook silty clay.....	990	.3
Malvern soils, 9 to 14 percent slopes, severely eroded.....	280	.1	Waste land, rock quarries, water.....	1,010	.3
Marsh.....	2,160	.6			
Marshall silty clay loam, 0 to 2 percent slopes.....	1,220	.4			
Marshall silty clay loam, benches, 0 to 2 percent slopes.....	5,550	1.7			
Marshall silty clay loam, 2 to 5 percent slopes.....	23,360	7.0			
Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded.....	840	.2			
			Total.....	335,232	100.0

<sup>1</sup> Less than 0.1 percent of county.

Representative profile of Adair clay loam, 9 to 14 percent slopes, just north of railroad right-of-way where the slope is convex and is about 11 percent, 396 feet south and 200 feet east of the northwest corner of NW¼SW¼ sec. 1, T. 69 N., R. 40 W.

- A1—0 to 11 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) crushed; weak, fine, granular structure; friable; many roots; slightly acid; clear, smooth boundary.
- B1t—11 to 21 inches, brown (7.5YR 4/4) clay loam; few, fine, distinct, reddish-brown (5YR 4/4) mottles; medium to fine subangular blocky structure; firm; some very dark brown (10YR 2/2) organic coatings on ped faces; some discontinuous clay films; few fine pebbles; slightly acid; clear, smooth boundary.
- IIB2t—21 to 30 inches, brown (7.5YR 4/4) clay; common, fine, distinct, reddish-brown (5YR 4/4) mottles; moderate, fine, subangular blocky structure; very firm; some dark stains but less than in the B1t horizon; about a 1-inch layer of pebbles at the upper boundary of this horizon; thin discontinuous clay films on ped faces and in root channels; slightly acid; gradual, smooth boundary.
- IIB2t—30 to 40 inches, dark yellowish-brown (10YR 4/4) light clay; few brown (7.5YR 4/4) and grayish-brown (2.5Y 5/2) mottles; moderate, medium to fine, subangular blocky structure; very firm; thick discontinuous clay films on ped faces; some, fine, dark-colored iron and manganese stains and concretions; few roots and pores; slightly acid; gradual, smooth boundary.
- IIB3—40 to 50 inches, dark yellowish-brown (10YR 4/4) clay loam; common grayish-brown (2.5Y 5/2) and light brownish-gray (2.5Y 6/2) mottles; mainly massive, but in places weak, medium, angular blocky structure; firm; some fine and medium dark-colored stains and oxide concretions; very few fine roots; few pebbles; slightly acid.

The A horizon ranges from very dark brown (10YR 2/2) to very dark gray (10YR 3/1) or black (10YR 2/1) in color and is clay loam or silty clay loam in texture. It generally ranges from 10 to 14 inches in thickness but is thinner in eroded areas. In places there is a very dark gray (10YR 3/1) to dark-brown (7.5Y 3/2) A3 horizon.

In places the B1t horizon, as shown in the representative profile, is not present, and the A horizon is underlain by the IIB2t horizon. The upper part of the IIB2t horizon has hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 4 or 6. Mottles of brown, dark grayish brown to light brownish gray, yellowish red, and yellowish brown are present, but reddish mottles predominate in the upper part of the IIB2t horizon and brownish and grayish mottles predominate in the lower part of the IIB2t and in the IIB3 horizons. Pebbles and stones are present in the IIB horizon and there is a pebble band in the upper part of the B horizon or in the lower part of the A horizon. The texture centers on clay in the upper part of the IIB2t horizon but, in places, grades to heavy clay loam in the lower part.

The C horizon is dark yellowish-brown (10YR 4/4) or yellowish-brown (10YR 5/4 or 5/6) clay loam that has low-chroma mottles. The representative profile was not described deeply enough to include this horizon.

Adair soils are slightly to medium acid in the A horizon and upper part of the B horizon. Carbonates are present at depths between 3½ and 5 feet.

In Fremont County, Adair soils, 9 to 14 percent slopes, severely eroded, have a surface layer that is thinner or lighter colored than is defined as the range for the series.

Adair soils have more clay and redder hues in the B horizon than the Shelby soils, which are associated on the landscape. They have more sand and pebbles in the profile than Malvern soils, which are similar in color and drainage.

**Adair clay loam, 5 to 9 percent slopes, moderately eroded (192C2).**—This soil is in narrow bands on the side slopes and on narrow points of ridges in the uplands. It generally is downslope from the Marshall soils, and in some areas it is upslope from the Shelby soils.

This soil has a profile similar to the one described as representative of the series except that the surface layer is thinner because of soil loss through erosion. The surface layer generally is a very dark grayish-brown plow layer in which some brown subsoil is exposed in places.

Included in mapping were small areas of soils that have a surface layer about as thick as that of the profile described and areas of severely eroded soils where the subsoil is exposed. These severely eroded areas are shown on the soil map by a symbol for severely eroded spots. Also included is a small acreage of soils that have a subsoil of gray clay and that are shown on the soil map by a special symbol for gray clay.

Because this soil generally is in small areas, it is commonly used for row crops and generally farmed with the surrounding soils. Erosion is a hazard. In some places a very narrow, wet, seepy band is near the boundary of higher adjacent slopes. If wetness and erosion are controlled, this soil is moderately well suited to row crops. It is also suited to hay or pasture. Capability unit IIIe-3; woodland group 5.

**Adair clay loam, 9 to 14 percent slopes (192D).**—This soil is on the lower part of side slopes in the uplands. It is downslope from the Marshall soils, and in some areas it is upslope from the Shelby soils. Areas are small, generally ranging from 2 to 10 acres in size.

This soil has the profile described as representative for the series.

Included in mapping were small areas of soils that have a thinner surface layer and some small areas of Shelby soils. Also included was a small acreage of soil that has a subsoil of gray clay and is shown on the soil map by a special symbol for gray clay.

Because this soil generally is in small areas, it is commonly farmed with the surrounding soils. This soil is used for row crops or hay and pasture, depending on how the field is farmed. It is subject to erosion. In places on side slopes, a narrow, wet, seepy band is near the boundary of the adjacent soils upslope. If erosion and wetness are controlled, this soil is moderately suited to row crops, but in most areas hay or pasture is a better use. Capability unit IVe-2; woodland group 5.

**Adair clay loam, 9 to 14 percent slopes, moderately eroded (192D2).**—This soil is on the lower part of side slopes in the uplands. It is downslope from Marshall soils, and in some areas it is upslope from the Shelby soils. Areas are small, generally ranging from 2 to 10 acres.

This soil has a profile similar to the one described as representative of the series except that the surface layer is thinner. Generally, it has a very dark grayish-brown plow layer and the brown or reddish-brown subsoil is exposed in places. Included in mapping were small areas of Shelby soils. Areas of severely eroded soils are shown on the soil map by a symbol for severe erosion, and a small acreage of soils that have a subsoil of gray clay is shown by a special symbol for gray clay.

Because this soil generally is in small areas, it is commonly used for row crops or hay and pasture, depending on how the surrounding soils are used. It is subject to erosion, and in places on side slopes, a narrow, wet, seepy band is near the boundary of the adjacent soils upslope. If erosion and wetness are controlled, this soil is moderately suited to row crops, but in most areas hay or pasture is a better use. Capability unit IVe-2; woodland group 5.

**Adair soils, 9 to 14 percent slopes, severely eroded (192D3).**—These soils are on the lower part of side slopes in the uplands. They are downslope from Marshall soils, and in some areas they are upslope from the Shelby soils. Because these soils have been severely eroded, the original surface layer has been mixed with part of the subsoil by plowing, and the present very thin surface layer is mostly dark-brown or very dark grayish-brown clay loam or clay. The subsoil of brown or reddish-brown clay loam or clay is exposed in places.

Included with these soils in mapping were small areas of soils that are only moderately eroded and small areas of Shelby soils. A small acreage of soils that have a subsoil of gray clay is shown on the soil map by a symbol for gray clay.

Because these soils generally are in small areas, they are commonly used for the same crops as are the surrounding soils. These soils are subject to erosion. In places on side slopes, a narrow, wet, seepy band is near the boundary of the higher adjacent slopes. Seedbeds are difficult to prepare because the plow layer is clayey and the tilth is poor. Because they are wet and severely eroded, these soils are poorly suited to row crops. They are better suited to hay or pasture. Capability unit VIe-2; woodland group 5.

## Albaton Series

The Albaton series consists of moderately dark colored, poorly drained, clayey soils on bottom lands along the Missouri River. These soils formed in fine-textured, recent alluvium. They are at low elevations on broad flats and in swales near the present river channel.

In a representative profile the surface layer is very dark gray silty clay about 5 inches thick. Beneath this is a 5-inch layer that is transitional between the surface layer and the substratum. This layer is very dark gray and dark-gray, firm silty clay. The substratum to a depth of 50 inches is dark grayish-brown, dark-gray, and olive-gray, very firm silty clay mottled with brown, gray, and dark reddish brown.

The Albaton soils are low in available nitrogen, very low in available phosphorus, and high in available potassium. The content of organic matter is low. The soils are mildly alkaline and are calcareous. Available water capacity is medium, and permeability is slow or very slow. Runoff is very slow.

Most areas of these soils are cultivated, but some are in pasture or woodland. Wetness is a major limitation. The power requirement for tillage operations is high. Before the large dams on the Missouri River and the levees were constructed, these soils were subject to almost yearly flooding. Most areas are now protected, but a few are not protected and are still subject to flooding.

Representative profile of Albaton silty clay in a cultivated field, 60 feet north and 520 feet west of the southeast corner of sec. 35, T. 69 N., R. 44 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay, light brownish gray (10YR 6/2) dry; cloddy, but breaking to moderate, fine, angular blocky structure adhering as a mass; firm; many fine roots; mildly alkaline; weakly calcareous; abrupt, smooth boundary.

ACg—5 to 10 inches, very dark gray (10YR 3/1) and dark-gray (5Y 4/1) silty clay, dark gray (5Y 4/1) kneaded; moderate, fine to medium, angular blocky structure;

firm; few fine roots; few very fine pores; mildly alkaline; calcareous; clear, smooth boundary.

C2g—10 to 28 inches, dark grayish-brown (2.5Y 4/2) and dark-gray (5Y 4/1) silty clay; few, fine, brown (7.5YR 4/4) mottles and common, fine, gray (5Y 5/1) mottles; moderate, very fine, subangular blocky structure adhering as a mass; very firm; few fine and very fine pores; very dark gray (10YR 3/1) material in root channels or cracks; mildly alkaline; calcareous; diffuse, smooth boundary.

C3g—28 to 50 inches, olive-gray (5Y 4/2) silty clay; common, medium, brown (10YR 4/3) mottles and common, fine, brown (7.5YR 4/4) grading to dark reddish-brown (5YR 3/4) mottles; moderate, fine to medium, subangular blocky structure adhering as a mass; very firm; few fine pores; few very fine roots; mildly alkaline; calcareous.

The Ap or A1 horizon is typically very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1) but is dark grayish brown (10YR or 2.5Y 4/2) in places. The A horizon is less than 10 inches thick and ranges from silty clay to silt loam. The ACg horizon is absent in many places.

The Cg horizon is typically dark grayish brown (2.5Y 4/2) but ranges from dark gray (5Y 4/1) to grayish brown (2.5Y 5/2) or olive gray (5Y 4/2). It is generally either silty clay or clay, except that in places there is a silt loam phase in which silt loam extends to a depth of about 15 inches.

Mottles range from dark reddish brown to brownish yellow. In places there are layers or strata of coarser textured sediments  $\frac{1}{4}$  inch to 6 inches thick. Albaton soils are mildly alkaline or moderately alkaline and calcareous throughout.

The Albaton soils have more clay throughout than the Haynie soils, and they have more clay in the C horizon than the Onawa and Percival soils. In contrast with Albaton soils, Onawa soils are silt loam below a depth of about 2 feet, and Percival soils are loamy sand or sand below a depth of about 2 feet. All of these soils formed in alluvium and are associated on the landscape.

**Albaton silt loam (0 to 2 percent slopes) (157).**—This soil is on bottom lands near the Missouri River. It generally is near or adjacent to Albaton silty clay and Haynie, Percival, and Onawa soils. Most areas are between 10 and 80 acres in size, but some are larger.

This soil has a profile similar to the one described as representative of the series, except that the present surface layer is silt loam that was deposited during floods. It is mainly dark grayish brown in color and from 6 to 15 inches in thickness. Included in mapping were very small areas of soils that have a sandy or more clayey surface layer.

This soil is used mainly for row crops, and it is well suited to such use. Wetness is a limitation, but the surface layer tends to dry out more quickly than that of Albaton silty clay. Most areas are protected by levees, but unprotected areas are subject to flooding. The power requirement for tillage operations is lower than on Albaton silty clay, and the surface layer is not so difficult to till. Capability unit IIIw-1; woodland group 7.

**Albaton silty clay (0 to 2 percent slopes) (156).**—This soil is on bottom lands near the Missouri River. It generally is at a lower elevation than the nearby Percival, Haynie, and Onawa soils. Some areas are on broad flats, and others are in slight swales. Most areas are 10 to 100 acres in size, but some are larger.

This soil has the profile described as representative of the series. Included in mapping were small areas of Onawa soils. Also included were about 80 acres of a soil that has about 20 inches of light-colored silty clay loam over darker colored clay. This included soil is in desilting basins in the eastern part of the bottom lands along the Missouri River.

Some areas of this soil are large enough to manage separately, but most are farmed along with other soils. The soil is well suited to row crops, and most cultivated areas are used for this purpose. Wetness is a limitation and often delays fieldwork in areas that are not drained. Most areas are protected by levees, but unprotected areas are subject to flooding. This soil has poor tilth in most areas. The surface layer becomes cloddy if worked when wet, and plowing is commonly done in fall to improve the workability of the surface layer and prevent the delay of fieldwork in spring. Capability unit IIIw-1; woodland group 7.

### Alluvial Land

Alluvial land (0 to 2 percent slopes) (315) consists of areas of recently deposited, highly stratified sediment that has not been in place long enough for a soil to form. The land is frequently flooded, and each flood adds new sediment. The sediment varies in texture but is mainly loam, sandy loam, and sand. Much of this land is along and near the Missouri River, and smaller areas are along the Nishnabotna Rivers.

This land is channeled and has many low natural levees, small ponds, sloughs, and small oxbow lakes. Natural drainage ranges from poorly drained in the channels to well drained on the natural levees. Because flooding is a hazard, this land is not suited to cultivation unless it is protected by levees.

Most of the acreage is covered by timber and brush, but some areas are used as pasture. Only a few acres are cultivated. Capability unit Vw-1; woodland group 6.

### Blake Series

The Blake series consists of stratified, moderately dark colored, somewhat poorly drained soils on bottom lands along the Missouri River. These soils formed in recent alluvium of silty clay loam texture that is underlain by stratified silt loam to very fine sandy loam. They generally are near the present river channel in nearly level, slightly elevated areas.

In a representative profile the surface layer is very dark grayish-brown, friable silty clay loam about 7 inches thick. The substratum, to a depth of 20 inches, is dark grayish-brown, friable silty clay loam that has a few dark yellowish-brown and yellowish-brown mottles. Below this and extending to a depth of 50 inches is grayish-brown and light brownish-gray, friable to very friable, stratified silt loam and very fine sandy loam that has a few strong-brown and light brownish-gray mottles.

The Blake soils are low in available nitrogen and phosphorus and high in available potassium. The organic-matter content is low. The soils are mildly alkaline or moderately alkaline and are calcareous. Available water capacity is high. Permeability is moderately slow in the upper part and moderate to moderately rapid in the lower part. Runoff is slow.

Most areas of these soils are cultivated. Before large dams on the Missouri River and the levees were constructed, these soils were subject to flooding almost yearly, but now the hazard of flooding is slight in most areas.

Representative profile of Blake silty clay loam in a cultivated field, 250 feet south and 50 feet west of the northeast corner of sec. 31, T. 70 N., R. 43 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; weak, fine, subangular blocky structure; friable; moderately alkaline; calcareous; clear, smooth boundary.

C1—7 to 20 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; few, fine, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) mottles; moderate, fine, subangular blocky structure; friable; common fine pores; moderately alkaline; calcareous; clear, smooth boundary.

IIC2—20 to 30 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, strong-brown (7.5YR 5/6) and light brownish-gray (2.5Y 6/2) mottles; some horizontal cleavage that breaks to weak, fine, subangular blocky structure; friable; stratified with thin lenses of very fine sand and silty clay loam; moderately alkaline; calcareous; clear, smooth boundary.

IIC3—30 to 36 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam; few, fine, strong-brown (7.5YR 5/6) mottles; massive, but evidence of stratification; very friable; moderately alkaline; calcareous; clear, smooth boundary.

IIC4—36 to 50 inches, grayish-brown (2.5Y 5/2) and light brownish-gray (2.5Y 6/2) silt loam; few strong-brown (7.5YR 5/6) mottles; massive; friable; stratified with thin lenses of very fine sand and silty clay loam; some fine, dark-colored, soft oxides; moderately alkaline; calcareous.

The Ap or A1 horizon is typically very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2), but it is dark grayish brown (10YR 4/2 or 2.5Y 4/2) in places. It is silty clay loam or silt loam. The A horizon is less than 10 inches thick.

The C1 horizon is silty clay loam, except that where the texture of the A horizon is silt loam the upper part of the C1 horizon is silt loam to a depth of 15 inches in places. Mottles of dark yellowish brown to reddish yellow or reddish brown are present. Depth to the IIC horizon is 18 to 30 inches. The IIC horizon is stratified, dark grayish-brown (2.5Y 4/2) to light brownish-gray (2.5Y 6/2), friable or very friable silt loam, or very fine sandy loam. It has mottles that range from very dark gray (10YR 3/1) to yellowish red (5YR 5/8). The soil is mildly alkaline or moderately alkaline, except that the Ap horizon ranges to neutral in some places.

The Blake soils are similar to the Onawa soils, except that they have less clay to a depth of about 2 feet. They have more clay to a depth of about 2 feet than the Haynie soils. They are not underlain by sand as are the Grable soils. All of these soils formed in alluvium and are associated on the landscape.

**Blake silt loam** (0 to 2 percent slopes) (844).—This soil is on bottom lands near the Missouri River. It is at a slightly higher elevation than the adjacent Albaton soils, about the same elevation as the Onawa soils, and at a slightly lower elevation than the adjacent Haynie soils. Most areas are 5 to 40 acres in size.

This soil has a profile similar to the one described as representative of the series, but the present surface layer is silt loam that was deposited during floods. It is typically dark grayish brown in color and from 6 to 15 inches in thickness. Included in mapping were small areas of soils that have a sandy surface layer and small areas of Onawa soils.

This soil is used mainly for row crops and is well suited to such use. In many places it is farmed in fields with soils that have poorer drainage, and as a result cultivation is delayed in spring. In places drainage ditches that help to drain wetter adjacent soils go through this soil. There are no serious limitations to the use of this soil for crops if the soil is protected from flooding. Most areas are protected by levees, but unprotected areas are subject to almost yearly flooding. Capability unit I-2; woodland group 6.

**Blake silty clay loam** (0 to 2 percent slopes) (144).—This soil occurs in the western part of bottom lands

along the Missouri River. It is at a slightly higher elevation than the adjacent Albaton soils, at about the same elevation as the nearby Onawa soils, but at a somewhat lower elevation than the Haynie soils. Areas range from about 5 acres to as much as 100 acres in size. Many areas are long and narrow.

This soil has the profile described as representative of the series. Included in mapping were small areas of Onawa and Haynie soils. Also included is about 300 acres of similar soils that are stratified and underlain by black silty clay at a depth of about 4 to 7 feet. These included soils are in desilting basins in the eastern part of the Missouri River valley.

This soil is used mainly for row crops and is well suited to such use. In many places it is farmed in fields with soils that are slower to dry out, and as a result cultivation is delayed in spring. In many places drainage ditches go through this soil so that adjacent wetter soils can be drained. There are no serious limitations to the use of this soil for crops if the soil is protected from flooding. Most areas are protected by levees, but unprotected areas are subject to almost yearly flooding. Capability unit I-2; woodland group 6.

### Blencoe Series

The Blencoe series consists of dark-colored, somewhat poorly drained to poorly drained soils in the central and eastern parts of the bottom lands along the Missouri River. These soils formed in clayey alluvium that is underlain by silty alluvium. They are nearly level and are on broad flats.

In a representative profile the surface layer is silty clay about 18 inches thick. The upper 12 inches of this layer is black, and the lower 6 inches is very dark grayish brown to very dark gray. The subsoil extends to a depth of about 32 inches. It is dark grayish-brown, very firm silty clay in the upper part and dark grayish-brown to grayish-brown, friable light silty clay loam in the lower part. The substratum, to a depth of 54 inches, is grayish-brown, friable silt loam that is mottled with strong brown.

The Blencoe soils generally are medium to low in available nitrogen, very low in available phosphorus, and high in available potassium. The organic-matter content is high. The surface layer and subsoil are neutral. Available water capacity is high, and permeability is very slow in the silty clay and moderate in the material below. Runoff is slow.

Most areas of these soils are cultivated. Some areas are subject to occasional overflow from manmade drainage ditches. Wetness restricts plant growth in some years.

Representative profile of Blencoe silty clay in a cultivated field, 520 feet south and 100 feet west of center of the NW¼ sec. 31, T. 68 N., R. 42 W.

- Ap—0 to 6 inches, black (10YR 2/1) silty clay; moderate, fine, subangular blocky structure; very firm; many roots; few fine pores; neutral; clear, smooth boundary.
- A12—6 to 12 inches, black (10YR 2/1) silty clay; strong, fine, subangular blocky structure; very firm; many roots; few fine pores; neutral; clear, smooth boundary.
- A3—12 to 18 inches, very dark grayish-brown (2.5Y 3/2) to very dark gray (10YR 3/1) silty clay; moderate, fine, subangular blocky structure; very firm; apparent black (10YR 2/1) stains on ped faces; few fine roots; very few fine pores; neutral; clear, smooth boundary.

B2—18 to 28 inches, dark grayish-brown (2.5Y 4/2) silty clay; weak, medium, prismatic structure and fine subangular blocky structure; very firm; few ped faces have black (10YR 2/1) coatings; numerous root channels; few, fine, dark-colored iron and manganese oxides; neutral; clear, smooth boundary.

B3—28 to 32 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) light silty clay loam; few, fine, strong-brown (7.5YR 5/6) mottles; weak, medium, prismatic structure; friable; common root channels; few fine pores; few, fine, soft, black (10YR 2/1) iron and manganese oxides; very few fine lime concretions; neutral; clear, smooth boundary.

Cg—32 to 54 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, strong-brown (7.5YR 5/6) mottles; massive; friable; numerous brownish-yellow (10YR 6/6) stains; numerous roots and pores; few wormholes and worm casts; both soft filamentary lime and hard lime concretions; moderately alkaline; calcareous.

The Ap and A1 horizons are black (N 2/0 or 10YR 2/1) or very dark gray (N 3/0 or 10YR 3/1). They typically are silty clay but range to heavy silty clay loam. The A horizon typically is 12 to 20 inches in total thickness. The A3 horizon, or B1 horizon where present, is very dark gray (10YR 3/1) to very dark grayish brown (2.5Y 3/2).

The B2 horizon typically is dark grayish brown (2.5Y 4/2 or 10YR 4/2) but ranges to grayish brown (2.5Y 5/2). It is mottled with dark brown, strong brown, grayish brown, or olive brown in many places. The silty clay texture generally extends to a depth of 20 to 30 inches. In places the B3 horizon is silt loam. The B horizon extends to a depth of about 30 to 40 inches.

The C horizon typically is grayish brown (2.5Y 5/2) but ranges from dark grayish brown (2.5Y 4/2) to yellowish brown (10YR 5/4). It is silt loam but, in places, has ¼- to 6-inch strata of other textures. The C horizon is mottled with the same colors as the B horizon.

The A horizon is typically neutral or slightly acid, the B horizon is neutral or mildly alkaline, and the C horizon is mildly alkaline or moderately alkaline and calcareous.

The Blencoe soils have a less clayey C horizon than the Luton soils. Their A horizon and the upper part of their B horizon are more clayey than those of the Keg and Salix soils.

**Blencoe silty clay** (0 to 2 percent slopes) (44).—This soil is in the central and eastern parts of bottom lands along the Missouri River. It is at slightly higher elevations than the associated Luton and Woodbury soils and at slightly lower elevations than the adjacent Buckney, Salix, and Keg soils. Areas generally are from 5 to 100 acres in size.

Included with this soil in mapping are very small areas of Woodbury soils and about 100 acres of Blencoe soils that have 6 to 15 inches of very dark grayish-brown silt loam to silty clay loam overwash.

This soil is mainly used for row crops. It is well suited to this use but tends to be wet and has a high water table in some seasons. If the soil is worked when wet, the surface layer tends to become cloddy and hard as it dries. The power requirement for tillage operations is high. Capability unit IIw-1; woodland group 7.

### Blend Series

The Blend series consists of moderately dark colored to dark colored, poorly drained, nearly level soils in the central and eastern parts of bottom lands along the Missouri River. These soils formed in clayey alluvium.

In a representative profile the surface layer is very dark gray silty clay about 14 inches thick. The substratum, to a depth of about 22 inches, is grayish-brown, friable silt loam that has brown mottles. Below this, extending to a depth of 52 inches, it is dark-gray and gray, very

firm clay that has dark yellowish-brown, dark-brown, and brown mottles.

The Blend soils are medium to low in available nitrogen, very low in available phosphorus, and high in available potassium. The organic-matter content is high. The surface layer is neutral. Available water capacity is medium or high, and permeability is very slow. Runoff is very slow.

Most areas of these soils are cultivated. Wetness often restricts crop growth and delays tillage operations. At times some areas are subject to overflow, and other areas tend to pond.

Representative profile of Blend silty clay in a cultivated field, 260 feet south and 100 feet east of the northwest corner of the SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 30, T. 67 N., R. 42 W.

- Ap—0 to 6 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) dry; massive; very firm; few roots; very few fine pores; neutral; clear, smooth boundary.
- A1—6 to 14 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate, fine, subangular blocky structure; firm; few roots; very few fine pores; neutral; clear, smooth boundary.
- IIC1—14 to 22 inches, grayish brown (2.5Y 5/2) silt loam; few, fine, brown (7.5YR 4/4) mottles; massive; friable; few fine roots; moderately alkaline; calcareous; clear, smooth boundary.
- IIACgb—22 to 33 inches, dark-gray (5Y 4/1) clay; few, fine, dark yellowish-brown (10YR 4/4) mottles in lower part of horizon; moderate, fine, subangular blocky structure; very firm; shiny ped faces; very fine roots; neutral; gradual, smooth boundary.
- IIICg—33 to 52 inches, gray (5Y 5/1) clay; moderate, medium to fine, subangular blocky structure; very firm; some fine, dark-brown (10YR 3/3) and brown (7.5YR 4/4), soft accumulations of oxides; shiny ped faces; small shell fragments, some filament lime; moderately alkaline; calcareous.

The Ap and A1 horizons are typically black (10YR 2/1) or very dark gray (10YR 3/1), but in places they are very dark brown (10YR 2/2). They are clay or silty clay and, combined, are typically 10 to 18 inches in total thickness. In places the silty clay extends into a B horizon and is as much as 24 inches thick.

The IIC1 horizon is silt loam or silty clay loam and centers on dark grayish brown (2.5Y 4/2) or grayish brown (2.5Y 5/2) that has some brown mottles. It is 8 to 18 inches thick. In places the silt loam or silty clay loam is leached in the upper part, and in these places a IIB horizon is present.

The IIICg horizon is dark-gray (10YR 4/1 or 5Y 4/1) to light brownish-gray (2.5Y 6/2) silty clay or clay. Mottles range from brown to dark brown and olive brown. In places the upper 8 to 12 inches of this layer is black or very dark gray, and it is believed to be the A horizon of an older soil before it was buried by more recent sediment.

The A horizon is typically slightly acid or neutral, but it is medium acid in places. The IIC horizon is neutral to moderately alkaline. The upper part of the buried clay layer is neutral to mildly alkaline, but it grades to mildly alkaline or moderately alkaline and is calcareous at greater depth.

The Blend soils differ from most soils in the county because they have three layers that have a distinct texture. They are more poorly drained than Cooper soils, and their A horizon is more clayey. They are finer textured below a depth of about 2 feet than Blencoe soils. They are not silty clay throughout, as are the Luton soils. All of these soils formed in alluvium.

**Blend silty clay** (0 to 2 percent slopes) (244).—This soil is in the central and eastern parts of bottom lands along the Missouri River. It is near the Luton, Salix, Woodbury, Lakeport, and Blencoe soils. Most areas are 10 to about 200 acres in size.

Included with this soil in mapping were small areas of Cooper soils.

Most areas of this soil are cultivated and used for row crops. The soil is moderately suited to this use if wetness is

controlled. Wetness and a high water table are limitations to the use of this soil for crops, and as a result tillage or other fieldwork is delayed at times. If the soil is tilled when wet, the surface layer tends to become cloddy and hard as it dries. The power requirement for tillage operations is high. Capability unit IIIw-1; woodland group 7.

## Buckney Series

The Buckney series consists of moderately dark colored to dark colored, excessively drained soils on bottom lands along the Missouri River but some distance from the present channel. These soils formed in sandy alluvium. Slopes are 1 to 3 percent.

In a representative profile the surface layer is about 22 inches thick. It is very dark gray fine sandy loam to a depth of about 13 inches and very dark grayish-brown loamy fine sand in the lower part. The substratum, to a depth of 42 inches, is dark grayish-brown and grayish-brown, very friable to loose loamy very fine sand. Below this, extending to a depth of 54 inches, it is dark grayish-brown loam that has dark yellowish-brown and olive-gray mottles.

The Buckney soils are low in available nitrogen and phosphorus and high in available potassium. The organic-matter content is moderate. The soils are neutral in the surface layer and mildly alkaline in the substratum. Available water capacity is low, and permeability is rapid. Runoff is slow.

Most areas of Buckney soils are cultivated. Droughtiness and soil blowing are limitations to the use of these soils for crops.

Representative profile of Buckney fine sandy loam in a permanent pasture, 1,720 feet south and 2,140 feet west of the northeast corner of sec. 36, T. 68 N., R. 44 W., or 60 feet west of farm lane and 400 feet south in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ .

- A1—0 to 13 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, granular structure; very friable; few, very thin, discontinuous lenses of dark grayish-brown (10YR 4/2 to 2.5Y 4/2) silty material; neutral; diffuse, smooth boundary.
- A3—13 to 22 inches, very dark grayish-brown (10YR 3/2) loamy very fine sand; very weak, medium, subangular blocky structure breaking to weak, fine, granular; very friable; few, very dark gray (10YR 3/1), vertical streaks of organic material; many fine roots; neutral; diffuse, smooth boundary.
- C1—22 to 30 inches, dark grayish-brown to grayish-brown (10YR 4/2 to 2.5Y 5/2) loamy very fine sand; single grained; very friable to loose; few fine roots; mildly alkaline; calcareous; diffuse, smooth boundary.
- C2—30 to 42 inches, grayish-brown (2.5Y 5/2) loamy very fine sand; few, very fine, dark yellowish-brown (10YR 4/4) mottles; single grained; very friable to loose; very few fine roots; mildly alkaline; calcareous; clear, smooth boundary.
- C3—42 to 54 inches, dark grayish-brown (10YR 4/2) loam; common, fine, olive-gray (5Y 5/2) mottles and few, fine, dark yellowish-brown (10YR 4/4) mottles; dark yellowish-brown mottles most common in the 42- to 46-inch layer; massive; friable; few fine pores; few very fine roots; moderately alkaline; calcareous.

The A1 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). The A horizon is 12 to 24 inches in total thickness.

The C horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) to grayish brown (10YR 5/2 or 2.5Y 5/2) or brown (10YR 4/3). It is generally loamy very fine sand but ranges to loamy fine sand and very fine sandy loam or fine sandy loam. The textures

below a depth of 40 inches are similar but range to loam. In places there are mottles of dark yellowish brown to light olive brown or olive gray. The C horizon is mildly alkaline or moderately alkaline and calcareous.

In Fremont County, Buckney soils have lower chroma in the upper part of the C horizon and have a higher proportion of very fine sand throughout the profile than is defined as the range for the series.

The Buckney soils have a darker colored and thicker A horizon than that of the Carr or Sarpy soils. They are sandier to a depth of about 2 feet than the Grable soils and are darker colored. All of these soils formed in alluvium.

**Buckney fine sandy loam, 1 to 3 percent slopes (636).**—

This soil is on bottom lands along the Missouri River. It is associated with the Keg, Cott, and Cooper soils and, in some places, with the Sarpy soils. Areas are small, generally ranging from 5 to 50 acres in size, but some are larger.

Included with this soil in mapping were small areas of Keg, Cott, and Sarpy soils.

Most areas of this soil are cultivated and used for row crops, but a few areas are in pasture (fig. 8). This soil is subject to droughtiness and soil blowing. It is suited to row crops, but yields are often reduced by drought. Most areas either are high enough or are protected so that flooding is seldom a hazard. The soil is easy to till and can be worked soon after rains. Capability unit IIIs-1; woodland group 6.

**Carr Series**

The Carr series consists of stratified, moderately dark colored, excessively drained soils on bottom lands along the Missouri River near the present channel. These soils

formed in sandy and loamy alluvium. Slopes are 1 to 3 percent.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 6 inches thick. The substratum, to a depth of about 16 inches, is stratified, dark grayish-brown and grayish-brown to light olive-brown, very friable fine sandy loam. Below this, extending to a depth of 60 inches, it is stratified, grayish-brown and light olive-brown, very friable loamy very fine sand that has thin lenses of sandy loam and silt loam. There are some gray and brown mottles throughout the substratum.

The Carr soils are very low in available nitrogen and phosphorus and, typically, are high in available potassium. The organic-matter content is low. The soils are mildly alkaline and are calcareous. Available water capacity is low, and permeability is rapid. Runoff is slow.

Most areas of these soils are cultivated. Droughtiness and soil blowing are limitations to their use for crops. Before the large dams on the Missouri River and the levees were constructed, these soils were subject to flooding, but now the hazard of flooding is slight in most areas.

Representative profile of Carr fine sandy loam, 1 to 3 percent slopes, in a cultivated field, 70 feet south of center of road directly opposite of driveway to vacant buildings in the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 29, T. 70 N., R. 43 W., or 2,172 feet east and 600 feet south of the northwest corner of sec. 29.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, some mixing of brown (10YR 4/3) colors, dark grayish brown (10YR 4/2) kneaded; weak, fine, granular structure to massive; very



**Figure 8.**—Pasture on Buckney soils. The trees are few and scattered.

- friable; few fine roots; some evidence of worm activity; mildly alkaline; calcareous; abrupt, smooth boundary.
- C1—6 to 16 inches, stratified dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2 to 2.5Y 5/2) to light olive-brown (2.5Y 5/4) fine sandy loam and thin very dark grayish-brown (10YR 3/2) lenses; common, medium, gray (N 5/0) and brown (7.5YR 4/4) mottles; massive; very friable; few fine roots; very few fine pores; some worm holes and casts; mildly alkaline; calcareous; abrupt, smooth boundary.
- C2—16 to 60 inches, stratified grayish-brown (10YR 5/2 to 2.5Y 5/2) to light olive-brown (2.5Y 5/4) loamy very fine sand and thin lenses of olive-brown (2.5Y 4/4) and grayish-brown (2.5Y 5/2) sandy loam and silt loam; indistinct olive-brown and grayish-brown mottles; single grained; very friable; mildly alkaline; calcareous.

The Ap horizon ranges from very dark grayish brown (10YR 3/2) to brown (10YR 4/3) in color and from 6 to 9 inches in thickness. The A1 horizon in uncultivated areas is about 2 to 10 inches thick.

The C horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) to light olive brown (2.5Y 5/4) and ranges from fine sandy loam to loamy very fine sand or sand. Strata of clayey or silty materials  $\frac{1}{4}$  inch to 6 inches thick are common. Mottles of gray or brown to yellowish brown and reddish brown occur.

The Ap horizon is neutral to moderately alkaline, and the C horizon is mildly alkaline or moderately alkaline and calcareous. There are small lime concretions in places.

The Carr soils differ from the Buckney soils in having lighter colored, thinner A horizons. They are somewhat finer textured than Sarpy soils in the A horizon and in the layer at a depth between 10 and 40 inches. They are sandier in the upper 2 feet than are the Grable soils. They lack the clay texture at a depth of 18 to 30 inches which is present in the Waubonsie soils. Carr soils are near Grable and Sarpy soils on the landscape. All of these soils formed in alluvium.

#### **Carr fine sandy loam, 1 to 3 percent slopes (538).**—

This nearly level to gently undulating soil is on bottom lands along the Missouri River. It is near the Vore, Sarpy, Haynie, or Grable soils or the Albaton, Onawa, Percival, or Blake soils. Most areas are 5 to 50 acres in size.

Included with this soil in mapping were very small areas of Vore and Sarpy soils.

This soil is used mainly for row crops and is suited to such use, but it is subject to droughtiness and soil blowing. A few areas are in pasture or trees. The soil is droughty when rainfall is average or below, but it is easily tilled. Areas that are not protected by levees are subject to flooding. Capability unit IIIs-1; woodland group 6.

### **Castana Series**

The Castana series consists of moderately dark-colored, well-drained soils on uplands. These soils formed in silty local alluvium washed or slumped from the adjacent hillsides. They are on high foot slopes, mainly along the bluffs at the eastern edge of the Missouri River Valley. Slopes are 9 to 20 percent.

In a representative profile the surface layer is very dark grayish-brown, calcareous silt loam about 12 inches thick. The substratum, to a depth of 50 inches, is dark grayish-brown and brown, very friable silt loam.

The Castana soils are low in available nitrogen, very low in available phosphorus, and high in available potassium. The organic-matter content is moderate. These soils are moderately alkaline and calcareous. Available water capacity is high, and permeability is moderate. Runoff is medium.

The larger areas of these soils are generally cultivated, and small areas near the more sloping Hamburg soils are typically in pasture. Areas near the less sloping Napier soils are generally cultivated along with the Napier soils. These soils are subject to erosion and to siltation and gullyng. In places large gullies have developed in the valleys and cut back into areas of these soils.

Representative profile of Castana silt loam, 9 to 20 percent slopes, on a west-facing slope that has a gradient of 16 percent, 500 feet east and 200 feet north of the southwest corner of the SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 8, T. 67 N., R. 42 W.

- A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; dark grayish brown (10YR 4/2) dry; some mixing of dark grayish brown (10YR 4/2) material from the C1 horizon (about 15 percent); weak, fine, granular structure; very friable; few small to medium lime concretions; many roots and pores; moderately alkaline; calcareous; gradual, smooth boundary.
- C1—12 to 22 inches, dark grayish-brown (10YR 4/2) silt loam; weak, very fine, granular structure; very friable; few fine lime concretions; many roots and pores; moderately alkaline; calcareous; gradual, smooth boundary.
- C2—22 to 50 inches, brown (10YR 4/3) silt loam; massive; very friable; few fine lime concretions; few roots; moderately alkaline; calcareous.

The A1 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). It ranges from 10 to 20 inches in thickness. It is noncalcareous to a depth of about 12 inches in places.

The C horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 4/3 or 5/3) or yellowish brown (10YR 5/4 or 5/6).

The Castana soils have an A horizon that is thinner than that of the Napier soils and not so deeply leached. They have an A horizon that is thicker than that of the Hamburg and Ida soils. These soils are associated on the landscape.

**Castana silt loam, 9 to 20 percent slopes (3E).**—This soil is along the bluffs at the eastern edge of the Missouri River valley. It is generally upslope from the Napier and Kennebec soils and downslope from the Hamburg and Ida soils. Areas are small and are long and narrow. They generally are 5 to 25 acres in size.

Included with this soil in mapping were small areas of soils that have slopes of 5 to 9 percent and 2 to 25 percent and small areas of Napier and Ida soils.

This soil is cultivated or used for pasture, depending on the slopes, the size of the area, and the associated soils. It is moderately suited to row crops if erosion and gullyng are controlled, but many areas are planted to grass and legumes and row-cropped only when renovation is necessary. Because areas are generally small, the soil is generally farmed with adjacent soils if it is cultivated. Because it is steep, it is subject to severe erosion. Because it is downslope from steeper soils, water from upslope areas runs across it and causes gullies and severe rill erosion in places. Capability unit IVE-1; woodland group 4.

### **Colo Series**

The Colo series consists of dark-colored, poorly drained, nearly level soils on the bottom lands. These soils formed in silty alluvium. They are on the first bottoms along streams that flow through the uplands to the Missouri River. They also occur with Judson soils in narrow drainageways on uplands.

In a representative profile the surface layer is silty clay loam about 36 inches thick. This layer is black in

the upper 26 inches and very dark gray in the lower 10 inches. It has some dark grayish-brown and grayish-brown mottles. The subsoil is dark-gray, firm silty clay loam about 8 inches thick. It has a few olive-gray mottles. The substratum, to a depth of 56 inches, is dark-gray, firm silty clay loam that is mottled with olive gray and brown.

The Colo soils are medium to low in available nitrogen, low to very low in available phosphorus, and medium in available potassium. The content of organic matter is high. The soils typically are slightly acid or neutral, but in places the plow layer is medium acid. Available water capacity is high, and permeability is moderately slow. Runoff is slow. These soils are subject to flooding during periods of heavy rainfall.

Most of the acreage is cultivated and is used for row crops. Wetness and a high water table restrict plant growth at times.

Representative profile of Colo silty clay loam in a cultivated field, 200 feet west and 50 feet south of the northeast corner of the SE $\frac{1}{4}$  sec. 12, T. 69 N., R. 40 W.

- Ap—0 to 4 inches, black (10YR 2/1) silty clay loam; cloddy; friable; numerous roots; very few fine pores; appears to be overwash; medium acid; abrupt, smooth boundary.
- A12—4 to 8 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure; friable; numerous fine roots; few fine pores; slightly acid; abrupt, smooth boundary.
- A13—8 to 26 inches, black (N 2/0) silty clay loam; few, fine, faint, dark grayish-brown (10YR 4/2) mottles; weak, very fine, subangular blocky structure to fine granular structure; friable; numerous fine roots and large pores; some worm casts; slightly acid; diffuse, smooth boundary.
- A3—26 to 36 inches, very dark gray (10YR 3/1) silty clay loam; common, fine, faint, grayish-brown (2.5Y 5/2) mottles; moderate, fine to medium, subangular blocky structure; friable; few fine roots; many fine pores; some large root channels; neutral; diffuse, smooth boundary.
- Bg—36 to 44 inches, dark-gray (10YR 4/1) silty clay loam; few, fine, faint, olive-gray (5Y 5/2) mottles; moderate, medium, subangular blocky structure; firm; few very fine roots; few very fine pores; neutral; gradual boundary.
- Cg—44 to 56 inches, dark-gray (10YR 4/1) silty clay loam; few, fine, faint, olive-gray (5Y 5/2) mottles and common, fine, brown (7.5YR 4/4) mottles; massive; neutral.

The A horizon ranges from 24 to 40 inches in thickness. It typically is silty clay loam, but in places the Ap horizon or the upper part of the A1 horizon is heavy silt loam. Recently deposited overwash that is very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam is present in places. A few dark grayish-brown, grayish-brown, reddish, or yellowish mottles are present in many places.

The Bg horizon is gleyed, very dark gray (10YR 3/1) to dark-gray (10YR 4/1) silty clay loam that has mottles ranging from dark brown and strong brown to yellowish brown and olive gray.

Black or very dark gray colors extend to a depth of 36 inches or more. In some places a B horizon is lacking, and in these places the A horizon is directly over the C horizon. Colo soils range from neutral to medium acid in the upper 12 inches and are neutral or slightly acid below.

Colo soils have a higher clay content throughout than the Kennebec soils and are not so well drained as those soils. They are not so high in clay content in the lower part of the A horizon and in the B horizon as the Zook soils. All of these soils formed in alluvium and are associated on the landscape.

**Colo silt loam, overwash** (0 to 2 percent slopes) (133+).—This soil is on low-lying first bottoms where flooding and siltation have occurred more frequently than on other Colo soils. The recent deposition has come from tributary streams that flow across the bottom lands toward the rivers. This soil is adjacent to Colo silty clay loam. It is near the Judson soils that are on slightly higher foot slopes. In many places it is near the Nodaway soils. It is at slightly higher elevations than the adjacent Zook soils. Most areas are about 10 to 100 acres in size.

This soil has a profile similar to the one described as representative of the series, but in most areas a layer of very dark grayish-brown or dark grayish-brown silt loam, 6 to 15 inches thick, has been washed over the original black surface layer. The present surface layer is lower in nitrogen than that of Colo silty clay loam.

Many areas of this soil are cultivated and are used for row crops, but some areas are in pasture. This soil is well suited to row crops if wetness and flooding are controlled. The surface layer is generally somewhat easier to till than that of Colo silty clay loam. Capability unit IIw-1; woodland group 7.

**Colo silty clay loam** (0 to 2 percent slopes) (133).—This soil is on bottom lands. It generally is near the Judson soils that are on alluvial fans upslope. It is near and is at slightly higher elevations than the Zook soils and is at lower elevations than the nearby Kennebec soils. It generally is not so close to the river channels as the nearby Nodaway soils. Areas generally are 25 to 150 acres in size, but some are larger.

This soil has the profile described as representative of the series. Included in mapping were small areas of Zook silty clay loam and Kennebec soils.

Much of the acreage of this soil is cultivated and is used for row crops, but some areas are in permanent pasture or timber. This soil has a seasonal high water table and is subject to variable degrees of flooding. In places levees are built to protect the soil from flooding. In some places the soil is adjacent to entrenched streams or drainage ditches, and in these places some areas are managed without additional provision for drainage. If drainage is adequate and overflow is infrequent, this soil is well suited to row crops. Capability unit IIw-1; woodland group 7.

**Colo-Judson silty clay loams, 2 to 5 percent slopes** (11B).—These soils are along drainageways in the uplands. Areas generally are long and narrow, and some are as much as several hundred acres in size.

Colo soils are adjacent to the streams along the narrow drainageways and, in many places, have 6 to 15 inches of recently deposited sediments on the surface. They make up about 60 percent of the complex. Judson soils are in bands at the base of slopes on uplands. They make up most of the remaining acreage.

These soils are managed in the same way as adjacent soils. Some areas are cultivated, but many are used for pasture along with the adjacent, steep soils on uplands. Runoff from adjacent soils causes gulying in places. In many areas there is a stream or drainageway that cannot be crossed by farm equipment. If wetness, flooding, and siltation are controlled, these soils are well suited to row crops. Capability unit IIw-1; woodland group 7.

## Cooper Series

The Cooper series consists of dark-colored, somewhat poorly drained, nearly level soils on bottom lands along the Missouri River. These soils are mainly in the central part of the bottom lands several miles from the river channel. They formed in silty and loamy alluvium that is underlain by silty clay or clay.

In a representative profile the surface layer is black silty clay loam in the upper part and very dark-gray loam to sandy clay loam that has a few brown and grayish-brown mottles in the lower part. It is about 11 inches thick. Below this is a layer of dark grayish-brown and light brownish-gray, friable loam, about 9 inches thick, that is mottled with brown. The next layer is very dark gray, dark grayish-brown, and grayish-brown, firm silty clay that has brown mottles. It was once the surface layer of a buried soil. Beneath this is a 5-inch layer of dark-gray, firm silty clay that has strata of light brownish-gray silty clay loam. The underlying material is dark-gray and olive-gray, very firm silty clay that has common brown mottles.

The Cooper soils are medium to low in available nitrogen, medium in available phosphorus, and high in available potassium. The content of organic-matter is high. Permeability is moderate in the silty and loamy upper part of the profile and slow or very slow in the clayey lower part. Available water capacity is high. The soils are typically slightly acid in the surface layer and mildly alkaline and calcareous in the rest of the silty and loamy upper part of the profile.

Most areas of Cooper soils are cultivated.

Representative profile of Cooper silty clay loam in a cultivated field, 150 feet west and 50 feet north of the southeast corner of sec. 35, T. 68 N., R. 43 W.

- Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark-gray (10YR 4/1) dry, black (10YR 2/1) crushed; cloddy; friable; few fine roots and pores; high in content of very fine sand; slightly acid; clear, smooth boundary.
- A3—7 to 11 inches, very dark gray (10YR 3/1) loam to sandy clay loam; common, fine, dark-brown (7.5YR 3/2) mottles and few, fine, brown (7.5YR 4/4) and grayish-brown (2.5Y 5/2) mottles; weak, fine, granular structure; friable; many fine roots and pores; high in content of very fine sand; apparent mixing by worms; slightly acid; clear, smooth boundary.
- C1—11 to 20 inches, dark grayish-brown (10YR 4/2) mixed with light brownish-gray (2.5Y 6/2) loam; common, fine, brown (7.5YR 4/4) mottles; massive; friable; many fine roots and pores; few dark-colored oxides; horizon apparently mixed extensively by worms; mildly alkaline; calcareous; clear, smooth boundary.
- IIAb—20 to 25 inches, about equal parts of very dark gray (10YR 3/1), dark grayish-brown (10YR 4/2), and grayish-brown (10YR 5/2) clay to silty clay; common, fine, brown (7.5YR 4/4) mottles; strong, very fine, subangular blocky structure; firm; few fine roots and pores; worm channels appear to be filled with light brownish-gray (10YR 6/2) material; few, very fine, dusky-red (10YR 3/4) oxides; neutral; clear, smooth boundary.
- IIBgb—25 to 31 inches, dark-gray (10YR 4/1) silty clay that has strata of light brownish-gray (2.5Y 6/2) silty clay loam; common, fine, dark yellowish-brown (10YR 4/4) mottles; strong, very fine, subangular blocky structure; firm; few very fine roots; few, very fine, dark-colored oxides; moderately alkaline; calcareous; clear, smooth boundary.
- IIC1g—31 to 41 inches, dark-gray (10YR 4/1 to 5Y 4/1) silty clay; common, fine, brown (7.5YR 4/4) mottles; massive; very firm; few very fine roots; some dark-colored oxide coatings on peds; filament lime and

shells; moderately alkaline; calcareous; gradual, smooth boundary.

IIC2g—41 to 50 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) silty clay; common, fine, brown (7.5YR 4/4) mottles; massive; very firm; some dark-colored oxide coatings on peds; filament lime; moderately alkaline; calcareous.

The A horizon is 10 to 20 inches in total thickness. The Ap and A3 horizons range from black (10YR 2/1) to very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) in color and from silty clay loam to loam in texture. In places silt loam or sandy clay loam occurs in these horizons.

The C1 horizon in the silty and loamy alluvial material ranges from dark grayish brown (10YR 4/2) to light olive brown (2.5Y 5/4) and from loam or silt loam to light silty clay loam. In some profiles a B horizon has formed in this material. The underlying material is silty clay or clay that is dark gray (10YR 4/1 or 5Y 4/1) to grayish brown (10YR 5/2 or 2.5Y 5/2) or light brownish gray (2.5Y 6/2) and has yellowish-brown to gray mottles. It is generally at a depth of 18 to 30 inches. In places the buried A horizon is lacking. In places it is very dark gray or very dark grayish brown and not mixed with other colors. In many places the strata of silty clay loam in the underlying silty clay or clay material are lacking.

The A horizon is slightly acid or neutral. The B or C horizon of the silty and loamy alluvial material is slightly acid to mildly alkaline, and the underlying silty clay or clay material is mildly or moderately alkaline and calcareous. However, IIAb horizons, where present, range to neutral.

In Fremont County, the Cooper soils have a higher proportion of sand in the silty and loamy alluvial material than is defined as the range for the series.

Cooper soils are underlain by silty clay or clay, but Salix, Blencoe, Keg, and Lakeport soils are not. Cooper soils are better drained and are less clayey in the upper part than the Blend soils. All of these soils formed in alluvium and are associated on the landscape.

**Cooper loam** (0 to 2 percent slopes) (437).—This soil occurs on bottom lands along the Missouri River, about midway between the uplands and the river channel. It is near or adjacent to Cooper silty clay loam, and the Keg, Salix, Lakeport, Luton, and Buckney soils. The areas are irregular in shape and range from 5 acres to more than 100 acres in size.

This soil has a profile similar to the one described as representative of the series except that it is loam to a depth of about 2 feet or more. It tends to be slightly deeper to the underlying silty clay or clay than Cooper silty clay loam and is better drained. Included in mapping were very small areas of Keg and Buckney soils.

This soil is used mainly for row crops, and it is well suited to this use. It has no severe limitations to its use for crops. Capability unit I-1; woodland group 7.

**Cooper silty clay loam** (0 to 2 percent slopes) (255).—This soil is on bottom lands along the Missouri River, about midway between the uplands and the river channel. It has the profile described as representative of the series. It is near Cooper loam and the Salix, Blencoe, Keg, Luton, and Lakeport soils. Areas generally are large and are irregular in shape. Some areas are as much as several hundred acres in size. Included in mapping were very small areas of Cooper loam and Luton soils.

Most areas of this soil are cultivated, and row crops are grown most of the time. The management of the soils adjacent to this soil in the same field may govern when and how the field is farmed. Where this soil is near Luton or Blencoe soils, fieldwork may be delayed at times. This soil tends to be somewhat wet, but many areas are farmed without additional drainage. Capability unit IIw-1; woodland group 7.

## Corley Series

The Corley series consists of dark-colored, poorly drained soils that formed in loess. These soils are typically in depressions on high benches along the Nishnabotna Rivers.

In a representative profile the surface layer is black silt loam about 8 inches thick. The subsurface layer is dark-gray, very friable silt loam about 10 inches thick. The subsoil extends to a depth of 60 inches. It is very dark gray, friable silty clay loam in the upper part and grayish-brown and light-gray, firm silty clay loam in the lower part. There are a few yellowish-brown, yellowish-red, and strong-brown mottles below a depth of 27 inches.

The Corley soils are medium to low in available nitrogen, very low in available phosphorus, and medium in available potassium. The content of organic matter is high. The soils typically are neutral or slightly acid throughout. Available water capacity is high, and permeability is moderately slow. Runoff is very slow.

Most areas of these soils are cultivated and are used for row crops. These soils are ponded and artificial drainage is needed.

Representative profile of Corley silt loam in a depression in a cultivated field, 1,300 feet south and 250 feet east of the northwest corner of sec. 28, T. 69 N., R. 41 W.

- Ap—0 to 8 inches, black (10YR 2/1) silt loam, gray (10YR 5/1) dry; cloddy breaking to weak, fine, granular structure; friable; many roots and pores; neutral; clear, smooth boundary.
- A2—8 to 18 inches, dark-gray (10YR 4/1) silt loam, light gray (10YR 6/1) dry; weak, fine, subangular blocky structure to weak, fine, granular; very friable; many roots and pores; neutral; clear, smooth boundary.
- B1—18 to 27 inches, very dark gray (10YR 3/1) silty clay loam; moderate to strong, medium, subangular blocky structure; friable; root channels filled with black (10YR 2/1) materials; few roots and pores; neutral; clear, smooth boundary.
- B21tg—27 to 36 inches, very dark gray (10YR 3/1) silty clay loam; few, fine, yellowish-brown (10YR 5/6) mottles; moderate, fine, prismatic structure breaking to moderate, fine, subangular blocky; friable; few pores; neutral; clear, smooth boundary.
- B22tg—36 to 51 inches, grayish-brown (10YR 5/2) to dark-gray (5Y 4/1) heavy silty clay loam; few, fine, yellowish-red (5YR 5/6 and 5/8) mottles; moderate, medium, prismatic structure breaking to medium and fine subangular blocky; firm; thin discontinuous clay films; small black oxides and fillings in root channels; few roots; very few fine pores; neutral; clear, smooth boundary.
- B3tg—51 to 60 inches, light-gray (5Y 6/1) silty clay loam; few, medium, strong-brown (7.5YR 5/8) mottles; weak, medium, prismatic structure; firm; black (10YR 2/1) material filling pore spaces and root channels; few, thin, discontinuous clay films; few very fine pores; neutral.

The Ap, or A1 horizon if present, is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). In some places the original black A1 horizon is covered by a few inches of very dark brown or very dark grayish-brown silt loam or light silty clay loam. The Ap and A1 horizons have a combined thickness of about 8 to 20 inches. The underlying A2 horizon is about 6 to 12 inches thick and generally dries to gray or light gray.

The B1 horizon does not occur in all places. The B2tg horizon ranges from black (N 2/0 or 10YR 2/1) to very dark gray (10YR 3/1) in the upper part and from dark gray (10YR 4/1 or 5Y 4/1) or dark grayish brown (10YR 4/2) to light gray (5Y 6/1) in the lower part. It is typically medium silty clay loam but ranges to heavy silty clay loam. The solum is about 3½ to 5 feet thick in most places.

The C horizon is olive-gray or light olive-gray silt loam or light silty clay loam. The representative profile was not described deeply enough to include this horizon.

In Fremont County, Corley soils are typically neutral or slightly acid in the solum, but some horizons range to medium acid or strongly acid.

Corley soils differ from the adjacent Minden and Marshall soils in that they have an A2 horizon of dark-gray silt loam and a gray B horizon. These soils formed in loess and are associated on the landscape.

**Corley silt loam** (0 to 2 percent slopes) (233).—This soil is in small depressions on stream benches along the Nishnabotna Rivers. It is generally adjacent to Marshall or Minden soils. The areas are mainly between 3 and 10 acres in size. Very small wet areas are shown on the soil map by a symbol for a wet spot.

If this soil is drained, it is well suited to row crops. A few undrained areas that are too wet to farm are left idle. Because the depressions in which this soil occurs are small, the soil is generally farmed with the surrounding better drained soils. It is subject to wetness, and water ponds in these areas. In places outlets for tile or drainage ditches are difficult to obtain, and the soil is farmed without artificial drainage. In wet years, crops may drown out in these places. Capability unit IIw-1; woodland group 7.

## Cott Series

The Cott series consists of dark-colored, moderately well drained soils in somewhat elevated areas in the central part of bottom lands along the Missouri River. These soils formed in loamy alluvium underlain by sandy alluvium.

The surface layer, to a depth of about 7 inches, is very dark brown clay loam. The lower part of the surface layer, which extends to a depth of about 13 inches, is clay loam. It is black mixed with some very dark grayish brown. The subsoil is about 17 inches thick. It is brown and dark grayish-brown, friable loam in the upper part and brown, very friable loam that has common dark grayish-brown mottles in the lower part. The substratum to a depth of 50 inches is loose fine sand. It is grayish brown mixed with some dark yellowish brown.

The Cott soils are low in available nitrogen, medium in available phosphorus, and high in available potassium. The content of organic matter is moderate. The surface layer is neutral; the subsoil is neutral to mildly alkaline; and the substratum is moderately alkaline and calcareous. Available water capacity is low. Permeability is moderate in the upper part of the soil and moderately rapid to rapid in the lower part. Runoff is slow.

Most areas of these soils are cultivated. These soils tend to be droughty.

Representative profile of Cott clay loam in a cultivated field, 280 feet west and 180 feet north of the southeast corner of the SW¼SE¼ sec. 8, T. 67 N., R. 42 W.

- Ap—0 to 7 inches, very dark brown (10YR 2/2) clay loam; cloddy but breaks to weak, fine, granular structure; friable; common roots and few fine pores; some mixing of very fine sand at the surface; neutral; abrupt, smooth boundary.
- A12—7 to 13 inches, black (10YR 2/1) clay loam, some mixing with very dark grayish brown (10YR 3/2); weak, fine, subangular blocky structure and fine granular structure; friable; common fine roots and fine pores; neutral; clear, smooth boundary.

- B2—13 to 19 inches, brown (10YR 4/3) and dark grayish-brown (10YR 4/2) loam, dark grayish brown (10YR 4/2) kneaded; weak, fine, subangular blocky structure; friable; very dark grayish-brown (10YR 3/2) coatings on peds; few fine roots; common fine pores; neutral to mildly alkaline; clear, smooth boundary.
- B3—19 to 30 inches, brown (10YR 4/3) light loam; common, fine, dark grayish-brown (10YR 4/2) mottles; single grained; very friable; mildly alkaline; calcareous; clear, smooth boundary.
- IIC—30 to 50 inches, grayish-brown (10YR 5/2) fine sand; some mixing with or mottles of dark yellowish brown (10YR 4/4); single grained; loose; moderately alkaline; calcareous.

The Ap and A1 horizons range from black (10YR 2/1) to very dark grayish brown (10YR 3/2). They are loam or clay loam. The Ap and A1 horizons generally have a combined thickness of 10 to 18 inches. An A3 horizon is present in some profiles.

The B2 horizon is dark grayish brown (10YR 5/2 or 2.5Y 5/2) or brown (10YR 4/3 or 5/3). The texture of the B horizon centers on loam but ranges to sandy loam, and in places the upper part is clay loam. Mottles of dark grayish brown to yellowish brown are few to common.

The IIC horizon, beginning at a depth of 18 to 26 inches, is grayish brown (10YR 5/2 or 2.5Y 5/2) or light brownish gray (10YR 6/2 or 2.5Y 6/2). In some places where low-chroma mottles are present, the chroma is 3. Mottles are similar to those in the B horizon.

The B horizon is neutral to mildly alkaline, and the IIC horizon is mildly alkaline or moderately alkaline and is calcareous.

The Cott soils have more sand, especially in the IIC horizon, than the Keg and Salix soils. These soils are associated on the landscape.

**Cott loam** (0 to 2 percent slopes) (447).—This soil is in slightly elevated areas on bottom lands along the Missouri River, about midway between the slack water areas to the east and the river channel. It is generally in areas adjacent to the Luton soils that are at a lower elevation and Salix and Keg soils that are at about the same elevation. Areas generally are 10 to 160 acres in size.

This soil has a profile similar to the one described as representative of the series except that it has a surface layer of loam. Included in mapping were small areas of Keg soils.

Because it has a sandy substratum, this soil tends to be droughty. Nearly all areas of this soil are cultivated, and row crops are grown most of the time. The soil is well suited to this use, but in most years production is reduced because of the droughtiness. Capability unit IIs-1; woodland group 6.

**Cott clay loam** (0 to 2 percent slopes) (448).—This soil is in slightly elevated areas in the central part of bottom lands along the Missouri River, about midway between the slack water areas to the east and the river channel. It generally is in areas adjacent to Luton soils that are at a lower elevation and Salix and Keg soils that are at a slightly higher elevation. Most areas are between 10 and 160 acres in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of Salix soils.

Because the substratum is sandy, this soil tends to be droughty. Nearly all of the areas of this soil are cultivated, and row crops are grown most of the time. The soil is well suited to this use, but in most years production is reduced because of the droughtiness. Capability unit IIs-1; woodland group 6.

## Dockery Series

The Dockery series consists of moderately dark colored, somewhat poorly drained, nearly level soils on bottom lands, generally near the stream channels. These soils formed in stratified silty alluvium.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 8 inches thick. The substratum, to a depth of about 17 inches, is stratified, light brownish-gray, friable silt loam. Below this, extending to a depth of 58 inches, it is very dark grayish-brown, stratified, friable silt loam that has common strata of very dark gray silty clay loam. Some yellowish-brown and reddish-brown mottles and stains are on cleavage faces.

The Dockery soils are low in available nitrogen, low in available phosphorus, and medium in available potassium. The organic-matter content is low. The soils are typically neutral throughout. Available water capacity is high, and permeability is moderate. Runoff is slow.

Most areas of these soils are cultivated, but a few very wet areas are in grass or support only willow and cottonwood trees and brush. A high water table and the overflowing of nearby streams cause these soils to be wet. The hazard of flooding is severe because of the low-lying position of these soils.

Representative profile of Dockery silty clay loam in a cultivated field, about 100 feet west and 150 feet north of the southwest corner of the SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 31, T. 69 N., R. 41 W.

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) and small amounts of light brownish gray (10YR 6/2) dry; weak, fine, granular and subangular blocky structure and some tendency to platy structure because of stratification; friable; many roots and pores; neutral; abrupt, smooth boundary.
- C1—8 to 17 inches, light brownish-gray (10YR 6/2) silt loam, light gray (10YR 7/2) dry; some tendency to platiness because of stratification; a 2-inch stratum of black (10YR 2/1) silty clay loam and numerous very fine strata of very dark gray (10YR 3/1) light silty clay loam; these strata have fine subangular blocky structure; friable; many roots and pores; few iron stains on cleavage faces and along root channels are yellowish brown (10YR 5/6 and 10YR 5/8); neutral; clear, smooth boundary.
- C2—17 to 58 inches, very dark grayish-brown (10YR 3/3) silt loam; platy structure because of stratification; common thin strata of very dark gray (10YR 3/3) silty clay loam; these strata have platy structure because of stratification, some parts have fine subangular blocky structure; some of the platy surfaces are covered with very thin strata of light-gray (10YR 7/2) silt loam; some yellowish-brown (10YR 5/6) iron stains and many dark reddish-brown (5YR 3/4) and reddish-brown (5YR 4/4) stains on cleavage faces; friable; many roots and pores; neutral.

The A horizon is generally very dark grayish brown (10YR 3/2) but ranges to very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2). It is silt loam or silty clay loam. The Ap horizon, or the A1 horizon in undisturbed areas, is about 6 to 8 inches thick. In the silty clay loam phase of Dockery soil, the A horizon is silty clay loam as much as 15 inches thick in places.

The C horizon has strata that are mainly very dark grayish brown (10YR 3/2) to grayish brown (10YR 5/2 or 2.5Y 5/2) or light brownish gray (10YR 6/2 or 2.5Y 6/2). Strata of light silty clay loam are common. They commonly have grayer colors than the soil matrix. Mottles and stains of brown or yellowish brown to reddish brown are common.

Dockery soils are neutral or slightly acid.

Dockery soils are wetter and are typically somewhat grayer and more mottled than Nodaway soils. They are lighter colored than Kennebec soils and are stratified. They are not calcareous as are the McPaul and Haynie soils. All of these soils formed in alluvium.

**Dockery silt loam** (0 to 2 percent slopes) (820).—This soil is next to stream channels on flood plains on which sediment has been deposited recently. In areas where the streams have been straightened, the soil may be some distance from the present stream channel. This soil is mainly near the Kennebec, Colo, and Nodaway soils and Dockery silty clay loam. Most areas are 25 to 200 acres in size.

This soil has a profile similar to that described as representative of the series, but it has a surface layer of silt loam. Included in mapping were very small areas of Colo soils and small areas of soil that have more sand in the surface layer.

Most areas of this soil are cultivated. Mainly because of its low position on the bottom lands, this soil is subject to flooding, and wetness is a limitation. This soil is well suited to row crops if the flooding and wetness are controlled. Capability unit IIw-1; woodland group 6.

**Dockery silty clay loam** (0 to 2 percent slopes) (821).—This soil is mainly along stream channels, but where the streams have been straightened, it may be some distance from the present stream. It is generally at a slightly lower elevation than the Nodaway soils and is near the Kennebec and Colo soils and Dockery silt loam. Areas are as much as several hundred acres in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of Colo soils.

Most areas of this soil are cultivated. The soil is subject to flooding and is wet at times. If drainage and flood control are provided, it is well suited to row crops. Capability unit IIw-1; woodland group 6.

## Dow Series

The Dow series consists of moderately dark colored, well-drained soils of the uplands. These soils formed in thick calcareous loess. They are generally in narrow bands on convex side slopes in almost all areas of the uplands in the county. The slopes are 9 to 14 percent.

In a representative profile the surface layer is very dark grayish-brown silt loam 6 inches thick. The substratum, extending to a depth of 50 inches, is grayish-brown and light olive-brown, very friable silt loam that has iron oxides and mottles of yellowish brown and light brownish gray.

Dow soils are very low in available nitrogen and available phosphorus and medium in available potassium. The content of organic matter is low. The soils are calcareous at or near the surface. Available water capacity is high, and permeability is moderate. Runoff is medium.

These soils are generally cropped or used for hay or pasture along with adjacent soils. They are subject to erosion, and their fertility is very low.

Representative profile of Dow silt loam, 9 to 14 percent slopes, in a cultivated field, on a west-facing slope that has a gradient of 11 percent, 160 feet west and 20 feet south of the northeast corner of sec. 33, T. 70 N., R. 42 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) heavy silt loam; moderate, very fine, granular structure; very friable; numerous fine roots; neutral; clear, smooth boundary.

C1—6 to 10 inches, grayish-brown (2.5Y 5/2) heavy silt loam; few very dark grayish-brown (10YR 3/2) coatings; moderate, very fine, granular structure; very friable; many fine roots; few medium iron oxides (pipestems); few carbonate concretions; neutral to mildly alkaline; clear, smooth boundary.

C2—10 to 31 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine to medium, yellowish-brown (10YR 5/6) mottles and few, fine, light brownish-gray (10YR 6/2) mottles; weak, fine, granular structure to massive; very friable; common fine roots; many fine to medium pores; large iron oxides (pipestems) ¼ inch in diameter; few worm casts; mildly alkaline; calcareous; diffuse, smooth boundary.

C3—31 to 50 inches, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) silt loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; very friable; very few fine roots; numerous worm casts; common iron oxides (pipestems); oxide bands of brown (7.5YR 4/4) are prominent; moderately alkaline; calcareous.

The A horizon is typically a plow layer that ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), and brown (10YR 4/3) in color. The lighter colors are in severely eroded areas.

The C horizon is generally grayish brown (10YR 5/2 or 2.5Y 5/2) or light brownish gray (10YR 6/2 or 2.5Y 6/2) but ranges to light olive gray (5Y 6/2) and light olive brown (2.5Y 5/4).

Dow soils are mainly moderately alkaline, and calcareous, but they range to mildly alkaline, and in places the upper few inches are neutral.

The Dow soils are grayer than the Ida and Hamburg soils. All of these soils are calcareous, and they formed in loess.

**Dow silt loam, 9 to 14 percent slopes** (22D).—This soil is on side slopes of the uplands. It is in bands both downslope and upslope from Marshall or Monona soils. Areas are small, generally 5 to 10 acres in size.

Included with this soil in mapping were a small acreage of Dow soils that have 5 to 9 percent slopes and areas where the soil profile is similar in color and texture to that described for the series, but the soil material is leached of carbonates to a greater depth. Areas of severely eroded soil, in which the present surface layer is mainly the original subsoil, are shown on the soil map by a symbol for severe erosion. In places very small areas of this Dow soil are shown on the soil map by a symbol for gray loess.

This soil is in small areas and is generally farmed with the adjacent Marshall or Monona soils. It is used for cultivated crops, hay, and pasture. Erosion is a hazard, but the soil is moderately suited to row crops if erosion is controlled. Capability unit IIIe-2; woodland group 4.

## Grable Series

The Grable series consists of stratified, moderately dark colored, nearly level, well-drained to somewhat excessively drained soils on bottom lands along the Missouri River. These soils formed in recently deposited, calcareous silty alluvium underlain by sandy alluvium. They are on the bottom lands adjacent to or within a few miles of the Missouri River channel.

In a representative profile, the surface layer is mainly very dark grayish brown mixed with some dark grayish brown. It is friable silt loam about 8 inches thick. The substratum, to a depth of about 24 inches, is stratified, dark grayish-brown, friable silt loam that has a few yel-

lowish-brown mottles. Beneath this, extending to a depth of 58 inches, it is stratified, grayish-brown to light olive-brown, very friable loamy fine sand.

The Grable soils are very low in available nitrogen and phosphorus and high in available potassium. The content of organic matter is low. The soils are moderately alkaline and are calcareous. Available water capacity is medium or low. Permeability is moderate in the upper 24 inches and rapid in the underlying sand. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops; only a few areas are not cultivated. Since the construction of levees and large dams on the Missouri River, there is only a slight hazard or no hazard of flooding in most areas. These soils are droughty during seasons of low rainfall. In places they are near sandy soils that are subject to soil blowing, and the blowing sand injures young plants on these soils.

Representative profile of Grable silt loam in a cultivated field, 150 feet west and 50 feet south of T intersection, at center of section of the southeast corner of sec. 19, T. 69 N., R. 43 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) (80 percent) mixed with dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) kneaded; weak, fine, granular structure; friable; many fine roots; moderately alkaline; calcareous; clear, smooth boundary.

C1—8 to 24 inches, stratified dark grayish-brown (2.5Y 4/2) silt loam; few, fine, yellowish-brown (10YR 5/6) mottles; some horizontal cleavage; friable; common fine roots; moderately alkaline; calcareous; clear, smooth boundary.

IIC2—24 to 58 inches, stratified grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) loamy fine sand; single grained; very friable; common fine roots; a 2-inch stratum of silty clay loam; moderately alkaline; calcareous.

The Ap horizon, or A1 horizon in uncultivated areas, is less than 10 inches thick. It ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color. It is mainly silt loam but ranges to very fine sandy loam, and in a few places it is light silty clay loam.

The C horizon, to a depth of 18 to 30 inches, is typically stratified silt loam but is very fine sandy loam in places. In places 1- to 2-inch strata of either finer textured or coarser textured material are present. This soil material is grayish brown (10YR or 2.5Y 5/2) or dark grayish brown (10YR 4/2 or 2.5Y 4/2). Some strong-brown, yellowish-brown, or gray mottles are present in most places. Below a depth of 18 to 30 inches, the IIC horizon is fine sand or loamy fine sand and in places has 1- to 4-inch strata of finer textured material. Grable soils are mildly alkaline or moderately alkaline and are calcareous.

Grable soils differ from Haynie and McPaul soils in being underlain by sand at a depth of about 24 inches. They are not so clayey as Percival soils in the upper part of the profile. Grable soils do not have clay in the IIC horizon as do Modale and Merville soils. They are silt loam to a depth of about 24 inches, but Carr soils are fine sandy loam. All of these soils formed in alluvium.

**Grable silt loam** (0 to 2 percent slopes) (514).—This soil is on bottom lands near the Missouri River. It is generally at a slightly higher elevation than the adjacent Blake, Onawa, Albaton, and Percival soils and at about the same elevation as the nearby Haynie soils. Areas generally range from 5 to 100 acres in size, but a few are considerably larger.

Included with this soil in mapping were very small areas of Haynie and Sarpy soils.

This soil is used mainly for row crops. It is well suited to such use but tends to be droughty unless rainfall is

above average. The limitations of the nearby soils generally affect the way this soil is farmed. For example, where this soil lies next to wet and clayey soils, fieldwork is commonly delayed and crops suited to the wet soils are grown, but where it lies next to sandier soils, crops adapted to droughty conditions are grown. In areas near the sandier soils, blowing sand may injure young plants on this soil. The hazard of flooding is slight in most areas. Capability unit IIs-1; woodland group 6.

## Hamburg Series

The Hamburg series consists of light-colored, very steep, somewhat excessively drained soils on bluffs that are adjacent to bottom lands along the Missouri River. These soils formed in thick calcareous loess. Slopes are 40 to 75 percent.

In a representative profile the surface layer is dark grayish-brown coarse silt loam about 2 inches thick. Below this, extending to a depth of 54 inches, the substratum is brown, yellowish-brown, and pale-brown, very friable coarse silt loam. A few light brownish-gray mottles are below a depth of 24 inches.

The Hamburg soils are very low in available nitrogen and phosphorus and high in available potassium. The organic-matter content is very low. The soils are mildly alkaline or moderately alkaline. They are calcareous, and lime nodules are on the surface on many places. Available water capacity is high, and permeability is moderately rapid. Runoff is very rapid, and the soils rarely reach the limit of their water holding capacity.

Hamburg soils are mainly in pasture. The native grass vegetation is sparse in most places, and semiarid plants, such as yucca, grow in places. Some areas are used mainly for recreation or wildlife habitat. In places scenic overlooks have been established on these soils.

Representative profile of Hamburg silt loam, 40 to 75 percent slopes, on a southwest-facing slope that has a gradient of 70 percent, in a permanent pasture, on section line about 300 feet west of the southeast corner of the SW $\frac{1}{4}$  sec. 30, T. 68 N., R. 42 W.

AC—0 to 2 inches, dark grayish-brown (10YR 4/2) coarse silt loam; weak, very fine, granular structure; very friable; abundant fine roots; very porous; many worm casts; mildly alkaline; calcareous; abrupt, smooth boundary.

C1—2 to 10 inches, brown (10YR 4/3) and yellowish-brown (10YR 5/4) coarse silt loam; weak, very fine, granular structure to massive; very friable; abundant very fine roots; many fine and medium pores; many worm casts; brown color seems to extend down along cleavage planes; mildly alkaline; calcareous; diffuse, smooth boundary.

C2—10 to 24 inches, yellowish-brown (10YR 5/4) and pale-brown (10YR 6/3) coarse silt loam; weak, very fine, granular structure to massive; very friable; few very fine roots; many fine and medium pores; few brown (10YR 5/3) worm casts; mildly alkaline; calcareous; diffuse, smooth boundary.

C3—24 to 54 inches, yellowish-brown (10YR 5/4) and pale-brown (10YR 6/3) coarse silt loam; few, fine, faint, light brownish-gray (2.5Y 6/2) mottles; weak, very fine, granular structure to massive; very friable; very few fine roots; many very fine pores; some filament lime present; moderately alkaline; calcareous.

The A horizon, generally less than 6 inches thick, ranges from dark grayish brown (10YR 4/2) to brown (10YR 4/3) or yellowish brown (10YR 5/4) in color. In places there is an AC horizon that has properties of both the A and C horizons instead of, or in addition to, an A1 horizon.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4) and pale brown (10YR 6/3). Strong-brown, yellowish-brown, or light brownish-gray mottles are below a depth of 20 inches in many places.

Hamburg soils are mildly alkaline or moderately alkaline and calcareous throughout.

The Hamburg soils are generally steeper than the Ida soils, and they contain more coarse silt and very fine sand and less clay. Because they are very steep, the Hamburg soils have small slump blocks that are called catsteps, which the Ida soils lack. These soils are associated on the landscape, and they formed in loess.

**Hamburg silt loam, 40 to 75 percent slopes (2G).**—This very steep soil is on upland bluffs adjacent to bottom lands along the Missouri River. Most areas are large; some are several hundred acres in size. Included in mapping were very small areas of Castana and Ida soils.

The use of this soil is limited because it is very steep and has slump blocks called catsteps (fig. 9). Most areas are in pasture. The pasture in most places consists of a rather sparse cover of such native grasses as big bluestem, little bluestem, and side-oats grama. Establishing and keeping a good stand of native grass is the main consideration in management. Keeping a good stand by limiting grazing is much easier than establishing a new stand. Some areas of this soil are in parks and wildlife areas. Capability unit VIIIe-1; woodland group 4.

### Haynie Series

The Haynie series consists of moderately dark colored, well drained or moderately well drained soils on bottom lands along the Missouri River. These soils formed in recently deposited, calcareous, stratified alluvium. They

are on slightly elevated rises on the flood plain adjacent to or within a few miles of the Missouri River channel.

In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. Below this and extending to a depth of 50 inches, the substratum is mainly stratified, dark grayish-brown and grayish-brown, friable silt loam, but it also has thin strata of silty clay loam.

The Haynie soils are very low in available nitrogen and available phosphorus and high in available potassium. The organic-matter content is low. The soils are moderately alkaline and calcareous. Available water capacity is high, and permeability is moderate. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops. Since the levees and large dams on the Missouri River have been constructed, flooding is only a slight hazard in most areas.

Representative profile of Haynie silt loam in a cultivated field, 200 feet south and 780 feet east of the northwest corner of sec. 30, T. 69 N., R. 43 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (2.5Y 5/2) dry; some mixing of grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2); cloddy breaking to weak, fine, subangular blocky and granular structure; friable; few roots; calcareous; moderately alkaline; clear, smooth boundary.

C1—9 to 15 inches, dark grayish-brown (10YR 4/2) silt loam, some mixing of very dark grayish brown (10YR 3/2) and grayish brown (2.5Y 5/2); very weak, fine, granular structure to fine subangular blocky structure; friable; some stratification; calcareous; moderately alkaline; clear, smooth boundary.



Figure 9.—Area of Hamburg silt loam, 40 to 75 percent slopes. The catsteps are characteristic of this soil.

C2—15 to 50 inches, grayish-brown (2.5Y 5/2) silt loam; highly stratified with some thin strata of silty clay loam; some dark grayish brown (10YR 4/2) and light brownish gray (2.5Y 6/2) mixed with the matrix color; tendency to be platy breaking to weak, fine, granular structure; friable; some iron stains of reddish brown (5YR 4/4) on cleavage faces; calcareous; moderately alkaline.

In most places the A horizon is a plow layer that ranges from 6 to 9 inches in thickness. The A1 horizon in uncultivated areas is thinner in places. The A horizon is typically very dark grayish brown (10YR 3/2 or 2.5Y 3/2), but ranges to dark grayish brown (10YR 4/2 or 2.5Y 4/2).

The C horizon is dark grayish brown (10YR or 2.5Y 4/2) to grayish brown (10YR or 2.5Y 5/2) and has strata that have a color value of 3 in places. It is typically silt loam but ranges to very fine sandy loam. There are thin strata of sand, loam, silty clay loam, or clay in many places. Mottles of brown, strong brown, and yellowish brown are common in places.

Haynie soils are similar to McPaul soils, but they have more sand and tend to have more thin strata of contrasting texture. They are not underlain by sand as are Grable soils or by clay as are Modale and Merville soils. They are near the Grable and Modale soils on the landscape. All of these soils formed in alluvium.

**Haynie silt loam** (0 to 2 percent slopes) (137).—This soil generally is on slightly convex rises near or within a few miles of the Missouri River. Among the adjacent soils are the Blake, Grable, Onawa, Albaton, Modale, Percival, and Carr soils. It is at slightly higher elevations than the Blake, Onawa, Albaton, Modale, and Percival soils and at about the same elevation as the Carr and Grable soils. Many areas of this soil are long and narrow, especially near the river. Some areas are as large as several hundred acres.

Included with this soil in mapping were a small acreage of soils that have 6 to 15 inches of silty clay loam on the surface and a few areas where sand is on the surface. Sandy areas are shown on the soil map by a spot symbol for sand.

Most areas of this soil are cultivated. Row crops are grown most of the time, and the soil is well suited to such use. The soil is well suited to irrigation if a water supply is developed. Capability unit I-2; woodland group 6.

## Ida Series

The Ida series consists of light-colored, well-drained soils on uplands. These soils formed in calcareous loess. They are generally on narrow ridges and side slopes. Slopes are 9 to 40 percent.

In a representative profile the surface layer is brown and dark grayish-brown silt loam about 7 inches thick. Below this, extending to a depth of 50 inches, the substratum is yellowish-brown, very friable silt loam that has light brownish-gray mottles. It has a few hard lime concretions.

The Ida soils are very low in available nitrogen and phosphorus and medium to high in available potassium. The organic-matter content is low or very low in most places. The soils are moderately alkaline or mildly alkaline. They are calcareous, and hard lime nodules are on the surface in places. Available water capacity is high, and permeability is moderate. Runoff is rapid to very rapid.

The less sloping Ida soils are commonly used for cultivated crops. The steeper soils are in pasture or timber. Erosion is a severe hazard, and gullies have formed in places.

Representative profile of Ida silt loam, 14 to 20 percent slopes, on a south-facing slope that has a gradient of 15 percent, in a cultivated field, 1,000 feet east and 250 feet north of the southwest corner of the SE¼NW¼ sec. 33, T. 69 N., R. 42 W.

Ap—0 to 7 inches, brown (10YR 4/3) and dark grayish-brown (10YR 4/2) heavy silt loam; very fine granular structure; very friable; common fine roots; some platiness in the lower part caused by compaction; many very fine pores; many worm casts; mildly alkaline; calcareous; gradual, wavy boundary.

C1—7 to 13 inches, yellowish-brown (10YR 5/4) silt loam; weak, fine, granular structure; very friable; few very fine roots; numerous very fine pores; many brown (10YR 4/3) worm casts and few dark-brown (10YR 3/3) worm casts; mildly alkaline; calcareous; gradual, smooth boundary.

C2—13 to 32 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, faint, light brownish-gray (2.5Y 6/2) mottles; weak, medium, prismatic structure breaking to very weak, fine, subangular blocky and fine granular; very friable; few fine roots; many fine pores; few, ¼- to ½-inch, hard lime concretions; many worm casts; moderately alkaline; calcareous; diffuse, smooth boundary.

C3—32 to 50 inches, yellowish-brown (10YR 5/6) coarse silt loam; few, fine, faint, light brownish-gray (2.5Y 6/2) mottles; weak, fine, subangular blocky structure to massive; very friable; abundant very fine and fine pores; very few fine roots; few, ¼- to ½-inch hard lime concretions; few, distinct, dark, soft oxides; moderately alkaline; calcareous.

The A1 horizon in uncultivated areas is generally very dark grayish brown (10YR 3/2) and ranges from 3 to 6 inches in thickness. In cultivated areas the plow layer, or Ap horizon, ranges from very dark grayish brown (10YR 3/2) to brown (10YR 4/3 or 5/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4).

The C horizon is typically yellowish brown (10YR 5/4 or 5/6) but also has colors that range to brown (10YR 5/3) or dark yellowish brown (10YR 4/4). Relict mottles of strong brown, grayish brown, and light brownish gray are present in places.

Hard lime concretions are abundant on the surface in many places. The Ap horizon is neutral to moderately alkaline, and the C horizon is typically moderately alkaline and calcareous, but in places the C1 horizon is mildly alkaline.

Ida soils have more clay but less very fine sand and coarse silt than Hamburg soils. They are brown or yellowish brown in the C horizon, but Dow soils are grayish brown to olive gray. All of these soils are calcareous and formed in loess.

**Ida silt loam, 9 to 14 percent slopes** (1D).—This strongly sloping soil is on narrow ridgetops and hillsides in the uplands. It is generally downslope from the Monona or Marshall soils and upslope from the Napier, Judson, or Castana soils. Areas are small, generally ranging from 2 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is generally a very dark grayish-brown or dark-brown plow layer. Included in mapping were small areas of soils that have a somewhat thicker and darker colored surface layer. Also included were few small areas that have slopes of 5 to 9 percent. Some small areas of severely eroded soils are shown on the soil map by a spot symbol.

Because this soil generally is in small areas, it is commonly used for row crops or hay and pasture, depending on how the surrounding soils are used. It is moderately suited to row crops, but erosion is a hazard. Capability unit IIIe-2; woodland group 4.

**Ida silt loam, 9 to 14 percent slopes, severely eroded** (1D3).—This soil is on narrow ridgetops and side slopes

in the uplands. It is generally downslope from the Monona or Marshall soils and upslope from the Napier, Judson, or Castana soils. Areas are small, generally ranging from 2 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the original surface layer has been mixed with part of the substratum in plowing. It is generally brown or dark yellowish brown. Included in mapping were about 100 acres of severely eroded Ida soil that has 5 to 9 percent slopes.

Because this soil generally is in small areas, it is commonly used for row crops or hay and pasture, depending on how the surrounding soils are used. It is moderately suited to row crops, but erosion is a hazard. Capability unit IIIe-2; woodland group 4.

**Ida silt loam, 14 to 20 percent slopes (1E).**—This soil is on uplands, mainly on side slopes. In many places it is downslope from the Monona or Marshall soils or other Ida soils, but in other places it occupies most of the hillside. It is upslope from the Napier, Judson, or Castana soils. Areas are 5 to 50 acres in size.

This soil has a profile described as representative of the series. In many places the surface layer is a little darker colored than that described for the series. Some small, severely eroded areas are shown on the soil map by spot symbols.

Because this soil occupies relatively small areas, it is commonly managed in the same way as the surrounding soils. Some areas are cultivated, but some are used for permanent pasture with steeper soils. The soil is subject to erosion and gullyng. It is moderately suited to row crops if erosion is controlled, but on many farms, this soil is in hay or pasture most of the time, and a row crop is grown only when the meadow needs reseeding. Capability unit IVe-1; woodland group 4.

**Ida silt loam, 14 to 20 percent slopes, severely eroded (1E3).**—This soil is on uplands. It is mainly on side slopes, and in places it occupies most of the hillside. It is generally downslope from the Monona, Marshall, or other Ida soils and upslope from Napier, Judson, or Castana soils. Most areas are 5 to 50 acres in size.

This soil has a profile similar to the one described as representative of the series, except that in most places the original surface layer has been mixed with part of the substratum in plowing, and the present surface layer is thinner and brown to yellowish brown. Included in mapping were a few areas of less eroded soils that have a darker colored, thicker surface layer.

Because this soil generally is in small areas, it is commonly managed in the same way as the surrounding soils. Most areas are cultivated, but a few areas near steeper soils are in permanent pasture. The soil is subject to erosion and gullyng. It is moderately suited to row crops if erosion is controlled, but on many farms, this soil remains in hay or pasture most of the time and is used for a row crop only when the meadow needs reseeding. Capability unit IVe-1; woodland group 4.

**Ida silt loam, 20 to 30 percent slopes (1F).**—This soil is on hillsides in the steeper parts of the uplands. This Ida soil is generally downslope from Monona, Hamburg or other Ida soils, and upslope from the Napier or Castana soils. Most areas are 5 to 100 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer ranges from very dark brown to brown. The surface layer is typically about 3 to 7 inches thick, but in some places it is a few inches thicker. In areas under trees, the surface layer is neutral, rather than calcareous, in many places. Severely eroded areas are shown on the soil map by spot symbols.

Most areas of this soil are in permanent or semi-permanent pasture. A few areas, generally those near Hamburg soils, have thin stands of trees but are managed as pasture. This soil is poorly suited to row crops because it is steep and the hazard of erosion and gullyng is very severe. This soil is better suited to hay or pasture. It is steep enough that using farm machinery involves some risk, but in many places it is possible to renovate thin pasture stands by applying fertilizer, disking, and reseedng. Hillside gullies should be shaped in places. Capability unit VIe-1; woodland group 4.

**Ida silt loam, 20 to 30 percent slopes, severely eroded (1F3).**—This soil is on hillsides in the steeper parts of the uplands. It is generally downslope from Monona, Hamburg, or other Ida soils and upslope from the Napier or Castana soils. Areas are small, generally 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is only about 3 inches or less in thickness and is brown to dark grayish brown. In places the original surface layer has been mixed with part of the substratum by plowing. In these places the color is brown to yellowish brown. Included in mapping were small areas of soils that are not severely eroded and that have a thicker, darker colored surface layer.

This soil is poorly suited to row crops. Only a few areas are now cultivated, but many areas have been cultivated. This soil is better suited to hay or pasture, and most areas are in permanent or semipermanent pasture. The soil is subject to erosion and gullyng, and some side-hill gullies have formed. The soil is steep enough that using farm machinery involves some risk. Pastures of legumes and brome grass have been established in many places, and it is possible to renovate thin stands by applying fertilizer, disking, and reseeding. Capability unit VIe-1; woodland group 4.

**Ida silt loam, 30 to 40 percent slopes (1G).**—This soil is on the steeper parts of uplands, mostly along the east side of the Missouri River valley. It is generally adjacent to Hamburg soils. In many places this soil occupies north- and east-facing slopes, and the Hamburg soils occupy the other slopes. It is generally upslope from the Castana or Napier soils. Areas range from 5 acres to more than 200 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is very dark grayish brown to dark brown or brown and in most places is about 3 to 6 inches thick. In wooded areas the surface layer is generally neutral rather than calcareous.

Included in mapping were about 200 acres of Ida soils that are steeper than this Ida soil. Also included are some small areas of Hamburg, Monona, Napier, and Castana soils. Small areas of severely eroded soils are shown on the soil map by a symbol for severe erosion.

Because this soil is very steep, the hazard of erosion is very severe. The soil is too steep for the use of farm machinery, so it is left in trees or native grasses. Both timbered and grassed areas are pastured, except in a few places. The timber is of poor quality. The quality of the native grass pasture is poor in many places, depending on past management. Stands that have been ruined by overgrazing are very hard to reestablish in many places. Many deep hillside gullies have formed. Capability unit VIIe-1; woodland group 4.

## Judson Series

The Judson series consists of dark-colored, well drained or moderately well drained soils mainly on alluvial fans and foot slopes in stream valleys. Where these soils are in a complex with Colo soils, they are in narrow stream valleys and upland drainageways. They are in the eastern part of the county. These soils formed in silty local alluvium eroded mostly from the adjacent uplands. Slopes are 2 to 5 percent.

In a representative profile the surface layer is very dark brown light silty clay loam about 23 inches thick. Beneath this is a 9-inch layer that is transitional between the surface layer and the subsoil. This layer is very dark grayish-brown, friable light silty clay loam. The subsoil, to a depth of about 40 inches, is very dark grayish-brown and dark-brown, friable light silty clay loam. Below this and extending to a depth of 50 inches, it is brown, friable heavy silt loam.

The Judson soils are medium to low in available nitrogen, low in available phosphorus, and medium in available potassium. The organic-matter content is high. The surface layer and subsoil are generally slightly acid or neutral. Available water capacity is high, and permeability is moderate. Runoff is generally medium.

Most areas of these soils are cultivated, but some are in pasture. In some areas runoff received from higher slopes and from side-valley waterways is a slight concern. Gullies form in places where water concentrates and flows across these soils.

Representative profile of Judson silty clay loam, 2 to 5 percent slopes, in a cultivated field where the slope is 3 percent, about 1,330 feet west and 100 feet south of the northeast corner of sec. 21, T. 69 N., R. 41 W.

- Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) kneaded, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; friable; many roots and pores; slightly acid to neutral; gradual, smooth boundary.
- A12—7 to 15 inches, very dark brown (10YR 2/2) light silty clay loam, very dark grayish brown (10YR 3/2) kneaded; weak, very fine, subangular blocky structure; friable; many roots and pores; slightly acid to neutral; gradual, smooth boundary.
- A13—15 to 23 inches, very dark brown (10YR 2/2) light silty clay loam, very dark grayish brown (10YR 3/2) kneaded; weak, very fine, subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.
- AB—23 to 32 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark brown (10YR 3/3) kneaded; moderate, fine, subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.
- B2—32 to 40 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) light silty clay loam, dark brown (10YR 3/3) kneaded; moderate, fine and medium, subangular blocky structure; friable; few

- roots and many pores; very few iron concretions; slightly acid; gradual, smooth boundary.
- B3—40 to 50 inches, brown (10YR 4/3) heavy silt loam, brown (10YR 4/3) kneaded; few, fine, grayish-brown (10YR 5/2) mottles; tends to be massive but breaks to weak, fine and medium, subangular blocky structure; friable; some fine oxide concretions; slightly acid.

The Ap and A1 horizons are black (10YR 2/1) or very dark brown (10YR 2/2). In places the AB horizon is lacking and a very dark grayish brown (10YR 3/2) A3 horizon is present. The A horizon is 20 to 36 inches in total thickness. It is generally light silty clay loam but ranges to silt loam.

The B2 horizon is generally brown (10YR 4/3) and dark brown (10YR 3/3), but among the colors in the upper part is very dark grayish brown (10YR 3/2). Darker colored organic coatings tend to mask the browner colors of the ped interiors. This horizon ranges from light to medium silty clay loam in texture and has few fine mottles of dark yellowish brown, yellowish brown, strong brown, or grayish brown.

The C horizon is not described in the representative profile, but it is dark-brown (10YR 3/3) to yellowish-brown (10YR 5/4), massive heavy silt loam or light silty clay loam.

The solum is 40 to 60 inches thick in most places. Judson soils are typically slightly acid to neutral in the solum but range to medium acid in the most acid part of the profile.

Judson soils have more clay and, in many places, are more acid than the Napier soils. They are dark brown or brown within a depth of 3 feet, but Kennebec soils are not. Their surface layer and much of the subsoil is finer textured than those of the Kennebec soils. Judson soils are silty and contain less sand than Terril soils. They occupy positions on the landscape similar to those occupied by Terril and Napier soils, and they formed in similar parent material.

### Judson silty clay loam, 2 to 5 percent slopes (8B).—

This soil is on alluvial fans and foot slopes that grade to bottom lands and benches. It is generally in narrow bands downslope from the Marshall soils and upslope from the Colo soils, but in places it is upslope from the Zook, Nevin, Minden, or Marshall soils. Areas typically are 5 to more than 100 acres in size.

Included with the soil in mapping were about 100 acres of Judson soils that have 5 to 9 percent slopes.

Most areas of this soil are cultivated along with adjacent soils on bottom lands or benches. Row crops are grown most of the time, and the soil is well suited to such use. In places runoff from upslope or from small water courses flows across this soil and causes rill and gully erosion as well as siltation. Capability unit IIe-1; woodland group 1.

## Keg Series

The Keg series consists of dark-colored, well drained or moderately well drained soils on bottom lands along the Missouri River. These soils formed in silty alluvium. They are at the highest elevations in the central part of the bottoms, about midway between the bluffs and the river channel. They are nearly level.

In a representative profile the surface layer, to a depth of about 13 inches, is black silt loam. The next 10 inches is very dark grayish-brown and brown silt loam. The subsoil is yellowish-brown, friable silt loam that extends to a depth of about 28 inches. It has light brownish-gray and brown mottles. The substratum, extending to a depth of 50 inches, is yellowish-brown, friable silt loam that has a few brown and yellowish-brown mottles.

The Keg soils are medium to low in available nitrogen, medium in available phosphorus, and high in available potassium. The organic-matter content is moderate.

The surface layer is neutral. Available water capacity is high, and permeability is moderate. Runoff is slow.

Most areas of the Keg soils are cultivated and are used for row crops. They have no serious limitations to their use for crops.

Representative profile of Keg silt loam, 120 feet east of corncrib on south side of field lane, 250 feet east of the southwest corner of the NW $\frac{1}{4}$  sec. 27, T. 70 N., R. 43 W.

- Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy but breaks to weak, fine, granular structure; friable; many fine roots; neutral; abrupt, smooth boundary.
- A12—6 to 13 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure to fine granular structure; some platy structure because of a plow sole about 2 inches below the Ap horizon; friable; very few fine pores; many fine roots; neutral; clear, smooth boundary.
- A3—13 to 23 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, some mixing of brown (10YR 4/3); weak, very fine, subangular blocky structure; friable; many fine roots; many fine pores; mildly alkaline; clear, smooth boundary.
- B—23 to 28 inches, yellowish-brown (10YR 5/4) heavy silt loam; common, fine, light brownish-gray (2.5Y 6/2) mottles and few, fine, brown (10YR 4/3) mottles; weak, fine, subangular blocky structure; friable; few fine roots; few fine pores; mildly alkaline; calcareous; clear, smooth boundary.
- C1—28 to 35 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, brown (10YR 4/3) mottles; very weak, medium, subangular blocky structure to massive; friable; few fine roots; many fine pores; filament lime and hard lime concretions; moderately alkaline; calcareous; clear, smooth boundary.
- C2—35 to 50 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) mottles; massive; friable; few fine roots and fine pores; filament lime and few fine hard lime concretions; moderately alkaline; calcareous; abrupt, smooth boundary.

The Ap and A1 horizons are black (10YR 2/1) to very dark brown (10YR 2/2) in color and 12 to 18 inches in total thickness. The AB horizon is lacking in some profiles, and there is an A3 horizon in places.

The B horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to brown (10YR 4/3) and yellowish brown (10YR 5/4). Mottles are common and range from light brownish gray to yellowish brown and brownish yellow. The B horizon is as much as 24 inches thick.

The C horizon is typically coarse silt loam, but very fine sandy loam is within the range of texture. It is dark grayish brown (10YR 4/2 or 2.5Y 4/2) to light olive brown (2.5Y 5/4) or yellowish brown (10YR 5/4) and generally has some mottles similar to those in the B horizon.

The A horizon ranges from slightly acid to mildly alkaline, and the B horizon is neutral to moderately alkaline and calcareous.

The Keg soils have less clay in the A horizon and upper part of the B horizon than the Salix soils and less clay throughout than the Luton and Lakeport soils. They have a thicker, darker colored A horizon than the Haynie and McPaul soils and are not calcareous. They are associated with Salix, Luton, and Lakeport soils on the landscape. All of these soils formed in alluvium.

**Keg silt loam** (0 to 2 percent slopes) (46).—This soil is in slightly elevated areas in the central part of bottom lands along the Missouri River. These soils are at slightly higher elevations than the nearby Salix, Luton, Woodbury, and Lakeport soils, and they are generally at about the same elevation as the Cott soils. Areas are quite large, and some are more than 200 acres in size.

Included with this soil in mapping were small areas of Salix and Cott soils and about 100 acres where an overwash of very dark grayish-brown or grayish-brown silt loam 6 to 15 inches thick has been deposited.

Most areas of this soil are cultivated and used for row crops, and the soil is well suited to such use. Because this soil is in fairly large areas, it may be farmed in separate fields and managed separately in many places. In places it is in fields with wetter soils, and in these places, field-work is sometimes delayed until the wetter soils can be tilled. Capability unit I-1; woodland group 6.

## Kennebec Series

The Kennebec series consists of nearly level, dark-colored, moderately well drained soils on bottom lands. These soils formed in silty alluvium. They are in many of the stream valleys throughout the county and on bottom lands along the Missouri River.

In a representative profile the surface layer is mainly silt loam, about 28 inches thick, that ranges from black in the upper part to very dark brown in the lower part. A transitional layer, between the surface layer and the substratum, is very dark grayish-brown, friable silt loam and extends to a depth of about 42 inches. The substratum, extending to a depth of 54 inches, is very dark grayish-brown, friable silt loam.

The Kennebec soils are medium to low in available nitrogen, medium in available phosphorus, and medium to high in available potassium. The content of organic matter is high. The soils are neutral. Available water capacity is very high, and permeability is moderate. Runoff is slow.

These soils are used mainly for row crops. In some places they are subject to flooding in times of high runoff.

Representative profile of Kennebec silt loam in a cultivated field, 300 feet south of bridge and 100 feet west of gravel road or 2,600 feet north and 1,400 feet west of the southeast corner of sec. 31, T. 70 N., R. 41 W.

- Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, very fine, granular structure; friable; neutral; clear, smooth boundary.
- A12—8 to 18 inches, black (10YR 2/1) silt loam, very dark brown (10YR 2/2) crushed; weak, fine, granular structure; friable; many roots and pores; neutral; clear, smooth boundary.
- A13—18 to 28 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) crushed; weak, fine, granular structure to fine subangular blocky structure; friable; many roots and pores; neutral; gradual, smooth boundary.
- AC—28 to 42 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, granular structure and subangular blocky structure; friable; many roots and pores; neutral; clear boundary.
- C1—42 to 54 inches, very dark grayish-brown (10YR 3/2) heavy silt loam; very weak, fine, granular and subangular blocky structure; friable; many pores; neutral.

The A horizon is typically 30 to 40 inches thick. The upper part is black (10YR 2/1) or very dark brown (10YR 2/2), and the lower part is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The boundary between the A1 horizon and the C horizon is somewhat arbitrary in most places and is indistinct as evidenced by an AC horizon in the representative profile. The texture is silt loam to light silty clay loam. In some areas 6 to 15 inches of very dark grayish-brown silt loam overwash is on the surface.

The C horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) in color and is silt loam or light silty clay loam in texture. Mottles of yellowish brown, dark brown, strong brown, or grayish brown are present in places. In places the horizon appears to be a buried soil, and in places strata of other textures occur below a depth of 40 inches.

The A horizon is neutral or slightly acid but ranges to medium acid in the upper part.

The Kennebec soils have less clay throughout than the Colo soils. They have darker colors and less stratification than the Nodaway soils, and they differ from the Napier and Judson soils in that they lack brown colors at a depth of less than 3 feet. They typically are not so fine textured as the Judson soils. All of these soils formed in similar parent material and are associated on the landscape.

**Kennebec silt loam** (0 to 2 percent slopes) (212).—This soil is on bottom lands along the Missouri River and its tributary streams. Most areas are in the larger valleys, but some are on narrow bottoms along the smaller streams. In most places this soil is near the Napier and Judson soils that generally are upslope and the Colo, Nodaway, and Luton soils that are at a slightly lower elevation. Areas are as much as several hundred acres in size.

This soil has the profile described as representative for the series. Included in mapping were small areas of Colo and Nodaway soils. Also included were about 1,600 acres of a soil that is similar in texture but that is dark grayish brown between depths of 24 and 40 inches rather than very dark grayish brown or darker. This included soil is on bottom lands along the Missouri River, near the mouths of tributary creeks.

Most of the acreage is cultivated and used for row crops. The soil is well suited to such use. In some places it is occasionally flooded, but the flooding generally occurs in the spring before crops are planted. Stream channels have been straightened and dikes constructed in places to help reduce flooding. Capability unit I-1; woodland group 6.

**Kennebec silt loam, overwash** (0 to 2 percent slopes) (212+).—This soil is on bottom lands along the Missouri River and its tributary streams. Most areas are in the larger stream valleys where overwash has been deposited. Most areas of this soil are near and downslope from the Napier and Judson soils and at slightly higher elevations than the Colo, Nodaway, and Luton soils. Areas are mainly 5 to more than 100 acres in size.

This soil has a profile similar to the one described as representative of the series, except that a 6- to 15-inch, very dark grayish-brown or grayish-brown, recent deposition is on the surface. Included in mapping were small areas of Colo soils that have recent overwash on the surface and small areas of Nodaway soils. Also included were about 300 acres of a soil that is similar in texture but is grayish brown at a depth between 24 and 40 inches rather than very dark grayish brown or darker. This included soil is on bottom lands along the Missouri River, near the mouth of tributary creeks.

Most of this soil is cultivated. It is well suited to row crops. It is occasionally flooded, and at these times more overwash is deposited. Channels have been straightened and dikes constructed in places to help reduce overflow. Capability unit I-1; woodland group 6.

## Knox Series

The Knox series consists of moderately dark colored, well-drained soils, mainly in the western part of the county within a few miles of the Missouri River valley. These soils formed in loess under native vegetation of grasses and trees. They are on ridgetops and side slopes. Slopes are 5 to 20 percent.

In a representative profile the surface layer is black silt loam about 6 inches thick. The subsurface layer is very dark grayish-brown to dark grayish-brown, very friable silt loam about 4 inches thick. This layer has gray coatings that appear abundant when dry. The subsoil is mainly dark-brown or brown, friable silty clay loam and extends to a depth of about 52 inches. The substratum, extending to a depth of 60 inches, is brown, friable silt loam.

The Knox soils are low to very low in available nitrogen and phosphorus and medium to high in available potassium. The organic-matter content is low. These soils are typically medium acid in the most acid part of the surface layer or subsoil. Available water capacity is high, and permeability is moderate. Runoff varies, depending on the slope.

Most of these soils that have been cleared of trees are cultivated. They are used for row crops, small grain, or hay and pasture. The cleared areas are subject to different degrees of erosion, depending on steepness. Areas still in trees are subject to a lesser amount of erosion. Almost all areas are small enough that they are used in the same way as the adjacent soils.

Representative profile of Knox silt loam, 5 to 14 percent slopes, on a ridgetop, 100 feet south of log barrier and 50 feet west of lane to shelter in the Girl Scout Camp, or 1,980 feet east and 396 feet south of the northwest corner of sec. 11, T. 68 N., R. 40 W.

- A1—0 to 6 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; fine subangular blocky structure; very friable; neutral; clear, smooth boundary.
- A2—6 to 10 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; some mixing of darker material from A1 horizon by the action of worms and by cracking; weak, fine, granular structure; very friable; gray coatings are abundant when dry but are not visible when wet; neutral; clear, smooth boundary.
- B1—10 to 18 inches, dark-brown (10YR 3/3) silt loam, some mixing of very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 4/3) crushed; moderate, medium to fine, subangular blocky structure; friable; grainy coatings on ped faces are visible only when dry; common roots and pores; medium acid; clear, smooth boundary.
- B21t—18 to 26 inches, brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) on faces of peds, brown (10YR 4/3) crushed; moderate, medium to fine, subangular blocky and angular blocky structure; friable; few grainy coatings of dark grayish brown (10YR 4/2); thin discontinuous clay films; common roots and pores; medium acid; clear, smooth boundary.
- B22t—26 to 38 inches, brown (10YR 4/3) silty clay loam, dark yellowish brown (10YR 4/4) crushed; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky; friable; few, thin, discontinuous clay films; common roots and pores; slightly acid; clear, smooth boundary.
- B3—38 to 52 inches, brown (10YR 4/3) light silty clay loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; friable; thin discontinuous clay films; very dark gray (10YR 3/1) stains in pores and root channels; common roots and pores; neutral; clear, smooth boundary.
- C—52 to 60 inches, brown (10YR 4/3) silt loam; friable; some tendency to vertical cleavage but mainly massive; very dark gray (10YR 3/1) stains in root channels; common roots and pores; slightly acid.

The A1 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) in color and from 6 to 10 inches in thickness. The A2 horizon

ranges from very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) to brown (10YR 4/3). It is 4 to 8 inches thick in most places, but in cultivated or eroded areas part or all of this layer is mixed with the plow layer.

The B2t horizon is yellowish brown (10YR 5/4), dark yellowish brown (10YR 4/4), or brown (10YR 4/3). The B1 and B3 horizons are silt loam or light silty clay loam. The B horizon generally is 30 to 48 inches in total thickness.

The C horizon generally is brown (10YR 4/3) to yellowish brown (10YR 5/4).

The A1, A2, and B horizons range from neutral to medium acid. The C horizon ranges from slightly acid to mildly alkaline or moderately alkaline. In places it is calcareous, but in most places it is noncalcareous to a depth of 6 feet or more.

The Knox soils generally have a somewhat thinner A horizon than that of the Monona and Marshall soils. They have a grayish A2 horizon, which the Monona and Marshall soils lack. Their A and B horizons differ more in content of clay than those of the Monona and Marshall soils. All of these soils formed loess.

**Knox silt loam, 5 to 14 percent slopes (268 D).**—This soil is on upland ridgetops and side slopes. Adjacent and nearby soils are other Knox soils or Monona or Marshall soils, and Judson or Napier soils are downslope in the narrow drainageways. Areas are small, generally 5 to 30 acres in size.

This soil has the profile described as representative for the series. In places the surface layer is up to about 10 inches thick. In cultivated areas, some of the original subsurface layer has been mixed in the plow layer, resulting in a plow layer that is very dark grayish brown. Included in mapping were a few areas of a soil that has slopes of 2 to 5 percent. Some severely eroded areas where the brownish subsoil is exposed are shown on the soil map by a symbol for severe erosion.

Because this soil generally is in small areas, it is commonly managed in the same way as the surrounding soils. Much of the acreage is in trees or woods and is used for pasture. Some areas are cultivated, but erosion is a hazard in cultivated areas. This soil is moderately suited to row crops if erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Knox silt loam, 14 to 20 percent slopes (268 E).**—This soil is on side slopes on uplands. Generally the less sloping Knox soils are upslope, and Judson or Napier soils are downslope in the narrow drainageways. Areas are small, generally 5 to 30 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is very dark brown silt loam about 6 to 10 inches thick. In cultivated areas, the plow layer is very dark grayish brown because it has been mixed with the subsurface layer. A few severely eroded areas where the brownish subsoil is exposed are shown on the soil map by a symbol for severe erosion.

Because this soil generally is in small areas, it is commonly managed in the same way as the adjacent soils. Some areas are cultivated, but most are in wooded pasture. This soil is subject to erosion. It is moderately suited to row crops if erosion is controlled, but on many farms cultivated areas are left in hay and pasture most of the time, and a row crop is grown on the contour only when meadows need reseeding. Capability unit IVe-1; woodland group 1.

## Lakeport Series

The Lakeport series consists of dark-colored, somewhat poorly drained soils in the central part of bottom lands along the Missouri River. These soils formed in silty alluvium. They are at intermediate elevations and are nearly level.

In a representative profile the surface layer, about 24 inches thick, is black silty clay loam that grades to very dark gray in the lower part. The subsoil extends to a depth of about 44 inches. It is very dark grayish-brown, dark grayish-brown, and grayish-brown, friable to firm silty clay loam that has few yellowish-brown mottles. The substratum, extending to a depth of 55 inches, is light olive-brown, friable light silty clay loam that has a few yellowish-brown mottles.

The Lakeport soils are medium to low in available nitrogen, medium in available phosphorous, and high in available potassium. The content of organic matter is high. The surface layer is typically slightly acid. Available water capacity is high, and permeability is moderately slow to moderate. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops. Their limitations for this use are slight. Some areas have a fluctuating water table, but most of these areas are not artificially drained.

Representative profile of Lakeport silty clay loam in a cultivated field, 50 feet south of field entrance, west of grain bins, 30 feet west and 50 feet south of the northeast corner of the NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 15, T. 69 N., R. 43 W.

- Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark grayish brown (10YR 3/2) dry; cloddy but breaks to weak, fine, subangular blocky structure; friable; many roots; slightly acid; clear, smooth boundary.
- A12—7 to 15 inches, black (10YR 2/1) silty clay loam; strong, fine, subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.
- A3—15 to 24 inches, very dark gray (10YR 3/1) silty clay loam, very dark gray (10YR 3/1) kneaded; strong, fine, subangular blocky structure; friable; some black (10YR 2/1) worm casts; many roots and pores; slightly acid; gradual, smooth boundary.
- B21—24 to 34 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam, dark grayish brown (2.5Y 4/2) kneaded; some vertical cleavage breaking to moderate, fine, subangular blocky structure; friable; some shiny ped faces; many roots and pores; neutral; gradual, smooth boundary.
- B22—34 to 44 inches, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) silty clay loam; few, fine, yellowish-brown (10YR 5/6) mottles; moderate prismatic structure breaking to medium and fine subangular blocky; firm; dark stains along root channels and pores; some shiny ped faces; neutral; gradual, smooth boundary.
- C—44 to 55 inches, light olive-brown (2.5Y 5/4) light silty clay loam; few, fine, yellowish-brown (10YR 5/6 and 10YR 5/8) mottles; some weak vertical cleavage faces but mainly massive; some ped coatings of dark gray (10YR 4/1); friable; few roots and pores; some dark stains along root channels and pores; neutral.

The Ap and A12 horizons are black (10YR 2/1) or very dark brown (10YR 2/2) in color and range from about 12 to 18 inches in thickness. The A3 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The Ap, A1, and A3 horizons range from light to heavy silty clay loam. In places 6 to 15 inches of overwash that is very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam is on the surface.

The B2 horizon generally is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in the upper part and dark grayish brown (2.5Y 4/2) or grayish brown (2.5Y 5/2) in the lower part. The colors in the lower part range to light olive brown (2.5Y 5/4), gray (5Y 5/1), or olive gray (5Y 5/2). Mottles are common and are yellowish brown, brown, or brownish yellow. The range of textures in the B2 horizon includes light silty clay.

The C horizon ranges from dark grayish brown (2.5Y 4/2) to light olive brown (2.5Y 5/4), light brownish gray (2.5Y 6/2), and olive gray (5Y 5/2) in color and from silty clay loam to silt loam or very fine sandy loam in texture. Yellowish-brown and brown mottles are present in most places. Strata of finer textured materials are present in places.

The solum ranges from 36 to 48 inches in thickness. The A and B horizons generally are neutral or slightly acid, and the C horizon generally is neutral to mildly alkaline or moderately alkaline and calcareous.

The Lakeport soils have more clay throughout than the Keg soils. They do not grade to silt loam within a depth of 20 to 30 inches as do the Salix soils. They have less clay throughout than the Luton and Woodbury soils. All of these soils formed in alluvium and are associated on the landscape.

**Lakeport silt loam, overwash** (0 to 2 percent slopes) (436+).—This soil is in the central part of bottom lands along the Missouri River. It is near and generally at a slightly lower elevation than the Keg and Salix soils and at a somewhat higher elevation than the Luton, Blencoe, and Woodbury soils. Areas generally are 5 to 50 acres in size.

This soil has a layer of very dark grayish-brown or dark grayish-brown silt loam overwash, 6 to 15 inches thick, at the surface. This coarser textured overwash was deposited on the surface during floods, which have occurred much more recently on this soil than on other Lakeport soils. Included in mapping were small areas of Luton, Blencoe, Woodbury, Keg, and Salix soils. A few areas that have a sandy overwash are shown on the soil map by the standard symbols for sand.

Most areas of this soil are cultivated and are used mainly for row crops. This soil is well suited to this use. In many places it is farmed in fields with soils that have poorer drainage, and this may delay cultivation in spring. In places drainage ditches that help to drain wetter adjacent soils go through areas of this soil. The power requirement for tillage operations is somewhat lower on this soil than other Lakeport soils. Tilt is generally satisfactory. Capability unit I-1; woodland group 7.

**Lakeport silty clay loam** (0 to 2 percent slopes) (436).—This soil is in the central part of bottom lands along the Missouri River. It is near and generally at a slightly lower elevation than the Keg and Salix soils and at a somewhat higher elevation than the Luton, Blencoe, and Woodbury soils. Most areas are 25 to about 200 acres in size, but some are considerably larger.

This soil has the profile described as representative of the series. Included in mapping were small areas of Keg, Blencoe, and Luton soils.

This soil is cultivated and used mainly for growing row crops. It is well suited to this use. In many places it is farmed in fields with soils that are slower to dry. This may delay cultivation in spring. In places drainage ditches that drain wetter adjacent soils go through areas of this soil. Capability unit I-1; woodland group 7.

## Luton Series

The Luton series consists of dark-colored, poorly drained or very poorly drained soils on bottom lands

along the Missouri River. These soils formed in clayey alluvium. They are nearly level and are in the eastern part of the flood plain.

In a representative profile the surface layer is silty clay about 28 inches thick. It is black in the upper part and very dark gray in the lower part. It has strong-brown mottles. The subsoil is dark-gray to gray, very firm silty clay that has strong-brown mottles. It is about 8 inches thick. The substratum, to a depth of 54 inches, is gray, very firm silty clay loam that has strong-brown and olive-brown mottles.

The Luton soils are medium to low in available nitrogen, very low in available phosphorus, and high in available potassium. The content of organic matter is high. The surface layer and subsoil generally are neutral to mildly alkaline. Available water capacity is medium, and permeability is very slow. Runoff is very slow, and the water table is high.

Most areas of these soils are cultivated. Row crops and small grain are grown. These soils are subject to flooding by tributary streams that flow across soil areas to the main stream. The water generally is in manmade ditches. Wetness often delays fieldwork, and it reduces crop production in some years.

Representative profile of Luton silty clay in a cultivated field, 50 feet east of the northwest corner of the NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 13, T. 68 N., R. 43 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay; cloddy; very firm; few fine roots; very few fine pores; few fine wormholes; neutral; gradual boundary.

A12—6 to 17 inches, black (10YR 2/1) silty clay; few, very fine, strong-brown (7.5YR 5/6) mottles; strong, fine, subangular blocky structure; very firm; few very fine roots; few fine pores; sheen on ped faces; mildly alkaline; clear, smooth boundary.

A3—17 to 28 inches, very dark gray (2.5Y 3/1) silty clay, some mixing with dark grayish brown (2.5Y 4/2); few, fine, strong-brown (7.5YR 5/6) mottles; moderate, fine, subangular blocky structure; very firm; few fine roots and pores; few hard lime concretions; sheen on ped faces; mildly alkaline; matrix is not calcareous; clear, smooth boundary.

Bg—28 to 36 inches, dark-gray (5Y 4/1) to gray (5Y 5/1) silty clay; common, fine, strong-brown (7.5YR 5/6 to 5/8) mottles; weak, medium, prismatic structure; very firm; few fine roots and pores; apparent filling of cracks by very dark gray and very dark grayish-brown material from the A horizon; few lime concretions; few slickensides; mildly alkaline; matrix is not calcareous; clear, smooth boundary.

C1g—36 to 42 inches, gray (5Y 5/1) silty clay; common, fine, strong-brown (7.5YR 5/6) mottles; massive; very firm; some vertical cleavage; few fine roots; numerous lime concretions; some slickensides; moderately alkaline; calcareous; clear, smooth boundary.

C2g—42 to 54 inches, gray (5Y 5/1) silty clay; common, fine, olive-brown (2.5Y 4/4) mottles; some vertical cleavage; very firm; some concretions; moderately alkaline; calcareous.

The A horizon is typically black (10YR 2/1 or N 2/0) to a depth of 12 to 24 inches but ranges to very dark gray (10YR 3/1 or 5Y 3/1 or N 3/0) in places. Colors that have a value of 3 and a chroma of 1 or less extend to a depth of 24 to 30 inches in most places. The A1 horizon generally is silty clay or clay, but some soils have about 6 to 15 inches of silty clay at the surface. In places there are 6 to 15 inches of overwash that is very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam.

The Bg horizon is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2) and has mottles that range from dark brown to strong brown and olive brown or olive.

The C horizon is dark gray (5Y 4/1) to olive gray (5Y 5/2) and has mottles of light olive brown to yellowish brown or strong brown. In places there are strata of silt loam or other textures.

The solum is typically about 36 to 48 inches thick. The A and B horizons are generally neutral to mildly alkaline, but in a few places the Ap or A1 horizon is slightly acid. The C horizon is mildly alkaline or moderately alkaline and calcareous in most places.

The Luton soils have more clay throughout than the Zook and Colo soils. They lack the silt loam texture below a depth of 20 to 30 inches, but silt loam is present below this depth in the Blencoe soils. They have a higher organic-matter content and are darker colored than Albaton soils. They are not calcareous beginning at or near the surface and extending throughout as are the Solomon soils. All of these soils formed in alluvium.

**Luton silt loam, overwash** (0 to 2 percent slopes) (66+).—This soil is in slack water areas in the eastern part of bottom lands along the Missouri River. It generally is adjacent to McPaul and Merville soils and at a lower elevation than the nearby Salix and Lakeport soils. It generally is near the tributary streams that flow across areas of Luton soils to the Missouri River. These streams have overflowed recently and deposited overwash to form this Luton soil. The overwash generally is very dark grayish-brown or grayish-brown, calcareous silt loam 6 to 15 inches thick. Areas vary in size, and some are as large as 160 acres or more.

Included with this soil in mapping were small areas of Merville and McPaul soils. A few areas that have sandy overwash are shown on the soil map by a symbol for sand.

This soil is mainly cultivated and used for row crops. The soil is moderately suited to row crops and small grain if drainage is adequate. Wetness is a limitation and is the result of the high water table, the nearly level topography, and the overflowing streams. Seeds generally tend to germinate more readily in this soil than in Luton silty clay. The power requirement for tillage operations is lower than on Luton silty clay, and tilth generally is better. Capability unit IIIw-1; woodland suitability group 7.

**Luton silty clay loam** (0 to 2 percent slopes) (366).—This soil is in slack water areas in the eastern part of bottom lands along the Missouri River. It generally is adjacent to Lakeport, Colo, and other Luton soils. Areas are mainly 25 to 160 acres in size, but some are larger.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is silty clay loam to a depth of about 6 to 15 inches. A few areas of soil that have as much as 12 inches of sandy overwash are shown on the soil map by a symbol for sand.

Most areas of Luton silty clay loam are used for row crops. This soil is well suited to row crops and small grain if the wetness is controlled. Wetness is a limitation, but the soil is not so wet as Luton silty clay. Less power is required to till this soil than is required to till Luton silty clay, and tilth generally is better. Capability unit IIw-1; woodland group 7.

**Luton silty clay** (0 to 2 percent slopes) (66).—This soil is in slack-water areas in the eastern part of bottom lands along the Missouri River. It generally is at a lower elevation than the adjacent, better drained Salix and Lakeport soils. Areas are large; some are more than 1,200 acres in size.

This soil has the profile described as representative for the series. Included in mapping were small areas of Blencoe, Woodbury, and Solomon soils.

Most drained areas are cultivated and are used for row crops and small grain. This soil is moderately well suited to row crops if drainage is adequate. Wetness is a severe limitation. The water table is often high, and runoff is very slow. If rainfall is above average, seeds may not germinate, and replanting of row crops may be necessary. Fieldwork is often hampered by wetness. It is often necessary to work the soil when wet, and cloddiness and poor tilth are concerns of management. As this soil dries late in summer, large cracks form in the surface layer and extend deep into the subsoil. Capability unit IIIw-1; woodland group 7.

## Malvern Series

The Malvern series consists of dark-colored, moderately well drained or somewhat poorly drained soils on uplands. These soils formed in loess that is older than that now on most parts of the landscape. Soils that formed in this loess were buried by later deposits of loess, but geologic erosion has exposed the once buried soils on the lower part of some ridges and on the lower part of side slopes. Slopes are 5 to 14 percent. Areas of the Malvern soils that are less than 1 acre in size and are within areas of other soils are shown on the soil map by a spot symbol for red clay.

In a representative profile the surface layer is silty clay loam about 16 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The subsoil is firm silty clay that extends to a depth of 54 inches or more. It is brown in the upper part, reddish brown and brown in the middle part, and strong brown in the lower part. It has mottles of strong brown, reddish gray, light gray, and dark reddish gray.

The Malvern soils are very low to low in available nitrogen and available phosphorus and low to medium in available potassium. The organic-matter content varies but is mainly about moderate. The upper part of the surface layer is medium acid, and the lower part of the surface layer and the upper part of the subsoil are slightly acid. Available water capacity is high, and permeability is slow. Runoff is medium to rapid, depending on the degree of slope.

Some areas of Malvern soils are cultivated, and others are in pasture. The use made of these soils often depends on the use made of the surrounding soils. Erosion is a hazard. During wet periods, a seepy area can develop at the border of Malvern soils and the better drained soils that formed in loess upslope.

Representative profile of Malvern silty clay loam, 9 to 14 percent slopes, on a convex side slope that has a gradient of about 11 percent, 800 feet east and 75 feet south of the northwest corner of the NE¼ sec. 26, T. 68 N., R. 40 W.

A1—0 to 10 inches, very dark brown (10YR 2/2) silty clay loam; weak, fine and very fine, granular structure; friable; many roots and fine pores; medium acid; clear, smooth boundary.

A3—10 to 16 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, fine and very fine, sub-angular blocky structure; friable; very dark brown (10YR 2/2) coatings on peds and in root channels; many roots and fine pores; slightly acid; clear, smooth boundary.

IIB21t—16 to 26 inches, brown (7.5YR 4/4) silty clay; few, fine, strong-brown (7.5YR 5/6) mottles and few, fine, distinct, grayish-brown (2.5Y 5/2) mottles; strong, fine, subangular blocky structure; very firm; some mixing or worm casts of very dark gray (10YR 3/1); thin discontinuous clay films; many roots and fine pores; slightly acid; clear, smooth boundary.

IIB22t—26 to 40 inches, reddish-brown (5YR 4/4) and brown (7.5YR 4/4) silty clay; common, medium, reddish-gray (5YR 5/2) mottles and few, fine, light-gray (10YR 7/1) mottles; moderate, medium, prismatic structure breaking to strong, medium and fine, subangular blocky; very firm; dark-gray (10YR 3/1) fillings in some pores; thick, nearly continuous clay films on ped faces; few roots and fine pores; slightly acid; clear, smooth boundary.

IIB3t—40 to 54 inches, strong-brown (7.5YR 5/8) and reddish-brown (5YR 5/4) light silty clay; common, fine, dark reddish-gray (5YR 4/2) mottles, common, medium, reddish-gray (5YR 5/2) mottles, and many, large, light-gray (10YR 7/1) mottles; weak, coarse, prismatic structure breaking to moderate, medium, subangular blocky; firm; some dark stains and fine concretions of iron and manganese; few pores; neutral.

The A horizon ranges from very dark brown (10YR 2/2 or 7.5YR 2/2) to very dark grayish brown (10YR 3/2) or dark brown (7.5YR 3/2 or 10YR 3/3). Unless eroded, the A1 and A3 horizons generally have a combined thickness of 10 to 18 inches. The thickness depends on the amount of erosion that has taken place.

The IIB2t horizon ranges from reddish brown (5YR 4/3) to yellowish brown (10YR 5/6). If matrix colors are yellowish brown, common to many reddish mottles are present. The IIB2t and IIB3t horizons have mottles in a wide range of hue, value, and chroma, and these mottles increase in size and abundance with increasing depth.

The IIC horizon generally is yellowish-brown or strong-brown, mottled, light to heavy silty clay loam. The representative profile was not described deeply enough to include this horizon.

The solum is 36 to 60 inches thick. The A horizon is slightly acid or medium acid, and the IIB horizon is slightly acid or neutral.

In Fremont County, Malvern soils, 9 to 14 percent slopes, severely eroded, have a surface horizon that is thinner and lighter colored than is defined as the range for the Malvern series.

Malvern soils have fewer pebbles and less sand than the Adair soils, which are similar in color and drainage.

**Malvern silty clay loam, 5 to 9 percent slopes, moderately eroded (60C2).**—This soil is on uplands in narrow bands on side slopes and on points of ridges. Areas generally are small, ranging from 2 to 10 acres in size. This soil generally is adjacent to Marshall or Monona soils that are upslope and Adair, Judson, or Napier soils that are downslope.

This soil has a profile similar to that described as representative of the series, except that in most places the surface layer is a very dark brown or very dark grayish-brown plow layer. In places some of the brown subsoil is mixed into the original surface layer.

Included in mapping were small areas of soils that have a thicker surface layer and areas of severely eroded soils where the present surface layer is mostly subsoil. Areas of severely eroded soils are shown on the soil map by a symbol for erosion.

Because this soil generally is in small areas, it is commonly farmed with adjacent soils. It is moderately suited to row crops, but erosion and wetness caused by seepage from upslope are limitations to its use. A narrow, wet, seepy band is directly upslope from this soil in some places. If tilled when wet this soil becomes cloddy and hard as it

dries. Tilth generally is fair to poor. Capability unit IIIe-3; woodland group 5.

**Malvern silty clay loam, 9 to 14 percent slopes (60D).**—This soil is mainly in narrow bands on the lower part of side slopes in the uplands. It generally is downslope from the Marshall and Monona soils and upslope from the Adair, Napier, or Judson soils. Areas are small, generally ranging from 2 to 10 acres in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of soils that have a somewhat thinner surface layer.

Because this soil generally occurs in small areas, it generally is managed in the same way as the adjacent soils. Many areas are in pasture, and a few are cultivated. This soil is moderately suited to row crops if erosion is controlled, but many areas are better suited to hay or pasture. In places a narrow, wet, seepy band is directly upslope and causes wetness in this soil. Tilth generally is fair. Capability unit IVe-2; woodland group 5.

**Malvern silty clay loam, 9 to 14 percent slopes, moderately eroded (60D2).**—This soil is mainly in narrow bands on the lower part of side slopes in the uplands. It generally is downslope from the Marshall or Monona soils and upslope from Adair, Napier, and Judson soils. Areas are small, generally ranging from 2 to 10 acres in size.

In many places the surface layer is a very dark grayish-brown or brown plow layer. In places the brown subsoil is mixed into the plow layer. In uncultivated areas the surface layer is about 3 to 7 inches thick and is very dark brown or very dark grayish brown.

Included in mapping were small areas of severely eroded soils where the present surface layer is mostly the original subsoil and some small areas of soils that have a thicker surface layer. Severely eroded spots are shown on the soil map by a symbol for erosion.

Because this soil generally is in small areas, it is commonly cultivated or used for hay or pasture, depending on how the adjacent soils are used. This soil is moderately well suited to row crops if erosion is controlled, but many areas are better suited to hay or pasture than to row crops. A narrow, wet, seepy band is directly upslope in some places and causes wetness in this soil. If tilled when wet, this soil tends to become cloddy and hard as it dries. Tilth generally is fair or poor. Capability unit IVe-2; woodland group 5.

**Malvern soils, 9 to 14 percent slopes, severely eroded (60D3).**—These soils are mainly on the lower part of side slopes in the uplands. They generally are downslope from the Marshall or Monona soils and upslope from Adair, Judson, or Napier soils. Areas are small, generally ranging from 2 to 10 acres in size.

These soils have a profile similar to the one described as representative of the series, except that in most places the present surface layer, or plow layer, is mostly subsoil that has been mixed in the original surface layer by plowing. It generally is dark grayish brown or brown. Included in mapping were small areas of soils that have a thicker, darker-colored surface layer.

Because these soils generally are in small areas, they are commonly farmed with the adjacent soils. Most areas are or have been cultivated. These soils are poorly suited to row crops, but they are suited to hay or pasture. They are subject to further erosion. Seedbeds are difficult to prepare because the eroded surface layer has poor tilth.

A narrow, wet, seepy band is directly upslope in some places and causes wetness in these soils. Capability unit VIe-2; woodland group 5.

## Marsh

Marsh (354) consists of depressions or flats, intermingled with ponds and small lakes, in areas where the water table is at or near the surface the year round. The natural vegetation consists of cattails, rushes, sedges, and other water-tolerant grasses. Most of this land type is around Forneys Lake on bottom lands along the Missouri River and within and around the Riverton wildlife area and other areas along the Nishnabotna Rivers and small streams. In places it is surrounded by Colo, Luton, and Zook soils.

Marsh is suited to wildlife habitat. In places it can be diked so that some areas are under water the year round. Some areas in and around the Riverton wildlife area and Forneys Lake were farmed, pastured, or timbered before the dikes were built and flooding controlled. These areas have a continuously high water table. Capability unit VIIw-1; not in a woodland group.

## Marshall Series

The Marshall series consists of dark-colored, well-drained soils that formed in loess on uplands. These soils are on moderately wide, upland ridges and benches where slopes are 0 to 2 percent and on narrow ridges and smooth side slopes where slopes are 2 to 14 percent.

In a representative profile the surface layer is black to very dark brown, friable silty clay loam about 12 inches thick. The subsoil is friable and extends to a depth of about 50 inches or more. It is very dark grayish-brown silty clay loam in the upper part, it grades to brown silty clay loam in the middle part, and it grades to dark yellowish-brown and yellowish-brown silty clay loam to silt loam in the lower part.

The Marshall soils are very low to medium in available nitrogen and phosphorus and medium to high in available potassium. The content of organic matter varies, depending on the slope and amount of erosion that has taken place, but it is low to moderate in most places. The surface layer is typically medium acid or slightly acid. Available water capacity is high, and permeability is moderate. Runoff is slow to rapid, depending on the slope.

Most areas of the these soils are cultivated. Many acres are used for seed and nursery crops. The sloping soils are subject to erosion.

Representative profile of Marshall silty clay loam, 2 to 5 percent slopes, in a cultivated field, on a ridgetop where the slope is 3 percent, about 150 feet west and 50 feet south of the northeast corner of the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 21, T. 69 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silty clay loam, very dark brown (10YR 2/2) kneaded, grayish brown (10YR 5/2) dry; weak, fine, subangular blocky structure; friable; many roots and pores; medium acid; clear, smooth boundary.

A12—7 to 12 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) kneaded; moderate, fine, subangular blocky structure; friable; some dark grayish-brown (10YR 4/2) worm casts; many roots and pores; slightly acid; gradual, smooth boundary.

B1—12 to 19 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark brown (10YR 3/3) kneaded; moderate, fine, subangular blocky structure; some coatings on ped faces are very dark brown (10YR 2/2); some dark grayish-brown (10YR 4/2) worm casts; many roots and pores; slightly acid; gradual, smooth boundary.

B2—19 to 27 inches, brown (10YR 4/3) silty clay loam; weak, fine, subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.

B31—27 to 38 inches, dark yellowish-brown (10YR 4/4) light silty clay loam, dark yellowish brown (10YR 4/4) kneaded; weak, fine, subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.

B32—38 to 50 inches, yellowish-brown (10YR 5/4) light silty clay loam to silt loam; few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; few, fine, hard oxide concretions; some dark staining in root channels; slightly acid.

The Ap and A1 horizons range from black (10YR 2/1) to very dark grayish brown (10YR 3/2). In places the B1 horizon described as very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) in the representative profile is lacking, and a very dark grayish brown A3 horizon is present. The A horizon is 10 to 20 inches in total thickness, unless the soils are eroded.

The B horizon is dark brown (10YR 3/3) or brown (10YR 4/3) in the upper part and brown (10YR 4/3) to yellowish brown (10YR 5/4) in the lower part. In many places the B2 or B3 horizon has olive-gray to strong-brown mottles below a depth of 30 inches.

The C horizon is not described in the representative profile, but it is brown to yellowish-brown silt loam that is mottled with olive gray and strong brown.

The A and B2 horizons are typically slightly acid or medium acid, but the B3 and C horizons range to neutral.

In Fremont County, Marshall silty clay loam, 9 to 14 percent slopes, severely eroded, has a surface layer that is lighter colored and thinner than is defined as the range for the Marshall series.

The Marshall soils are better drained than the Minden soils and do not have grayish-brown colors in the B horizon. They have more clay than the Monona soils. They differ from Knox soils in having a thicker A1 horizon, lacking a grayish A2 horizon, and having less difference between the amount of clay in the A horizon and that in the B horizon. All of these soils formed in loess.

### Marshall silty clay loam, 0 to 2 percent slopes (9A).—

This soil is on ridges in the uplands. Generally, other Marshall soils are downslope. Areas vary from small to large, but generally are 5 to more than 100 acres in size.

This soil has a profile similar to the one described as representative of the series except that the surface layer tends to be thicker. Black or very dark brown colors generally extend to a depth of more than 12 inches. In places more grayish mottles are present. Included in mapping were small areas of somewhat poorly drained Minden soils.

This soil is used extensively for cultivated crops. It is well suited to row crops. Limitations to the intensive use of this soil for crops are slight. Capability unit I-3; woodland group 1.

### Marshall silty clay loam, benches, 0 to 2 percent slopes (T9A).—

This soil is on high benches near the Nishnabotna Rivers. It is near the Judson, Minden, and Corley soils. The areas are generally quite large; some are several hundred acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is a little thicker. The black or very dark brown colors extend to a depth of more than 12 inches. In places more grayish mottles are present. The loess on benches in which

this soil formed differs from that on uplands in being underlain by alluvial sediment rather than glacial till. Included in mapping were small areas of Minden and Corley soils.

This soil is used extensively for cultivated crops. A large amount of nursery crops are grown. The soil is well suited to these uses. In many places it is managed as individual fields. Limitations to intensive use for crops are slight. Capability unit I-3; woodland group 1.

**Marshall silty clay loam, 2 to 5 percent slopes (9B).**—This soil is on ridgetops in the north-central and eastern parts of the county. Generally, other Marshall soils or Monona or Judson soils are downslope. Areas generally are large, elongated, and irregularly shaped. Many are as much as several hundred acres in size.

This soil has the profile described as representative for the series.

Except for the areas that have farmsteads and some small areas in pasture, this soil is cultivated. Erosion is a slight hazard. This soil is well suited to row crops if the erosion is controlled. Capability unit IIe-2; woodland group 1.

**Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded (9B2).**—This soil is on ridgetops. Generally, other Marshall soils or Monona or Judson soils are downslope. Areas generally are 5 to 50 acres in size and generally are elongated.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is a plow layer that is very dark brown or very dark grayish brown. Included in mapping were small areas of severely eroded soils where the present surface layer is mostly dark-brown subsoil.

Most areas of this soil are cultivated. This soil is moderately eroded, and further erosion is a hazard. It is well suited to row crops if the erosion is controlled. Capability unit IIe-2; woodland group 1.

**Marshall silty clay loam, benches, 2 to 5 percent slopes (T9B).**—This soil is on high benches near the Nishnabotna Rivers. It is near the nearly level Marshall soils and Judson, Minden, and Corley soils that are on the benches and nearby foot slopes. Areas generally are about 10 to more than 50 acres in size.

This soil is similar to the soil described as representative of the series, but it formed in loess that is underlain by alluvial sediment rather than in loess that is underlain by glacial till. Also, it is on benches rather than on uplands.

Nearly all areas of this soil are cultivated. This soil is well suited to row crops if the hazard of erosion is controlled. Nursery crops also are grown on this soil, and it is well suited to this use. Capability unit IIe-2; woodland group 1.

**Marshall silty clay loam, 5 to 9 percent slopes (9C).**—This soil is on upland ridges and side slopes. It generally is near other Marshall soils that are upslope or Monona, Malvern, or Judson soils that are downslope. Areas generally are about 50 acres or more in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer generally is a few inches thinner. Included in mapping were small moderately eroded areas and small areas of Judson and Monona soils.

Some areas of this soil are in pasture or farmsteads, and the rest are cultivated. Erosion is a hazard, but this soil is

moderately well suited to row crops if erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded (9C2).**—This soil is on upland ridges and side slopes. It generally is near other Marshall soils that are upslope or Monona, Malvern, or Judson soils that are downslope. These areas are typically large; many are as much as 100 acres or more in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer generally is a plow layer that is very dark brown or very dark grayish brown. In places there has been some mixing of dark-brown subsoil into the plow layer. Included are small areas of Judson, Dow, and Monona soils. Areas of severely eroded soils where the plow layer is mostly dark-brown subsoil are shown on the map by a spot symbol for severe erosion.

Most areas of this soil are cultivated. This soil is moderately eroded, and further erosion is a hazard. It is moderately suited to row crops if the erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Marshall silty clay loam, 9 to 14 percent slopes (9D).**—This soil is on side slopes on uplands. It generally is near other Marshall soils that are upslope and Judson soils that are downslope. In places Malvern, Dow, and Adair soils are downslope. Areas generally are 5 to more than 50 acres in size.

This soil has a profile similar to the one described as representative of a series, except that the surface layer tends to be a few inches thinner, the subsoil tends to be thinner, and in places gray to strong-brown mottles are present below a depth of about 2½ feet. Included in mapping were small areas of moderately eroded soils that have a surface layer of very dark grayish brown and small areas of Monona, Dow, Malvern, and Judson soils.

This soil is used for cultivated crops, hay, and pasture. Erosion is a hazard on this strongly sloping soil. This soil is moderately well suited to row crops if the erosion is controlled. Sidehill drainageways are common, and some are gullied and should be shaped if they are to be cultivated. Capability unit IIIe-1; woodland group 1.

**Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded (9D2).**—This soil is on side slopes on uplands. Areas are about 5 to more than 100 acres in size.

The surface layer of this soil generally is a plow layer that is very dark grayish brown. In places there has been some mixing of the brownish subsoil. The subsoil tends to be thinner and in places has gray to strong-brown mottles below a depth of about 2½ feet. Included in mapping were small areas of severely eroded soils where the present surface layer is mostly brownish subsoil and small areas of Monona, Dow, Adair, Malvern, and Judson soils.

Most of this soil is cultivated, but a few areas are in permanent pasture. Erosion is a serious hazard on this strongly sloping soil. This soil is moderately suited to row crops if the erosion is controlled. Sidehill drainageways are common. Some are gullied and should be shaped and seeded, but most are crossable. Capability unit IIIe-1; woodland group 1.

**Marshall silty clay loam, 9 to 14 percent slopes, severely eroded (9D3).**—This soil is on side slopes on uplands. It generally is near other Marshall soils or Judson soils but in some places is adjacent to Monona, Malvern,

Dow, and Adair soils. Areas are small, generally 5 to 20 acres in size.

The present surface layer of this soil generally is a dark-brown or brown plow layer that is mostly subsoil. The present subsoil tends to be thinner than the original and in places has gray to strong-brown mottles below a depth of about 2½ feet. Included in mapping were small areas of Monona, Dow, Adair, Malvern, and Judson soils.

Most areas of this soil are cultivated. This soil is severely eroded, and further erosion is a hazard. It is moderately suited to row crops if erosion is controlled. Sidehill drainageways are common. In places they are gullied and should be shaped and seeded to improve the waterways. This soil has poorer tilth than the less eroded Marshall soils. Capability unit IIIe-1; woodland group 1.

### McPaul Series

The McPaul series consists of moderately dark, well drained or moderately well drained soils on bottom lands along the Missouri River. These soils formed in stratified, calcareous, silty alluvium washed from the adjacent uplands. They are nearly level and generally are in desilting basins in the eastern part of bottom lands, near streams that flow from the uplands.

In a representative profile the surface layer is very dark grayish-brown and dark grayish-brown light silt loam about 7 inches thick. The substratum, extending to a depth of 50 inches, is stratified grayish-brown, dark grayish-brown, and brown, very friable light silt loam. Below a depth of 40 inches, yellowish-brown and strong-brown mottles are common.

The McPaul soils are very low in available nitrogen, low in available phosphorus, and high in available potassium. The content of organic matter is low. These soils are mildly alkaline and calcareous. Available water capacity is high, and permeability is moderate. Runoff is slow.

Most areas of McPaul soils are cultivated. Some areas are subject to occasional flooding.

Representative profile of McPaul silt loam in a cultivated field about 100 feet south of large round grain bin and 30 feet west of farm lane, 180 feet west and 860 feet north of the southeast corner of the SW¼SE¼ sec. 36, T. 69 N., R. 43 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) light silt loam, about 20 percent dark grayish brown (10YR 4/2), a few peds of brown (10YR 4/3), grayish brown (10YR 5/2) dry; cloddy, but breaks to weak, fine, granular structure; very friable; mildly alkaline; calcareous; abrupt, smooth boundary.

C—7 to 50 inches, stratified grayish-brown (10YR 5/2), dark grayish-brown (10YR 4/2), and brown (10YR 5/3) light silt loam, pale brown (10YR 6/3) dry; very friable; few, very thin, darker-colored horizontal strata; common yellowish-brown (10YR 5/8) and strong-brown (7.5YR 5/6 and 5/8) mottles in 40- to 50-inch zone; weak platy structure in some parts reflects stratification; very friable; mildly alkaline; calcareous.

In most places the A horizon is a very dark grayish-brown (10YR 3/2) plow layer less than 10 inches thick. In places it is dark grayish brown (10YR 4/2).

The C horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3) and has stratified layers. Mottles and stains of yellowish brown, brown, strong brown, and gray are present in many places. Thin strata of very dark grayish

brown are present in places. The texture is silt loam throughout, except that light silty clay loam is present in darkened buried layers that, in places, are below a depth of 24 inches. The soils are mildly alkaline or moderately alkaline throughout and are calcareous.

The McPaul soils are lower in content of sand than the Haynie soils and do not tend to have as many thin strata of contrasting texture. They are calcareous throughout, but Nodaway soils are not. They are not underlain by a buried clayey soil at a depth of 18 to 30 inches as are the Merville soils. They are associated with the Merville soils on the landscape. All of these soils formed in alluvium.

**McPaul silt loam** (0 to 2 percent slopes) (70).—This soil is on level bottom lands in the eastern part of the Missouri River valley. It generally is downslope from the Napier and Castana soils, which are on foot slopes below soils of the uplands. It is near the Colo, Luton, Kennebec, and Merville soils in many places. Areas range from small to large, and some are more than 600 acres in size.

Included with this soil in mapping were small areas of Merville soils.

This soil is well suited to row crops, and nearly all of the acreage is used for this purpose (fig. 10). Some areas are subject to occasional flooding, but in most places the hazard of flooding is not serious. Capability unit 1-2, woodland group 6.

### Minden Series

The Minden series consists of dark-colored, nearly level, somewhat poorly drained soils. These soils formed in loess. They are on high benches along the Nishnabotna Rivers.

In a representative profile the surface layer is black, very dark gray, or very dark brown in the upper part and very dark brown and very dark grayish brown in the lower part. It is friable silty clay loam about 22 inches thick. The subsoil is mainly dark grayish-brown and grayish-brown silty clay loam. It is about 19 inches thick and has yellowish-brown mottles. The substratum, extending to a depth of 50 inches, is grayish-brown, friable silt loam to silty clay loam that has many yellowish-brown mottles.

The Minden soils are low to medium in available nitrogen and phosphorus and medium to high in available potassium. The organic-matter content is high. The soils are neutral. Available water capacity is high, and permeability is moderate. Runoff is slow to medium.

Nearly all areas of these soils are used for cultivated crops. To a limited extent, nursery stock, including shrubs, trees, and flowers, is grown. There are no severe limitations to the use of these soils for crops.

Representative profile of Minden silty clay loam, benches, in a cultivated field, 150 feet west and 150 feet north of the southeast corner of the NE¼NE¼ sec. 20, T. 69 N., R. 41 W.

Ap—0 to 7 inches, black (10YR 2/1) or very dark gray (10YR 3/1) light silty clay loam, dark gray (10YR 4/1) dry; moderate, fine, granular structure; friable; many roots and pores; neutral; abrupt, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) kneaded; weak, very fine, subangular blocky structure breaking to moderate, fine, granular; friable; neutral; clear, smooth boundary.

A3—15 to 22 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) silty clay loam; weak, very fine, subangular blocky structure breaking

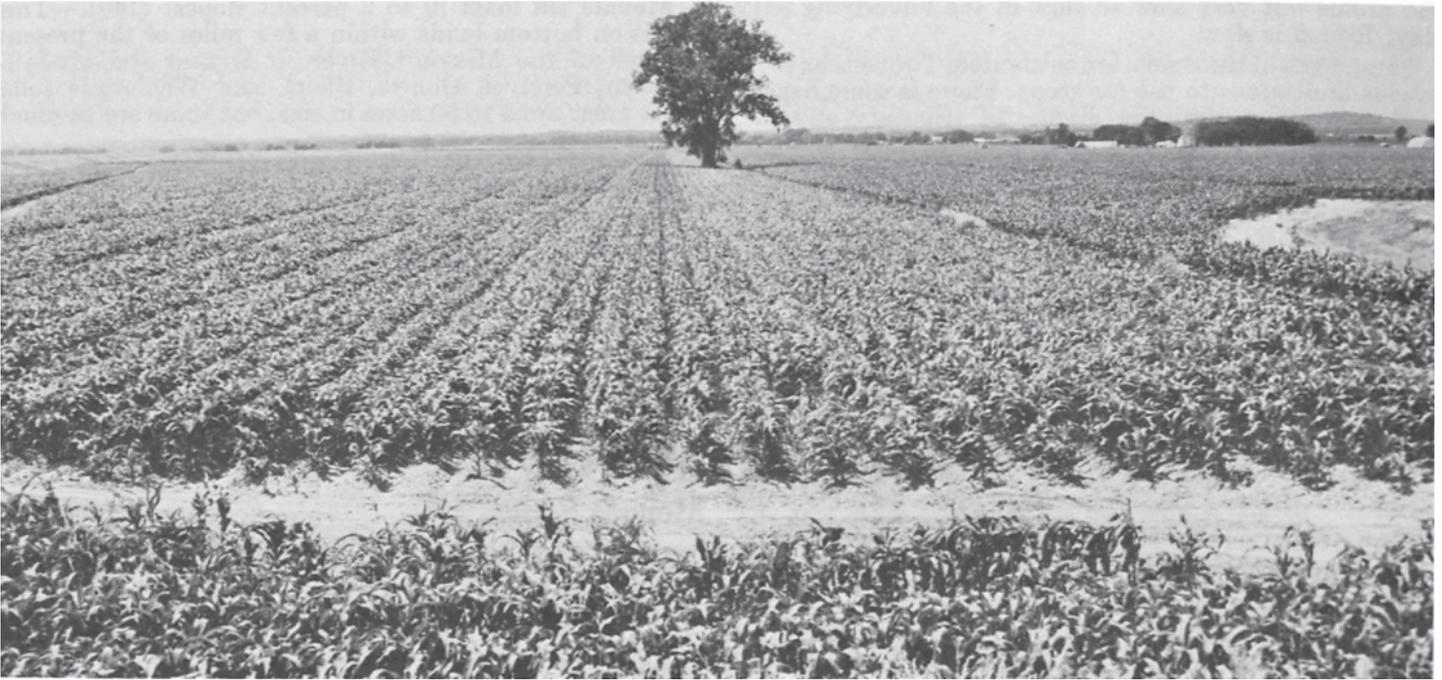


Figure 10.—Field of corn on McPaul soil.

to moderate, fine and medium, granular; friable; many roots and pores; neutral; gradual, smooth boundary.

B2—22 to 30 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silty clay loam, dark grayish brown (10YR 4/2) kneaded; few, fine, yellowish-brown (10YR 5/4) mottles; weak, fine, subangular blocky structure; friable; few dark-colored oxides; some roots; many pores and worm channels; neutral; clear, smooth boundary.

B3—30 to 41 inches, grayish-brown (10YR 5/2) and (2.5Y 5/2) and brown (10YR 4/3) silty clay loam, dark yellowish brown (10YR 4/4) kneaded; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine, subangular blocky structure; friable; some oxide concretions; many pores and worm channels; neutral; gradual, smooth boundary.

C—41 to 50 inches, grayish-brown (2.5Y 5/2) silt loam to silty clay loam; many yellowish-brown (10YR 5/6) stains or mottles; weak, coarse, subangular blocky structure to massive; friable; numerous fine pores; some oxide concretions; neutral.

The Ap and A1 horizons range from black (10YR 2/1) to very dark gray (10YR 3/2) or very dark brown (10YR 2/2) in color and from silt loam to light silty clay loam in texture. The A horizon ranges from 18 to 24 inches in total thickness.

The B2 horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (2.5Y 5/2 or 10YR 5/2). In places the upper part of this horizon is mixed with very dark grayish brown (10YR 3/2), or ped exteriors are this color. Few to many mottles of yellowish brown, strong brown, and grayish brown are present. The B3 horizon ranges to silt loam in texture and to light olive brown (2.5Y 5/4) in color.

The C horizon is mottled and varies in color, ranging from grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4), olive (5Y 5/3), and olive gray (5Y 5/2). Mottles similar to those in the B horizon are present and increase in size and abundance with increasing depth.

The solum is dominantly neutral or slightly acid but ranges to medium acid in some places.

The Minden soils are not so gray in the B horizon as Corley soils and lack a dark-gray A2 horizon. They have more grayish-brown colors in the B horizon than the Marshall soils and have a thicker A horizon. All of these soils formed in loess and are associated on the landscape.

**Minden silty clay loam, benches** (0 to 2 percent slopes) (T299).—This soil is on high benches near the Nishnabotna Rivers. It is near the Marshall and Corley soils. Areas vary in size but are as much as 200 acres or more.

This soil formed in loess on benches and is underlain by alluvial sediment.

Most areas of this soil are cultivated and are used for row crops. In some areas nursery crops are grown. This soil is well suited to these uses, and limitations to its use for crops are slight. Capability unit I-3; woodland group 1.

### Modale Series

The Modale series consists of stratified, moderately dark colored, moderately well drained or somewhat poorly drained soils on bottom lands along the Missouri River. These soils formed in recently deposited, calcareous, silty alluvium that is underlain by silty clay. They are nearly level and are on bottom lands adjacent to or within a few miles of the Missouri River channel.

In a representative profile the surface layer is very dark grayish-brown, very friable silt loam about 8 inches thick. The next layer is stratified, dark grayish-brown, very friable coarse silt loam to very fine sandy loam 10 inches thick that has dark reddish-brown mottles. Beneath this layer is a 6-inch layer of very dark gray; olive-gray, and dark-gray, firm silty clay that has strong-brown mottles. Below this is dark-gray, very firm or firm silty clay that has brown, dusky-red, and yellowish-red mottles.

The Modale soils are very low in available nitrogen and phosphorus and high in available potassium. The organic-matter content is low. The soils are typically mildly alkaline and calcareous. Available water capacity is high. Permeability is moderate in the upper part of

the profile but very slow to slow in the underlying silty clay. Runoff is slow.

Most areas of these soils are cultivated. The soils have no serious limitations to use for crops. There is some hazard of flooding from drainage ditches of tributary streams, but the risk of flooding by the Missouri River is slight because the flow has been stabilized by large dams, and levees have been constructed. Soils not protected by the levees are subject to flooding.

Representative profile of Modale silt loam in a slightly elevated area in a cultivated field, 792 feet east and 135 feet north of the southwest corner of sec. 21, T. 68 N., R. 43 W.

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (2.5Y 5/2) dry; single grained; very friable; abundant roots; few worm casts; calcareous; mildly alkaline; clear, smooth boundary.
- C1—8 to 18 inches, stratified dark grayish-brown (10YR 4/2) coarse silt loam to very fine sandy loam, light brownish gray (2.5Y 6/2) dry; dark reddish-brown (5YR 3/3 to 3/4) mottles that appear to increase in both size and number with increasing depth; some horizontal cleavage; very friable; common roots; few dark-colored worm casts; mildly alkaline; calcareous; abrupt, smooth boundary.
- IIACgb—18 to 24 inches, very dark gray (10YR 3/1), olive-gray (5Y 5/2), and dark-gray (N 4/0) silty clay; common, fine, strong-brown (7.5YR 5/6 to 5/8) mottles that increase in number with increasing depth; moderate, fine, subangular blocky structure; firm; few fine roots; few, fine, black oxides; mildly alkaline; calcareous; clear, smooth boundary.
- IIC1g—24 to 30 inches, dark-gray (5Y 4/1) silty clay, dark grayish brown (2.5Y 4/2) crushed; common, fine, brown (7.5YR 4/4) mottles; strong, medium, subangular blocky structure; very firm; continuous shiny coatings on ped faces; some organic coatings of very dark gray (10YR 3/1) on ped surfaces; few very fine roots; few fine pores; few wormholes; mildly alkaline; calcareous; abrupt, smooth boundary.
- IIC2g—30 to 58 inches, gray (5Y 5/1) silty clay; few dusky-red (10R 3/4) and yellowish-red (5YR 4/6) mottles; massive; firm; very dark gray (10YR 3/1) strata at a depth of 30 to 35 inches; few fine roots; few very fine pores; few, soft, dark-colored oxides; mildly alkaline; calcareous.

The Ap horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2 or 2.5Y 3/2) to dark grayish brown (10YR 4/2 or 2.5Y 4/2). The A1 horizon in uncultivated areas is similar in color and is as much as 10 inches thick.

The C1 horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) to grayish brown (10YR 5/2 or 2.5Y 5/2) and, in places, has strata that have a chroma of 3 or 4. It has mottles that range from yellowish red to yellowish brown and dark reddish brown to dark brown. The texture is silt loam or very fine sandy loam.

The underlying silty clay material is at a depth of 18 to 30 inches. It is dark grayish brown (2.5Y 4/2) or grayish brown (2.5Y 5/2) to dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2). A buried A horizon is in the upper part of this material in places. It is very dark gray (N 3/0 or 10YR 3/1) or very dark grayish brown (10YR 3/2 or 2.5Y 3/2). These darker colors also occur in thin strata at a greater depth in some profiles. This horizon has mottles that vary in size and color, but the common colors are strong brown, brown, reddish brown, and yellowish brown.

The A horizon is neutral to mildly alkaline and calcareous. The rest of the profile is mildly alkaline or moderately alkaline and calcareous.

The Modale soils have more sand in the silty upper layers than Moville soils do, and the underlying silty clay is not so dark colored. They are similar to Waubonsie soils, except that they are silt loam rather than fine sandy loam or loamy very fine sand in the upper part of the profile overlying the silty clay material. All of these soils formed in alluvium and are associated on the landscape.

**Modale silt loam** (0 to 2 percent slopes) (149).—This soil is on bottom lands within a few miles of the present channel of the Missouri River. It is near the Modale, Albaton, Percival, Onawa, Blake, and Waubonsie soils. Most areas are 5 to 50 acres in size, but some are as much as 200 acres.

Included with this soil in mapping were very small areas of Waubonsie and Percival soils.

This soil is used mainly for row crops. It is well suited to this use. In many places it is farmed in fields with soils that are slower to dry out. This can delay cultivation in the spring. In many places drainage ditches that drain the wetter adjacent soils go through areas of this soil. This soil generally has no serious limitations, but in some seasons there is a perched water table above the clayey part of the substratum. In years of above average rainfall, root growth is restricted and the production of some crops may be reduced. Capability unit 1-2; woodland group 6.

## Monona Series

The Monona series consists of dark-colored, well-drained soils on uplands. These soils formed in loess. They are on moderately wide upland ridges and high benches where slopes are 0 to 2 percent. They are also on narrow ridges and smooth side slopes where slopes are 2 to 30 percent.

In a representative profile the surface layer is mainly very dark brown silt loam about 16 inches thick. The subsoil is friable silt loam that extends to a depth of about 34 inches. It is dark brown to a depth of about 24 inches, and below this it is brown. The substratum, extending to a depth of 50 inches, is brown, very friable silt loam.

The Monona soils are very low or low in available nitrogen and phosphorus and high in available potassium. Content of organic matter varies, depending upon the slope and the erosion that has taken place. It ranges from moderate to low. The surface layer is medium acid or slightly acid, and the subsoil is slightly acid or neutral. Available water capacity is high, and permeability is moderate. Runoff is slow to rapid, depending on the slope.

Most areas of these soils are used for cultivated crops, but the steep areas are used for pasture. In some pastures there are scattered trees or thin stands of timber. Some areas of this soil are used for nursery crops and for orchards. Areas of sloping soils are subject to erosion, and the hazard increases with increasing slope.

Representative profile of Monona silt loam, 2 to 5 percent slopes, in a cultivated field where the slope is 3 percent, about 100 feet west and 200 feet south of field entrance, which is at the northeast corner of the NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec. 16, T. 68 N., R. 42 W.

- Ap—0 to 8 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry, very dark brown (10YR 2/2) kneaded; weak, fine, granular structure and fine subangular blocky structure; friable; many roots and pores; medium acid; gradual, smooth boundary.
- A12—8 to 16 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) kneaded; weak, fine, granular structure and fine subangular blocky structure; friable; many roots and pores; slightly acid; gradual, smooth boundary.
- B1—16 to 24 inches, dark-brown (10YR 3/3) silt loam, very dark grayish brown (10YR 3/2) on faces of peds; weak, fine, subangular blocky structure; friable; many roots and pores; animal burrow filled with very dark brown (10YR 2/2) material; slightly acid to neutral; clear, smooth boundary.

- B2—24 to 34 inches, brown (10YR 4/3) silt loam; weak, fine, subangular blocky structure; friable; many roots and pores; very dark brown (10YR 2/2) worm casts; slightly acid to neutral; gradual, smooth boundary.
- C—34 to 50 inches, brown (10YR 4/3) silt loam; weak vertical cleavage; massive; very friable; very porous; very few roots; neutral.

The solum is 24 to 42 inches in thickness. The Ap and A1 horizons range from black (10YR 2/1) to very dark grayish brown (10YR 3/2). A very dark grayish-brown (10YR 3/2) A3 horizon occurs in some profiles. The A horizon is 10 to 18 inches in total thickness in nearly level or uneroded sites.

The B1 horizon is brown (10YR 4/3) in places. The B2 horizon is brown (10YR 4/3) to yellowish brown (10YR 5/4) in color and is silt loam or light silty clay loam in texture.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6) has some mottles of grayish brown, light brownish gray, strong brown, or yellowish brown in places.

The A horizon is typically slightly acid but ranges to medium acid. The B horizon is neutral or slightly acid, and the C horizon is neutral to moderately alkaline and calcareous.

In Fremont County, Monona silt loam, 5 to 9 percent slopes, severely eroded, Monona silt loam, 9 to 14 percent slopes, severely eroded, and Monona silt loam, 14 to 20 percent slopes, severely eroded, have a surface layer that is thinner and lighter colored than is defined as the range for the Monona series.

The Monona soils have less clay in the A and B horizons than the Marshall soils. They are more acid and are not calcareous as are the Ida soils. All of these soils formed in loess and are associated on the landscape.

**Monona silt loam, 0 to 2 percent slopes (10A).**—This soil is on high benches near and on the west side of the Nishnabotna River. Areas are small, generally ranging from 5 to 25 acres in size.

This soil has a profile that is similar to the one described as representative of the series, but in places the surface layer is slightly darker colored and a little thicker. This soil is underlain by stratified alluvial sediments. It tends to be more deeply leached than other Monona soils. Carbonates generally are absent above a depth of about 4 feet. Included in mapping were a few small areas of soils that have slopes of more than 2 percent.

Most areas of this soil are used for row crops. This soil is well suited to this use. Some nursery crops also are grown. The limitations to intensive use of this soil for crops are slight. Capability unit I-3; woodland group 1.

**Monona silt loam, 2 to 5 percent slopes (10B).**—This soil is mainly on ridgetops in the uplands. Some areas are on high benches near the Nishnabotna Rivers. It generally is upslope from other Monona soils. Areas range from small to large, and some are as much as 50 acres or more.

This soil has the profile described as representative of the series. This soil is on benches, is underlain by stratified alluvial sediments, and tends to be more deeply leached than Monona soils in the uplands. Included in mapping were a few areas of moderately eroded soils that have a plow layer that is very dark brown to very dark grayish brown.

Most areas of this soil are cultivated, and row crops are grown most of the time. Some fruit trees and nursery crops also are grown. This soil is subject to erosion, but it is well suited to these crops if the erosion is controlled. Capability unit IIe-2; woodland group 1.

**Monona silt loam, 5 to 9 percent slopes (10C).**—This soil is on ridges and side slopes in the uplands. In most places it is near other Monona soils or the Ida or Napier soils, but in some areas it is near the Marshall or Dow soils. Areas are 5 to more than 50 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer generally is a few inches thinner. Also, the subsoil is somewhat thinner, and carbonates generally are present at a depth of 3 to 4 feet. Included in mapping were small areas of eroded soils that have a dark surface layer that is less than 7 inches thick and small areas of Ida and Napier soils.

Many areas of this soil are cultivated, but some are in pasture. Some fruit trees are grown on this soil. This soil is subject to erosion, but it is moderately well suited to row crops if erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 5 to 9 percent slopes, moderately eroded (10C2).**—This soil is on ridges and side slopes in the uplands. It generally is near other Monona soils or Ida or Napier soils, but in places it is downslope from Marshall soils, which are on ridgetops, or upslope from Dow soils. Areas are as much as 50 acres or more in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is a plow layer that is very dark grayish brown. In places there has been some mixing of the dark-brown or brown subsoil into the original surface layer. The subsoil is slightly thinner and carbonates generally are present at a depth of 3 to 4 feet.

Included with this soil in mapping were small areas of severely eroded soils where the plow layer is mostly subsoil and a few areas of soils that have a darker-colored, thicker surface layer. Also included were small areas of Ida, Dow, and Napier soils.

Most areas of this soil are cultivated. This soil is moderately eroded, and further erosion is a hazard. It is moderately suited to row crops if erosion is controlled. In places sidehill drainageways are present. They are crossable in most places, but some should be shaped and seeded. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 5 to 9 percent slopes, severely eroded (10C3).**—This soil is on ridgetops and side slopes in the uplands. It generally is near other Monona soils or Ida or Napier soils, but in places it is downslope from Marshall soils, which are on the ridgetops, or upslope from Dow soils. Areas generally are only 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the present surface layer is mostly dark-brown to brown subsoil material. The subsoil is thinner than that described in the representative profile, and carbonates generally are present at a depth of 3 to 4 feet. Included in mapping were small areas of soils that have a somewhat thicker surface layer and small areas of Ida, Dow, and Napier soils.

Most areas of this soil are cultivated. This soil is severely eroded, and further erosion is a hazard. It is moderately well suited to row crops if erosion is controlled. In places sidehill drainageways are present. They are crossable in most places, but some need to be shaped and seeded. This soil is lower in fertility and organic-matter content than other less eroded Monona soils. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 9 to 14 percent slopes (10D).**—This soil is on side slopes in the uplands. It generally is downslope from Monona soils but upslope from steeper Monona soils or Ida or Napier soils, but in places it is downslope

from Marshall soils, which are on the ridgetops, or up slope from Dow or Malvern soils. Areas generally are 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is black to very dark brown, friable silt loam 7 to 12 inches thick, and the subsoil is thinner and more mottled. Carbonates are present at a depth of 30 and 40 inches in many places. Included in mapping were small areas of soils that have a thinner surface layer and small areas of Ida, Dow, and Napier soils.

Some of the acreage is cultivated, but much of it is in permanent pasture. Erosion is a hazard on this strongly sloping soil. This soil is moderately suited to row crops if erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 9 to 14 percent slopes, moderately eroded (10D2).**—This strongly sloping soil occurs on side slopes in the uplands. It generally is upslope from steeper Monona or Ida or Napier soils, but in places it is downslope from Marshall soils, which are on ridgetops, or upslope from Dow or Malvern soils. Areas are as much as 50 acres or more in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is a plow layer that is very dark grayish brown and, in places, has been mixed with some of the dark-brown or brown subsoil. The subsoil is typically thinner and more mottled. Carbonates are present at a depth of 30 and 40 inches in many places.

Included with this soil in mapping were some areas of soil where the plow layer is mostly subsoil material. Also included were small areas of Ida, Dow, and Napier soils.

Most areas of this soil are cultivated. Erosion is a hazard on this strongly sloping soil. This soil is moderately well suited to row crops if the erosion is controlled. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 9 to 14 percent slopes, severely eroded (10D3).**—This soil is on side slopes in the uplands. It generally is near other Monona soils and is upslope from the Ida or Napier soils, but in places it is downslope from Marshall soils, which are on ridgetops, or upslope from Dow soils. Areas are small and are 5 to 25 acres in size in most places.

The soil has a profile similar to the one described as representative of the series, except that the present surface layer is mostly dark-brown or brown subsoil, and the subsoil is thinner and more mottled. Carbonates are present at a depth of 30 and 40 inches in many places. Included in mapping were a few areas of less eroded soils that have a somewhat darker colored surface layer and small areas of Ida, Dow, and Napier soils.

Most areas of this soil are cultivated. This soil is severely eroded, and further erosion is a hazard. It is moderately suited to row crops if the erosion is controlled. Some side-hill drainageways are gullied and should be shaped and seeded, but most are crossable. This soil generally needs more fertilizer, and it is lower in organic-matter content than the less eroded Monona soils. Capability unit IIIe-1; woodland group 1.

**Monona silt loam, 14 to 20 percent slopes (10E).**—This soil is on side slopes in the uplands. It is near other

Monona soils and Ida and Dow soils. Areas are small, generally ranging from 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer in most places is black to very dark brown silt loam 7 to 12 inches thick. The subsoil is typically thinner and more mottled. The calcareous substratum is within a depth of 30 to 40 inches in many places, but in some places it is at a depth of only 24 to 30 inches. Included in mapping were small areas of soils that have a dark-colored surface layer less than 7 inches thick and small areas of Ida, Dow, and Napier soils.

Because this soil is in small areas and near steeper soil in many places, most areas are in permanent pasture. Some are cultivated. This soil is moderately well suited to row crops if erosion is controlled, but on many farms a row crop is grown only when the meadow needs reseeding. Erosion and gullyng are severe hazards. In places gullies should be shaped and seeded. Capability unit IVe-1; woodland group 1.

**Monona silt loam, 14 to 20 percent slopes, moderately eroded (10E2).**—This soil is on side slopes in the uplands. It is generally near other Monona soils on ridgetops and is adjacent to them on side slopes in many places. It is near Ida and Dow soils and is upslope from Napier soils in many places. Areas are 25 acres or more in size in many places.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is a plow layer that is very dark grayish brown. Some of the subsoil is mixed into the plow layer in places. The subsoil is typically thinner and more mottled. The calcareous substratum is at a depth of only 24 to 30 inches in many places. Included in mapping were small areas of severely eroded soils that have a thinner, lighter colored surface layer and small areas of Ida, Dow, and Napier soils.

Most areas of this soil have been cultivated, and some are in permanent pasture. The degree of slope and the use of the surrounding soils influence the use of this soil in many places. This soil is moderately well suited to row crops if erosion is controlled, but on many farms a row crop is grown only when the meadow needs reseeding. Erosion and gullyng are severe hazards. In places gullies should be shaped and seeded for waterways. Capability unit IVe-1; woodland group 1.

**Monona silt loam, 14 to 20 percent slopes, severely eroded (10E3).**—This soil is on side slopes in the uplands. It generally is near other Monona soils and Ida and Napier soils, and in places it is adjacent to Dow soils. Areas are small, generally 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the present surface layer is mostly dark-brown or brown subsoil material, and in most places the subsoil is thinner and more mottled. The calcareous substratum is at a depth of 24 to 30 inches in many places. Included in mapping were some small areas of less eroded soils that have a thicker, darker colored surface layer and small areas of the Ida, Dow, and Napier soils.

This soil is in small areas that generally are managed in the same way as the surrounding soils. Most areas are cultivated. This soil is moderately suited to row crops if erosion is controlled, but on many farms a row crop is grown only when the meadow needs reseeding. In a few

places gullies are present and should be shaped and seeded for waterways. Capability unit IVE-1; woodland group 1.

**Monona silt loam, 20 to 30 percent slopes, moderately eroded (10F2).**—This soil is on side slopes in the uplands. It generally is near Ida or Dow soils or other Monona soils and is upslope from Napier soils. Areas are mainly about 5 to more than 25 acres in size.

The soil has a profile similar to the one described as representative for the series, except that in most places the surface layer is very dark brown or very dark grayish-brown and is about 3 to 7 inches thick. The subsoil is thinner and typically more mottled. The calcareous substratum is at a depth of 24 to 30 inches in many places. Included were some areas of soils that have a surface layer about 7 to 10 inches thick and some small areas of Ida, Dow, and Napier soils. Small areas of severely eroded soils that have a thinner, lighter colored surface layer are shown on the soil map by a spot symbol.

Most areas of this soil are in permanent or semipermanent pasture. Legume and brome-grass pastures have been established in many places. Some areas have trees but are managed as pasture. This soil is poorly suited to row crops because it is steep and the hazards of erosion and gullying are very severe. It is steep enough that using farm machines involves some risk, but in many places it is possible to renovate thin pasture stands by fertilizing, disking, and reseeding. Hillside gullies should be shaped in places. Capability unit VIe-1; woodland group 2 where slopes face north and east and woodland group 3 where slopes face south and southwest.

## Moville Series

The Moville series consists of moderately dark colored, moderately well drained or somewhat poorly drained soils on bottom lands along the Missouri River. These soils formed in calcareous silt loam alluvium deposited by tributary streams over a buried clayey soil. This buried soil formed in slack water sediment of the Missouri River. These soils are nearly level and are in areas adjacent to streams or manmade ditches that extend through bottom lands along the Missouri River. Some areas are in or near desilting basins.

In a representative profile the surface layer is stratified, very dark grayish-brown, very friable silt loam about 9 inches thick. Beneath this is dark grayish-brown, very friable silt loam that has strata of silty clay loam. At a depth of about 26 inches is dark-gray, very firm silty clay and black layers that were the surface layer of the now buried soil.

The Moville soils are very low in available nitrogen, low in available phosphorus, and high in available potassium. The content of organic matter is low. These soils are mildly alkaline and calcareous throughout. Available water capacity is high. Permeability is moderate in the silt loam and very slow in the underlying silty clay or clay. Runoff is slow.

Most areas of the Moville soils are cultivated. There is some hazard of flooding from drainage ditches and tributary streams.

Representative profile of Moville silt loam in a cultivated field, 200 feet north and 180 feet west of the southeast corner of sec. 22, T. 69 N., R. 43 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, light grayish brown (10YR 5/2) dry; weak granular structure; very friable; stratified with a 2-inch layer at base of this horizon showing weak subangular blocky structure; common roots and pores; mildly alkaline; calcareous; abrupt, smooth boundary.

C1—9 to 18 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; stratified; very friable; mildly alkaline; calcareous; clear, smooth boundary.

C2—18 to 26 inches, dark grayish-brown (10YR 4/2) silt loam; strata of very dark-gray (10YR 3/1) silty clay loam  $\frac{1}{4}$  to 1 inch thick; weak platy structure because of stratification; friable; mildly alkaline; calcareous; abrupt, smooth boundary.

IIA1b—26 to 33 inches, black (10YR 2/1) silty clay; moderate, fine, subangular blocky structure; very firm; few roots and common pores; neutral; clear, smooth boundary.

IIBgb—33 to 43 inches, dark-gray (10YR 4/1) clay; few, fine, light-gray (10YR 7/2) mottles; moderate, fine, subangular blocky structure; very firm; few pores; few shell fragments; mildly alkaline; calcareous; abrupt, smooth boundary.

IIIA1b—43 to 54 inches, black (10YR 2/1) silty clay; weak to moderate subangular blocky structure tending to prismatic structure; firm; common fine pores; mildly alkaline; calcareous.

The Ap horizon, or A1 horizon if present, ranges from very dark grayish brown (10YR 3/2 or 2.5Y 3/2) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color and is less than 10 inches in thickness.

The C horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to light brownish gray (10YR 6/2 or 2.5Y 6/2), but thin strata of darker colors are present in places. Dark reddish-brown and strong-brown mottles are common in places.

Depth to the buried soil is 18 to 30 inches, and the texture is silty clay or clay. The IIIAb horizon, which is a former surface layer that has been buried by more recent sediments, is black (N 2/0 or 10YR 2/1) or very dark gray (N 3/0 or 10YR 3/1). The IIBgb horizon is very dark gray (N 3/0) to gray (5Y 5/1).

The A and C horizons generally are mildly alkaline or moderately alkaline and calcareous, but in places the A horizon is neutral. The buried clayey soil is neutral or mildly alkaline and is calcareous.

The Moville soils have Ap and C horizons similar to the McPaul soils. They have a buried clayey soil at a depth of 18 to 30 inches that the McPaul soils lack. They have less sand in the upper part than Modale soils, and the underlying clayey material is darker colored. All of these soils formed in alluvium. Moville and McPaul soils are associated on the landscape.

**Moville silt loam (0 to 2 percent slopes) (275).**—This soil is on bottom lands in the eastern part of the Missouri River valley. It is near Luton soils that are at lower elevations and near the McPaul soils. Areas generally are 10 to 80 acres in size. Included in mapping were very small areas of McPaul soils and some areas of soils that are somewhat sandy to a depth of 18 to 30 inches.

Most areas are cultivated and are used for row crops. The soil is well suited for this use. Most of the areas are drained, and some land has been graded for irrigation. Some areas are subject to flooding from streams or man-made ditches that extend through the Missouri River bottom lands. In active desilting basins, water from drainage ditches or tributary streams empties onto this soil. In these places the soil is wet during periods of high rainfall and runoff. This soil also tends to be wet in areas where the silt loam is relatively thin over the clayey buried soil. Capability unit I-2; woodland group 7.

## Napier Series

The Napier series consists of dark-colored, well-drained soils in narrow drainageways and on alluvial fans and foot slopes. These soils formed in silty local alluvium washed mostly from soils on adjacent uplands. They are in the uplands in the western part of the county. Slopes are 2 to 10 percent.

In a representative profile the surface layer is very dark brown silt loam about 29 inches thick. The subsoil extends to a depth of about 50 inches or more. It is dark-brown, friable silt loam to a depth of about 37 inches. Below this it is brown, very friable silt loam.

The Napier soils are medium to low in available nitrogen, low in available phosphorus, and high in available potassium. The content of organic matter is high. These soils are slightly acid or neutral in the plow layer and neutral below. Available water capacity is very high, and permeability is moderate. Runoff is about medium.

Most areas of Napier soils are cultivated, but some are in permanent pasture. Some areas of these soils are subject to siltation and receive runoff from upslope areas. Gullies are cutting back from deep stream channels, and they have almost destroyed some areas.

Representative profile of Napier silt loam, 2 to 5 percent slopes, in a cultivated field where the slope is 3 percent, 640 feet south and 200 feet west of the northeast corner of the SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 18, T. 69 N., R. 42 W.

- Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) dry; moderate, fine, granular structure; friable to very friable; many roots and pores; slightly acid to neutral; gradual, smooth boundary.
- A12—8 to 29 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) crushed; weak, very fine, subangular blocky structure to fine granular structure; friable; many roots and large continuous pores; many root channels and worm casts; neutral; gradual, smooth boundary.
- B1—29 to 37 inches, dark-brown (10YR 3/3) silt loam, dark brown (10YR 3/3) crushed; weak, very fine, subangular blocky structure to fine granular structure; friable; few worm casts; coatings of very dark brown (10YR 2/2) in root channels; few fine roots; many pores; neutral; diffuse, smooth boundary.
- B2—37 to 50 inches, brown (10YR 4/3) silt loam, dark yellowish brown (10YR 4/4) dry; weak, very fine, subangular blocky structure to massive; very friable; many root channels but very few roots; many pores; some dark-brown (10YR 3/3) worm casts; neutral.

The Ap and A1 horizons center on very dark brown (10YR 2/2) but range from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Horizons that have a color value of 3 or less are 24 to 40 inches in total thickness.

In some profiles the B1 horizon has ped exteriors of very dark grayish brown.

The C horizon is brown (10YR 4/3) to yellowish brown (10YR 5/4) in color and is silt loam in texture. The representative profile was not described deeply enough to show the C horizon.

The solum is 3 to 5 feet thick. The A and B horizons are typically neutral or slightly acid, and the C horizon is neutral to moderately alkaline and calcareous.

Napier soils contain less clay in the A and B horizons than do the Judson soils. They have a brownish B horizon, but the Kennebec soils are dark colored to a depth of 3 feet or more. Napier soils have a thicker A horizon than the Castana soils and are not calcareous in the surface layer and subsoil. These soils formed in similar parent material. Napier soils occupy positions on the landscape similar to those of Judson soils.

**Napier silt loam, 2 to 5 percent slopes (12B).**—This soil is on alluvial fans and foot slopes and in narrow

drainageways in the uplands in the western part of the county. It is mainly near the Kennebec and Colo soils that are at a lower elevation and the Monona soils that are upslope in most places. Areas generally are long and narrow and range from 5 to more than 75 acres in size.

This soil has the profile described as representative of the series. In places the surface layer is a little thicker. Included in mapping was a small acreage of soils that have a recent deposition of light-colored silt loam 6 to 15 inches thick on the surface.

This soil is generally managed in the same way as adjacent soils. Most areas are cultivated, but some areas adjacent to steep soils are in pasture. Runoff from the adjacent soils upslope is a hazard that can cause gullying or sheet erosion. If erosion is controlled, this soil is well suited to row crops. Capability unit IIe-1; woodland group 1.

**Napier silt loam, 5 to 9 percent slopes (12C).**—This soil is on the alluvial fans and foot slopes and in narrow drainageways in the uplands in the western part of the county. In most places it is near the Kennebec and Colo soils that are at a lower elevation and near Monona soils that are upslope. Areas generally are small, and most are long and narrow. They generally are 5 to 25 acres in size.

Included with this soil in mapping were small areas of Castana soils that are calcareous at or near the surface and a few acres that have slopes of 9 to 14 percent.

Because this soil generally is in small, narrow areas, it is commonly managed in the same way as the adjacent soils. Most areas are cultivated, but some areas adjacent to steep soils are in permanent pasture. Runoff from upslope is a hazard and causes erosion and gullying. If erosion is controlled, this soil is moderately suited to row crops. Capability unit IIIe-1; woodland group 1.

**Napier-Gullied land complex, 2 to 10 percent slopes (717C).**—This complex generally is in narrow drainageways downslope from steep to very steep Hamburg, Ida. and Monona soils. Gullied land occupies as much as about one-half or more of the areas, and Napier soils occupy the rest. Areas vary but generally are long and narrow. The gullies generally have steep banks and are overgrown by trees and brush along the edges.

This soil is not suitable for cultivation and is severely limited for other uses. Most areas are waste or idle. Many areas are suited to wildlife habitat. Runoff has caused erosion, and the gullies formed range from 10 to 100 feet in depth. Gullied areas continue to enlarge as the sides fall in and erosion cuts into the slope toward the head of drainageways. Controlling the formation and enlargement of these gullies is difficult, but some can be shaped. Most control measures involve considerable earthmoving. Capability unit VIIe-1; woodland group 1.

## Nevin Series

The Nevin series consists of dark-colored, somewhat poorly drained, nearly level soils on low stream benches. These soils formed in silty alluvium.

In a representative profile the surface layer is black silty clay loam about 24 inches thick. The subsoil is friable silty clay loam that extends to a depth of about 50 inches. It is very dark gray in the upper part, dark grayish brown in the middle part, and dark gray and grayish brown in the lower part. The middle and lower parts are mottled with dark yellowish brown.

The Nevin soils are medium to low in available nitrogen and medium in available phosphorus and available potassium. The organic-matter content is high. The surface layer is neutral or slightly acid. Available water capacity is high, and permeability is moderate to moderately slow. Runoff is slow.

Most areas of these soils are used for row crops. These soils are slightly wet during periods of high rainfall, but wetness generally does not limit crop growth. In places runoff from soils upslope causes some wetness.

Representative profile of Nevin silty clay loam in a cultivated field, 700 feet north and 100 feet east of the southwest corner of the NW $\frac{1}{4}$  sec. 10, T. 70 N., R. 41 W.

- Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) dry; moderate, fine, subangular blocky structure; friable; common roots and pores; neutral; clear, smooth boundary.
- A12—8 to 16 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) crushed; strong, fine, subangular blocky structure; friable; common fine roots and pores; worm casts; neutral; gradual, smooth boundary.
- A3—16 to 24 inches, black (10YR 2/1) silty clay loam, very dark brown (10YR 2/2) crushed; strong, fine, subangular blocky structure; friable; common roots and pores; slightly acid; gradual, smooth boundary.
- B21—24 to 30 inches, very dark gray (10YR 3/1) silty clay loam; strong, medium, subangular blocky structure; friable; few roots and common pores; worm casts; slightly acid; gradual, smooth boundary.
- B22t—30 to 38 inches, dark grayish-brown (10YR 4/2) light silty clay loam and some very dark grayish-brown (10YR 3/2), dark grayish brown (10YR 4/2) crushed; few dark yellowish-brown (10YR 4/4) mottles; weak subangular blocky structure; friable; few discontinuous clay films; few black oxides; neutral; gradual, smooth boundary.
- B3—38 to 50 inches, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) (about equal) light silty clay loam, dark grayish brown (10YR 4/2) crushed; common dark yellowish-brown (10YR 4/4) mottles; massive; friable; few fine roots and pores; few black oxides; neutral.

The Ap and A1 horizons range from black (10YR 2/1) to very dark gray (10YR 3/1) or very dark brown (10YR 2/2). The A3 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A horizon generally is about 24 inches in total thickness, but it ranges from about 18 to 30 inches.

The B2 horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in the upper part and from dark gray (10YR 4/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (10YR 5/2 or 2.5Y 5/2) in the lower part. Consistence is firm in places. The B2 and B3 horizons have mottles of brown, yellowish brown, grayish brown, or light olive brown. The B3 horizon is olive brown (2.5Y 4/4) in places.

The C horizon generally is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (10YR 5/2 or 2.5Y 5/2) but ranges to dark gray (5Y 4/1) or olive brown (2.5Y 4/2). It generally is silty clay loam but ranges to clay loam, loam, and sandy loam in places. The representative profile was not described deeply enough to include this horizon.

The A horizon and upper part of the B horizon are typically slightly or medium acid, but in places the upper part of the A horizon is neutral. The lower part of the B horizon and the C horizon generally are slightly acid or neutral.

The Nevin soils have a thinner A horizon and are better drained than the Colo soils. These soils formed in alluvium and are associated on the landscape.

**Nevin silty clay loam** (0 to 2 percent slopes) (88).—This soil is on low stream benches along the Nishnabotna Rivers and some of their smaller tributaries. It is at slightly higher elevations than the nearby Colo, Nodaway, and Kennebec soils. It is downslope from the Judson or

Napier soils that are on adjacent foot slopes. Areas are 5 to about 200 acres in size.

Included with this soil in mapping were about 250 acres of Nevin soils that have a deposition of very dark grayish-brown or very dark brown silt loam 6 to 15 inches thick on the surface.

Nearly all areas of this soil are cultivated, and row crops are grown most of the time. In places runoff from other soils upslope causes slight wetness. This soil is well suited to row crops if runoff is controlled. Nearly all of this soil is farmed without supplemental drainage. Capability unit I-1; woodland group 1.

## Nishna Series

The Nishna series consists of dark-colored, poorly drained soils on bottom lands. These soils formed in clayey alluvium. They generally are level or in slight depressions at some distance from the stream channels.

In a representative profile the surface layer is black light silty clay. It is about 26 inches thick and has some small lime concretions in the lower part. The subsoil, about 10 inches thick, is very dark gray, firm light silty clay and has many lime concretions. The substratum is dark-gray, firm silty clay that has many lime concretions.

The Nishna soils are medium to low in available nitrogen, very low in available phosphorus, and medium to low in available potassium. The organic-matter content is high. These soils are mostly mildly alkaline or moderately alkaline and are calcareous, but the plow layer is neutral in places. Available water capacity is high, and permeability is slow. Runoff is slow.

Most of the Nishna soils are cultivated and used for row crops in drained areas. A few areas are in pasture. Wetness is a limitation to the use of these soils, and artificial drainage is needed. Some areas are flooded when streams overflow.

Representative profile of Nishna silty clay in a cultivated field, in the northeast corner of the SW $\frac{1}{4}$ /SW $\frac{1}{4}$  sec. 5, T. 70 N., R. 41 W.

- Ap—0 to 7 inches, black (10YR 2/1) light silty clay; moderate, medium, subangular blocky structure breaking to weak, fine, granular; friable; very few silt coatings of grayish brown (10YR 5/2) dry; many roots; many pores; neutral; clear, smooth boundary.
- A12—7 to 16 inches, black (N 2/0) light silty clay; moderate, fine, subangular blocky structure; firm; sheen on ped faces; many roots and fine pores; mildly alkaline; calcareous; clear, smooth boundary.
- A13—16 to 26 inches, black (10YR 2/1) light silty clay; moderate, medium to fine, subangular blocky structure; firm; few roots and fine pores; gray lime flecks and small hard lime concretions; moderately alkaline; calcareous; clear, smooth boundary.
- Bg—26 to 36 inches, very dark gray (N 3/0) light silty clay; moderate, fine, subangular blocky structure; firm; few roots; few fine pores; many soft and hard, small lime concretions; moderately alkaline; calcareous; clear, smooth boundary.
- Cg—36 to 50 inches, dark-gray (5Y 4/1) light silty clay, dark gray (5Y 4/1) kneaded; very weak, fine subangular blocky structure to massive; firm; few fine roots; few fine pores; many soft and hard lime concretions; moderately alkaline; calcareous.

The Ap and A1 horizons generally are light silty clay or heavy silty clay loam. In places 6 to 15 inches of recently deposited overwash that is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) silt loam is on the surface. The A horizon generally ranges from 20 to 30 inches in total thickness.

The Bg horizon, if present, is very dark gray (10YR 3/1 or N 3/0) in color and generally is 8 to 15 inches in thickness. It generally is light silty clay, but it is heavy silty clay loam in places.

The C horizon is very dark gray (N 3/0, 10YR 3/1, 2.5Y 3/1, or 5Y 3/1) to gray (5Y 4/1) light silty clay or heavy silty clay loam. Mottles of yellowish brown to olive brown are present below a depth of 36 inches in places.

Nishna soils are typically mildly alkaline or moderately alkaline and calcareous, but in places the upper few inches is neutral.

Nishna soils are calcareous, but the Zook and Colo soils are not. They are finer textured than Colo soils to a depth of 40 inches or more. All of these soils formed in alluvium and are associated on the landscape.

**Nishna silt loam, overwash** (0 to 2 percent slopes) (234+).—This soil is nearly level or in slight depressions away from the main stream channels on bottom lands along the Nishnabotna Rivers and smaller streams. It generally is adjacent to Colo and Zook soils, and the Judson and Napier soils are on foot slopes between this soil and the uplands. They generally are near manmade drainage ditches that cross the bottom lands and drain into larger streams. The overflow of these ditches has recently deposited light-colored sediment from the uplands on this soil. Areas generally are 5 to 50 acres in size.

This soil has a profile similar to the one described as representative for the series, but it has a recent deposition of very dark grayish-brown to dark grayish-brown silt loam 6 to 15 inches thick on the surface. Included in mapping were small areas of Nishna silty clays that do not have as much deposition on the surface.

Most areas of this soil are cultivated and are used for row crops most of the time. Wetness, sedimentation, and flooding are limitations to the use of this soil. Because the surface layer is silt loam, this soil dries a little more rapidly than Nishna silty clay. It is moderately suited to row crops if wetness and flooding are controlled. Capability unit IIIw-1; woodland group 7.

**Nishna silty clay** (0 to 2 percent slopes) (234).—This soil is nearly level and in slight depressions away from the stream channels on bottom lands along the Nishnabotna Rivers and smaller streams. It generally is at a slightly lower elevation than the adjacent Colo and Zook soils, and the Judson or Napier soils are on foot slopes closer to the uplands. Areas are about 5 to 100 acres in size.

This soil has the profile described as representative of the series. Included with this soil in mapping were small areas of Colo and Zook soils.

Most areas of this soil are cultivated and are used for row crops most of the time. Wetness is a serious limitation. Runoff from other soils tends to pond in the slight depressions. Some areas flood when streams overflow. This soil is moderately suited to row crops if the wetness is controlled. The power requirement for tillage operations is high. This soil tends to dry out cloddy and hard if tilled when wet. Fieldwork is often delayed because of wetness. Capability unit IIIw-1; woodland group 7.

### Nodaway Series

The Nodaway series consists of stratified, moderately dark colored, moderately well drained, nearly level soils on bottom lands near stream channels. Most of these soils formed in recently deposited silty alluvium.

In a representative profile the surface layer is very dark grayish-brown silt loam about 7 inches thick. The sub-

stratum, extending to a depth of 50 inches, is stratified dark grayish-brown, grayish-brown, and very dark grayish-brown, friable silt loam.

The Nodaway soils are very low in available nitrogen and medium in available phosphorus and available potassium. The organic-matter content is low. These soils are typically neutral throughout. Available water capacity is high, and permeability is moderate. Runoff is slow.

Most areas of these soils are cultivated, but some small uncleared areas are still in cottonwood trees, willow trees, and brush. If not protected, these soils are subject to flooding.

Representative profile of Nodaway silt loam in a cultivated field, about 150 feet west of bridge, ½ mile south of the northeast corner of sec. 30, and 100 feet south of Highway 2 in the NE¼NE¼ sec. 30, T. 69 N., R. 41 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

C—7 to 50 inches, stratified dark grayish-brown (10YR 4/2), grayish-brown (10YR 5/2), and very dark grayish-brown (10YR 3/2) silt loam, few very thin strata of very dark brown (10YR 2/2) silt loam, very few thin strata of silty clay loam; massive tending to be platy because of stratification; friable; few, fine, faint, brown (10YR 4/3) iron stains; numerous wormholes and root channels; neutral.

The Ap horizon, or A1 horizon in uncultivated areas, is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) and less than 10 inches thick.

The C horizon has thin strata of lighter and darker colors in places. It is silt loam and has thin strata of finer texture in some places. There are few to common mottles and stains. Below a depth of 3½ feet, sandy strata are present in places.

Nodaway soils are slightly acid or neutral.

Nodaway soils are not calcareous as are the McPaul and Haynie soils. They are not so wet as the Dockery soils and generally are not so gray or so mottled. All of these soils formed in alluvium.

**Nodaway silt loam** (0 to 2 percent slopes) (220).—This soil is adjacent to stream channels on flood plains that have recently received sediments and on alluvial fans along tributary streams. This soil is generally near Kennebec and Colo soils. Areas are about 25 acres to more than 1,200 acres in size.

Included with this soil in mapping were very small areas of Colo soils and small areas of soils that have more sand in the surface layer.

Nearly all of the acreage is cultivated. This soil is used for row crops most of the time and is well suited to such use if flooding is controlled. Flooding when streams overflow is a hazard in some places, but most areas are protected by dikes. Capability unit I-2; woodland group 6.

### Onawa Series

The Onawa series consists of stratified, moderately dark colored, somewhat poorly drained or poorly drained soils on bottom lands along the Missouri River. These soils are nearly level and are near or within a few miles of the present river channel. They formed in calcareous silty clay alluvium over loam to very fine sandy loam.

In a representative profile the surface layer is very dark grayish-brown silty clay about 6 inches thick. The substratum, to a depth of about 22 inches, is stratified, dark grayish-brown, firm silty clay. Below this, to a depth of 50 inches, it is stratified loam to very fine sandy loam that

has mottles of brown, light brownish gray, and yellowish brown.

The Onawa soils are low in available nitrogen, very low in available phosphorus, and high in available potassium. The content of organic matter is low. These soils are typically mildly alkaline and calcareous, but in places the plow layer is neutral. Available water capacity is high, and permeability is slow in the upper part and moderate to moderately rapid in the lower part. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops. A few areas have not been cleared of trees and brush. Before the large dams and levees on the Missouri River were constructed, some areas of these soils were subject to flooding almost yearly. The hazard of flooding is slight in most areas, but a few areas are still not protected and are subject to flooding. These soils have a seasonal high water table, and wetness is a limitation.

Representative profile of Onawa silty clay, 70 feet south and 1,320 feet west of the northeast corner of NW $\frac{1}{4}$  sec. 36, T. 69 N., R. 44 W.

Ap—0 to 6 inches, very dark grayish-brown (2.5Y 3/2) silty clay; cloddy but breaks to coarse angular blocky structure; firm; few fine roots; neutral; abrupt, smooth boundary.

C1g—6 to 22 inches, stratified dark grayish-brown (2.5Y 4/2) silty clay; few, fine, light olive-brown (2.5Y 5/4) or dark-gray (5Y 4/1) mottles; weak, very fine, subangular blocky structure in strata; firm; the 6- to 13-inch layer has more clay; few fine roots; few fine pores; very dark gray (10YR 3/1) material in old root channels; mildly alkaline; calcareous; abrupt, smooth boundary.

IIC2g—22 to 50 inches, stratified dark grayish-brown (2.5Y 4/2), grayish-brown (2.5Y 5/2), and olive-gray (5Y 5/2) loam to very fine sandy loam; few, fine, brown (7.5YR 4/4) mottles, common, fine, light brownish-gray (2.5Y 6/2) mottles, and few, fine, yellowish-brown (10YR 5/4) mottles; massive; friable; brown (10YR 5/3) strata at a depth of 22 to 37 inches and a silty clay layer at a depth of 37 to 41 inches; many fine pores; very few fine roots; calcareous; mildly alkaline.

The Ap horizon, or A1 horizon in uncultivated areas, ranges from very dark grayish brown (10YR 3/2 or 2.5Y 3/2) to very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color and is less than 10 inches in thickness. The texture of the surface layer ranges from silty clay or clay to silt loam.

The C1g horizon is stratified. The strata range from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to olive gray (5Y 5/2), but in some places they are dark gray (10YR 4/1 or 5Y 4/1) or gray (5Y 5/1). Some mottles of dark gray to olive brown, yellowish brown, or dark reddish brown are present. This horizon generally is silty clay, but it is clay in places. In many places there is a transitional layer of silty clay loam, generally less than 6 inches thick, between the clayey material and the silt loam to very fine sandy loam. The color and mottling in the IIC horizon is similar to that of the C1g horizon. Depth to the IIC horizon is 18 to 30 inches.

The Ap and A1 horizons are neutral or mildly alkaline and calcareous. The rest of the profile is mildly alkaline or moderately alkaline and calcareous.

The Onawa soils are silt loam to very fine sandy loam below a depth of about 2 feet, but the Albaton soils are not. They have thinner, lighter colored A horizons than Blencoe soils and are calcareous. They are finer textured in the upper part than Haynie, Modale, and Grable soils. Onawa soils are not clayey in the IIC horizon as are the Modale soils. They are not underlain by sand as are the Percival soils. All of these soils formed in alluvium.

**Onawa silt loam** (0 to 2 percent slopes) (145).—This soil is on bottom lands along the Missouri River near the present channel. This soil is near Albaton soils that are at

a lower elevation, Blake and Haynie soils that are at a slightly higher elevation, and Percival soils that are at about the same elevation. Areas are small, generally 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer consists of recently deposited silt loam sediment 6 to 15 inches thick, and in places the silty clay part of the substratum is thicker than typical.

Included in mapping were very small areas of Blake, Haynie, and Albaton soils. Also included were about 100 acres of soils where the underlying material is loamy sand or sand rather than silt loam or very fine sandy loam.

Most areas of this soil are cultivated and are used for row crops. Wetness is a hazard, but this soil is not so wet as Onawa silty clay. Areas that are not protected by levees are subject to flooding. This soil is well suited to row crops if it is adequately drained and protected from flooding. Capability unit IIw-2; woodland group 7.

**Onawa silty clay** (0 to 2 percent slopes) (146).—This soil is on bottom lands along the Missouri River near the present channel. It is near the Albaton soils that are at a slightly lower elevation, Haynie or Blake soils that are at a slightly higher elevation, and Percival soils that are at about the same elevation. Areas generally are 5 to as much as 160 acres in size, and most are long, narrow, and swalelike.

This soil has the profile described as representative of the series. Included in mapping were very small areas of Blake or Haynie soils.

Most areas of this soil are cultivated and are used for row crops. Wetness is a hazard, and this soil is slower to dry out than soils that have a coarser textured surface layer. This soil is well suited to row crops if drainage is adequate and the soil is protected from flooding. Even in drained areas, farm work is delayed in some years. The surface layer puddles easily and dries out cloddy and hard if the soil is tilled when wet. The power requirement for tillage of the soil is high. Areas that are not protected by levees are subject to flooding. Capability unit IIw-2; woodland group 7.

## Percival Series

The Percival series consists of stratified, moderately dark colored, somewhat poorly drained soils on bottom lands along the Missouri River. These soils are nearly level and are near or within a few miles of the present river channel. They formed in calcareous silty clay alluvium that is underlain by loamy fine sand.

In a representative profile the surface layer is a very dark grayish-brown, firm silty clay about 6 inches thick. The next layer, about 11 inches thick, is very dark grayish-brown and dark grayish-brown, firm silty clay. Beneath this is stratified, grayish-brown grading to light brownish-gray, very friable loamy fine sand.

The Percival soils are low in available nitrogen and available phosphorus and high in available potassium. The content of organic matter is low. These soils are typically moderately alkaline and calcareous throughout. Available water capacity is medium or low. Permeability is slow in the upper part of the profile and rapid in the lower part. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops. Wetness is a slight limitation during wet periods. Before the large dams and levees on the Missouri River were constructed, these soils were subject to flooding almost yearly. A few areas are still not protected and are subject to flooding.

Representative profile of Percival silty clay in a cultivated field, 260 feet south and 100 feet east of the northwest corner of the SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 24, T. 68 N., R. 44 W.

- Ap—0 to 6 inches, very dark grayish-brown (2.5Y 3/2) silty clay, light gray (10YR 6/1) dry; massive; firm; few roots; calcareous; moderately alkaline; abrupt, smooth boundary.
- C1—6 to 17 inches, very dark grayish-brown (2.5Y 3/2) and dark grayish-brown (2.5Y 4/2) silty clay, dark grayish brown (2.5Y 4/2) kneaded; strong, fine, subangular blocky structure that has some horizontal cleavage; firm; few roots; few very fine pores; calcareous; moderately alkaline; abrupt, smooth boundary.
- IIC2g—17 to 50 inches, stratified grayish-brown (2.5Y 5/2) grading to light brownish-gray (2.5Y 6/2) loamy fine sand, sandy loam at a depth between 17 and 28 inches and loam grading to sand below a depth of 40 inches; weak, thin, platy structure because of stratification; very friable; few iron oxide stains along root channels and wormholes; few roots; calcareous; moderately alkaline.

The Ap horizon, or A1 horizon in uncultivated areas, is less than 10 inches in thickness and ranges from very dark grayish brown (10YR 3/2 or 2.5Y 3/2) to very dark gray (10YR 3/1) or dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color.

The C1 horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to grayish brown (10YR 5/2 or 2.5Y 5/2) and dark gray (5Y 4/1) and is silty clay or clay. Some mottles of dark reddish brown, strong brown, or olive brown are present in places. The C1 horizon is underlain at a depth of 15 to 30 inches by a IIC horizon of fine sand or loamy fine sand. The IIC horizon has stratified material that centers on a color of grayish brown (2.5Y 5/2) or light brownish gray (2.5Y 6/2). Mottles that are similar to those in the clayey material of the C1 horizon are present in places. This horizon generally is loose and has some evidence of platy structure because of the stratification.

Percival soils are mildly alkaline or moderately alkaline and calcareous.

The Percival soils are underlain by sand, but the Albaton soils are underlain by silty clay or clay, and the similar Onawa soils are underlain by silt loam or very fine sandy loam. They are more clayey in the upper part than the Blake and Grable soils. All of these soils formed in alluvium and are calcareous.

**Percival silty clay** (0 to 2 percent slopes) (515).—This soil is on bottom lands along the Missouri River near the present channel. It is near the Onawa, Blake, Vore, Carr, Sarpy, and Albaton soils. In many places it is in slight swales, but in others it is on slight rises. Areas generally are 5 to 50 acres in size. Included in mapping were very small areas of the Sarpy, Carr, and Vore soils.

Most areas of this soil are cultivated and are used for row crops. A few areas near the river are in trees and brush. If drained, this soil is well suited to row crops. The water table is high at times, and wetness is a slight limitation. Areas of this soil that are not protected by levees are subject to flooding. Capability unit IIw-2; woodland group 7.

## Riverwash

Riverwash (53) consists of areas of coarse, medium, and fine sand along the major streams, mostly along the Missouri River. These areas have little or no vegetation because of frequent flooding. They have little or no value

for farming but are used by some kinds of wildlife and have some potential for recreational uses. Capability unit VIIIs-1, not in a woodland group.

## Salix Series

The Salix series consists of dark-colored, moderately well drained soils on bottom lands along the Missouri River. These soils formed in silty alluvium. They are nearly level and are at the higher elevations in the central part of the bottom lands.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil extends to a depth of about 26 inches. It is dark grayish-brown, friable silty clay loam that has a few yellowish-brown mottles to a depth of about 19 inches. The lower 7 inches is dark grayish-brown, friable silt loam that has dark yellowish-brown, and grayish-brown mottles. The substratum, extending to a depth of 66 inches, is dark grayish-brown to gray, friable silt loam that has olive-brown and olive-gray mottles.

The Salix soils are medium to low in available nitrogen, medium in available phosphorus, and high in available potassium. The organic-matter content is moderate. The surface layer and upper part of the subsoil are neutral or slightly acid. Available water capacity is high, and permeability is moderate. Runoff is slow.

Nearly all areas of the Salix soils are cultivated and are used for row crops. These soils have no serious limitations to their use for crops.

Representative profile of Salix silty clay loam in a cultivated field, 650 feet east and 60 feet south of the northwest corner of the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 34, T. 69 N., R. 43 W.

- Ap—0 to 5 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) crushed; weak, fine, granular structure and fine subangular blocky structure; friable; many roots; few fine pores; slightly acid; clear, smooth boundary.
- A3—5 to 13 inches, black (10YR 2/1) silty clay loam, very dark grayish-brown (10YR 3/2) crushed; weak, fine, granular structure and fine subangular blocky structure; friable; many roots; many fine and very fine pores; worm casts of dark grayish brown (2.5Y 4/2); neutral; gradual, smooth boundary.
- B2—13 to 19 inches, dark grayish-brown (10YR 4/2) silty clay loam; few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable; very dark grayish-brown (10YR 3/2) coatings on peds; many roots; many fine and very fine pores; few root channels and wormholes; neutral; gradual, smooth boundary.
- B3—19 to 26 inches, dark grayish-brown (2.5Y 4/2) silt loam, dark grayish-brown (2.5Y 4/2) crushed; many, fine, distinct, dark yellowish-brown (10YR 4/4) and few, fine, faint, grayish-brown (2.5Y 5/2) mottles; weak, medium, prismatic structure; friable; many fine and medium pores; few fine roots; mildly alkaline; calcareous; gradual, smooth boundary.
- C1—26 to 34 inches, dark grayish-brown (2.5Y 4/2) silt loam; many, medium, distinct, olive-brown (2.5Y 4/4) and olive-gray (5Y 5/2) mottles; weak, fine, granular structure to massive; friable; many fine and medium pores; few root channels and few fine roots; few worm casts; moderately alkaline; calcareous; gradual, smooth boundary.
- C2—34 to 66 inches, gray (5Y 5/1) silt loam; many, coarse, prominent, olive-brown (2.5Y 4/4) mottles; weak, medium, subangular blocky structure to massive; friable; few fine roots; many fine pores; soft lime on

cleavage planes and along root channels; some stratification of dark grayish brown (10YR 4/2) at a depth of 60 inches; moderately alkaline; calcareous.

The Ap horizon, or A1 horizon where present, generally is black (10YR 2/1) or very dark brown (10YR 2/2), but it is very dark gray (10YR 3/1) in places. The A3 horizon is very dark grayish brown (10YR 3/2) in places.

The B2 horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to brown (10YR 5/3). In places very dark grayish-brown colors are on the exteriors of peds in the upper part of the horizon. Mottles range from dark yellowish brown to gray.

The C horizon generally is dark grayish brown (2.5Y 4/2), grayish brown (2.5Y 5/2), or gray (5Y 5/1) and is typically silt loam but ranges to loam or very fine sandy loam. Mottles are similar to those in the B horizon.

The A horizon is typically neutral or slightly acid. The B2 horizon is typically neutral but ranges to mildly alkaline and calcareous. The C horizon is mildly alkaline or moderately alkaline and calcareous.

The Salix soils have less clay in the A horizon and upper part of the B horizon than do the Blencoe soils and they are browner in the B horizon. They are less clayey throughout than the Lakeport soils. They have a profile similar to that of the Keg soils, but have a higher content of clay in the A horizon and upper part of the B horizon. All of these soils formed in alluvium.

**Salix silty clay loam** (0 to 2 percent slopes) (36).—This soil is on the central part of bottom lands along the Missouri River. It is at about the same elevation as the nearby Keg soils and at a slightly higher elevation than the nearby Cooper and Lakeport soils. Most areas are large, and some are more than 200 acres in size.

Included with this soil in mapping were about 50 acres of Salix soils that have an overwash of very dark grayish-brown or dark grayish-brown silt loam 6 to 15 inches thick.

Nearly all areas of this soil are cultivated, and row crops are grown most of the time. The soil is well suited to this use and has no limitations to its use for crops. Capability unit I-1; woodland group 6.

## Sarpy Series

The Sarpy series consists of moderately dark colored to light-colored, sandy, undulating to hummocky, excessively drained soils on bottom lands along the Missouri River. These soils formed in recently deposited, calcareous, sandy alluvium. Slopes are 1 to 7 percent. In some areas, these soils appear to have been reworked by wind.

In a representative profile the surface layer is very dark grayish-brown loamy fine sand about 5 inches thick. Beneath this is dark grayish-brown and grayish-brown, loose loamy fine sand and fine sand.

The Sarpy soils are very low in available nitrogen and available phosphorus and low in available potassium. The organic-matter content is very low. These soils are mildly alkaline and calcareous throughout. Available water capacity is low or very low, and permeability is very rapid. Runoff is slow.

Most areas of these soils are in pasture or are idle. Some small areas are in fields of other soils that are cultivated. These soils are droughty and subject to severe soil blowing. Before the dams on the Missouri River and the levees were constructed, these soils were subject to flooding. Some areas not protected by levees are still subject to flooding.

Representative profile of Sarpy loamy fine sand, 3 to 7 percent slopes; in a pasture, 230 feet west and 1,050 feet

south of the northeast corner of the NW $\frac{1}{4}$  sec. 25, T. 69 N., R. 44 W.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grained but adhering as weak, fine and medium, subangular blocky structure; very friable to loose; few fine roots; mildly alkaline; calcareous; gradual, smooth boundary.

C1—5 to 9 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand; single grained; loose; very few fine roots; appears to have a few strata of very dark grayish-brown (10YR 3/2) silt, which may be the result of mixing with the A1 horizon; mildly alkaline; calcareous; diffuse, smooth boundary.

C2—9 to 15 inches, grayish-brown (2.5Y 5/2) fine sand; light gray (2.5Y 7/2) dry, single grained; loose, mildly alkaline; calcareous; diffuse, smooth boundary.

C3—15 to 50 inches, grayish-brown (2.5Y 5/2) fine sand, light gray (2.5Y 7/2) dry; single grained; loose; sand appears to be washed free of silt; very incoherent; mildly alkaline; calcareous.

The A1 horizon is very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) loamy fine sand or fine sand. It generally is about 4 to 8 inches thick, but it ranges from as little as 2 inches to as much as 10 inches in thickness.

The C horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to light yellowish brown (10YR 6/4) in color and from loamy fine sand to sand in texture. In places there are thin strata of finer texture. Mottles of yellowish brown, strong brown, or grayish brown are present in places.

The A horizon is typically mildly alkaline and calcareous but ranges from neutral to moderately alkaline. The C horizon is moderately alkaline or mildly alkaline and calcareous.

The Sarpy soils have more sand in the upper part of the profile than do the Grable and Percival soils. They are somewhat coarser textured in the A horizon and between a depth of 10 and 40 inches than Carr soils. All of these soils formed in alluvium and are associated on the landscape.

**Sarpy loamy fine sand, 1 to 3 percent slopes** (237 A).—This undulating soil is on bottom lands along the Missouri River near the present river channel. It generally is at a higher elevation than the nearby Albaton, Percival, and Onawa soils and at about the same elevation as the nearby Carr, Haynie, and Grable soils. Areas generally are 5 to 75 acres in size.

In cultivated areas, the present plow layer is partly grayish-brown substratum. Included in mapping were about 300 acres of soils that have a surface layer of fine sand and areas of Carr, Haynie, and Grable soils.

This soil is used mainly for pasture, but some areas are idle. Some areas are farmed along with nearby soils that are better suited to cultivation, but production of row crops is seldom satisfactory. Some areas are suitable for wildlife habitat. This soil is droughty and is subject to soil blowing. Soil blowing scars or blowouts are quite common. Areas not protected by levees are subject to flooding. Capability unit IVs-1; woodland group 6.

**Sarpy loamy fine sand, 3 to 7 percent slopes** (237 B).—This soil is hummocky and is in slightly elevated areas on bottom lands along the Missouri River near the present river channel. It generally is at a higher elevation than the nearby Albaton, Percival, and Onawa soils and is more hummocky than the nearby Carr, Haynie, and Grable soils. Areas generally are 5 to 75 acres in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of less sloping soils, small areas of soils that have a surface layer of fine sand, and areas of Carr, Haynie, and Grable soils.

Most areas of this soil are in native grasses or grasses and trees and are used mainly for pasture. Most areas

that are within fields of cultivated soils are left idle. This soil is suitable for wildlife habitat. It is droughty and is subject to soil blowing. Soil blowing scars or blowouts are quite common. Areas not protected by levees are subject to flooding. Capability unit IVs-1; woodland group 6.

## Shelby Series

The Shelby series consists of dark-colored, moderately well drained soils on side slopes in the uplands. These soils formed in glacial till. Slopes are 9 to 25 percent.

In a representative profile the upper 6 inches of the surface layer is very dark brown loam, and the lower part, to a depth of 12 inches, is very dark grayish-brown, friable clay loam. The subsoil is dark brown in the upper part, brown in the middle part, and dark yellowish brown in the lower part. It is firm clay loam and is about 25 inches thick. The substratum is yellowish-brown, firm clay loam that has light-gray mottles.

The Shelby soils are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium. The content of organic matter varies, depending on the erosion that has taken place, but in most places it is low. These soils are typically slightly acid. Available water capacity is high, and permeability is moderately slow. Runoff is rapid.

The strongly sloping Shelby soils are used for cultivated crops in many areas, but the steeper soils are used mainly for meadow and permanent pasture. The hazard of erosion is severe. Sidehill drainageways are present in many places and are subject to gullying unless they are protected.

Representative profile of Shelby loam, 9 to 14 percent slopes, moderately eroded, in pasture on a west-facing slope where the gradient is 11 percent, 500 feet south and 50 feet west of the northeast corner of the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 14, T. 67 N., R. 41 W.

- Ap—0 to 6 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; fine subangular blocky structure; friable; many roots and pores; few, small, hard, lime concretions that appear to have come from an eroded area upslope; neutral; clear, smooth boundary.
- A12—6 to 12 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) kneaded; strong, fine, subangular blocky structure; friable; many roots and many fine pores; slightly acid; clear, smooth boundary.
- B1—12 to 20 inches, dark-brown (10YR 3/3) clay loam; moderate, fine, subangular blocky structure; friable; very dark grayish brown (10YR 3/2) on faces of peds; many roots; few fine pores; slightly acid; clear, smooth boundary.
- B21t—20 to 30 inches, brown (10YR 4/3) clay loam, dark yellowish brown (10YR 4/4) kneaded; moderate, fine, subangular blocky structure; firm; some very dark grayish brown (10YR 3/2) on faces of peds, thin discontinuous clay films on ped faces; few black oxides; common small pebbles; few fine roots; few fine pores; slightly acid; clear, smooth boundary.
- B22t—30 to 37 inches, dark yellowish-brown (10YR 4/4) clay loam, dark yellowish brown (10YR 4/4) kneaded; moderate, fine, subangular blocky structure; firm; few fine roots and pores; thin discontinuous clay films on ped faces; many pebbles; slightly acid; clear, smooth boundary.
- C—37 to 52 inches, yellowish-brown (10YR 5/4) clay loam; common, medium and coarse, light-gray (10YR 6/1) mottles; massive; firm; common black (10YR 2/1) oxides and stains on vertical ped faces; many pebbles; neutral.

The Ap and A1 horizons range from black (10YR 2/1) to very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2). The A horizon is loam or light clay loam. In some places an A3 horizon of very dark grayish brown (10YR 3/2) is present. The A horizon is 10 to 18 inches in total thickness unless the soil is eroded.

The B2t horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6). In places it has some mottles of grayish brown, olive brown, or strong brown in the lower part, and the mottles increase in size and abundance with increasing depth. The B1 horizon does not occur in some places, and in places a B3t horizon of brown (10YR 4/3) to yellowish brown (10YR 5/4) is present above the C horizon.

The C horizon is dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/6) light or medium clay loam. It has mottles of gray, grayish brown, strong brown, and reddish brown, and in places the mottles are so common that they make up about half of the matrix.

The solum ranges from about 30 to more than 60 inches in thickness. The A and B horizons are slightly acid or medium acid but range to neutral where limed. The C horizon is slightly acid to mildly alkaline or moderately alkaline and calcareous.

The Shelby soils have less clay in the A and B horizons and do not have hues so reddish as the Adair soils. They have more sand throughout than the Marshall and Monona soils. They are not calcareous throughout as are the Steinauer soils. These soils are associated on the landscape.

**Shelby loam, 9 to 14 percent slopes, moderately eroded (24D2).**—This soil is on side slopes in the uplands, mainly near the Nishnabotna Rivers. It generally is near and down-slope from the Adair, Malvern, Marshall, or Monona soils and upslope from the Terril soils. Areas are small, generally ranging from 5 to 25 acres in size.

This soil has the profile described as representative of the series. In many places, the surface layer is a few inches thinner. In many places this soil has a very dark grayish-brown plow layer and in places the browner subsoil has been mixed into the plow layer.

Included were small areas of Adair and Malvern soils. Some small areas of severely eroded soil are shown on the soil map by an erosion symbol.

Many areas of this soil are cultivated, but some are in permanent pasture. Erosion is a hazard on these strongly sloping soils. Sidehill drainageways are common, and in places they develop into gullies. This soil is moderately suited to row crops if erosion is controlled. It generally is cultivated along with adjacent soils. Tillage generally is only fair. Capability unit IIIe-3; woodland group 1.

**Shelby loam, 14 to 18 percent slopes, moderately eroded (24E2).**—This soil is on side slopes in the uplands, mainly near the Nishnabotna Rivers. It generally is near and downslope from the Adair, Malvern, Marshall, or Monona soils and upslope from the Terril soils. In places it is adjacent to areas of Steinauer soils. Areas are small, generally ranging from 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer generally is a very dark grayish-brown plow layer, but in places it is very dark brown and about 3 to 7 inches thick. In places some of the browner subsoil has been mixed into the plow layer, and in places the texture is clay loam. The subsoil tends to be thinner than in the representative profile, and carbonates are present within a depth of 3½ feet in places. Included in mapping were small areas of Adair and Malvern soils and areas of soils that have a very dark brown to very dark grayish-brown surface layer about 10 or 12 inches thick. Also included are some small areas of severely eroded soils that are shown on the soil map by an erosion symbol.

Because this soil is moderately steep and is in somewhat small areas, it generally is farmed with adjacent soils.

Erosion and gullying are severe hazards in cultivated areas. This soil is moderately suited to row crops if erosion is controlled, but it is left in meadow most of the time. In places, stock ponds or erosion control structures have been built. Capability unit IVE-1; woodland group 1.

**Shelby loam, 18 to 25 percent slopes, moderately eroded (24F2).**—This soil is on side slopes in the uplands, mainly near the Nishnabotna Rivers. It generally is near and downslope from the Adair, Marshall, or Monona soils and upslope from the Terril soils. In places it is adjacent to areas of Steinauer soils. Areas are small, generally ranging from 5 to 10 acres in size.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is very dark brown or very dark grayish brown and about 3 to 7 inches thick. The subsoil is thinner than in the representative profile and it has mottles of olive gray or grayish brown below a depth of 24 inches in places. Carbonates are present at a depth of 30 to 42 inches in many places.

Included with this soil in mapping were small areas of Adair and Steinauer soils, a small acreage of soils where the dark-colored surface layer is more than 7 inches thick, and some areas of eroded soils where the dark-colored surface layer is less than 3 inches thick. Some small severely eroded areas are shown on the soil map by a symbol for erosion.

Most of this soil is in permanent pasture. Some areas have been cultivated in the past. Gullies form in sidehill drainageways if vegetation is sparse. The very severe hazard of erosion is a limitation to the use of this soil. This soil is poorly suited to row crops, but it is suited to pasture. Many areas can be made more productive by tearing up the bluegrass sod and seeding more productive pasture plants. Using modern farm machinery involves some risk on this moderately steep soil. In places the gullies must be shaped and seeded for waterways before tillage implements can be used. In places erosion control structures and stock ponds have been built. Capability unit VIe-1; woodland groups 2 where slopes face north and east and 3 where slopes face south and southwest.

## Solomon Series

The Solomon series consists of dark-colored, poorly drained or very poorly drained soils on bottom lands along the Missouri River. These soils are nearly level to slightly depressional and are at the lowest elevations in the eastern part of bottom lands along the Missouri River. They formed in clayey alluvium in slack water areas.

In a representative profile the surface layer, to a depth of about 6 inches, is black clay. Below this, to a depth of 13 inches, it is black silty clay. The subsoil, which is about 33 inches thick, is very dark gray, very firm silty clay to a depth of about 32 inches. Below this it is dark-gray and dark grayish-brown, very firm clay. The substratum is black, very firm clay that has many olive-colored mottles.

The Solomon soils are medium to low in available nitrogen, very low in available phosphorus, and medium in available potassium. These soils are moderately

alkaline, and they are calcareous. The content of organic matter is high. Available water capacity is medium, and permeability is very slow. Runoff is very slow.

Most areas of Solomon soils are cultivated, but some are in permanent pasture. These soils are very wet. They frequently have a high water table. During wet periods water tends to stand in fields and road ditches. It is fairly common for crops to drown out and for replanting to be necessary. The power requirement for tillage operations on these soils is high. The soils tend to dry out very cloddy and hard after they have been tilled.

Representative profile of Solomon clay in a slight depression in a permanent pasture, 260 feet west and 50 feet south of the northeast corner of sec. 34, T. 69 N., R. 43 W.

- Ap—0 to 6 inches, black (10YR 2/1) clay; massive but upper part is very cloddy; very firm; few fine roots; many white shell fragments; calcareous; moderately alkaline; abrupt, smooth boundary.
- A3—6 to 13 inches, black (10YR 2/1) silty clay; few, fine, olive (5Y 4/3) mottles; moderate to strong, fine, subangular blocky structure adhering as a mass; very firm; few fine roots and pores; many fine shell fragments; moderately alkaline; calcareous; gradual, smooth boundary.
- B2g—13 to 32 inches, very dark gray (5Y 3/1) silty clay; many, fine, distinct, olive-gray (5Y 4/2) mottles; moderate, very fine, subangular blocky structure adhering as a mass; very firm; very few fine roots and pores; some old root channels; olive (5Y 4/3) zone at a depth between 19 and 23 inches; many shell fragments; strongly alkaline; calcareous; clear, smooth boundary.
- B3g—32 to 46 inches, dark-gray (5Y 4/1) and dark grayish-brown (2.5Y 4/2) clay; strong, fine, subangular blocky structure; very firm; no roots; few very fine pores; few fine shell fragments; some soft lime concretions on surface of ped; moderately alkaline; calcareous; gradual, smooth boundary.
- C1—46 to 70 inches, black (5Y 2/1) clay; few olive (5Y 4/3) ped; many, fine, distinct, olive (5Y 4/4) mottles; very firm; strong, medium, angular blocky structure adhering as a mass; no roots; few very fine pores; numerous fine shell fragments and soft lime concretions; moderately alkaline; calcareous.

The Ap, or A1 horizon if present, is black (N 2/0 or 10YR 2/1) to very dark gray (N 3/0 or 10YR 3/1) in color and clay or silty clay in texture. The A horizon is 10 to 25 inches in total thickness in most places. In some places the A3 horizon is lacking.

The B2g and B3g horizons range from very dark gray (N 3/0, 10YR 3/1, or 5Y 3/1) to dark gray (10YR 4/1 to 5Y 4/1) and dark grayish brown (2.5Y 4/2) clay. Mottles of olive gray and olive are common in many places. The B horizon is 24 to 36 inches thick.

The C horizon ranges from dark gray (10YR 4/1 to 5Y 4/1) to black (10YR 2/1 to 5Y 2/1) and has mottles of olive or olive gray. It is silty clay or clay.

Solomon soils are moderately alkaline and calcareous and have small shell fragments and lime concretions in all horizons.

The Solomon soils are calcareous, but the Luton and Lakeport soils are not. They have more clay throughout than the Lakeport soils. They do not have silty clay loam below a depth of about 30 inches, as do the Woodbury soils. All of these soils formed in alluvium and are associated on the landscape.

**Solomon clay (0 to 2 percent slopes) (466).**—This soil is in slack water areas or in slight depressions on bottom lands along the Missouri River. It is near the Luton, Blencoe, and Woodbury soils and the Keg, Salix, and Lakeport soils that are at slightly higher elevations. Areas are 5 to more than 100 acres in size.

Included with this soil in mapping were very small areas of Luton soils.

Most areas of this soil are cultivated, but wetness is a severe limitation. The soil is moderately well suited to row crops if drainage is provided. Because it is in slight depressions and has a high clay content, this soil is very difficult to drain. In some years it may be late in the season before the soil is dry enough to work. In many places such crops as wheat are planted in fall to avoid tilling the soil in spring. Some hay and pasture crops also are grown. On many farms this soil is plowed in fall to improve workability and prevent delay of fieldwork in spring. In some years harvest must be delayed until the ground freezes in fall. Capability unit IIIw-1; woodland group 7.

### Steinauer Series

The Steinauer series consists of moderately dark colored, well-drained soils in the uplands. These soils formed in calcareous glacial till. They are mainly on the bluffs adjacent to the Nishnabotna Rivers. Slopes are 18 to 25 percent.

In a representative profile the surface layer is very dark grayish-brown, friable loam about 7 inches thick. Beneath this is a 6-inch transitional layer that is between the surface layer and the substratum. This layer is very dark gray and brown, friable clay loam. The substratum, extending to a depth of 50 inches, is brown, friable to firm clay loam that is mottled with grayish brown. It is light brownish gray in the upper part and yellowish brown in the lower part. Stones and pebbles are present throughout.

The Steinauer soils are very low in available nitrogen and available phosphorus and medium in available potassium. The organic-matter content is low. These soils are moderately alkaline, and they are calcareous throughout. Available water capacity is high, but the water held in these soils is seldom at capacity because so much runs off. Permeability is moderately slow. Runoff is rapid.

Steinauer soils are used mainly for pasture. The hazard of erosion is severe because the soils are steep.

Representative profile of Steinauer loam, 18 to 25 percent slopes, in a pasture on an east-facing slope that has a gradient of 23 percent, 700 feet west and 50 feet north of the southeast corner of sec. 11, T. 69 N., R. 40 W.

- A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, some mixing with brown (10YR 4/3), dark grayish brown (10YR 4/2) kneaded; weak, fine, subangular blocky structure to fine granular structure; friable; few small pebbles; many roots; moderately alkaline; calcareous; clear, smooth boundary.
- AC—7 to 13 inches, very dark grayish-brown (10YR 3/2) and brown (10YR 4/3), in about equal amounts, clay loam, dark grayish brown (10YR 4/2) kneaded; weak, fine, subangular blocky structure; friable; few pebbles; many roots and pores; fine soft and hard lime concretions; moderately alkaline; calcareous; gradual, smooth boundary.
- C2—13 to 25 inches, brown (10YR 4/3) clay loam, dark yellowish brown (10YR 4/4) kneaded; few, fine, grayish-brown (10YR 5/2) mottles; weak, fine, subangular blocky structure; friable; many pebbles; some dark worm casts; many roots and pores; many soft and hard lime concretions; moderately alkaline; calcareous; gradual, smooth boundary.
- C3—25 to 50 inches, light brownish-gray (2.5Y 6/2) and yellowish-brown (10YR 5/4) clay loam, olive brown (2.5Y 4/4) kneaded; weak, medium, subangular blocky structure to massive; firm; many pebbles; dark worm casts; few roots; few fine pores; many, large and small, hard and soft lime concretions; moderately alkaline; calcareous.

The A1 horizon, generally 7 inches or less in thickness, ranges from very dark brown (10YR 2/2) to dark grayish brown (10YR 4/2). It generally is loam but ranges to clay loam.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6) and to light brownish gray (10YR 6/2 or 2.5Y 6/2). It has strong-brown to grayish-brown mottles in many places.

Pebbles and stones are in the A1 and C horizons. Stones and lime concretions vary in size and amount from place to place throughout the profile, and pockets or lenses of sand occur in places. The A horizon is typically moderately alkaline and calcareous but ranges to neutral in places.

Steinauer soils are calcareous at or near the surface and throughout, but Shelby soils are not. They lack a well-developed subsoil, such as that of the Shelby soils. These soils formed in glacial till.

**Steinauer loam, 18 to 25 percent slopes (33F).**—This soil is on side slopes in the uplands, mostly near the Nishnabotna Rivers. It is downslope from the Marshall and Monona soils, upslope from the Terril soils, and adjacent to Shelby soils on the side slopes. Areas are small, generally ranging from 5 to 25 acres in size. Included in mapping were a small acreage of Steinauer soils that have slopes of 14 to 18 percent and small areas of Shelby soils.

This soil is poorly suited to cultivated crops. It is better suited to pasture, and most areas are in permanent pasture. The very severe hazard of erosion is a limitation to the use of this soil. In many places farm machinery can be used to renovate pastures, but its use involves some risk. Gullies should be shaped and seeded in places. Capability unit VIe-1; woodland group 4.

### Terril Series

The Terril series consists of dark-colored, moderately well drained soils on foot slopes and alluvial fans downslope from steeper soils along rivers and streams. These soils formed in local alluvium. Areas generally are long and narrow. Slopes are 3 to 8 percent.

In a representative profile the surface layer is loam about 36 inches thick. This layer is black to very dark brown in the upper part grading to very dark grayish brown in the lower part. The subsoil, to a depth of about 45 inches, is dark-brown, friable, light clay loam. Below this, extending to a depth of 55 inches, it is brown, friable loam.

The Terril soils are medium to low in available nitrogen, low in available phosphorus, and medium in available potassium. The content of organic matter is high. The surface layer is slightly acid or neutral. Available water capacity is high, and permeability is moderate. Runoff is generally medium.

The Terril soils are cultivated, except where they are near or in the same fields with steeper soils that are used for pasture. The use of the adjoining soils often governs the use of these soils. Erosion is a hazard, and runoff from higher areas causes rilling and gullyng in places.

Representative profile of Terril loam, 3 to 8 percent slopes, in pasture where the slope is about 7 percent, 600 feet west and 60 feet north of the southeast corner of sec. 19, T. 69 N., R. 40 W.

- A1—0 to 16 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) crushed; moderate, fine to very fine, subangular blocky structure; friable; common roots and pores; visible coarse sand grains; slightly acid; gradual, smooth boundary.
- A12—16 to 24 inches, very dark brown (10YR 2/2) loam; weak, fine and very fine, subangular blocky structure; friable; common roots and pores; visible coarse sand grains; neutral; gradual, smooth boundary.

A3—24 to 36 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine and very fine, subangular blocky structure; friable; few fine roots and common fine pores; visible coarse sand grains; slightly acid; gradual, smooth boundary.

B2—36 to 45 inches, dark-brown (10YR 3/3) light clay loam, brown (10YR 4/3) crushed; weak, fine and very fine, subangular blocky structure; friable; few roots and common pores; few small pebbles; neutral; gradual, smooth boundary.

B3—45 to 55 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure to massive; friable; few pores; few small pebbles; neutral.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2). The A3 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). The A horizon generally is loam but ranges to silt loam that has a high content of sand or to light clay loam. It ranges from 24 to 36 inches in total thickness.

The B2 and B3 horizons are loam or light clay loam. In places the B2 horizon has very dark grayish-brown organic coatings, and in places in the lower part of the B horizon, there are faint mottles.

The C horizon, which generally is present at a depth of 3 to 5 feet, is similar to the lower part of the B horizon in color, texture, and reaction. The representative profile was not described deeply enough to include this horizon. The A and B horizons are neutral to slightly acid.

The Terril soils have more sand throughout than do the Judson and Napier soils. These soils occupy similar positions on the landscape.

**Terril loam, 3 to 8 percent slopes (27C).**—This soil is on foot slopes or alluvial fans downslope from steeper soils. It is downslope from Shelby or Steinauer soils (fig. 11), and generally upslope from Colo and Zook soils that are on bottom lands. Areas are long and narrow and generally are 5 to 25 acres in size.

This soil generally is cultivated. Where it is in a small area in a field that includes steep Shelby or Steinauer

soils, it is used along with those soils for pasture. Where it is in a small area in a field that includes Colo or Zook soils that are on bottom lands, it is cultivated along with those soils. This soil is subject to erosion, and it receives runoff from steeper soils upslope. As a result, rilling and gullying occur in places. The soil is moderately well suited to row crops much of the time if the runoff and erosion are controlled. Capability unit IIIe-1; woodland group 1.

### Vore Series

The Vore series consists of moderately dark colored, moderately well drained soils on bottom lands along the Missouri River. These soils formed in recent silty alluvium that is underlain by sandy alluvium. They are nearly level and are in slightly elevated areas in the western part of the bottom lands, near or within a few miles of the present river channel.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 8 inches thick. The substratum, to a depth of about 22 inches, is stratified, dark grayish-brown, friable silty clay loam that has some strata of sandy and clayey texture. Below this, to a depth of 50 inches, is dark grayish-brown, loose loamy fine sand and fine sand.

The Vore soils are low in available nitrogen and available phosphorous and high in available potassium. The organic-matter content is low. These soils are moderately alkaline, and they are calcareous. Available water capacity is medium or low. Permeability is moderately slow in the upper part of the profile and rapid in the lower part. Runoff is slow.



Figure 11.—On foot slopes in foreground are Terril soils. In the background are the more strongly sloping Shelby soils.

Most areas of these soils are used for row crops. Before the large dams and levees on the Missouri River were constructed, these areas were subject to almost yearly flooding. Most areas are now protected, and flooding is no longer a hazard. Because they have a sandy substratum, these soils tend to be droughty.

Representative profile of Vore silty clay loam in a cultivated field, 300 feet east and 200 feet north of the southwest corner of sec. 20, T. 68 N., R. 43 W.

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; cloddy; friable; few roots; moderately alkaline; calcareous; clear, smooth boundary.
- C1—8 to 22 inches, stratified dark grayish-brown (10YR 4/2) silty clay loam; some horizontal cleavage; friable; some strata of sandy and clayey material; moderately alkaline; calcareous; abrupt, smooth boundary.
- IIC2—22 to 32 inches, dark grayish-brown (10YR 4/2) loamy fine sand; single grained; loose; some thin lenses of silt; calcareous; moderately alkaline; gradual, smooth boundary.
- IIC3—32 to 50 inches, dark grayish-brown (10YR 4/2) fine sand; single grained; loose; moderately alkaline; calcareous.

The Ap horizon, or A1 horizon, is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color and less than 10 inches in thickness.

The C1 horizon is typically dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (10YR 5/2 or 2.5Y 5/2), but it ranges to colors that have a value of 6 and a chroma of 3 or 4. Mottles are few to common and are gray to yellowish brown or strong brown in color. The IIC horizon, which occurs at a depth of 15 to 30 inches, has colors and mottles similar to those of the C1 horizon. In places it has thin strata of finer texture.

Vore soils are mildly alkaline or moderately alkaline and calcareous throughout.

The Vore soils have more sand below a depth of about 2 feet than the Blake soils. They have less clay in the A horizon and upper part of the C horizon than the Onawa and Percival soils. All of these soils have formed in alluvium and are associated on the landscape.

**Vore silty clay loam** (0 to 2 percent slopes) (516).—This soil is on bottom lands along the Missouri River near the present channel. This soil is at a slightly higher elevation than the nearby Onawa and Albaton soils. It is at or near the same elevation as the adjacent Blake and Percival soils. Most areas are 10 to 100 acres in size, but a few are larger.

Included with this soil in mapping were very small areas of Blake and Onawa soils.

Most areas of this soil are cultivated and used for row crops. This soil is well suited to such use, but because of the sandy substratum, it has a tendency to be droughty. Most areas are protected by levees, but unprotected areas are subject to almost yearly flooding. Capability unit IIs-1; woodland group 7.

## Waubonsie Series

The Waubonsie series consists of moderately dark colored, moderately well drained or somewhat poorly drained, nearly level soils on bottom lands along the Missouri River. These soils formed in recently deposited sandy alluvium, about 2 feet thick, that overlies silty clay or clay. They are in areas within a few miles of the present Missouri River channel.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 9 inches thick. The substratum, to a depth of 21 inches, is stratified

grayish-brown and dark grayish-brown, loose loamy very fine sand. Below this, to a depth of 50 inches, it is firm silty clay. It is black in the upper part and dark gray in the lower part, and it has some brown mottles. The black layer in the upper part was once the surface layer of a now buried soil.

The Waubonsie soils are very low in available nitrogen and available phosphorus and high in available potassium. The organic-matter content is low. These soils are mildly alkaline or moderately alkaline. Available water capacity is medium to high. Permeability is moderately rapid in the upper part of the profile and very slow or slow in the underlying clay. Runoff is slow.

Most areas of these soils are cultivated and are used for row crops. Because of the sandy texture in the surface layer, these soils tend to be droughty. Before the large dams and levees on the Missouri River were constructed, these areas were subject to almost yearly flooding, but most areas are now protected and flooding is not a hazard.

Representative profile of Waubonsie fine sandy loam in a cultivated field, 1,220 feet west and 250 feet south of the northeast corner of sec. 16, T. 70 N., R. 43 W.

- Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; very weak, fine, granular structure; loose; moderately alkaline; calcareous; clear, smooth boundary.
- C1—9 to 21 inches, stratified grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/3) loamy very fine sand, some mixing with very dark grayish brown (10YR 3/2); single grained; loose; mildly alkaline; calcareous; abrupt, smooth boundary.
- IIA1b—21 to 31 inches, black (10YR 2/1) silty clay; strong, medium to fine, subangular blocky structure; firm; few fine roots and pores; mildly alkaline; calcareous; clear, smooth boundary.
- IIB2bg—31 to 50 inches, dark-gray (10YR 4/1) silty clay grading to light silty clay with increasing depth; common brown (7.5YR 4/4) mottles; strong, fine, subangular blocky structure; firm; few roots and pores; mildly alkaline; calcareous.

The Ap horizon, or A1 horizon in uncultivated areas, is very dark grayish brown (10YR 3/2 or 2.5Y 3/2) or dark grayish brown (10YR 4/2 or 2.5Y 4/2). It has a texture that centers on fine sandy loam but ranges to silt loam or silty clay loam and is less than 10 inches in thickness.

The C1 horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (10YR 5/2 or 2.5Y 5/2) silty clay loam or fine sandy loam to loamy very fine sand. The silty clay loam extends to a depth of about 15 inches in places. This horizon has mottles that, if present, range from dark red to brownish yellow.

The underlying silty clay or clay is at a depth of 18 to 30 inches. In places thin strata of coarser texture are present. The underlying material ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to grayish brown (10YR 5/2 or 2.5Y 5/2), olive gray (5Y 5/2), or gray (5Y 5/1), but the IIA1b horizon (former surface layer) may be black (N 2/0 or 10YR 2/1) or very dark gray (N 3/0 or 10YR 3/1). This IIA1b horizon is not present in all places.

Waubonsie soils are mildly alkaline or moderately alkaline and calcareous throughout.

The Waubonsie soils have more sand to a depth of about 2 feet than do the Modale soils. They differ from Carr soils in being underlain by silty clay or clay at a depth of about 2 feet. All of these soils formed in alluvium.

**Waubonsie fine sandy loam** (0 to 2 percent slopes) (49).—This soil is on bottom lands along the Missouri River and is near the Onawa, Albaton, Percival, and Sarpy soils. It generally is in elongated areas that are at a slightly higher elevation than all of the nearby soils except the Sarpy soils. Most areas are less than 50 acres in size.

This soil has the profile described as representative of the series. Included in mapping were very small areas of Sarpy and Modale soils.

This soil is used mainly for row crops and is well suited to this use. Because of the sandy texture of the surface layer and upper part of the substratum, this soil has a tendency to be droughty. If the surface is bare, this soil is subject to soil blowing. During wet periods there is sometimes a perched water table above the clay, but wetness is rarely a concern. Some areas have been leveled for irrigation, and some have been deep-plowed to mix clayey material into the sand and thus improve the water-holding capacity of the soil. Capability unit IIs-1; woodland group 6.

**Waubonsie silty clay loam** (0 to 2 percent slopes) (449).—This soil is on level bottom lands along the Missouri River and is near the Onawa, Albaton, Modale, and Percival soils, generally at a slightly higher elevation. Most areas are less than 50 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam 6 to 15 inches thick.

Included in mapping were some areas of soil that has a texture of silty clay loam to a depth of as much as 24 inches. The number of these areas is small, but the acreage of each is large, generally more than 100 acres. Also included were very small areas of Onawa and Percival soils.

Most areas of this soil are cultivated and are used for row crops. Because of the silty clay loam surface layer, this soil is wetter than other Waubonsie soils. It is well suited to row crops if adequate drainage is provided. Capability unit IIw-2; woodland group 6.

## Woodbury Series

The Woodbury series consists of dark-colored, poorly drained or somewhat poorly drained soils on bottom lands along the Missouri River. These nearly level soils are on low bottom lands in areas about midway between the river channel and the upland foot slopes. In places they are adjacent to slack water areas or low swales within old meander scars. These soils formed in clayey alluvium which is underlain by less clayey sediments at a depth of about 2 to 3 feet.

In a representative profile the surface layer is black silty clay about 16 inches thick. The subsoil is very dark gray and very dark grayish-brown, firm silty clay to a depth of about 24 inches. Below this, it is dark grayish-brown, firm clay that has grayish-brown and strong-brown mottles. The substratum, between depths of 34 and 43 inches, is dark-gray, friable clay loam. Below this, it is olive-gray loam that is mottled with strong brown to light olive brown and that extends to a depth of about 54 inches.

The Woodbury soils are medium to low in available nitrogen, very low in available phosphorus, and high in available potassium. The content of organic matter is high. The surface layer and upper part of the subsoil are neutral or mildly alkaline. Available water capacity is high. Permeability is slow or very slow in the upper part of the profile and moderate or moderately slow in the substratum. Runoff is slow.

Most areas of Woodbury soils are cultivated and used for row crops. Wetness is a limitation to the use of these

soils for crops. The power requirement for tilling these soils is high.

Representative profile of Woodbury silty clay in a cultivated field, 150 feet west and 20 feet north of the southeast corner of the SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 14, T. 68 N., R. 43 W.

- Ap—0 to 6 inches, black (10YR 2/1) silty clay; cloddy; very firm, hard; few roots; neutral; clear, smooth boundary.
- A1—6 to 16 inches, black (10YR 2/1) silty clay; strong, fine, subangular blocky structure; very firm; few fine roots and pores; few fine worm channels; mildly alkaline; gradual, smooth boundary.
- B2g—16 to 24 inches, mixture of about 50 percent very dark gray (N 3/0) and 50 percent very dark grayish-brown (2.5Y 3/2) silty clay; few, fine, distinct, brown (7.5YR 4/4) mottles; strong, fine, subangular blocky structure; firm; few fine roots; few slickensides; mildly alkaline; gradual, smooth boundary.
- B3g—24 to 34 inches, dark grayish-brown (2.5Y 4/2) clay; few, fine, faint, grayish-brown (2.5Y 5/2) mottles and distinct strong-brown (7.5YR 5/6) mottles; moderate to strong, fine, subangular blocky structure adhering as a mass; firm; wormholes and root channels filled with black (10YR 2/1) organic material; few slickensides; mildly alkaline; calcareous; clear, smooth boundary.
- Cg—34 to 54 inches, dark-gray (N 4/0) clay loam; common strong-brown (7.5YR 5/6) to light olive-brown (2.5Y 5/6) mottles; massive; friable; olive gray (5Y 5/2) at a depth of 43 inches grading to dark gray (5Y 4/1) with increasing depth; loam texture at a depth of 43 to 50 inches; few roots and few pores; moderately alkaline; calcareous.

The Ap and A1 horizons generally are black (10YR 2/1) or very dark gray (10YR 3/1). In places an A3 horizon of very dark gray (10YR 3/1 or N 3/0) is present.

The B2g horizon ranges from very dark gray (N 3/0) to dark grayish brown (2.5Y 4/2) and is silty clay or clay. It has mottles that range from yellowish brown to strong brown, brown, olive, and olive brown. In places the B3g horizon ranges to light olive brown (2.5Y 5/4) in color and to silty clay loam in texture. It has mottles similar to those in the B2 horizon.

The C horizon has colors of dark gray (5Y 4/1 or N 4/0), olive gray (5Y 5/2), light olive brown (2.5Y 5/4), and olive brown (2.5Y 4/4). It generally is silty clay loam or clay loam but ranges to silt loam or loam in some places. Mottles are common and similar to those in the B horizon.

The solum ranges from 30 to 48 inches in thickness, and the silty clay or clay is 24 to 36 inches thick. The soils have neutral or mildly alkaline A and B2g horizons that are non-calcareous. The B3g horizon is neutral to mildly alkaline, and the Cg horizon is mildly alkaline or moderately alkaline and calcareous.

The Woodbury soils are underlain by silty clay loam or clay loam at a depth of 24 to 36 inches, but the Luton, Solomon, and Zook soils are clayey to a depth of 40 inches or more. Woodbury soils are gleyed in the B horizon, but Blencoe soils are not, and they generally are not underlain by silt loam. They do not have silty clay or clay below a depth of about 30 inches as do the Blend soils. All of these soils formed in alluvium.

**Woodbury silty clay** (0 to 2 percent slopes) (67).—This soil is in low areas in the central part of bottom lands along the Missouri River. It is adjacent mainly to Luton, Blencoe, and Lakeport soils. Areas are 5 to more than 100 acres in size.

Included with this soil in mapping were very small areas of Luton and Blencoe soils and a small acreage of soils that have recent deposition of light-colored silt loam on the surface.

Most areas of this soil are cultivated and are used for row crops. Wetness is a limitation. When drained this soil is moderately well suited to row crops. In some years crops drown out and replanting is necessary. Fieldwork is often delayed because of wetness. The

surface layer tends to dry out cloddy and hard if the soil is tilled when wet. In many places the soil is plowed in fall to avoid tilling early in spring and so that the freezing and thawing during winter will improve the tilth. Capability unit IIIw-1; woodland group 7.

### Zook Series

The Zook series consists of dark-colored, poorly drained, nearly level soils on bottom lands. These soils formed in alluvium along streams. They generally are on the lowest part of first bottoms back from the stream channel near the base of foot slopes and stream benches.

In a representative profile the surface layer is about 32 inches thick. It is black silty clay loam to a depth of about 20 inches, and below this it is black silty clay. The subsoil is very dark gray to dark-gray, firm silty clay that extends to a depth of about 53 inches.

The Zook soils are medium to low in available nitrogen, very low to low in available phosphorus, and medium in available potassium. The content of organic matter is high. These soils are neutral. Available water capacity is high, and permeability is slow. Runoff is slow.

Most of the Zook soils are cultivated and are used for row crops. Some areas are in pasture. These soils are wet unless drained. Most areas are subject to flooding during periods of high rainfall.

Representative profile of Zook silty clay loam in a cultivated field, 75 feet south of the northeast corner of the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 13, T. 70 N., R. 40 W.

- Ap—0 to 8 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; medium to fine granular structure and fine subangular blocky structure; friable; many roots and pores; neutral; clear, smooth boundary.
- A12—8 to 20 inches, black (N 2/0) silty clay loam; fine subangular blocky structure; firm; many roots and pores; neutral; clear, smooth boundary.
- A3—20 to 32 inches, black (10YR 2/1) silty clay; weak, medium, prismatic structure to strong, medium and fine, subangular blocky structure; firm; many roots and pores; neutral; clear, smooth boundary.
- B2—32 to 44 inches, very dark gray (10YR 3/1) silty clay; medium to fine subangular blocky structure; firm; few roots and many pores; neutral; clear, smooth boundary.
- B3g—44 to 53 inches, very dark gray (5Y 3/1) to dark-gray (5Y 4/1) silty clay; medium subangular blocky structure; firm; few roots and pores; mildly alkaline.

The A horizon ranges from silty clay loam to silty clay in texture to a depth of about 20 inches. In places there is recently deposited overwash that is silt loam about 6 to 15 inches thick. In places the A3 horizon is very dark gray (10YR 3/1 or N 3/0). The A horizon is about 24 to 36 inches in total thickness.

The B2 horizon ranges from black (N 2/0 or 10YR 2/1) or very dark gray (N 3/0, 10YR 3/1, or 5Y 3/1) to dark gray (5Y 4/1) in color and is silty clay or clay in texture. It extends to a depth of about 60 inches in places. Mottles of yellowish brown to olive are present in the lower part of the B horizon and in the C horizon in places.

The C horizon generally is dark-gray (5Y 4/1) to very dark gray (5Y 3/1) or olive-gray (5Y 5/2) silty clay. The representative profile was not described deeply enough to include this horizon.

Zook soils are typically neutral or slightly acid throughout but range to medium acid.

The Zook soils have a higher clay content in the lower part of the A horizon and in the B horizon than do the Colo soils. They are not so high in clay throughout and have a thicker A horizon than do the Luton soils. All of these soils formed in alluvium.

**Zook silt loam, overwash** (0 to 2 percent slopes) (54+).—This soil is on bottom lands, generally back from the stream channels and near foot slopes. It is generally adjacent to the other Zook soils and Colo soils and near Judson soils that are upslope and closer to the uplands. It generally is near tributary streams or manmade ditches that cross the bottom lands and flow into the larger streams. The overflow of these streams and ditches has deposited light-colored sediment on this soil. Areas are small, ranging from 5 to 25 acres in size.

This soil has a profile similar to the one described as representative of the series, except that it has recently deposited sediment that is very dark grayish-brown to dark grayish-brown silt loam 6 to 15 inches thick on the surface.

Most areas of this soil are cultivated and used for row crops. Wetness, sedimentation, and flooding are limitations to the use of this soil for crops. Because the overwash is silt loam, this soil dries faster than the other Zook soils. It is well suited to row crops if wetness and flooding are controlled.

The power requirement to till this soil is lower than that for other Zook soils, and tilth generally is better. The overwash has lower fertility than the dark-colored surface layer of other Zook soils, and more fertilizers may be needed in places. Capability unit IIw-1; woodland group 7.

**Zook silty clay loam** (0 to 2 percent slopes) (54).—This soil is on bottom lands, generally back from the stream channels and near the base of foot slopes. It generally is adjacent to areas of Colo and Zook silty clay soils. Areas are large, ranging to as much as 100 acres or more in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of Zook silty clay and Colo soils.

Most areas of this soil are cultivated and are used for row crops. Wetness and flooding are limitations. The surface layer dries slowly after rains, and tillage operations are delayed. This soil is well suited to row crops, which can be grown frequently if the wetness is controlled. Capability unit IIw-1; woodland group 7.

**Zook silty clay** (0 to 2 percent slopes) (134).—This soil is on bottom lands, generally back from the stream channel, and in some places it is in slight depressions. It generally is adjacent to areas of Colo soils and Zook silty clay loam. Areas are as much as 200 acres or more in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay. Included in mapping were small areas of Zook silty clay loam and Colo soils and some areas of soils that have a recognizable overwash of dark-colored silty clay.

Most areas of this soil are cultivated and used for row crops much of the time. Some of the wettest areas are in a permanent pasture. Wetness is a severe limitation to the use of this soil for crops. Because it is in depressions in some places, the water tends to pond and must be drained before this soil can be farmed easily. Fieldwork is often delayed. Most areas are subject to flooding when streams overflow during periods of high runoff. This soil is moderately suited to row crops if drainage and protection from flooding are provided. In some places, fall-planted crops are used to avoid the wetness limitation in spring. The power requirement for tillage operations is high. This soil tends to dry out cloddy and hard if tilled when wet. Capability unit IIIw-1; woodland group 7.

## *Use and Management of the Soils*

This section discusses the management of the soils for crops and pasture, explains the system of capability grouping used by the Soil Conservation Service, and discusses the management of the soils in Fremont County by capability units. Predicted yields of the principal crops are given. Also discussed are the management of the soils for woodland, wildlife, and recreation. The soil properties and features that affect engineering practices are enumerated, mainly in tables.

### **Use and Management for Crops and Pasture**

In Fremont County in 1969 (9), about 158,000 acres was used for crops and about 49,000 acres for pasture. Much of the land that is wooded is also used for pasture and is included in the pasture acreage. About 96,000 acres of other land in farms includes the acreage in roads, farmsteads, idle land, cropland not harvested, and all other uses.

Corn, soybeans, legumes, and legume-grass hay are the main crops. Wheat, oats, sorghums, and popcorn are also grown, but the acreages are smaller.

There are a few hundred acres of commercial orchards in the county. Apples are the main produce, but cherries, plums, pears, and peaches are also grown. An area in the uplands north of Hamburg has had commercial orchards since the early settlement of the area, but the storm on Armistice Day in 1940 nearly eliminated the existing orchards. About 300 acres presently in commercial orchards has been planted since that storm. The soils in Fremont County that formed in thick loess are well suited to the

production of fruit crops. Monona and Marshall soils are deep, well-drained, slightly acid, have a high available water capacity, and permit the development of good, deep, root systems. They are especially well suited.

The climate is a somewhat limiting factor as drought occasionally reduces yields of all fruits. Temperature extremes, particularly in spring, are common and at times are disastrous to most crops other than apples, but high elevations and favorable exposures can offset some of the hazard of frost.

About 2,000 acres are used for raising nursery stock in Fremont County. Conifers of all types, fruit trees, hardwood trees, shrubs, a variety of bulbs, and flower and vegetable seeds of many kinds are grown. Areas in adjacent counties are also used for nursery crops, and this general area is often referred to as the "Nursery Capital of the World."

The Marshall and Monona soils which are on both uplands and on benches, are ideal for the production of nursery stock of all kinds. They are the soils most used for nurseries (fig. 12). They are deep, well drained, have high available water capacity, and are free of impervious layers that restrict good root development. Their silt loam and silty clay loam surface layers are favorable for maintaining good tilth, and they are relatively fertile. These characteristics are responsible for their being so well suited to this use.

Most permanent pastures are in bluegrass. Some have been renovated. Among the grasses used for pasture are brome grass and orchard grass. Also used are grass-legume mixtures, such as alfalfa and brome grass.

Many soils in the county are subject to sheet erosion and gullying. Among these are soils of the Monona,



*Figure 12.*—Nursery stock growing on Marshall soils.

Ida, Marshall, Hamburg, and Shelby series. Regular level terraces and grassed blackslope terraces as well as tilling on the contour are commonly used for erosion control. Gully control structures, farm ponds, and grassed waterways are used to control gully in water courses. The farm ponds furnish water for livestock and for recreation.

The use of levees to protect bottom lands from flooding is a common practice, especially on the bottom lands along the Missouri River. These have mainly been constructed by the U.S. Army Corps of Engineers or other governmental bodies rather than by individuals. Since large dams have been constructed upstream on the Missouri River, the hazard of flooding has been lessened greatly, and there has been considerable clearing of brush and trees and cultivation of land that previously was largely idle.

Drain tile is used to reduce wetness in soils, such as those of the Colo, Judson, Nishna, Zook, and Corley series. Drainage ditches are commonly used to lower the water table and reduce wetness in soils such as those of the Luton, Solomon, Merville, Blend, and Blencoe series. In addition, shallow field drainage ditches and land grading are used in places to remove water that tends to stand on the surface. Interceptor tile placed in soils upslope from Adair and Malvern soils can be used to reduce seepiness and wetness in those soils, but this practice has been used in only a few places.

### 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. The grouping does not take into account major and generally expensive land-forming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

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

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife habitat.

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

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

**CAPABILITY UNITS** are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-2 or IIIe-1. 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 following pages each of the capability units in Fremont County is described, and suggestions for use and management of the soils in each unit are given. The names of the soil series represented are mentioned in the description of each unit, but this does not mean that all the soils in a given series are in the unit. The capability classification of each individual soil is given in the "Guide to Mapping Units."

#### CAPABILITY UNIT I-1

This unit consists of nearly level, dark-colored, well-drained to somewhat poorly drained soils of the Cooper, Keg, Kennebec, Lakeport, Nevin, and Salix series. These

soils are on the bottom lands. Although they are nearly level and have little or no runoff, they have good to only slightly restricted internal drainage and are seldom wet. Erosion is not a hazard. The soils on bottom lands along the Missouri River have been flooded in the past, but most of them are now protected by levees and dams and are not subject to flooding. Kennebec soils are flooded occasionally, but generally crops are not damaged.

The soils in this unit have a surface layer of friable loam, silt loam, or silty clay loam. They have similar texture in the subsoil and substratum, except that the Cooper soils are underlain by silty clay. A Kennebec and a Lakeport soil in this unit are covered by very dark grayish-brown or dark grayish-brown silt loam overwash.

Most of the soils in this unit have moderate or moderately slow permeability and high available water capacity, but the Cooper soil has slow or very slow permeability in the clayey substratum, and the Kennebec soils have very high available water capacity. The soils are medium to low in available nitrogen, high to low in available phosphorus, and medium to high in available potassium with the exception of the Nevin soil, which is low to medium in potassium.

These soils readily absorb most of the rain when it falls in normal amounts, and they hold much of this moisture available for plants. Aeration is generally good. The soils warm up quickly in spring, and they can be worked soon after rains. Tilth is generally good.

These soils are well suited to cultivated crops, and most areas are cultivated. Areas are generally large. Corn is the major crop, but a large acreage of soybeans is also grown. If fertility and good tilth are maintained, these soils are well suited to frequent use for row crops. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to be as worthwhile on these soils as on any soil in the county.

Corn and other crops respond well to application of nitrogen and phosphate, but the need for potassium, if any, generally is small. Some of these soils may need applications of lime for high production, but the need is generally not large.

Irrigation of the soils in this group is a possibility, because many are in areas where water is available. The Keg and Salix soils are especially well suited to irrigation.

#### CAPABILITY UNIT I-2

This unit consists of nearly level, well-drained and somewhat poorly drained, stratified silty soils of the Blake, Haynie, McPaul, Modale, Moville, and Nodaway series. These soils mainly occupy slightly elevated positions in areas of recent depositions on the bottom lands. They mostly are on bottom lands along the Missouri River, but some are in tributary stream valleys. Generally most of these soils are not subject to flooding, and wetness is not a limitation. Some were formerly subject to flooding but are now protected by levees. A few areas not protected are still subject to flooding. The Nodaway soil, which is on tributary streams, is subject to flooding in many places, but the water generally recedes rapidly and the soil does not stay wet long. A few areas, especially of Moville and McPaul soils, receive runoff and deposition from the adjacent uplands at times. The tilth of the soils in this unit is generally good.

The soils in this unit have a surface layer of friable silt loam or silty clay loam. Most of the soils are moderately permeable, but the Moville and Modale soils have clayey substrata that are slowly or very slowly permeable. Available water capacity is high. The content of organic matter is low, and the reaction is moderately alkaline to neutral in the surface layer and upper part of the subsoil or substratum. The soils are very low to low in available nitrogen and very low to medium in available phosphorus, but most are high in available potassium. The Nodaway soil is about medium in potassium.

Most of the soils in this unit are used for corn, soybeans, and other crops, and they are well suited to frequent use for these crops if fertility and good tilth are maintained. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to be as worthwhile on these soils as on any soils in the county.

Corn and other crops respond well to fertilizers, but the need for potassium generally is small. Applications of lime are not needed.

These soils are well suited to irrigation, and most are in areas where water is available.

#### CAPABILITY UNIT I-3

This unit consists of nearly level, dark-colored, well-drained and somewhat poorly drained soils of the Marshall, Minden and Monona series. These soils are on benches and upland divides that are mantled with loess. After heavy rains or during thaws in spring, runoff may collect on the nearly level benches, but water generally does not stand on the surface for long periods. The soils absorb water readily. They generally have good tilth.

The soils in this unit have a surface layer of friable silt loam or silty clay loam and a subsoil of similar texture. Permeability is moderate, and available water capacity is high. The content of organic matter is moderate to high. The soils are low to medium in available nitrogen and phosphorus and medium to high in available potassium.

These soils are mostly cultivated and are used for row crops. They are well suited to this use. The main crop is corn, but a large acreage of soybeans is also grown. Nursery stock is grown on some of the soils, especially those on benches and the soils are well suited to this use.

The major management needs are maintaining the content of organic matter, the fertility, and good tilth. The hazard of erosion is slight. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to be as worthwhile on these soils as on any soils in the county.

Crops respond well to applications of fertilizers. Corn responds well to nitrogen and phosphorus, but the need for potassium, if any, is generally small. Applications of lime are needed in many places.

The soils in this group, especially those on benches, are suited to irrigation.

#### CAPABILITY UNIT IIe-1

This unit consists of gently sloping, well drained and moderately well drained soils of the Judson and Napier series. These soils are on low foot slopes and alluvial fans and in narrow upland drainageways. Wetness is not a limitation, but the soils receive runoff and are subject to

erosion. In periods of heavy rainfall, runoff from higher areas causes rilling and gullying in places. The soils have good tilth.

The soils in this unit have a surface layer of friable silt loam or silty clay loam and a subsoil of similar texture. Permeability is moderate, and available water capacity is very high. The content of organic matter is high. The soils are medium to low in available nitrogen, low in available phosphorus, and medium or high in available potassium.

Most areas of these soils are cultivated, but a few are in permanent pasture, because they are inaccessible or are near soils that are not suited to cultivation. The cultivated areas are used for corn, soybeans, small grain, and meadow plants. They are subject to erosion but are well suited to frequent use for row crops if erosion is controlled.

These soils are generally in narrow strips and are managed in the same way as adjacent soils. In wide valleys they can be farmed along with soils on adjacent bottom lands. In narrow valleys they are managed in the same way as steeper soils on the hillsides.

Terracing the soils upslope will benefit the soils in this unit by intercepting runoff and sediment that would otherwise be deposited on them. Where runoff has caused gullying, shaping and seeding of the waterway may be needed. In many places these soils are tilled on the contour to control further erosion.

Crops respond well to applications of fertilizers. Corn responds well to nitrogen and phosphorus, but the need for potassium is generally small. Some applications of lime may be needed in places, but the amount is generally small.

#### CAPABILITY UNIT IIw-1

This unit consists of very poorly drained to somewhat poorly drained soils of the Blencoe, Colo, Cooper, Corley, Dockery, Judson, Luton, and Zook series. The Judson soil and one Colo soil are gently sloping, but the rest of the soils are nearly level. The gently sloping Colo and Judson soils are in narrow drainageways on uplands, Corley soil is on benches, but the rest of the soils are on bottom lands.

The soils are wet, mainly because they are flooded or have a high water table, or both. Some are flooded occasionally, but others are seldom if ever flooded. In some places flooding is caused by the overflowing of streams, but in others it is caused by runoff from the uplands or from adjacent soils.

Most of the soils in this unit have a surface layer of friable to firm silty clay loam or silty clay, but the Corley soil has a surface layer of silt loam. Some soils have a 6- to 15-inch deposit of friable silt loam on the surface. The Dockery soil is mainly silt loam below the surface layer, but the other soils have a subsoil mainly of friable to very firm silty clay loam or silty clay.

Permeability is moderate in Judson and Dockery soils but moderately slow to very slow in the other soils. Available water capacity is medium to high. The content of organic matter is low in Dockery soils but high in the other soils. The soils are low to medium in available nitrogen, very low to medium in available phosphorus, and medium to high in available potassium.

Most of the acreage is cultivated, but some areas, particularly of Colo and Judson soils, are in pasture. Corn

and soybeans are the main crops, but small grain and hay are also grown. The soils are well suited to row crops if wetness is controlled.

Artificial drainage is generally required if the soils are to be used successfully for crops. On some soils, land grading has been used to improve the drainage. The soils dry out somewhat slowly in spring, and working them must be delayed longer after rains than the working of better drained soils. Some of them tend to puddle and become cloddy and hard if they have been worked when wet. Plowing in fall improves the timeliness of field operations in spring and allows freezing and thawing to improve the tilth. The power requirement is high for the soils that have a surface layer of silty clay.

Crops respond fairly well to applications of fertilizer if the drainage is adequate. Corn responds well to nitrogen and phosphorus. The need for potassium is generally small, and lime is generally not needed.

#### CAPABILITY UNIT IIb-1

This unit consists of nearly level, somewhat excessively drained to somewhat poorly drained stratified soils of the Cott, Grable, Vore, and Waubonsie series. These soils are generally at a slightly higher elevation than nearby soils on bottom lands along the Missouri River. Cott soils are at high enough elevations that they are not subject to flooding. Most of the other soils are protected by levees and are no longer subject to flooding. A few areas are not protected and are still subject to flooding in most years.

The Waubonsie soil has a surface layer of sandy loam that grades to loamy fine sand and is underlain by silty clay. The rest of the soils are silt loam, loam, clay loam, or silty clay loam to a depth of about 2 feet and are underlain by sand.

Permeability is rapid in the surface layer of the Waubonsie soils and slow or very slow in the subsoil. It is moderate or moderately slow in the upper part of the rest of the soils and moderately rapid or rapid in the lower part. Available water capacity is mainly medium, but it is low or high in some of the soils. The content of organic matter is low. The soils are very low or low in available nitrogen, very low to medium in available phosphorus, but are high in available potassium.

Most areas of these soils are cultivated and are used for row crops, and they are well suited to such use. Corn is the main crop, but some oats and meadow plants are also grown. The main limitation to the use of these soils is drought. In dry periods, crops are damaged by lack of moisture. The soils can be tilled soon after rains, and generally tilth is good. Waubonsie soil is subject to soil blowing, and young plants on this soil may be damaged by blowing sand.

Corn and other crops respond well to applications of fertilizers if moisture is adequate, but the need for potassium is small. Applications of lime are not needed. Practices that increase the organic-matter content and conserve moisture are appropriate for these soils.

#### CAPABILITY UNIT IIc-2

This unit consists of gently sloping, well-drained soils of the Marshall and Monona series. These soils are on benches and upland ridgetops that are mantled with loess. They are subject to runoff and erosion, especially in periods of heavy rain. Tilth is generally good, but the moderately

eroded soil generally has somewhat poorer tilth than the other soils in this unit.

The soils in this unit have a surface layer of friable silt loam and silty clay loam, and a subsoil of similar texture. The moderately eroded soil in this unit does not have so thick a surface layer as the other soils.

Permeability is moderate, and available water capacity is high. The content of organic matter is about moderate. The soils are low to medium in available nitrogen and phosphorus and medium to high in available potassium.

Most areas of these soils are cultivated. Corn, soybeans, oats, and meadow plants are the main crops. These soils are subject to some erosion, but they are well suited to row crops if erosion is controlled. The Marshall soil on benches is used for growing nursery stock and is well suited to this use.

The major management need is controlling erosion. Terraces and contour tillage are generally used. Maintaining the content of organic matter, fertility, and good tilth are also important.

Crops respond well to applications of fertilizer. Corn responds well to nitrogen and phosphorus, but the need for potassium is generally small. Applications of lime are needed in some areas.

#### CAPABILITY UNIT IIw-2

This unit consists of nearly level, moderately well drained to poorly drained, stratified soils of the Onawa, Percival, and Waubonsie series. These soils are on bottom lands along the Missouri River, not far from the present channel. Most areas are protected by levees and are seldom flooded, but some areas are unprotected and are subject to more frequent flooding.

Most of the soils in this unit have a surface layer of firm silty clay or silty clay loam, but Onawa silt loam is covered by 6 to 15 inches of silt loam overwash. Beneath the surface layer of Onawa and Percival soils, to a depth of about 1½ to 2 feet, is silty clay. This, in turn, is underlain by silt loam to loamy fine sand. Beneath the surface layer of the Waubonsie soil, to a depth of 18 to 30 inches, is loamy fine sand or fine sandy loam. Beneath this is silty clay.

Permeability is slow in the upper part of the Onawa and Percival soils and moderate to rapid in the lower part. It is moderately rapid in the upper part of the Waubonsie soils and slow or very slow in the lower part. Available water capacity ranges from low to high. The content of organic matter is low. The soils are low or very low in available nitrogen and phosphorus, but are high in available potassium.

Most areas of these soils are cultivated, but a few are still in grass and trees. Corn and soybeans are the major crops grown, but oats and meadow plants are also grown.

If these soils are drained and are protected from flooding, they are well suited to row crops. Wetness is a limitation in most years, but many areas are managed without artificial drainage. Drainage ditches are generally used to improve drainage, but tile generally does not work well because suitable outlets are lacking. In places land grading is also used. Fertility and good tilth need to be maintained. If worked when wet, those soils that have a clayey surface layer tend to dry out cloddy and hard. At times fieldwork is delayed. Many farmers plow in fall to allow more timely

work in spring and to allow the freezing and thawing in winter to improve the tilth.

Corn responds well to applications of nitrogen and phosphorus, but the need for potassium is generally small. Applications of lime are not needed.

#### CAPABILITY UNIT IIIe-1

This unit consists of moderately sloping to strongly sloping, well drained and moderately well drained soils of the Knox, Marshall, Monona, Napier, and Terril series. The Knox, Marshall, and Monona soils formed in loess on upland ridges and side slopes, and the Napier and Terril soils formed in local alluvium. The Napier soil is in the narrow upland drainageways and on alluvial fans, and the Terril soil is on foot slopes and alluvial fans. These soils are subject to sheet and gully erosion. Some of these soils are moderately eroded or severely eroded, but others are only slightly eroded. The Terril and Napier soils are subject to rill and gully erosion because of the runoff that they receive from the adjacent uplands, and in some places silty sediment is deposited on the surface. Terraces, contour tillage, and grassed waterways are used to help control erosion. In places diversions are used to control water that runs across the Napier and Terril soils.

The soils in this unit have a surface layer of friable loam, silt loam, or silty clay loam, and a subsoil of similar texture.

Permeability is moderate. Napier soils have very high available water capacity, and the rest of the soils have high available water capacity. The content of organic matter ranges from high to very low. The soils are very low to medium in available nitrogen and phosphorus, and medium to high in available potassium. These soils are relatively fertile and easy to cultivate, but the severely eroded soils have poorer tilth and lower fertility than the other soils in this unit.

Most areas of these soils are cultivated, but a few, especially of Napier and Terril soils, are in pasture. Corn, oats, and meadow plants are the main crops. Soybeans are grown on the least sloping soils but are not often grown on the strongly sloping soils. If erosion is controlled, these soils are moderately well suited to row crops. For the strongly sloping soils, more close-growing crops should be included in the rotation system.

Crops respond well to applications of fertilizers. Corn responds well to applications of nitrogen and phosphorus, and meadow plants respond well to phosphorus. The need for potassium is small. In some areas application of lime is beneficial to crops. Practices that maintain or improve tilth and the organic-matter content of the moderately eroded and severely eroded soils are needed.

#### CAPABILITY UNIT IIIw-1

This unit consists of nearly level, poorly drained and very poorly drained soils of the Albaton, Blend, Luton, Nishna, Solomon, Woodbury, and Zook series. These soils are mainly on bottom lands along the Missouri River, but some are along tributary streams. These soils absorb rainfall slowly and they are poorly aerated. They warm up slowly in spring, and fieldwork is delayed by wetness. The seasonal water table is high and in some years crops are drowned out and must be replanted in some places. Most of the soils are difficult to work and puddle very easily. The surface layer generally becomes cloddy and

hard when dry, but a few of the soils that have a less fine textured surface layer are easier to till. Cracks in the surface are common in dry seasons. Some of the soils are subject to flooding.

The soils in this unit have a surface layer of silt loam to silty clay and clay. In some places the surface layer is very thick. Some of the soils are covered by 6 to 15 inches of silt loam or silty clay loam overwash. Most soils have a clayey subsoil or substratum but Blend and Woodbury soils have a subsoil or substratum that contains medium textured or moderately fine textured sediment.

Permeability is very slow to slow, and available water capacity is medium to high. Runoff is slow. The content of organic matter is low to high. The soils are medium to low in available nitrogen, very low or low in available phosphorus, but are low to high in potassium.

Most areas of the soils in this unit are cultivated, but some areas that are not drained are in pasture. Corn and soybeans are the main crops, but sorghum, wheat, and oats and hay are also grown. These soils are moderately well suited to row crops if drainage is adequate.

Many of these soils, especially those on bottom lands along the Missouri River, are drained by land grading and drainage ditches. Tile is used in a few places, mainly on bottom lands along tributary streams where outlets are available. The Zook soil is more often drained by tile than the other soils in this unit. In places levees are used to prevent flooding. The soils are often plowed in fall to improve timeliness of fieldwork in spring and to allow freezing and thawing in winter to improve the tilth. The power requirement for tilling the soils that have a surface layer of silty clay is high.

In some years, limited moisture reduces crop production. Excess water in spring limits root growth, and the crop cannot always get enough moisture from the soil during the summer. Irrigation is a possibility, but care is needed to avoid increasing wetness.

If excessive wetness is controlled, crops respond fairly well to nitrogen and phosphorus. The need for potassium is small. Albaton, Nishna, and Solomon soils are calcareous and do not need applications of lime, and the other soils seldom need lime.

#### CAPABILITY UNIT IIIe-1

This unit consists of nearly level to gently sloping or undulating, excessively drained soils of the Buckney and Carr series. These soils occupy slight rises on bottom lands along the Missouri River. The soils absorb rainfall readily, but they are droughty because generally they hold only a small amount for plant use. They warm up early in spring and can be worked soon after rains. Water erosion is not a serious hazard, but wind-blown sand can damage young crops.

The soils in this unit have a surface layer of very friable fine sandy loam that is underlain by very friable to loose, loamy very fine sand.

Permeability is moderate, and available water capacity is low. The content of organic matter is moderate to low. The soils are very low to low in available nitrogen and phosphorus and high in available potassium.

Most areas of these soils are cultivated, but some are in trees or pasture. Corn, sorghum, small grains, and alfalfa are grown. The soils are suited to row crops, but production is often reduced because of drought.

Droughtiness is the main limitation to the use of these soils. Maintaining the content of organic matter, maintaining fertility, and controlling soil blowing are the major management needs. Leaving the surface bare increases the risk of erosion and the damage to crops by blowing sand, but good management of residue helps to control soil blowing and prevent crop damage.

Applications of lime are not needed. The response to fertilizers depends largely on the available moisture, and the response to nitrogen and phosphorus is fairly good if moisture is adequate. The need for potassium is small.

These soils are well suited to irrigation and are in areas where water is available, but water may have to be applied fairly often.

#### CAPABILITY UNIT IIIe-2

This unit consists of strongly sloping, well-drained soils of the Dow and Ida series. These soils formed in loess on side slopes in the uplands. They are subject to erosion. Rills and gullies have formed in some places.

The more severely eroded soils in this unit have a very thin surface layer, or the present surface layer or plow layer is mostly material from below the original surface layer. The soils in this unit are friable silt loam throughout.

Permeability is moderate, and available water capacity is high. The content of organic matter is low to very low. The soils are very low in available nitrogen and in available phosphorus and medium to high in available potassium. They are low in natural fertility. Even though they are low in organic matter, tilth is good.

Most areas of these soils are cultivated, but many small areas near steeper soils are left in pasture. Corn, oats, and meadow plants are the major crops. Soybeans are not often grown on these sloping soils. These soils are moderately suited to row crops if erosion is controlled. In places gullies should be shaped and seeded. Terracing and tilling on the contour are the practices most used for controlling erosion.

Corn responds well to nitrogen and phosphorus fertilizers, but the need for potassium is generally small. Applications of phosphorus are important for meadow plants. Applications of lime are not needed. Additions of organic matter in the form of crop residues or barnyard manure are especially beneficial.

#### CAPABILITY UNIT IIIe-3

This unit consists of moderately sloping to strongly sloping, moderately well drained and somewhat poorly drained soils of the Adair, Malvern, and Shelby series. These soils are mainly on the lower part of side slopes, but they also are on some sloping upland ridges. The soils are subject to erosion, and all are moderately eroded. The hazard of erosion is more severe on the Shelby soils than on the other soils, because they are steeper. In many places in wet periods, narrow, seepy areas occur where the Adair and Malvern soils border the loess soils that are upslope, but in years when rainfall is normal, wetness is generally not a severe limitation.

These soils have a surface layer of friable silty clay loam, clay loam, or loam. The subsoil is firm to very firm silty clay, clay, or clay loam.

Permeability is slow to moderately slow, and available water capacity is high. Runoff is fairly rapid. The organic-

matter content is generally low to moderate. The soils are very low to low in available nitrogen and phosphorus and low to medium in available potassium.

Most areas of these soils are cultivated, but some are in permanent pasture. Corn, oats, and meadow plants are the main crops. Some very seepy areas of Adair and Malvern soils are better suited to meadow than to cultivated crops. These soils are moderately suited to row crops if erosion is controlled. On the Shelby soil, terraces and contour tillage are used to control erosion. But the clayey Malvern and Adair soils are not well suited to terraces. On these clayey soils, construction is difficult, areas where cuts are made into the clayey subsoil are difficult to till and vegetate, and in places irregular slopes hamper the layout and construction of terraces. Interceptor tile drains should be used in many places in the soils upslope from Adair and Malvern soils to reduce wetness and seepage, but only a few areas have been drained in this way.

The response of crops to fertilizer applications is fair to good. Phosphorus is important for meadow plants. Many areas should be limed. Tilth is poor in many places, and practices that increase the organic-matter content and improve tilth are needed.

#### CAPABILITY UNIT IVe-1

This unit consists of well drained and moderately well drained soils of the Castana, Ida, Knox, Monona, and Shelby series. These soils are mainly moderately steep and on side slopes, but the Castana soil is strongly sloping to moderately steep and is on foot slopes. The Shelby soil formed in glacial till, but the rest of the soils formed in loess.

The use of these soils is limited by their erodibility. Also, the soil moisture supply is often not at capacity because of the rapid runoff. Uncrossable gullies are present in places. In places the Shelby soil contains stones and pebbles that hinder tillage operations to some degree.

The soils in this unit have a surface layer of friable silt loam or loam and a subsoil or substratum of friable to firm silt loam, silty clay loam, or clay loam. Most of the soils are moderately permeable, but the Shelby soil is moderately slowly permeable. Available water capacity is high. The content of organic matter is moderate to very low. The soils are very low to low in available nitrogen and phosphorus, but are low to high in available potassium.

Many areas of these soils are cultivated or have been cultivated, but some are in permanent pasture. Corn is the major row crop. Soybeans are seldom planted. A few areas have trees but are generally managed as pasture. These soils are moderately well suited to row crops if erosion is controlled.

Terraces and contour tillage are generally used for controlling erosion. Many farmers leave these soils in hay or pasture most of the time and grow a row crop only when meadows need reseeding. In places gullies should be shaped and seeded for waterways.

Corn responds satisfactorily to applications of nitrogen and phosphorus. Phosphorus is important for meadow plants. The need for potassium is generally small, because available potassium is generally high. Applications of lime are not needed on the Castana and Ida soils but are needed on the other soils in places.

#### CAPABILITY UNIT IVe-1

This unit consists of stratified, excessively drained soils in the Sarpy series.

The soils in this unit have a surface layer of loose, loamy, fine sand and a loose, sandy substratum. Permeability is very rapid, and the available water capacity is low or very low. The organic matter content is very low. These soils are very low in available nitrogen and phosphorus and low in available potassium.

These soils are better suited to pasture plants or other close-growing vegetation than to other uses. Production of row crops is seldom satisfactory. Alfalfa is well suited because of its deep root system. Most areas are in native vegetation that includes trees and grass and are used for pasture. Some areas are suited to timber production if they are well managed. Some areas have a potential for wildlife habitat and recreational uses.

Droughtiness and soil blowing are the major limitations to the use of these soils. Blowing sand from these soils sometimes damages young seedlings as well as young plants on adjacent soils. Areas not protected by levees are subject to flooding. These soils can be cultivated soon after rains, and they warm up quickly in spring. Where small areas are farmed and used with other soils for cultivated crops, good management of crop residues helps to control soil blowing. Maintaining fertility is rather difficult because of rapid permeability.

Crop response to fertilizer is variable, depending on the moisture supply, but it is generally fair or poor, and using large amounts is not practical. Successful use of the soil for crops is dependent largely on the amount of rainfall received during the growing season.

#### CAPABILITY UNIT IVe-2

This unit consists of moderately sloping, moderately well drained and somewhat poorly drained soils of the Adair and Malvern series. These soils are on the lower part of side slopes on uplands.

The soils in this unit have a surface layer of friable to firm silty clay loam or clay loam and a subsoil of firm clay loam, clay, or silty clay. Permeability in the subsoil is slow, and available water capacity is high. The content of organic matter is moderate to low. The soils are very low to low in available nitrogen and phosphorus and low to medium in available potassium.

These soils are moderately suited to crops if wetness and erosion are controlled, but many areas are better suited to hay and pasture. Seedlings are difficult to establish in eroded areas.

These soils are seasonally wet because of seepage from more permeable soils upslope. Cultivated areas are susceptible to rather severe erosion because the rate of water intake is relatively slow and runoff is rapid. Tilth on the moderately eroded soils is often only fair or poor. Interceptor tile placed in the more permeable soils upslope will remove excess water and reduce seepage, but only a few areas have been drained in this manner in the county at the present time. Terraces are generally not constructed on these soils, because the clayey subsoil hinders construction, and the soils are difficult to vegetate. Contour tillage and terracing the soils upslope, which are better suited to terrace construction, helps to control erosion.

These soils commonly are in narrow bands within areas of more productive soils, and in places are used in the

same way as the adjoining soils, and row crops are grown more often than in other areas of these soils. Applications of fertilizer and lime are generally needed for satisfactory crop production.

#### CAPABILITY UNIT Vw-1

This unit consists only of nearly level Alluvial land. Alluvial land is near the river channel. Much of it is along the Missouri River, but some is along other streams.

Alluvial land ranges from sandy to clayey but is mostly sandy or loamy. Drainage ranges from excessive to poor, and permeability is rapid to slow. Available water capacity is generally low but is variable. The organic matter content is variable but generally is very low.

Alluvial land is flooded frequently. Depositions of varying texture accumulate each year. Unless flooding is controlled, artificial drainage provided, the land leveled, and stream channels straightened, this land is generally not suited to cultivation. Some areas are used for pasture. Most areas are in willows or other trees and brushy vegetation. Recreational uses and wildlife habitats are possible uses for many areas.

#### CAPABILITY UNIT VIe-1

This unit consists of steep, well drained and moderately well drained soils of the Ida, Monona, Shelby, and Steinauer series. These soils are on side slopes in the uplands and are mainly moderately eroded and severely eroded.

The soils in this unit have a surface layer of friable silt loam or loam and a subsoil of very friable to firm silt loam to clay loam. Permeability is moderate to moderately slow, and available water capacity is high. The content of organic matter is variable but is generally low or very low. The soils are very low to low in available nitrogen and phosphorus, but are low to high in available potassium.

Because of the steepness and the hazard of erosion, these soils are poorly suited to cultivated crops. They are better suited to hay or pasture plants, and most areas are presently in pasture. Some areas can be worked with farm machinery and are planted to grasses and legumes for more productive pasture, but many areas are too steep, irregular, or gullied to till. Steepness, severe erosion, and gullies are severe limitations to the use of these soils. Even though their capacity to hold water available for plants is high, these soils seldom hold as much water as they have the capacity for, because the water runs off rapidly.

Good grazing management is important in maintaining or increasing the forage in steep, irregular, and gullied areas. In some places gullies should be shaped and seeded. Where possible, fertilizing pastures is generally beneficial. Ida and Steinauer soils are calcareous and applications of lime are not needed, but applications may be needed on other soils.

#### CAPABILITY UNIT VIe-2

This unit consists of strongly sloping, moderately well drained and somewhat poorly drained soils of the Adair and Malvern series. These severely eroded soils are on side slopes in the uplands.

The soils in this unit have a surface layer of firm silty clay to clay loam and a subsoil of firm to very firm, silty clay or clay. The present surface layer is thin or, if it is a plow layer, it consists mostly of the original subsoil.

Permeability is slow, and available water capacity is high. The content of organic matter is low. The soils are very low to low in available nitrogen and phosphorus and low to medium in available potassium.

Many areas are cultivated, but some are in pasture. Because of erosion, low fertility, poor tilth, and seasonal wetness, these soils are better suited to hay or pasture plants than to row crops.

These soils are in poor tilth and are difficult to work and manage. Because these soils are in narrow bands, most areas are managed in the same way as other soils upslope or downslope. The surface tends to seal during rains, and runoff is generally rapid if the vegetation is sparse. The soils dry out hard and cloddy if tilled when wet. In spring a seepy area occurs in many places near the upslope border of these soils. Interceptor tile can be placed upslope to reduce wetness, but not much of this has been done. These soils are not well suited to terraces, because the clayey subsoil hinders construction and the soils are difficult to vegetate. Because of poor tilth and wetness, it is often difficult to seed these soils to pasture or hay plants. Applications of lime and fertilizers are generally beneficial in establishing stands and maintaining the growth of hay and pasture plants.

#### CAPABILITY UNIT VIIe-1

This unit consists of steep and very steep, well-drained soils of the Hamburg, Ida, and Napier series and Gullied land. These soils are on side slopes in the uplands. They are extremely erodible, and many areas are dry in mid-summer.

The Ida and Hamburg soils have a thin surface layer and are friable or very friable silt loam in texture throughout. They have moderate to moderately rapid permeability and high available water capacity. However, runoff is so rapid that the soils generally do not contain water to their capacity. The content of organic matter is low or very low. These soils are very low in available nitrogen and phosphorus and high in available potassium.

The Napier soils and Gullied land are silt loam in texture throughout, have moderate permeability, high available water capacity, and high organic-matter content.

These soils are not suited to cultivation and are poorly suited to pasture. Many areas are in permanent pasture or trees. Some areas are in native grasses. In many areas recreational uses and wildlife habitat are possible uses.

Steepness and deep gullies are severe limitations. Because of the steepness, water runs off rapidly. A protective cover of vegetation is needed to help control the erosion. Because of the trees, uncrossable gullies, or steepness, it is generally not possible to renovate pastures. Controlling grazing is important in maintaining the productivity of pasture. Controlling the formation or enlargement of gullies, such as those in the Napier-Gullied land complex or in other areas, is difficult and generally involves considerable earthmoving and expense. Some gullies can be shaped. Diverting water around gullies, terracing the soils upslope, and placing special retention structures in major channels to trap sediment and raise the level of stream bottoms are other methods used. The soils are not suited to commercial saw-log production, but the stands of timber have value in reducing losses of soil and water and in using the soils for recreational and wildlife areas.

CAPABILITY UNIT VIIw-1

This unit consists only of Marsh. Marsh is generally in depressions, around lakes and ponds, and in areas of intermittent water. The water table is at or near the surface throughout the year. Some areas of Marsh are man-made and some are natural. The natural vegetation consists of cattails, rushes, and other water-tolerant grasses.

Areas of Marsh are not used for crops. The surface water and the drainage are limiting factors. Some areas in and around the Riverton Wildlife Refuge and Forneys Lake were farmed, pastured, or in timber before the dikes were built and these areas were flooded.

Most areas are used for wildlife habitat. Areas of Marsh provide habitat and resting places for waterfowl, and hunting these is an important recreational activity in the county. Muskrat, mink, other mammals, and birds also find habitat in areas of Marsh.

CAPABILITY UNIT VIIb-1

This unit consists only of Riverwash, mainly near the main channel of the Missouri River. It is mainly sandbars that generally are not protected by levees. They are subject to frequent deposition of sand and frequent flooding.

Riverwash is sandy throughout. It has very low available water capacity and fertility. Areas are largely barren of vegetation, but willows and cottonwoods

grow rapidly. The principal use of Riverwash is wildlife habitat. Some areas have possibilities for development as recreational areas.

Predicted Yields

In table 2 the average acre yields of the principal crops are predicted for soils of the county under a high level of management. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of adapted varieties; erosion is controlled; the organic matter content and soil tilth are maintained; the level of fertility for each crop is maintained (as indicated by soil tests and field trials); the water level in wet soil is controlled; excellent control of weeds and pests is provided; and operations are timely.

The yield figures are based on estimates, using data from the Federal census, the Iowa census, data from experimental farms and from cooperative experiments with farmers, and the onfarm experience of soil scientists, extension workers, and others.

The yield predictions are meant to serve as guides. They are only approximate values, and this should be kept in mind. Of more value than actual yield figures to many users are the comparative yields of different soils. These relationships are likely to remain consistent over a period of years, but actual yields have been increasing in recent years.

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

[Dashes indicate the crop is not suited to the soil or is not ordinarily grown on it]

Mapping unit	Corn	Soybeans	Oats	Alfalfa-grass (for hay)	Pasture
	Bu.	Bu.	Bu.	Tons	Animal-unit-days <sup>1</sup>
Adair clay loam, 5 to 9 percent slopes, moderately eroded.....	65	25	42	3.0	150
Adair clay loam, 9 to 14 percent slopes.....	64	24	42	2.5	125
Adair clay loam, 9 to 14 percent slopes, moderately eroded.....	56	21	36	2.0	100
Adair soils, 9 to 14 percent slopes, severely eroded.....				2.0	100
Albaton silt loam.....	85	32	55	3.5	175
Albaton silty clay.....	80	30	52	3.0	150
Alluvial land.....					<sup>2</sup> 30
Blake silt loam.....	98	37	64	3.5	175
Blake silty clay loam.....	98	37	64	3.5	175
Blencoe silty clay.....	85	32	55	3.5	175
Blend silty clay.....	70	27	46	3.0	150
Buckney fine sandy loam, 1 to 3 percent slopes.....	75	28	49	2.5	125
Carr fine sandy loam, 1 to 3 percent slopes.....	75	29	49	3.0	150
Castana silt loam, 9 to 20 percent slopes.....	80	30	52	3.5	175
Colo silt loam, overwash.....	107	41	70	5.0	250
Colo silty clay loam.....	104	40	68	5.0	250
Colo-Judson silty clay loams, 2 to 5 percent slopes.....	108	41	70	5.0	250
Cooper loam.....	100	38	65	4.5	225
Cooper silty clay loam.....	98	37	64	4.5	225
Corley silt loam.....	91	35	59	3.5	175
Cott loam.....	80	30	52	2.5	125
Cott clay loam.....	88	33	57	2.5	125
Dockery silt loam.....	85	32	55	3.0	150
Dockery silty clay loam.....	106	40	69	3.5	175
Dow silt loam, 9 to 14 percent slopes.....	72	27	47	3.0	150
Grable silt loam.....	80	30	52	2.5	125
Hamburg silt loam, 40 to 75 percent slopes.....					<sup>2</sup> 30
Haynie silt loam.....	96	36	62	5.0	250
Ida silt loam, 9 to 14 percent slopes.....	74	28	48	3.0	150
Ida silt loam, 9 to 14 percent slopes, severely eroded.....	68	26	44	3.0	150
Ida silt loam, 14 to 20 percent slopes.....	59		39	2.5	125

See footnotes at end of table.

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

Mapping unit	Corn	Soybeans	Oats	Alfalfa-grass (for hay)	Pasture
	Bu.	Bu.	Bu.	Tons	Animal-unit-days <sup>1</sup>
Ida silt loam, 14 to 20 percent slopes, severely eroded	53		35	2.0	100
Ida silt loam, 20 to 30 percent slopes				1.5	75
Ida silt loam, 20 to 30 percent slopes, severely eroded				1.5	75
Ida silt loam, 30 to 40 percent slopes					<sup>2</sup> 50
Judson silty clay loam, 2 to 5 percent slopes	114	43	74	5.0	250
Keg silt loam	118	45	77	4.5	225
Kennebec silt loam	118	45	77	5.0	250
Kennebec silt loam, overwash	118	45	77	5.0	250
Knox silt loam, 5 to 14 percent slopes	87	33	57	4.0	200
Knox silt loam, 14 to 20 percent slopes	78		51	3.0	150
Lakeport silt loam, overwash	111	42	72	4.5	225
Lakeport silty clay loam	111	42	72	4.5	225
Luton silt loam, overwash	75	29	49	3.0	150
Luton silty clay loam	85	32	55	4.0	200
Luton silty clay	65	25	42	3.0	150
Malvern silty clay loam, 5 to 9 percent slopes, moderately eroded	80	30	52	3.0	150
Malvern silty clay loam, 9 to 14 percent slopes	76	29	49	2.5	125
Malvern silty clay loam, 9 to 14 percent slopes, moderately eroded	71	27	46	2.0	100
Malvern soils, 9 to 14 percent slopes, severely eroded				1.5	75
Marsh					
Marshall silty clay loam, 0 to 2 percent slopes	109	41	71	5.0	250
Marshall silty clay loam, benches, 0 to 2 percent slopes	109	41	71	5.0	250
Marshall silty clay loam, 2 to 5 percent slopes	107	41	70	5.0	250
Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	104	40	68	4.5	225
Marshall silty clay loam, benches, 2 to 5 percent slopes	107	41	70	5.0	250
Marshall silty clay loam, 5 to 9 percent slopes	102	39	66	4.5	225
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	99	38	65	4.5	225
Marshall silty clay loam, 9 to 14 percent slopes	93	35	60	4.2	210
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	90	34	58	4.0	200
Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	84	32	57	4.0	200
McPaul silt loam	98	37	64	4.5	225
Minden silty clay loam, benches	115	44	73	5.0	250
Modale silt loam	92	35	60	3.5	175
Monona silt loam, 0 to 2 percent slopes	104	40	68	4.8	250
Monona silt loam, 2 to 5 percent slopes	102	39	66	4.5	225
Monona silt loam, 5 to 9 percent slopes	97	38	63	4.0	200
Monona silt loam, 5 to 9 percent slopes, moderately eroded	94	36	61	4.0	200
Monona silt loam, 5 to 9 percent slopes, severely eroded	88	33	57	3.8	190
Monona silt loam, 9 to 14 percent slopes	88	33	57	3.8	190
Monona silt loam, 9 to 14 percent slopes, moderately eroded	85	32	55	3.8	190
Monona silt loam, 9 to 14 percent slopes, severely eroded	79	30	51	3.6	180
Monona silt loam, 14 to 20 percent slopes	76	30	49	3.0	150
Monona silt loam, 14 to 20 percent slopes, moderately eroded	70	28	45	3.0	150
Monona silt loam, 14 to 20 percent slopes, severely eroded	63	25	41	2.0	100
Monona silt loam, 20 to 30 percent slopes, moderately eroded				2.0	100
Moville silt loam	98	37	64	4.0	200
Napier silt loam, 2 to 5 percent slopes	105	40	68	4.0	200
Napier silt loam, 5 to 9 percent slopes	100	38	65	4.0	200
Napier-Gullied land complex, 2 to 10 percent slopes					<sup>2</sup> 15
Nevin silty clay loam	114	43	74	4.5	225
Nishna silt loam, overwash	85	32	55	3.5	175
Nishna silty clay	77	29	50	3.0	150
Nodaway silt loam	108	41	70	4.5	225
Onawa silt loam	100	38	65	4.0	200
Onawa silty clay	90	34	59	3.5	175
Percival silty clay	85	33	55	3.0	150
Riverwash					
Salix silty clay loam	114	43	74	4.5	225
Sarpy loamy fine sand, 1 to 3 percent slopes	25	10	16	1.0	50
Sarpy loamy fine sand, 3 to 7 percent slopes	25	10	16	1.0	50
Shelby loam, 9 to 14 percent slopes, moderately eroded	81	31	53	3.0	150
Shelby loam, 14 to 18 percent slopes, moderately eroded	66		43	2.5	125
Shelby loam, 18 to 25 percent slopes, moderately eroded				2.0	100
Solomon clay	60	23	39	3.0	150
Steinauer loam, 18 to 25 percent slopes				2.0	100
Terril loam, 3 to 8 percent slopes	107	41	70	4.0	200
Vore silty clay loam	93	35	61	4.0	200

See footnotes at end of table.

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

Mapping unit	Corn	Soybeans	Oats	Alfalfa-grass (for hay)	Pasture
	Bu.	Bu.	Bu.	Tons	Animal-unit-days <sup>1</sup>
Waubonsie fine sandy loam.....	82	31	53	3.5	175
Waubonsie silty clay loam.....	89	34	58	3.5	175
Woodbury silty clay.....	75	28	49	3.0	150
Zook silt loam, overwash.....	100	38	65	4.0	200
Zook silty clay loam.....	96	36	62	4.0	200
Zook silty clay.....	92	35	60	3.5	175

<sup>1</sup> Animal-unit-days is a term used to express the carrying capacity of pasture. On alfalfa-grass pasture, it is the number of days 1 acre can carry 1 animal unit during a single grazing season without injury to the sod. One animal unit is defined as 1 cow, 2 yearling calves, 1 horse, 7 sheep, or 4 brood sows. Each animal unit will consume an estimated 40 pounds of dry matter each day.

<sup>2</sup> Based on bluegrass.

### Woodland<sup>3</sup>

Approximately 31,000 acres, or about 9 percent of the county, is wooded. At the time of settlement, about 57,000 acres was in timber. Some native timber is still being cleared, but the acreage is not extensive. Large, wooded areas are now mainly on the steep soils just east of the Missouri River on bottom lands along the valleys of small streams and in steep areas adjacent to valleys of the other streams.

The uses of the soils for woodland, wildlife, and recreation are related in many ways. This section is of interest to those who are concerned with the preservation of areas not suited to crops or not well suited to pasture but that are suited to managed woodland, wildlife habitat, or for recreation.

Much of the natural forest in the county is in an area a few miles wide and adjacent to bottom lands along the Missouri River. Soils in this area are mainly steep or very steep Monona, Ida, and Hamburg soils. Apparently, the soils have not been forested long enough to markedly influence their characteristics. Other areas of forest are mainly in steep areas adjacent to other bottom lands, on bottom lands, and in upland drainageways. Knox soils are generally wooded. They have characteristics that reflect the influence of the forest vegetation on the soil profile. On the uplands the common trees are red oak, bur oak, hackberry, black walnut, and butternut. Some oak-hickory forests are near the eastern edge of the county. Trees common on the bottom lands are soft maple, boxelder, green ash, cottonwood, and willow.

Many farms have windbreaks, and some have small woodlots. The planting of trees and shrubs for windbreaks and landscaping has been a common practice in the county since the time of settlement. As the size of individual farm units has increased, many farmstead sites have been converted to crops or pasture. This generally involves some clearing of trees.

Most of the woodland areas in the county are used as timbered pasture, and little is managed only as woodland. Some walnut timber is about the only timber marketed. Very steep areas produce little feed and in many places provide little more than shade for livestock and wildlife.

<sup>3</sup> SYLVAN T. RUNKEL, biologist, Soil Conservation Service, helped prepare this section.

Proper management of areas suitable for use as woodland can increase the value of the land and increase the chance for profitable use.

The acreage of wooded areas has not changed significantly in recent years, but some clearing and conversion to cropland has taken place. Other than the small woodlots on former farmstead sites, the more recent conversions have been mainly on bottom lands, on ridgetops, and on some side slopes. In the uplands the Monona, Ida, or Knox soils are the ones generally cleared. On bottom lands the soils most often cleared are the Napier, Kennebec, Colo, Judson, and Nodaway soils. In a few areas, the Haynie or Onawa soils on bottom lands along the Missouri River are also cleared.

The small demand for timber of the quality and volume produced in the county accounts largely for the lack of acreage used as woodland. The farmers plant trees and shrubs chiefly for windbreaks or beautification. Several agencies in Iowa have programs that assist woodland owners in improving the quality of their product and that provide information on basic marketing practices. Further assistance in planning the management of woodlands may be obtained from the nearest office of the Soil Conservation Service and from foresters of the Iowa State Conservation Commission.

### Features affecting management

Tree growth is directly related to the capacity of the soil to supply moisture. A number of factors influence available moisture supply. These factors are slope, direction of exposure or aspect, soil depth, soil texture, permeability, and internal drainage. The moisture supply is somewhat limited on the very steep south- and west-facing slopes in the uplands. Some of the sandy soils on the bottom lands are also somewhat excessively drained.

Direction of exposure also directly affects the rate of tree growth. Trees generally grow better on slopes facing north or east than on slopes facing south and west.

Flooding and poor drainage limit tree growth on some of the bottom lands and alluvial land along the rivers.

In general, hardwoods do better than conifers on high-lime soils. The one exception is eastern redcedar. Pines seem to do reasonably well on the loess soils that have been leached of lime. These soils are mainly the Monona and Marshall soils.

### Management by woodland groups

The soils of Fremont County have been placed in seven woodland groups to assist landowners in planning the use of existing woodland and as a guide in selecting the kinds of trees to plant. In each group are soils that have about the same available water capacity and other characteristics that influence the growth of trees. These soils also have similar limitations and are subject to the same hazards when they are used for trees. The soils in one group support similar kinds of trees, have about the same potential productivity, and require similar kinds of management. Riverwash and Marsh are not suited to trees and were not placed in a woodland group.

Each group is briefly described, giving some of the main characteristics of the soils and existing conditions and hazards that affect trees and woodland crop production. Some suitable species for planting are listed for each group. Of those species listed as suitable for windbreaks, the conifers are especially suited to farmstead windbreaks, and the hardwoods are especially suited to field windbreaks. Among the other uses for which these species are suitable are veneer, lumber, windbreaks, and Christmas trees as well as wildlife habitat.

For most of the groups, the site index ratings for suitable trees are given. The site index is the total height, in feet, of the dominant and codominant trees in the stand at 50 years of age and shows potential productivity.

#### WOODLAND GROUP 1

This group consists of moderately well drained and well drained, medium textured to moderately fine textured, nearly level to moderately steep soils of the uplands and on benches. These soils are members of the Judson, Knox, Marshall, Mindens, Monona, Napier, Nevins, Shelby, and Terril series and of Gullied land. Permeability is moderate or moderately slow, and the available moisture capacity is high to very high. Erosion is a slight to moderate hazard. The main limitation to tree growth is a climate characterized by lack of adequate moisture.

The suitability of these soils is fair to good for hardwoods, good for conifers, and good or very good for cottonwood.<sup>4</sup> The average site index for upland hardwoods ranges from 46 to 55. Estimated production of timber from existing stands ranges from 100 to 150 board feet per acre per year.

Trees that should be favored in existing stands are green ash, hackberry, cottonwood, red oak, and white oak. Walnut should be favored in such sites as protected coves.

Trees most suitable for noncommercial, open-land planting or for wildlife or beautification are Scotch pine, European larch, eastern redcedar, and cottonwood. These trees and red oak, white oak, and basswood are also suitable for interplanting in existing stands. Walnut is suited to planting in coves occupied by Judson and Napier soils. Also suitable for wildlife plantings are ninebark, honeysuckle, dogwood, and wild plum.

Among the trees most suitable for windbreaks, the conifers are Scotch pine, eastern redcedar, Austrian pine, and ponderosa pine, and the hardwoods are Norway poplar, Siouland poplar, robusta poplar, green ash, Russian-olive, and hackberry.

<sup>4</sup> BRENDEMUEHL, RAY H., Growth, yield, and site requirements of Eastern cottonwood. 1957. Ph.D. thesis, Iowa State University, Ames.

#### WOODLAND GROUP 2

This group consists of well drained and moderately well drained, medium textured to moderately fine textured, steep soils of the uplands. Slopes face north and east. These soils are in the Monona and Shelby series. They have moderate or moderately slow permeability and high available moisture capacity. Erosion is a moderate hazard. The main limitation to tree growth is the lack of adequate moisture caused by climate and runoff.

The suitability of these soils is fair for hardwoods and good for conifers and cottonwood. The average site index for upland hardwoods ranges from 46 to 55. Estimated production of timber from existing stands ranges from 100 to 150 board feet per acre per year.

Trees that should be favored in existing stands of hardwoods are green ash, hackberry, cottonwood, red oak, and white oak. Walnut should be favored in protected coves and on similar sites.

Trees most suitable for noncommercial, open-land planting or for wildlife habitat or beautification are Scotch pine, European larch, eastern redcedar, and cottonwood. These trees and basswood, red oak, and white oak are also suitable for interplanting in existing stands. Also suitable for wildlife plantings are ninebark, honeysuckle, dogwood, and wild plum.

Among the trees most suitable for windbreaks, the conifers are Scotch pine, eastern redcedar, Austrian pine, and ponderosa pine, and the hardwoods are Norway poplar, Siouland poplar, robusta poplar, green ash, Russian-olive, and hackberry.

#### WOODLAND GROUP 3

This group consists of moderately well drained and well drained, medium textured to moderately fine textured, steep soils of the uplands. Slopes face south and southwest. These soils are in the Monona and Shelby series. They have moderate or moderately slow permeability and high available water capacity. The main limitation to tree growth is lack of adequate moisture caused by climate and runoff.

According to Brendemuehl (see footnote 4), the suitability of these soils is poor for hardwoods, fair for conifers, and good for cottonwood. The average site index for upland hardwoods is less than 45. Estimated production of timber from existing stands is less than 100 board feet per acre per year.

Trees that should be favored in existing stands are green ash, hackberry, cottonwood, red oak, and white oak. Walnut should be favored in coves.

Trees most suitable for noncommercial, open-land planting or for wildlife or beautification are Scotch pine, European larch, and eastern redcedar. These trees and basswood, red oak, and white oak are suitable for interplanting in existing stands. Also suitable for wildlife plantings is wild plum.

Among the trees most suitable for windbreaks, the conifers are eastern redcedar, ponderosa pine, and Austrian pine.

#### WOODLAND GROUP 4

This group consists of well-drained, medium-textured, strongly sloping to very steep, soils of the uplands. These soils are in the Castana, Dow, Hamburg, Ida, and Steinauer series. They generally have moderate permeability, but the Steinauer soil has moderately slow permeability.

Available moisture capacity is high. Erosion is a slight to severe hazard, depending on slope. The main limitation to tree growth is lack of adequate moisture caused by climate, runoff, and alkalinity.

The suitability of these soils is poor for hardwoods and conifers and fair for cottonwood. The average site index for hardwoods is less than 45. Estimated production of upland hardwoods on these soils is less than 100 board feet per acre per year.

Trees most suitable for wood crops are ponderosa pine, Austrian pine, Scotch pine, hackberry, cottonwood, and green ash.

Among the trees most suitable for windbreaks, the conifers are ponderosa pine, Austrian pine, Scotch pine, and the hardwoods are Norway poplar, Siouxland poplar, robusta poplar, green ash, hackberry, and Russian-olive.

Suitable for wildlife plantings are wild plum, honeysuckle, aromatic sumac, Russian-olive, and redcedar.

#### WOODLAND GROUP 5

This group consists of moderately well drained and somewhat poorly drained, moderately fine textured to fine textured, moderately sloping to strongly sloping soils of the uplands. These soils are in the Adair and Malvern series. They have slow permeability and high available water capacity. The main limitations to tree growth are the texture of the soil and the permeability.

The suitability of these soils is poor for hardwoods and conifers and fair for cottonwood. The average site index for the hardwood trees is less than 45. Estimated production of upland hardwoods on these soils is less than 100 board feet per year.

Among the trees most suitable for windbreaks, the conifers are eastern white pine, Scotch pine, eastern redcedar, and Norway spruce, and the hardwoods are Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry. Shrubs suitable for windbreaks are honeysuckle and dogwood. Windbreak site quality is poor.

Trees most suitable for planting for wildlife cover and beautification are eastern white pine, Scotch pine, eastern redcedar, Norway spruce, green ash, hackberry, red oak, and white oak.

#### WOODLAND GROUP 6

This group consists of excessively drained to somewhat poorly drained, coarse textured to moderately fine textured, nearly level soils. They are in the Blake, Buckney, Carr, Cott, Dockery, Grable, Haynie, Keg, Kennebec, McPaul, Modale, Nodaway, Salix, Sarpy, and Waubonsie series and Alluvial land. These soils are mainly on bottom lands. Most of these soils have moderate permeability and high available moisture capacity. The Buckney, Carr, Cott, Grable, and Sarpy soils, however, have more rapid permeability and lower available moisture capacity because of their sand content, but tree roots can generally reach the water table.

Suitability of these soils is generally fair for hardwoods, but fair to good for bottom-land hardwoods, and poor for conifers. Estimated production of bottom-land hardwoods and cottonwood ranges from 300 to 700 board feet per acre per year.

Trees that should be favored in existing stands are cottonwood, soft maple, green ash, and walnut, but these soils are not well suited to hardwoods or conifers. Walnut

can be grown on well-drained soils that have adequate available moisture capacity.

The trees most suitable for windbreaks are cottonwood, soft maple, and green ash. The quality of windbreak sites is high for cottonwood and soft maple.

#### WOODLAND GROUP 7

This group consists of poorly drained, medium-textured to fine-textured soils that are mainly on bottom lands. These soils are in the Albaton, Blencoe, Blend, Colo, Cooper, Corley, Judsons Lakeport, Luton, Merville, Nishna, Onawa, Percival, Solomon, Vore, Woodbury, and Zook series. Permeability ranges from moderate to very slow. The suitability of these soils for commercial wood crops is fair to poor.

Trees most suited to those soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry. Site suitability for these trees is good.

#### Wildlife <sup>5</sup>

Fremont County supports many kinds of wildlife that contribute to its income and recreational facilities. The kinds and numbers of wildlife that can be produced and maintained are determined largely by the kinds and amounts of plants that soils can produce and the distribution of these plants.

Topography affects wildlife mainly through its effect on land use. Nearly level to moderately sloping areas are often rather intensively cropped. This reduces the food and cover needed by many kinds of wildlife. Extremely rough, irregular areas may be a hazard to livestock and unsuited for crops. If these areas are left undisturbed, the plants are often valuable as food and cover for wildlife. Suitable vegetation can be provided where it is lacking, and these areas developed for desirable kinds of wildlife. Fertile soils are capable of supporting more wildlife than infertile soils. The wetness of soils and their available water capacity are important in selecting sites for ponds and in maintaining aquatic or semiaquatic habitats for wild fowl and some kinds of furbearing animals.

Because of its wildlife Fremont County provides many opportunities for recreation. Many kinds of wildlife are also beneficial because they feed on harmful insects and rodents.

Pheasant, quail, wild ducks, geese, cottontail rabbit, squirrel, and deer provide much of the hunting in the county. The distribution of pheasant, quail, and rabbit is probably greater in upland areas of the county, but they inhabit all areas. The number of pheasant and quail have increased in recent years. Deer find the food supply and cover that they most favor in the stream bottom lands and adjacent uplands. In Fremont County the Nodaway-Kennebec-Colo, Ida-Monona-Hamburg, and Haynie-Albaton-Onawa soil associations are most favorable for deer. Since public hunting has been allowed, the deer population has scattered somewhat and is now found, to some extent, in most parts of the county that have some suitable habitat. Squirrel are in all parts of the county where there are trees but are most numerous

<sup>5</sup> SYLVAN T. RUNKEL, biologist, Soil Conservation Service, helped prepare this section.

in the Ida-Monona-Hamburg soil association. The number of opossum, raccoon, weasel, woodchuck, badger, fox, coyote, and skunk vary throughout the county.

Muskrat, mink, beaver, and other furbearers are along streams and in marsh areas. Soil associations 3, 7, 8, and 9 are most favorable for these furbearers, but they are also along streams in other associations.

Fish, mainly catfish, bullhead, and carp, are fairly numerous in the major streams. There are many private ponds and water impounded by road and watershed structures that provide fishing for bass, bluegill, crappie, and catfish.

Areas in soil associations 3, 7, 8, and 9 are feeding grounds for several hundred thousand wild duck and geese on migratory flights in spring and fall. These birds are hunted extensively. Manmade lakes and marshes as well as natural marshes furnish resting areas for these and other migratory waterfowl.

Many areas that cannot be used for crops are well suited to habitat for useful wildlife, and on most farms, areas of little economic value for other uses can be developed for that purpose. Adair, Hamburg, Ida, Malvern, Napier, Sarpy, Shelby, and Steinauer soils and gullied land are most likely to have these kinds of areas. Also suitable as wildlife habitat are small, steep, or eroded parts of cropped fields, railroad rights-of-way, or tracts cut off from the rest of a field by a stream or drainage ditch. Even on soils that are suitable for crops, wildlife can be produced as a primary or secondary crop for income or for recreational purposes.

## Recreation <sup>6</sup>

Because of the character of the soils and the topography, Fremont County is suitable for many recreational facilities. The rolling topography of the uplands, particularly of the Monona and the Ida-Monona-Hamburg soil associations, is well suited to park development. Some of the marsh areas in the associations on bottom lands are well suited for the development of wetland wildlife areas. The Missouri River offers a potential for those who are interested in boating and fishing.

Several parks have been developed in the uplands. The most prominent is Waubonsie State Park. This park has facilities for camping, for picnicking, and for hiking and horseback riding. It is in the Ida-Monona-Hamburg soil association south of Sidney on Iowa Highway 2. Pinkeys Glen, also in this association, was developed for picnicking by the County Conservation Board. It is just west of Tabor. Manti Park, in the Marshall association, is a picnic and fishing area. A Girl Scout Camp has been developed in a sizable area south of Waubonsie State Park.

Numerous marsh areas on bottom lands have been developed both by the Conservation Commission and by private groups. The Riverton area and the area around Forney Lake have been developed as areas for migratory waterfowl, and some public hunting is allowed. There are numerous private areas on the flood plains of the Nishnabotna River and Missouri River that are leased for hunting by private groups. Access to the Missouri River for boating

and fishing is somewhat limited, but plans indicate that it will be expanded.

On bottom lands, especially along the Missouri River and other major streams, are resting and feeding areas for hundreds of thousands of blue geese, snow geese, and Canada geese. These waterfowl use these areas each fall and spring. Many people travel great distances each year to see this concentration of waterfowl.

Fishing is an important recreational activity on the Missouri and Nishnabotna Rivers, private ponds, and along road and watershed structures that impound water.

## Engineering Uses of the Soils

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 highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degree 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.

The information in this survey can be helpful to those who—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, or other construction materials.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that will be useful in designing and maintaining specified engineering practices and structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

Most of the information in this section is presented in tables. Table 3 shows several estimated soil properties

<sup>6</sup> SYLVAN T. RUNKEL, biologist, Soil Conservation Service, helped prepare this section.

significant to engineering; table 4 shows interpretations for various engineering uses; and table 5 shows results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 3, 4, and 5, and it also can be used to make other useful maps.

This information, however, does not eliminate the 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 6 feet. Also, inspection of sites, especially the small ones, is needed because many mapped areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitability 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 classification systems**

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (17) used by the SCS engineers, Department of Defense, and others, and the AASHO system (1) adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML-CL.

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups 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 5. The estimated classification, also with group index numbers, is given in table 3 for all soils mapped in the survey area.

### **Soil properties significant to engineering**

Several estimated soil properties significant in engineering are given in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. 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 3. Depth to bedrock was not included because the soils in Fremont County are so deep to bedrock that it does not generally affect their use.

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

The USDA soil texture is described in table 3 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "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, 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.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 3 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

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

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is 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. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

### **Engineering interpretations of soils**

The estimated interpretations in table 4 are based on the engineering properties of soils shown in table 3, 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 Fremont County.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties are generally favorable for the rated use, or that limitations are minor and are 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 that major soil reclamation and special designs are needed. For some uses, the rating of severe is divided to obtain ratings of severe and very severe. *Very severe* means one or more soil properties so unfavorable for a

TABLE 3.—*Estimated soil*

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

Series name and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Adair: 192C2, 192D, 192D2, 192D3	<i>Feet</i> (1)	<i>Inches</i> 0-11	Clay loam	CL	A-6(8-12)
		11-21	Clay loam	CL	A-6(8) to A-7-6(14)
		21-40	Clay	CL or CH	A-7-6 (17-20)
		40-50	Clay loam	CL	A-6(8) to A-7-6(14)
Albaton:					
156	1-3	0-50	Silty clay	CH	A-7-6(20)
157	1-3	0-10	Silt loam	ML or ML-CL	A-4(6) to A-6(12)
		10-50	Silty clay	CH	A-7-6(20)
Alluvial land: 315	1-3				
Properties too variable to be estimated. Subject to flooding.					
Blake:					
144	2-4	0-20	Silty clay loam	ML-CL or CL	A-7-6(14-19)
		20-50	Silt loam	ML or CL	A-4(6-8) or A-6(8-12)
844	2-4	0-12	Silt loam	ML or ML-CL	A-4(6) to A-6(12)
		12-24	Silty clay loam	ML-CL or CL	A-7-6 (14-19)
		24-50	Silt loam	ML or CL	A-4(6-8) or A-6(8-12)
Blencoe: 44	1-3	0-28	Silty clay	OH or CH	A-7-5(20) or A-7-6(20)
		28-32	Silty clay loam	CL or CH	A-7-6(14-18)
		32-54	Silt loam	ML or CL	A-4(6-8) or A-6(8-12)
Blend: 244	1-3	0-14	Silty clay	OH or CH	A-7-6(16-20)
		14-22	Silt loam	ML-CL or CL	A-4(8) or A-6(8-12)
		22-52	Clay	CH	A-7-6(20)
Buckney: 636	4-6	0-13	Fine sandy loam	SM	A-2-4(0) to A-4(4)
		13-54	Loamy very fine sand	SM	A-2-4(0)
Carr: 538	3-6	0-16	Fine sandy loam	SM, SC, or ML-CL	A-2 or A-4(0-4)
		16-60	Loamy very fine sand	SM or SP-SM	A-2 or A-3(0)
Castana: 3E	>5	0-12	Silt loam	ML or CL	A-4(6-8) or A-6(8-12)
		12-50	Silt loam	ML or CL	A-4(6-8) or A-6(8-12)
*Colo:					
11B	1-3	36-50	Silty clay loam	CH or CL	A-7-6(14-20)
For Judson part of 11B, see Judson series.					
133	1-3	0-36	Silty clay loam	OH, CH, or CL	A-7-5 or A-7-6(16-20)
Subject to flooding.					
133+	1-3	0-12	Silt loam	ML or CL	A-6(8) to A-7-6(12)
Subject to flooding.					
		12-36	Silty clay loam	OH, CH, or CL	A-7-5 or A-7-6(16-20)
		36-50	Silty clay loam	CH or CL	A-7-6(14-20)
Cooper:					
255	1-3	0-7	Silty clay loam	OL, ML, or CL	A-7-5 or A-7-6(10-14)
		7-20	Loam and sandy clay loam	CL	A-6(6-12)
		20-50	Silty clay and clay	CH	A-7-6(20)
437	1-3	0-24	Loam	ML or CO	A-4 or A-6(6-10)
		24-50	Silty clay	CH	A-7-6(20)

See footnote at end of table.

*properties significant to engineering*

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

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
95-100	80-95	60-80	<i>Inches per hour</i> 0.2-0.63	<i>Inches per inch of soil</i> 0.16-0.18	<i>pH value</i> 6.1-6.5	Moderate.
95-100	80-95	55-80	0.2-0.63	0.16-0.18	6.1-6.5	Moderate.
95-100	80-100	65-90	0.06-0.2	0.12-0.14	6.1-6.5	High.
95-100	80-95	55-80	0.2-0.63	0.14-0.16	6.1-6.5	Moderate.
100	100	95-100	<0.2	0.13-0.15	7.4-7.8	High.
100	100	85-100	0.63-2.0	0.18-0.20	7.4-8.4	Moderate.
100	100	95-100	<0.2	0.13-0.15	7.4-7.8	High.
100	100	95-100	0.2-0.63	0.18-0.20	7.9-8.4	Moderate to high.
100	100	90-100	0.63-6.3	0.17-0.19	7.9-8.4	Moderate.
100	100	90-100	0.63-2.0	0.18-0.20	7.4-8.4	Low.
100	100	95-100	0.2-0.63	0.18-0.20	7.9-8.4	Moderate to high.
100	100	90-100	0.63-6.3	0.17-0.19	7.9-8.4	Moderate.
100	100	95-100	<0.06	0.16-0.18	6.6-7.3	High.
100	100	90-100	0.2-0.63	0.18-0.20	6.6-7.3	Moderate to high.
100	100	85-100	0.63-2.0	0.19-0.21	7.9-8.4	Moderate.
100	100	95-100	<0.06	0.16-0.18	6.6-7.3	High.
100	100	85-100	0.63-2.0	0.19-0.21	7.9-8.4	Moderate.
100	100	95-100	<0.06	0.11-0.13	6.6-8.4	High.
100	100	30-50	2.0-6.3	0.13-0.15	6.6-7.3	Low.
100	100	20-35	6.3-20.0	0.06-0.08	7.4-8.4	Low.
100	100	25-55	2.0-6.3	0.11-0.13	7.4-7.8	Low.
100	100	5-30	6.3-20.0	0.06-0.08	7.4-7.8	Low.
100	100	95-100	0.63-2.0	0.20-0.22	7.9-8.4	Low to moderate.
100	100	95-100	0.63-2.0	0.17-0.19	7.9-8.4	Low to moderate.
100	100	85-100	0.2-0.63	0.17-0.19	6.6-7.3	High.
100	100	90-100	0.2-0.63	0.20-0.22	6.1-7.3	High.
100	100	85-100	0.63-2.0	0.18-0.20	6.6-7.3	Low to moderate.
100	100	85-100	0.2-0.63	0.20-0.22	6.6-7.3	High.
100	100	85-100	0.2-0.63	0.17-0.19	6.6-7.3	High.
100	100	95-100	0.2-0.63	0.19-0.21	6.1-6.5	Moderate.
100	100	50-75	0.63-2.0	0.13-0.15	6.1-7.8	Moderate.
100	100	95-100	<0.20	0.13-0.15	6.6-8.4	High.
100	100	60-85	0.63-2.0	0.16-0.18	6.1-7.8	Moderate.
100	100	95-100	<0.20	0.13-0.15	6.6-8.4	High.

TABLE 3.—Estimated soil properties

Series name and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Corley: 233..... Subject to ponding.	<i>Feet</i> 0-2	<i>Inches</i> 0-18 18-60	Silt loam..... Silty clay loam.....	ML, CL, or OL CL or CH	A-6(8-12) or A-7-6(10-14) A-7-6(16-18)
Cott: 447.....	>4	0-18 18-31 31-50	Loam..... Loam and very fine sandy loam. Loamy fine sand and fine sand.	ML or ML-CL SM or ML-CL SM, SP-SM	A-4(4-6) A-2-4(0) to A-4(4) A-2-4(0) or A-3-0
448.....	2-4	0-13 13-30 30-50	Clay loam..... Loam..... Fine sand.....	ML or ML-CL SM or ML-CL SM or SP	A-4(6) to A-6(12) A-2-4(0) to A-4(6) A-2-4(0) or A-3(0)
Dockery: 820..... Subject to flooding.	1-3	0-58	Silt loam.....	ML or CL	A-6(6) to A-7-6(12)
821..... Subject to flooding.	1-3	0-8 8-58	Silty clay loam..... Silt loam.....	CL ML or CL	A-6(8) to A-7-6(12) A-6(6) to A-7-6(12)
Dow: 22D.....	>5	0-10 10-50	Silt loam..... Silt loam.....	ML-CL or CL ML-CL or CL	A-4(6-8) or A-6(8-10) A-4(6-8) or A-6(8-10)
Grable: 514.....	>4	0-24 24-58	Silt loam..... Loamy fine sand.....	ML SM or SP-SM	A-4(4) to A-6(12) A-3(0) or A-2-4(0)
Gullied land. Mapped only with Napier soils. Proper- ties too variable to be estimated.					
Hamburg: 2G.....	>5	0-54	Silt loam.....	ML or ML-CL	A-4(4) to A-6(10)
Haynie: 137.....	3-5	0-50	Silt loam.....	ML or ML-CL	A-4(4) to A-6(12)
Ida: 1D, 1D3, 1E, 1E3, 1F, 1F3, 1G.....	>5	0-50	Silt loam.....	ML or CL	A-4(8) to A-6(10)
Judson: 8B.....	>4	0-32 32-50	Silty clay loam..... Silty clay loam and heavy silt loam.	CL or OL CL	A-6(9) to A-7-6(13) A-6(10) to A-7-6(12)
Keg: 46.....	>5	0-23 23-50	Silt loam..... Silt loam.....	ML-CL or CL ML or CL	A-6(8-12) or A-7-6(10-14) A-6(8-12)
Kennbec: 212, 212+..... Subject to flooding.	3-5	0-54	Silt loam.....	OL or CL	A-6(8-12) or A-7-6(10-14)
Knox: 268D, 268E.....	>5	0-18 18-52 52-60	Silt loam..... Silty clay loam..... Silt loam.....	ML or CL ML-CL or CL CL or ML-CL	A-4(6) to A-6(13) A-7-6(12-16) A-6(10-13)
Lakeport: 436.....	2-4	0-24	Silty clay loam.....	OH, CH, or CL	A-7-5 or A-7-6(16- 20)
436+.....	2-4	24-55 0-12 12-50	Silty clay loam..... Silt loam..... Silty clay loam.....	CH or CL ML-CL or CL CH or CL	A-7-6(13-20) A-4(6) to A-6(12) A-7-6(14-19)
Luton: 66.....	0-3	0-28 28-54	Silty clay..... Silty clay.....	CH or OH CH	A-7-6(20) A-7-6(20)
66+.....	1-3	0-14 14-50	Silt loam..... Silty clay.....	ML-CL or CL CH	A-4(6) to A-6(12) A-7-6(20)
366.....	0-3	0-14 14-26 26-50	Silty clay loam..... Silty clay..... Silty clay.....	OH, CH, or CL CH CH	A-7-6(14-19) A-7-6(20) A-7-6(20)

See footnote at end of table.

significant to engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
100	100	95-100	<i>Inches per hour</i> 0.63-2.0	<i>Inches per inch of soil</i> 0.19-0.21	<i>pH value</i> 6.6-7.3	Moderate.
100	100	95-100	0.2-0.63	0.16-0.18	6.6-7.3	High.
100	100	70-80	0.63-2.0	0.18-0.20	6.6-7.3	Moderate.
100	100	30-55	2.0-6.3	0.13-0.15	7.4-8.4	Low.
100	100	5-30	6.3-20.0	0.03-0.05	7.4-8.4	Low.
100	100	70-80	0.63-2.0	0.17-0.19	6.6-7.3	Moderate.
100	100	30-60	2.0-6.3	0.16-0.18	7.4-7.8	Low.
100	100	3-20	6.3-20.0	0.03-0.05	7.9-8.4	Low.
100	100	85-100	0.63-2.0	0.18-0.20	6.6-7.3	Moderate.
100	100	85-100	0.63-2.0	0.19-0.21	6.6-7.3	Moderate.
100	100	85-100	0.63-2.0	0.18-0.20	6.6-7.3	Moderate.
100	100	95-100	0.63-2.0	0.19-0.21	6.6-7.3	Low.
100	100	95-100	0.63-2.0	0.18-0.20	7.4-8.4	Low.
100	100	80-95	0.63-2.0	0.18-0.20	7.9-8.4	Low.
100	100	5-30	6.3-20.0	0.05-0.07	7.9-8.4	Low.
100	100	95-100	2.0-6.3	0.16-0.18	7.4-8.4	Low.
100	100	70-100	0.63-2.0	0.17-0.19	7.9-8.4	Low.
100	100	95-100	0.63-2.0	0.17-0.19	7.4-7.4	Low.
100	100	95-100	0.63-2.0	0.21-0.23	6.1-7.3	Moderate.
100	100	95-100	0.63-2.0	0.18-0.20	6.1-6.5	Moderate.
100	100	95-100	0.63-2.0	0.20-0.22	6.6-7.8	Moderate.
100	100	90-100	0.63-2.0	0.17-0.19	7.4-8.4	Moderate.
100	100	90-100	0.63-2.0	0.20-0.22	6.6-7.3	Moderate.
100	100	95-100	0.63-2.0	0.20-0.22	5.6-7.3	Moderate.
100	100	95-100	0.63-2.0	0.18-0.20	5.6-7.3	Moderate.
100	100	95-100	0.63-2.0	0.17-0.19	6.1-6.5	Moderate.
100	100	95-100	0.2-2.0	0.20-0.22	6.1-6.5	High.
100	100	95-100	0.2-2.0	0.18-0.20	6.6-7.3	High.
100	100	90-100	0.63-2.0	0.19-0.21	6.6-7.8	Low to moderate.
100	100	95-100	0.2-2.0	0.18-0.20	6.6-7.3	High.
100	100	95-100	< 0.06	0.14-0.16	6.6-7.8	High.
100	100	95-100	< 0.06	0.13-0.15	7.4-8.4	High.
100	100	90-100	0.63-2.0	0.20-0.22	7.4-8.4	Low to moderate.
100	100	95-100	< 0.06	0.13-0.15	6.6-8.4	High.
100	100	95-100	0.2-0.63	0.20-0.22	6.1-7.3	High.
100	100	95-100	< 0.06	0.13-0.15	6.6-7.3	High.
100	100	95-100	< 0.06	0.13-0.15	6.6-8.4	High.

TABLE 3.—Estimated soil properties

Series name and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Malvern: 60C2, 60D, 60D2, 60D3-----	Feet >5	Inches 0-16 16-54	Silty clay loam----- Silty clay-----	ML-CL or CL CH	A-7-6(13-17) A-7-6(20)
Marsh: 354. Subject to flooding and to ponding. Properties too variable to be estimated. Soil material is generally highly organic.					
Marshall: 9A, 9B, 9B2, 9C, 9C2, 9D, 9D2, 9D3, T9A, T9B.	>5	0-12 12-38 38-50	Silty clay loam----- Silty clay loam----- Light silty clay loam to silt loam.	ML-CL or CL CL or CH ML-CL or CL	A-6(11) to A-7-6(10-13) A-7-6(12-18) A-7-6(10-16)
McPaul: 70----- Subject to flooding.	3-5	0-50	Silt loam-----	ML or CL or ML-CL	A-4(6) to A-6(8-12)
Minden: T299-----	2-4	0-22 22-41 41-50	Silty clay loam----- Silty clay loam----- Silt loam to silty clay loam.	OL, ML-CL, or CL CL or CH ML-CL or CL	A-7-6(10-14) A-7-6(12-18) A-7-6(10-14)
Modale: 149-----	1-3	0-18 18-58	Silt loam to very fine sandy loam. Silty clay-----	ML-CL or ML CH	A-4(4) to A-6(12) A-7-6(20)
Monona: 10A, 10B, 10C, 10C2, 10C3, 10D, 10D2, 10D3, 10E, 10E2, 10E3, 10F2.	>5	0-16 16-34 34-50	Silt loam----- Silt loam----- Silt loam-----	ML or CL ML or CL ML or CL	A-7-6(10-15) A-7-6(10-15) A-6(8-12) to A-7-6(10-14)
Moville: 275----- Subject to flooding.	1-3	0-26 26-54	Silt loam----- Silty clay and clay-----	ML or CL CH or OH	A-4(6) to A-6(12) A-7-6(20)
*Napier: 12B, 12C, 717C----- For Gullied land part of 717C, see Gullied land.	>5	0-29 29-50	Silt loam----- Silt loam-----	OL or CL ML-CL or CL	A-6(8-12) or A-7-6(10-13) A-6(8-12) or A-7-6(10-13)
Nevine: 88-----	2-4	0-16 16-38 38-50	Silty clay loam----- Silty clay loam----- Silty clay loam-----	CL or OL CL or CH CL	A-6(9) to A-7-6(14) A-7-6(12-18) A-6(10) to A-7-6(16)
Nishna: 234+-----	1-3	0-12 12-36	Silt loam----- Silty clay-----	ML or CL CH	A-6(8) to A-7-6(12) A-7-6(16-20)
234-----	1-3	0-36 36-50	Silty clay----- Silty clay-----	CH CH	A-7-6(16-20) A-7-6(16-20)
Nodaway: 220----- Subject to flooding.	3-5	0-50	Silt loam-----	ML-CL or CL	A-4(6) to A-6(10)
Onawa: 145-----	1-3	0-12 12-24 24-48	Silt loam----- Silty clay----- Loam to very fine sandy loam.	ML or ML-CL CH ML-CL	A-4(8) to A-6(12) A-7-6(20) A-4(2-8) to A-6(8-12)
146-----	1-3	0-22 22-50	Silty clay----- Loam to very fine sandy loam.	CH ML or ML-CL	A-7-6(20) A-4(2-8) to A-6(8-12)
Percival: 515-----	1-3	0-17 17-50	Silty clay----- Loamy fine sand-----	CH SM	A-7-6(20) A-2-4(0)

See footnote at end of table.

significant to engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
100 100	100 100	95-100 95-100	<i>Inches per hour</i> 0.20-0.63 <0.2	<i>Inches per inch of soil</i> 0.19-0.21 0.13-0.15	<i>pH value</i> 5.6-6.5 6.1-7.3	Moderate to high. High.
100	100	95-100	0.63-2.0	0.20-0.22	5.6-6.5	Moderate.
100 100	100 100	95-100 95-100	0.63-2.0 0.63-2.0	0.18-0.20 0.18-0.20	6.1-6.5 6.1-6.5	Moderate to high. Moderate.
100	100	95-100	0.63-2.0	0.18-0.20	7.4-7.8	Moderate.
100	100	95-100	0.63-2.0	0.20-0.22	6.6-7.3	Moderate.
100 100	100 100	95-100 95-100	0.63-2.0 0.63-2.0	0.18-0.20 0.18-0.20	6.6-7.3 6.6-7.3	Moderate to high. Moderate.
100	100	70-90	0.63-2.0	0.20-0.22	7.4-7.8	Low.
100	100	95-100	<0.2	0.13-0.15	7.4-7.8	High.
100 100 100	100 100 100	95-100 95-100 95-100	0.63-2.0 0.63-2.0 0.63-2.0	0.21-0.23 0.18-0.20 0.18-0.20	5.6-6.5 6.1-7.3 6.6-7.3	Moderate. Moderate. Moderate.
100 100	100 100	90-100 95-100	0.63-2.0 <0.6	0.18-0.20 0.13-0.15	7.4-7.8 6.6-8.4	Moderate. High.
100	100	95-100	0.63-2.0	0.22-0.24	6.1-7.3	Moderate.
100	100	95-100	0.63-2.0	0.19-0.21	6.6-7.3	Moderate.
100 100 100	100 100 100	90-100 90-100 90-100	0.63-2.0 0.2-2.0 0.63-2.0	0.21-0.23 0.18-0.20 0.17-0.19	6.1-7.3 6.1-7.3 6.6-7.3	Moderate or high. High. Moderate or high.
100 100 100 100	100 100 100 100	85-100 85-100 90-100 90-100	0.63-2.0 0.06-0.20 0.06-0.20 0.06-0.20	0.18-0.20 0.15-0.17 0.16-0.18 0.15-0.17	6.6-7.3 7.4-8.4 6.6-8.4 7.9-8.4	Low to moderate. High. High. High.
100	100	90-100	0.63-2.0	0.18-0.20	6.6-7.3	Moderate.
100 100 100	100 100 100	90-100 95-100 60-90	0.63-2.0 <0.20 0.63-6.3	0.17-0.19 0.13-0.15 0.15-0.17	7.4-8.4 7.4-7.8 7.4-7.8	Low. High. Low.
100 100	100 100	95-100 60-90	0.06-0.20 0.63-6.3	0.13-0.15 0.15-0.17	6.6-7.8 7.4-7.8	High. Low.
100 100	100 100	95-100 12-30	0.06-0.20 6.3-20.0	0.16-0.18 0.05-0.07	7.9-8.4 7.9-8.4	High. Low.

TABLE 3.—Estimated soil properties

Series name and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Riverwash: 53. Properties too variable to be estimated. Subject to flooding. Soil material is generally sandy or gravelly.	<i>Feet</i>	<i>Inches</i>			
Salix: 36 .....	3-5	0-13 13-19 19-60	Silty clay loam..... Silty clay loam..... Silt loam .....	OL, CL, or CH ML-CL or CL ML-CL or CL	A-7-6(12-18) A-6(8) to A-7-6(14) A-6(8-12)
Sarpy: 237A, 237B.....	>5	0-9 9-50	Loamy fine sand..... Fine sand .....	SM or SP-SM SM or SP-SM	A-2-4(0) or A-3(0) A-2-4 or A-3(0)
Shelby: 24D2, 24E2, 24F2.....	>5	0-12 12-52	Loam and clay loam... Clay loam.....	CL CL	A-6(8) to A-7-6(16) A-6(8) to A-7-6(16)
Solomon: 466.....	0-3	0-13 13-70	Silty clay and clay.... Silty clay and clay....	CH or OH CH	A-7-6(20) A-7-6(20)
Steinauer: 33F.....	>5	0-13 13-50	Loam and clay loam... Clay loam.....	CL CL	A-6(8) to A-7-6(14) A-6(8) to A-7-6(14)
Terril: 27C.....	>5	0-24 24-55	Loam..... Loam and light clay loam.	OL or CL CL	A-6(5) to A-7-6(10) A-6(8-12)
Vore: 516.....	1-3	0-22 22-50	Silty clay loam..... Loamy fine sand and fine sand.	CL or CH SM or SP-SM	A-7-6(15-20) A-2-4(0) or A-3(0)
Waubonsie: 49.....	1-3	0-21	Fine sandy loam and loamy very fine sand.	SM	A-2-4(0) to A-4(4)
449.....	1-3	21-50 0-12 12-24 24-50	Silty clay..... Silty clay loam..... Fine sandy loam..... Silty clay.....	CH ML-CL or CL SM or SC CH	A-7-6(20) A-7-6(14-18) A-2-4(0) to A-4(4) A-7-6(20)
Woodbury: 67.....	1-3	0-16 16-34 34-54	Silty clay..... Silty clay and clay.... Clay loam.....	CH or OH CH CL or CH	A-7-6(20) A-7-6(20) A-6(10) to A-7-6(16)
Zook: 54..... Subject to flooding.	1-3	0-20	Silty clay loam.....	OH or CH	A-7-6(15-20) or A-7-5(15-20)
54+..... Subject to flooding.	1-3	20-53 0-12	Silty clay..... Silt loam .....	CH ML or CL	A-7-6(20) A-6(8) to A-7-6(12)
134..... Subject to flooding.	1-3	12-30 30-48 0-23 23-60	Silty clay..... Silty clay..... Silty clay..... Silty clay.....	CH CH CH or OH CH	A-7-6(16-20) A-7-6(16-20) A-7-5 or A-7-6(16-20) A-7-6(20)

<sup>1</sup> Soils seasonally wet because of seepage from more permeable soils upslope.

significant to engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
			<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH value</i>	
100	100	95-100	0.63-2.0	0.20-0.22	6.1-7.3	Moderate or high.
100	100	95-100	0.63-2.0	0.19-0.21	6.6-7.3	Moderate or high.
100	100	90-100	0.63-2.0	0.18-0.20	7.4-8.4	Moderate.
100	100	5-30	6.3-20.0	0.07-0.09	7.4-7.8	Low.
100	100	5-35	>20.0	0.03-0.05	7.4-7.8	Low.
95-100	80-95	55-70	0.63-2.0	0.17-0.19	6.1-7.3	Moderate.
90-100	80-95	55-70	0.2-0.63	0.15-0.17	6.1-7.3	Moderate.
100	100	95-100	<0.06	0.14-0.16	7.9-8.4	High.
100	100	95-100	<0.06	0.13-0.15	7.9-8.4	High.
95-100	80-95	55-75	0.63-2.0	0.17-0.19	7.9-8.4	Moderate.
95-100	80-95	55-75	0.2-0.63	0.15-0.17	7.9-8.4	Moderate.
100	90-100	60-80	0.63-2.0	0.18-0.20	6.1-7.3	Moderate.
100	90-100	60-80	0.63-2.0	0.16-0.18	6.1-7.3	Moderate.
100	100	90-100	0.20-0.63	0.18-0.20	7.9-8.4	Moderate to high.
100	100	5-35	6.3-20.3	0.04-0.06	7.9-8.4	Low.
100	100	30-50	2.0-6.3	0.11-0.13	7.4-8.4	Low.
100	100	95-100	<0.2	0.13-0.15	7.4-7.8	High.
100	100	95-100	0.2-0.63	0.18-0.20	7.4-8.4	Moderate to high.
100	100	30-50	2.0-6.3	0.11-0.13	7.4-8.4	Low.
100	100	95-100	<0.2	0.13-0.15	7.4-7.8	High.
100	100	95-100	<0.2	0.14-0.16	6.6-7.8	High.
100	100	90-100	<0.2	0.13-0.15	7.4-7.8	High.
100	100	70-80	0.2-2.0	0.16-0.18	7.9-8.4	Moderate.
100	100	90-100	0.20-0.63	0.18-0.20	6.6-7.3	High.
100	100	90-100	0.06-0.20	0.15-0.17	6.6-7.8	High.
100	100	90-100	0.63-2.0	0.19-0.21	6.6-7.3	Moderate.
100	100	95-100	0.06-0.20	0.16-0.18	6.6-7.3	High.
100	100	95-100	0.06-0.20	0.15-0.17	6.6-7.3	High.
100	100	90-100	0.06-0.20	0.16-0.18	6.6-7.3	High.
100	100	90-100	0.06-0.20	0.15-0.17	6.6-7.3	High.

TABLE 4.—*Engineering interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Adair: 192C2, 192D, 192D2, 192D3.....	Poor: thin layer of suitable material.	Not suitable....	Not suitable....	Very poor in subsoil: high shrink-swell potential; fair or good in substratum.	Rolling topography; seasonal seepage can be expected in cuts; difficult to vegetate.	Slight compressibility; seepy and wet in many places; high shrink-swell potential.
Albaton: 156, 157.....	Poor in 156: silty clay surface layer. Good in 157: silt loam surface layer.	Not suitable....	Not suitable....	Very poor: poor bearing capacity; high shrink-swell potential; very clayey.	Nearly level; seasonal high water table; very plastic soil material.	Poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; unprotected areas are subject to flooding.
Alluvial land: 315.....	Poor to good: variable soil materials; onsite investigation needed.	Not suitable....	Not suitable....	Poor to good: frequent high water table; onsite investigation needed.	Subject to flooding; high water table; roadbeds must be raised above level reached by floodwater; possible settlement.	Subject to flooding; high water table.
Blake: 144, 844.....	Fair in 144: silty clay loam surface layer. Good in 844: silt loam surface layer.	Not suitable....	Not suitable....	Fair to poor: fair to poor bearing capacity; fair to poor workability and compaction characteristics.	Nearly level; plastic soil material in the upper part.	Fair to poor bearing capacity; medium to high compressibility; fair resistance to piping; seasonal high water table; unprotected areas are subject to flooding.
Blencoe: 44.....	Poor: high clay content.	Not suitable....	Not suitable....	Very poor: clayey and high organic-matter content to a depth of about 2 feet; high shrink-swell potential to a depth of about 3 feet.	Seasonal high water table; poor source of embankment material.	Seasonal high water table; poor bearing capacity and shear strength; subject to flooding in a few places.
Blend: 244.....	Poor: high clay content.	Not suitable....	Not suitable....	Very poor: very clayey; fair to poor bearing capacity; high shrink-swell potential.	Nearly level; seasonal high water table; poor foundation for high fills.	Seasonal high water table; fair to poor bearing capacity; high shrink-swell potential; subject to flooding in a few places.
Buckney: 636.....	Fair: moderate organic-matter content; moderately coarse texture.	Fair to poor in substratum: fine grained; poorly graded.	Not suitable....	Good: good to fair bearing capacity; low compressibility; low shrink-swell potential.	Good borrow potential; nearly level; erodible.	Good to fair bearing capacity; low shrink-swell potential; susceptible to piping.

See footnote at end of table.

*of soils*

different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Farm ponds		Soil features that affect suitability for—Continued					Degree and kind of limitation for—	
Reservoir area	Embankment	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields	
Very slow permeability if compacted; easily compacted.	Fair or good stability; shrink-swell potential is high in subsoil, but moderate below; good for impervious cores.	Seasonal wetness caused by seepage; interceptor tile placed up-slope helps reduce wetness.	High available water capacity; slow intake rate; subject to runoff and erosion.	Subsoil unfavorable for crop growth and difficult to vegetate; channels likely to be seepy and wet.	Seepy and wet in many places; subsoil unfavorable for crop growth and difficult to vegetate.	Moderate where slopes are less than 9 percent. Severe where slopes are more than 9 percent.	Severe: slow permeability.	
Very slow to slow permeability; seasonal high water table; nearly level.	Fair stability where level; poor compaction characteristics; generally not used because of unfavorable position.	Very slowly to slowly permeable.	Medium available water capacity; intake rate varies with the amount of vertical cracking.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: very slow to slow permeability; seasonal high water table; unprotected areas are subject to flooding.	Severe: very slow to slow permeability.	
Many sites too porous to hold water; nearly level.	Onsite investigation needed, generally not used because of unfavorable position.	Subject to flooding; soil features variable.	Soil features favorable; subject to flooding.	Nearly level bottom land.	Nearly level bottom land.	Severe: variable but generally rapid permeability; high water table; subject to flooding.	Severe: high water table; subject to flooding.	
Nearly level; moderate to moderately rapid permeability in the lower part.	Fair stability; fair to poor workability; generally not used because of unfavorable position.	Generally not needed; moderate to moderately rapidly permeable below a depth of about 2 feet.	High available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Slight or moderate unless subject to flooding; moderately slow permeability in the upper part.	Slight or moderate unless subject to flooding; moderate to moderately rapid permeability below a depth of about 2 feet; seasonal high water table.	
Nearly level; moderate permeability in substratum.	Fair to poor stability; medium to high compressibility; the underlying silt loam has poor resistance to piping; generally not used because of unfavorable position.	Very slow permeability in upper part, moderate permeability in lower part; outlets for tile lacking in many places.	High available water capacity; intake rate varies with the amount of vertical cracking in the clayey material.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: high organic-matter content; very slow permeability to a depth of about 2 feet; seasonal high water table; subject to flooding in a few places.	Severe: seasonal high water table; moderate permeability in the substratum.	
Nearly level; very slow permeability.	Fair to poor stability; poor compaction characteristics; generally not used because of unfavorable position.	Very slow permeability.	Medium to high available water capacity; intake rate varies with the amount of vertical cracking.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: high organic-matter content; seasonal high water table; very slow permeability except for silt loam layer.	Severe: very slow permeability; seasonal high water table.	
Nearly level; rapid permeability.	Fair stability; pervious when compacted; subject to piping; generally not used because of unfavorable position.	Not needed; excessively drained.	Low available water capacity; rapid water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability.	Slight: poor filtering materials; rapid permeability; danger of pollution.	

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Carr: 538.....	Fair: low organic-matter content; droughty.	Fair to good; poorly graded.	Not suitable....	Good: good bearing capacity; low compressibility; low shrink-swell potential.	Good borrow potential; nearly level; erodible in embankments.	Low compressibility; fair shear strength; good to fair bearing capacity; low shrink-swell potential; susceptible to piping; unprotected areas are subject to flooding.
Castana: 3E.....	Good: medium texture.	Not suitable....	Not suitable....	Fair to poor: low bearing capacity when wet; narrow range of moisture content for good compaction.	Strongly sloping to moderately steep; highly erodible in ditches and gutters; subject to gullyng.	Poor bearing capacity; receives runoff; poor resistance to piping.
*Colo: 11B, 133, 133+..... For Judson part of 11B, see Judson series.	Fair to good: high in organic-matter content; moderately fine texture; overwash (where present) is medium textured but low in organic-matter content.	Not suitable....	Not suitable....	Very poor: poor bearing capacity and shear strength; seasonal high water table; highly compressible; high in organic-matter content to a depth of 3 feet or more.	Seasonal high water table; subject to flooding; poor foundation for high fills.	Seasonal high water table; subject to flooding; high compressibility with uneven consolidation; high shrink-swell potential.
Cooper: 255, 437.....	Good for loam soil. Fair for silty clay loam: high organic-matter content.	Not suitable....	Not suitable....	Very poor: seasonal high water table; material below a depth of about 2 feet is very plastic.	Nearly level; seasonal high water table; high organic-matter content in surface layer; very poor source of borrow.	Seasonal high water table; high shrink-swell potential; poor bearing capacity.
Corley: 233.....	Good: subject to ponding and wetness.	Not suitable....	Not suitable....	Poor: seasonal high water table; subject to ponding; fair to poor bearing capacity; fair to poor compaction characteristics.	Subject to ponding after heavy rains; seasonal high water table.	Seasonal high water table; subject to ponding after heavy rains; fair to poor bearing capacity and shear strength.
Cott: 447, 448.....	Good for loam soil. Fair for clay loam: moderate organic-matter content.	Not suitable....	Not suitable....	Fair in the upper part. Good in the underlying sandy material: underlying material is erodible in embankments.	Nearly level; fair borrow potential.	Fair bearing capacity; low shrink-swell potential; poor resistance to piping.
Dockery: 820, 821.....	Good: medium textured to moderately fine textured; low organic-matter content.	Not suitable....	Not suitable....	Poor to fair: fair to poor bearing capacity and shear strength; difficult to compact to high density.	Nearly level; subject to flooding; frequent change in foundation support where old channels are present.	Poor bearing capacity; high compressibility; subject to flooding in unprotected areas; seasonal high water table.
Dow: 22D.....	Fair: low organic-matter content.	Not suitable....	Not suitable....	Fair: fair to poor bearing capacity and shear strength; medium compressibility; narrow range of moisture content for satisfactory compaction.	Very erodible; rolling topography.	Fair to poor bearing capacity; medium to high compressibility; low shrink-swell potential.

See footnote at end of table.

of soils—Continued

Soil features that affect suitability for—Continued						Degree and kind of limitation for—	
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Nearly level; rapid permeability.	Fair stability; pervious when compacted; susceptible to piping; not used because of unfavorable position.	Not needed; excessively drained.	Low available water capacity; rapid water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability.	Slight unless subject to flooding; rapid permeability; poor filtering material; danger of pollution.
Moderate permeability if uncompacted.	Fair to poor stability; difficult to compact to high density; poor resistance to piping.	Not needed; well drained.	High available water capacity; medium intake rate; slopes and unfavorable position limit potential.	Soil features favorable; gullies hinder construction in places.	Subject to erosion in waterway channels; gullies hinder construction in places.	Severe: strongly sloping to moderately steep; receives runoff; moderate permeability.	Severe: where slopes are more than 9 percent.
Nearly level; moderately slow permeability; high in organic-matter content.	High in content of organic-matter to a depth of 3 feet or more; high shrink-swell potential; difficult to compact.	Moderately slow permeability; outlets difficult to obtain in places; subject to overflow.	Medium water intake rate; high available water capacity; generally subject to flooding.	Nearly level bottom land.	Nearly level bottom land.	Severe: subject to flooding; high in organic-matter content; seasonal high water table.	Severe: seasonal high water table; subject to flooding; moderately slow permeability.
Nearly level; slow or very slow permeability in the substratum.	Fair stability; impervious when compacted; high shrink-swell potential; generally not used because of unfavorable position.	Seasonal high water table; slow to very slow permeability in the substratum.	High available water capacity; water intake rate is medium in upper part but slow in substratum.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: high organic-matter content; slow or very slow permeability in the substratum; seasonal high water table.	Severe: seasonal high water table; slow to very slow permeability in the substratum.
Depressions; moderately slow permeability in the subsoil.	Seasonal high water table; subject to ponding; not used because of unfavorable position.	Moderately slow permeability; subject to ponding of surface water.	High available water capacity; medium intake rate; subject to ponding.	Depressions.....	Depressions.....	Moderate: moderately slow permeability; high organic-matter content; seasonal high water table.	Severe: seasonal high water table; subject to ponding after heavy rains.
Nearly level; rapid permeability in substratum.	Poor stability; poor resistance to piping; erodible where exposed on embankments; generally not used because of unfavorable position.	Not needed; moderately well drained.	Low available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability in underlying sand.	Slight or moderate: rapid permeability in the underlying sand; risk of pollution.
Nearly level; moderate permeability when uncompacted.	Fair stability; difficult to compact to high density; poor resistance to piping.	Subject to flooding; moderate permeability; outlets for tile lacking in many places.	High available water capacity; medium water intake rate; subject to flooding.	Nearly level bottom land.	Nearly level bottom land.	Severe: subject to flooding; seasonal high water table; moderate permeability.	Severe: subject to flooding; seasonal high water table.
Strongly sloping; moderate permeability when uncompacted.	Fair to poor stability; difficult to compact to high density; generally poor resistance to piping; erodible.	Not needed; well drained.	Strongly sloping; high available water capacity; highly erodible.	Soil features favorable for construction; low fertility.	Highly erodible; low fertility.	Severe: slopes are more than 9 percent; moderate permeability.	Severe: slopes are more than 9 percent; moderate permeability.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Grable: 514.....  Gullied land. Mapped only with Napier soils. Properties too variable for reliable evaluation for most uses.	Good: low organic-matter content.	Fair to poor in substratum: fine grained; poorly graded.	Not suitable....	Fair to good: fair bearing capacity; narrow range of moisture content for satisfactory compaction; low shrink-swell potential; erodible where exposed on embankments.	Nearly level; fair to good borrow potential.	Fair bearing capacity; low shrink-swell potential; susceptible to piping; unprotected areas are subject to flooding.
Hamburg: 2G.....	Fair: very low organic-matter content; low fertility.	Not suitable....	Not suitable....	Fair: fair bearing capacity; narrow range of moisture content for satisfactory compaction; very erodible where exposed on embankments.	Very steep; need for cuts and fills in many places; very erodible in cuts and on embankments; low shrink-swell potential.	Fair to poor bearing capacity; medium to high compressibility; poor resistance to liquefaction and piping.
Haynie: 137.....	Good: low organic-matter content.	Not suitable....	Not suitable....	Fair to poor: fair to poor bearing capacity; narrow range of moisture content for satisfactory compaction; low shrink-swell potential; very erodible.	Exposed backslopes are very erodible.	Fair to poor bearing capacity; low shrink-swell potential; poor resistance to piping; unprotected areas are subject to flooding.
Ida: 1D, 1D3, 1E, 1E3, 1F, 1F3, 1G.....	Fair to good: low to very low organic-matter content; low fertility.	Not suitable....	Not suitable....	Fair: fair to poor bearing capacity; narrow range of moisture content for satisfactory compaction; medium compressibility; low shrink-swell potential.	Strongly sloping to steep; very erodible on backslopes and in ditches.	Fair to poor bearing capacity and shear strength; medium compressibility; poor resistance to piping.
Judson: 8B.....	Good: thick layer of material that has high organic-matter content.	Not suitable....	Not suitable....	Poor: high in organic-matter content in the upper 2 or 3 feet; fair to poor bearing capacity; difficult to compact.	Gently sloping foot slopes and alluvial fans; subject to flooding by runoff in places; low borrow potential; high organic-matter content.	Fair to poor bearing capacity; high compressibility with possible uneven consolidation; some areas subject to concentration of runoff.
Keg: 46.....	Good: medium texture; moderate organic-matter content.	Not suitable....	Not suitable....	Fair to poor: fair to poor bearing capacity; moderate shrink-swell potential.	Nearly level; exposed backslopes are very erodible.	Fair to poor bearing capacity; medium to high compressibility; poor resistance to piping; moderate shrink-swell potential.
Kennebec: 212, 212+.....	Good: a thick layer that has high organic-matter content.	Not suitable....	Not suitable....	Poor: high in organic-matter content in the upper 2 to 3 feet; poor bearing capacity; high compressibility.	Nearly level; high in organic-matter content; subject to flooding; poor foundation for high fills.	Poor bearing capacity; high compressibility with possible uneven consolidation; subject to flooding.

See footnote at end of table.

of soils—Continued

Soil features that affect suitability for—Continued					Degree and kind of limitation for—		
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Nearly level; substratum is rapidly permeable.	Poor stability; poor resistance to piping; erodible when exposed on embankments; not ordinarily used because of position.	Not needed; well drained to somewhat excessively drained.	Medium to low available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability.	Slight: rapid permeability in underlying material; danger of pollution.
Very steep; moderately rapid permeability.	Poor stability; poor resistance to piping; very erodible; narrow range of moisture content for satisfactory compaction.	Not needed; somewhat excessively drained.	Slopes generally too steep for cultivation.	Slopes generally too steep for terrace construction.	Slopes are too steep for waterway construction.	Severe: very steep slopes.	Severe: very steep slopes.
Nearly level; moderate permeability.	Poor stability; narrow range of moisture content for satisfactory compaction; poor resistance to piping; generally not used because of unfavorable position; very erodible.	Not needed; well drained to moderately well drained.	High available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Moderate: moderate permeability; subject to piping. Severe if subject to flooding.	Slight: moderate permeability.
Strongly sloping to steep; moderate permeability if uncompacted.	Generally poor stability; narrow range of moisture content for satisfactory compaction; poor resistance to liquefaction and piping.	Not needed; well drained.	High available water capacity; medium intake rate; subject to runoff and erosion; low fertility.	Features favorable for construction; low fertility hinders vegetation.	Very erodible; low fertility hinders vegetation.	Severe: slopes too steep; moderate permeability.	Severe: slopes are more than 9 percent; moderate permeability.
Moderate permeability if uncompacted; high organic-matter content.	Fair stability; high compressibility; high in organic-matter content; difficult to compact.	Drainage seldom needed; well drained to moderately well drained; moderate permeability.	Very high available water capacity; medium water intake rate.	Soil features favorable for construction and vegetation.	Soil features favorable for construction and vegetation.	Moderate: subject to runoff; high in organic-matter content; moderate permeability.	Slight: moderate permeability.
Nearly level; moderate permeability.	Poor stability; erodible if exposed on embankments; generally not used because of unfavorable position.	Not needed; well drained to moderately well drained.	High available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Moderate: moderate permeability.	Slight: moderate permeability.
Nearly level; high organic-matter content; moderate permeability if uncompacted.	High organic-matter content; high compressibility; poor embankment foundation.	Most areas do not need drainage; moderately well drained.	Very high available water capacity; medium water intake rate; subject to flooding.	Nearly level bottom land.	Nearly level bottom land.	Severe: moderate permeability; subject to flooding.	Severe: moderate permeability; subject to flooding.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Knox: 268D, 268E.....	Good in thin surface layer that had appreciable organic-matter content. Fair below the surface layer.	Not suitable....	Not suitable....	Fair: fair to poor bearing capacity and shear strength; moderate shrink-swell potential.	Strongly sloping to moderately steep; seepy in some deep cuts; fair source of borrow.	Fair to poor bearing capacity; medium to high compressibility; moderate shrink-swell potential.
Lakeport: 436, 436+.....	Fair: moderately fine texture. Good where overwash is present.	Not suitable....	Not suitable....	Very poor: poor bearing capacity and shear strength; high organic-matter content to a depth of about 2 feet; seasonal high water table.	Nearly level; seasonal high water table; very poor source of borrow.	Seasonal high water table; fair to poor bearing capacity.
Luton: 66, 66+, 366.....	Poor: high clay content. Good where overwash is present.	Not suitable....	Not suitable....	Very poor: high organic-matter content; high shrink-swell potential; very clayey.	Seasonal high water table; poor foundation for high fills; very poor source of borrow.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; subject to flooding in some areas.
Malvern: 60C2, 60D, 60D2, 60D3.....	Fair to poor: thin layer of suitable material where eroded.	Not suitable....	Not suitable....	Poor: high clay content; high shrink-swell potential.	Moderately to strongly sloping; high moisture content in some cuts; very poor source of borrow.	Fair to poor bearing capacity and shear strength; high shrink-swell potential.
Marsh: 354.....	Not suitable: covered with water or very wet most of the time.	Not suitable....	Not suitable....	Not suitable: covered with water or very wet most of the time; highly organic.	Covered with water or very wet most of the time; poor foundation for embankments.	Covered with water or very wet most of the time.
Marshall: 9A, 9B, 9B2, 9C, 9C2, 9D, 9D2, 9D3, T9A, T9B.....	Good in surface layer. Fair in subsoil: moderately fine texture.	Not suitable....	Not suitable....	Fair: fair to poor bearing capacity and shear strength; fair workability and compaction characteristics; medium or high compressibility.	Nearly level to strongly sloping; high moisture content in some deep cuts.	Fair to poor bearing capacity and shear strength; medium to high compressibility.
McPaul: 70.....	Good: low organic-matter content.	Not suitable....	Not suitable....	Fair to poor: fair to poor bearing capacity; narrow range of moisture content for satisfactory compaction.	Nearly level; some areas subject to flooding.	Fair to poor bearing capacity; medium to high compressibility; occasional seasonal high water table; some areas subject to flooding.
Minden: T299.....	Good in surface layer. Fair in subsoil: moderately fine-textured.	Not suitable....	Not suitable....	Fair to poor: fair to poor bearing capacity and shear strength; medium or high compressibility; high in organic-matter content to a depth of about 1½ feet.	Nearly level; high organic-matter content in surface layer; occasional high water table.	Fair to poor bearing capacity and shear strength; occasional high water table.

See footnote at end of table.

of soil—Continued

Soil features that affect suitability for—Continued					Degree and kind of limitation for—		
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Moderate permeability if uncompacted.	Fair stability; difficult to compact to high density; moderate shrink-swell potential.	Not needed; well drained.	High available water capacity; medium water intake rate; sloping soils subject to erosion.	Soil features favorable.	Soil features favorable.	Moderate where slopes are 5 to 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Moderate where slopes are 5 to 9 percent. Severe where slopes are more than 9 percent: moderately permeable.
Nearly level; moderate to moderately slow permeability.	High in organic-matter content to a depth of about 2 feet; generally not used because of unfavorable position.	Moderately slow to moderate permeability.	High available water capacity; medium water intake rate.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: moderately slow or moderate permeability; high organic-matter content; seasonal high water table.	Severe: seasonal high water table; moderately slow to moderate permeability.
Nearly level; very slow permeability.	Fair to poor stability; poor compaction characteristics; high compressibility; generally not used because of unfavorable position.	Very slow permeability.	Medium available water capacity; water intake rate varies with the amount of vertical cracking.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: some areas subject to flooding; very slow permeability; seasonal high water table; high organic-matter content.	Severe: very slow permeability; seasonal high water table.
Reservoir areas seldom wholly within this soil, slowly permeable.	Fair to poor stability; impervious when compacted; high shrink-swell potential.	Wetness caused by seepage and slow permeability.	High available water capacity; highly erodible; slow water intake rate.	Clayey subsoil; subsoil is low in fertility; seasonally seepy.	Waterways generally are not on this soil; low fertility in the subsoil.	Moderate where slopes are 5 to 9 percent. Severe where slopes are more than 9 percent: slow permeability.	Severe: slow permeability.
Flat or depression; covered with water or very wet most of the time.	Covered with water or very wet most of the time; generally highly organic.	Not practical in many places because outlets are lacking.	Not farmland.....	Covered with water most of the time; flat or depression.	Covered with water or very wet most of the time; flat or depression.	Very severe: high in organic-matter content; water table at or near surface most of the time.	Severe: water table at or near surface most of the time.
Moderate permeability if uncompacted; uniform materials.	Fair stability; fair workability and compaction characteristics.	Not needed; well drained.	High available water capacity; medium water intake rate; subject to erosion on slopes.	Soil features are favorable.	Soil features are favorable.	Moderate where slopes are less than 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Moderate where slopes are less than 9 percent. Severe where slopes are more than 9 percent: moderately permeable.
Nearly level; moderate permeability.	Fair to poor stability; difficult to compact to high density.	Drainage generally not needed; well drained to moderately well drained.	High available water capacity; nearly level; medium water intake rate.	Nearly level bottom land.	Soil features favorable; seldom needed.	Severe: some areas subject to flooding; moderate permeability.	Moderate or severe: occasional high water table; moderate permeability; some areas subject to flooding.
Nearly level; moderate permeability.	Fair to poor stability; seldom used because of position.	Moderate permeability.	High available water capacity; medium water intake rate.	Nearly level.....	Soil features are favorable.	Moderate: moderate permeability.	Moderate: occasional high water table; moderate permeability.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Modale: 149.....	Good: low organic-matter content.	Not suitable....	Not suitable....	Fair in upper part but very poor in silty clay below; fair to poor bearing capacity; high shrink-swell potential in the silty clay.	Nearly level; very poor source of borrow material below a depth of about 1½ or 2 feet.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; occasional high water table; unprotected areas are subject to flooding.
Monona: 10A, 10B, 10C, 10C2, 10C3, 10D, 10D2, 10D3, 10E, 10E2, 10E3, 10F2.	Good: severely eroded soils are low in organic-matter content, and the surface layer is thin.	Not suitable....	Not suitable....	Fair: fair to poor bearing capacity and shear strength; narrow range of moisture content for satisfactory compaction; moderate shrink-swell potential.	Nearly level to steep slopes; erodible in gutters and on exposed slopes.	Fair to poor bearing capacity and shear strength; medium to high compressibility; fair to poor resistance to liquefaction and piping.
Moville: 275.....	Good: low organic-matter content.	Not suitable....	Not suitable....	Fair to a depth of about 2 feet, but very poor below: underlying silty clay or clay has high shrink-swell potential.	Nearly level; poor source of borrow material.	Fair to poor bearing capacity; poor shear strength; very high shrink-swell potential below a depth of about 2 feet; seasonal high water table; high compressibility; some hazard of flooding.
Napier: 12B, 12C, 717C.....	Good: thick surface layer is high in organic-matter content.	Not suitable....	Not suitable....	Poor: high in organic-matter content to a depth of 2 feet or more; poor bearing capacity; difficult to compact to high density.	Poor source of borrow; poor foundation for high fills; severe gully-ing in gullied land part of 717C.	Poor bearing capacity; high compressibility and uneven consolidation; subject to runoff.
Nevin: 88.....	Good: high in organic-matter content to a depth of about 1½ or 2 feet.	Not suitable....	Not suitable....	Poor: poor bearing capacity; moderate or high shrink-swell potential; high in organic-matter content to a depth of about 1½ to 2 feet.	Nearly level; seasonal high water table; high organic-matter content.	High compressibility; poor bearing capacity; seasonal high water table.
Nishna: 234, 234+.....	Poor: high clay content. Good where overwash is present.	Not suitable....	Not suitable....	Very poor: high shrink-swell potential; poor bearing capacity; high compressibility; seasonal high water table.	High organic-matter content; seasonal high water table; poor foundation for high fills.	Poor bearing capacity and shear strength; high shrink-swell potential; high compressibility with uneven consolidation; subject to flooding in places.
Nodaway: 220.....	Good: low in organic-matter content.	Not suitable....	Not suitable....	Poor: poor bearing capacity and shear strength; difficult to compact to high density.	Nearly level; subject to flooding; frequent change in foundation support where old channels are present.	Poor bearing capacity; high compressibility; subject to flooding where unprotected; occasional high water table.

See footnote at end of table.

of soils—Continued

Soil features that affect suitability for—Continued					Degree and kind of limitation for—		
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Nearly level; very slow to slow permeability in underlying silty clay.	Very clayey material that has high shrink-swell potential below a depth of about ½ to 2 feet; generally not used because of unfavorable position.	Generally not needed; very slow to slow permeability in the underlying silty clay.	High available water capacity; water intake rate is medium in the silt loam but slow in material below.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: moderate permeability in upper part, very slow or slow below; seasonal high water table; unprotected areas are subject to flooding.	Severe: very slow or slow permeability in substratum.
Moderate permeability if uncompacted.	Fair stability; narrow range of moisture content for satisfactory compaction; fair to poor resistance to liquefaction and piping.	Not needed; well drained.	High available water capacity; sloping soils are subject to runoff and erosion.	Soil features favorable.	Soil features favorable; erodible.	Moderate where slopes are less than 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Slight where slopes are less than 5 percent. Moderate where slopes are 5 to 9 percent. Severe where slopes are more than 9 percent: moderate permeability.
Nearly level; very slow permeability in the underlying silty clay or clay.	Very clayey material that has high shrink-swell potential below a depth of about 2 feet; poor stability; high compressibility.	Very slow permeability in underlying material.	High available water capacity; water intake rate is medium in the silt loam, but slow below.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: seasonal high water table; moderate permeability in upper part, very slow below; some hazard of flooding.	Severe: very slow permeability below a depth of 2 feet.
Moderate permeability if uncompacted; severe gullyng in Gullied land part of 717C.	High in organic-matter content to a depth of 2 feet or more, difficult to compact to high density; high compressibility with uneven consolidation.	Not needed; well drained.	High available water capacity; medium water intake rate; subject to runoff and severe erosion and gullyng.	Soil features favorable.	Soil features favorable; severe gullyng in Gullied land part of 717C.	Moderate or severe: moderate permeability; subject to runoff of short duration; severe gullyng in Gullied land part of 717C.	Slight where slopes are less than 5 percent. Moderate where slopes are more than 5 percent: subject to runoff of short duration.
Nearly level; moderate to moderately slow permeability if uncompacted.	Fair stability; difficult to compact; moderate or high shrink-swell potential.	Moderate to moderately slow permeability.	High available water capacity; medium water intake rate.	Terraces not needed; features favorable for diversions.	Generally not needed; seasonal high water table; other features favorable.	Slight or moderate: high in organic-matter content; moderate to moderately slow permeability.	Moderate or severe: seasonal high water table; moderate to moderately slow permeability.
Nearly level; slow permeability.	Fair stability; high shrink-swell potential; high in organic-matter content.	Slow permeability; subject to flooding in places.	High available water capacity; water intake rate varies with amount of vertical cracking; subject to flooding in places.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe depending on frequency of flooding: high in organic-matter content.	Severe: slow permeability; seasonal high water table; subject to flooding in places.
Nearly level; moderate permeability if uncompacted.	Fair stability; difficult to compact to high density; poor resistance to piping.	Subject to flooding if unprotected; moderately well drained.	High available water capacity; medium water intake rate; subject to flooding if unprotected.	Nearly level bottom land.	Soil features are favorable; generally not needed.	Severe: subject to flooding; moderate permeability.	Severe: subject to flooding if unprotected; occasional high water table.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Onawa: 145, 146.....	Poor: high clay content; low organic-matter content. Good where surface layer is silt loam.	Not suitable....	Not suitable....	Very poor: the clayey material in the upper part should not be placed within 5 feet of grade in embankments. Fair below a depth of 5 feet.	Seasonal high water table; very plastic soil material.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; unprotected areas are subject to flooding.
Percival: 515.....	Poor: high clay content; low in organic-matter content.	Not suitable....	Not suitable....	Very poor in the clayey material. Good in underlying material.	Very plastic material in upper part; seasonal high water table.	Seasonal high water table; fair bearing capacity and fair shear strength below a depth of 2 feet; underlying sand subject to liquefaction and piping; unprotected areas are subject to flooding.
Riverwash: 53.....	Poor: mostly sands..	Fair to good....	Variable, but generally low sand content.	Good: good bearing capacity; erodible.	Good source of borrow; subject to frequent flooding.	Subject to frequent flooding.
Salix: 36.....	Good: moderate organic-matter content.	Not suitable....	Not suitable....	Poor: fair to poor bearing capacity; fair to poor workability and compaction characteristics; moderate to high shrink-swell potential.	Poor source of borrow material; nearly level.	Fair to poor bearing capacity; medium to high compressibility; occasional high water table; fair to poor resistance to piping.
Sarpy: 237A, 237B.....	Poor: low fertility, droughty.	Fair to good: fine grained and poorly graded.	Not suitable....	Good: good bearing capacity; can be compacted to high density; very erodible if exposed on embankments.	Good source of borrow; good foundation for fills.	Good bearing capacity; low shrink-swell potential; slight compressibility; poor resistance to liquefaction and piping; unprotected areas are subject to flooding.
Shelby: 24D2, 24E2, 24F2.....	Fair: only a thin layer of medium-textured material or high in organic-matter content.	Not suitable....	Not suitable....	Good: good bearing capacity; slight compressibility; good workability and compaction.	Strongly sloping to steep; some cuts tend to be seepy; good borrow potential.	Good bearing capacity and shear strength; slight compressibility.
Solomon: 466.....	Poor: high clay content.	Not suitable....	Not suitable....	Very poor: high shrink-swell potential; high organic-matter content; very clayey.	Seasonal high water table; very poor foundation for high fills; very poor for borrow.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table.

See footnote at end of table.

of soils—Continued

Soil features that affect suitability for—Continued						Degree and kind of limitation for—	
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Not suitable for reservoir areas because of unfavorable position.	Fair to poor stability; generally poor compaction characteristics; underlying silty materials are medium to highly compressible; generally not used because of unfavorable position.	Slow permeability in the upper part, moderate to moderately rapid below.	High available water capacity; water intake rate varies with amount of cracking in surface; medium water intake rate in the silts beneath.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: slow permeability to a depth of about 2 feet; seasonal high water table; unprotected areas are subject to flooding.	Severe: seasonal high water table; slow permeability in upper part; moderate to moderately rapid below.
Nearly level; rapid permeability in the underlying sand.	Fair to poor stability; generally poor compaction characteristics; underlying materials have poor resistance to piping and liquefaction; generally not used because of unfavorable position.	Permeability is slow in the upper part but rapid below.	Medium to low available water capacity; water intake rate varies with amount of surface cracking; rapid permeability in the sandy substratum.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability in underlying sands; seasonal high water table.	Moderate or severe: seasonal high water table; rapid permeability in substratum; danger of pollution.
Frequently flooded; very porous.	Poor resistance to piping and liquefaction; erodible on embankments; not used because of unfavorable position.	Not needed; frequently flooded; not farmland.	Land not suitable for farming.	Nearly level bottom land.	Nearly level bottom land.	Severe: subject to frequent flooding.	Severe: high water table and flooding.
Nearly level; moderate permeability.	Fair stability; fair to poor compaction characteristics; generally not used because of unfavorable position.	Not needed; moderately well drained.	High available water capacity; medium intake rate.	Nearly level bottom land.	Nearly level bottom land.	Moderate: moderate permeability.	Slight: moderate permeability; occasional high water table.
Undulating; very rapid permeability.	Poor resistance to liquefaction and piping; erodible if exposed on embankments; generally not used because of unfavorable position.	Not needed; excessively drained.	Low or very low available water capacity; rapid water intake rate.	Undulating bottom land; very droughty; very erodible.	Undulating bottom land; very droughty; very erodible.	Severe: very rapid permeability.	Slight: very rapid permeability; danger of pollution.
Moderately slow permeability if uncompacted; sand pockets or stones in places.	Good stability; easily compacted; good workability; suitable for cores.	Not needed; moderately well drained.	Strongly sloping to steep; high available water capacity; subject to runoff and erosion.	Soil features favorable for construction except for a few stones and boulders; subsoil is firm and is low in fertility.	Soil features are favorable for construction except for a few stones and boulders; subsoil is firm and is low in fertility.	Severe: slopes are more than 9 percent.	Severe: moderately slow permeability; slopes are more than 9 percent.
Nearly level; very slow permeability.	Fair to poor stability; poor compaction characteristics; high compressibility; not used because of unfavorable position.	Very slow permeability; outlets for ditches inadequate in places.	Medium available water capacity; water intake rate varies with the amount of vertical cracking.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: very slow permeability; high organic-matter content; seasonal high water table.	Severe: very slow permeability; seasonal high water table.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill <sup>1</sup>	Highway location	Foundations for low buildings <sup>1</sup>
Steinauer: 33F.....	Poor: low in organic-matter content; gravelly in places.	Not suitable....	Not suitable....	Good: good bearing capacity; easily compacted to high density, slight compressibility.	Steep: good source of borrow; seepy in some cuts.	Good bearing capacity and shear strength; slight compressibility; deep to seasonal high water table.
Terril: 27C.....	Good: high in organic-matter content.	Not suitable....	Not suitable....	Poor: high in organic-matter content to a depth of 2 feet or more; fair to poor bearing capacity; moderate shrink-swell potential.	High in organic-matter content to a depth of 2 feet or more; poor source of embankment material.	Fair to poor bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential.
Vore: 516.....	Fair: moderately fine texture, but low organic-matter content.	Not suitable....	Not suitable....	Poor in upper 2 feet. Good in underlying sands; low shrink-swell potential and fair bearing capacity.	Seasonal high water table.	Fair bearing capacity and fair shear strength below a depth of about 2 feet; underlying sands subject to liquefaction and piping; unprotected areas are subject to flooding.
Waubonsie: 49, 449.....	Fair to good to a depth of 1½ or 2 feet: low in organic-matter content.	Not suitable....	Not suitable....	Poor: the material in the upper part is fair but the clayey material beneath has poor bearing capacity and high shrink-swell potential.	Very poor source of borrow material below a depth of about 2 feet.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; high compressibility; unprotected areas are subject to flooding.
Woodbury: 67.....	Poor: high clay content; seasonally wet.	Not suitable....	Not suitable....	Very poor: high shrink-swell potential; high organic-matter content; very clayey.	Seasonal high water table; very poor for borrow; poor foundation for fills.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table.
Zook: 54, 54+, 134.....	Poor: high clay content. Fair or good where overwash is present.	Not suitable....	Not suitable....	Very poor: high shrink-swell potential; poor bearing capacity; high organic-matter content; seasonal high water table.	High organic-matter content; seasonal high water table; poor foundation for high fills.	Poor bearing capacity and shear strength; high shrink-swell potential; high compressibility with uneven consolidation; subject to flooding.

<sup>1</sup> Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

of soils—Continued

Soil features that affect suitability for—Continued						Degree and kind of limitation for—	
Farm ponds		Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Sewage lagoons	Septic tank disposal fields
Reservoir area	Embankment						
Moderately slow permeability if uncompacted; occasional pockets of sand and gravel.	Fair to good stability; good for impervious cores and blankets; a few stones or boulders; easily compacted to high density.	Not needed; well drained.	Steep slopes.....	Soil properties generally favorable, but soil has some stones; steep slopes; good management needed to establish vegetation.	Steep slopes; some stones; good management needed to establish vegetation.	Severe: steep slopes.	Severe: steep slopes; moderately slow permeability.
Moderate permeability; high in organic-matter content to a depth of 2 feet or more.	High in organic-matter content to a depth of 2 feet or more; fair stability; fair to poor compaction characteristics; medium to high compressibility.	Not needed; moderately well drained.	High available water capacity; medium water intake rate; subject to runoff, erosion, and gullyng.	Soil properties are favorable.	Soil properties are favorable.	Moderate: subject to runoff; high in organic-matter content; moderate permeability.	Moderate: slopes; moderate permeability.
Nearly level; rapid permeability in the underlying sand.	Fair to poor stability; the underlying sandy material has poor resistance to liquefaction and piping; generally not used because of unfavorable position.	Not needed; moderately well drained.	Low or medium available water capacity; medium water intake rate in surface layer, rapid below a depth of about 2 feet.	Nearly level bottom land.	Nearly level bottom land.	Severe: rapid permeability in underlying sands, seasonal high water table.	Moderate to severe: seasonal high water table; rapid permeability in the substratum; danger of pollution.
Nearly level; slow or very slow permeability in the underlying silty clay.	Very clayey material that has high shrink-swell potential below a depth of about 2 feet; poor stability; generally not used because of unfavorable position.	Generally not needed; very slow or slow permeability below a depth of about 2 feet.	Medium available water capacity; medium to rapid water intake rate in the upper part, slow below.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: moderately rapid permeability in the upper part, very slow or slow below; seasonal high water table; unprotected areas are subject to flooding.	Severe: very low or slow permeability below a depth of about 2 feet.
Nearly level; slow or very slow permeability to a depth of about 2 to 3 feet, moderate or moderately slow permeability below.	Fair to poor stability; poor compaction characteristics; high compressibility; not generally used because of unfavorable position.	Slow or very slow permeability to a depth of about 2 to 3 feet; moderate to moderately slow below.	High available water capacity; water intake rate varies with the amount of vertical cracking.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: seasonal high water table; high organic-matter content; slow or very slow permeability; seasonal high water table.	Severe: seasonal high water table; slow or very slow permeability to a depth of about 2 to 3 feet; moderate or moderately slow below.
Nearly level; high in organic-matter content; slow permeability.	Fair stability; high shrink-swell potential; high in organic-matter content.	Slow permeability; subject to flooding.	High available water capacity; slow permeability; water intake rate varies with the amount of vertical cracking; subject to flooding.	Nearly level bottom land.	Nearly level bottom land.	Moderate or severe: high in organic-matter content; subject to flooding; seasonal high water table.	Severe: slow permeability; seasonal high water table; subject to flooding.

TABLE 5.—Engineering

[Tests performed by the Iowa State Highway Commission according to

Soil name and location	Parent material	Iowa report No.	Depth	Moisture-density <sup>1</sup>	
				Maximum dry density	Optimum moisture
Hamburg silt loam: 60 feet N. and 120 feet E. of T intersection, S. side sec. 30, T. 68 N., R. 42 W. (Modal).	Wisconsin loess.	AAD1-4411 AAD1-4412	<i>In.</i>	<i>Lb. per cu. ft.</i>	<i>Pct.</i>
			2-10	105	17
Judson silty clay loam: SE¼NE¼ sec. 12, R. 40 W., T. 70 N. (Modal) -----	Alluvium.	AAD2-475 AAD2-476	0-29	97	22
			45-60	102	17
Marshall silty clay loam: 375 feet W. and 70 feet N. of SE. corner of sec. 14, T. 68 N., R. 40 W. (Modal).	Wisconsin loess.	AAD2-472 AAD2-473 AAD2-474	0-8	98	20
			13-32	94	24
			32-54	102	19
McPaul silt loam: SW¼NE¼ sec. 11, T. 70 N., R. 43 W. (Modal) -----	Alluvium.	AAD2-477 AAD2-478	9-31	102	16
			44-96	103	19
Nevin silty clay loam: 200 feet E. and 70 feet S. of NW. corner of NE¼ sec. 35, T. 69 N., R. 40 W. (Modal).	Alluvium.	AAD2-12785 AAD2-12786 AAD2-12787	0-17	94	23
			25-42	97	22
			42-56	100	20

<sup>1</sup> Based on the Moisture-density Relations of Soils Using 5.5-lb. Rammer and 12-in. Drop, AASHO Designation T 99-57, Method A (1).

<sup>2</sup> Mechanical analyses according to the AASHO Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

particular use that overcoming the limitations is most difficult and costly and commonly not practical for the rated use.

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

Following are explanations of some of the columns in table 4.

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 in preparing a seedbed; natural fertility of the material, or its 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 are characteristics that affect suitability, but also considered in the ratings is damage that will result in the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 4 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 of sand or gravel at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the

materials, and neither do they indicate quality of the deposit.

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.

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

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

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil

test data—Continued

standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis <sup>2</sup>					Liquid limit	Plasticity index	Classification	
Percentage passing sieve—	Percentage smaller than—						AASHO <sup>3</sup>	Unified <sup>4</sup>
	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
					<i>Pct.</i>			
99	78	13	11	11	31	7	A-4(8)	ML-CL
99	80	11	8	5	30	6	A-4(8)	ML-CL
98	90	35	27	23	43	20	A-7-6(13)	CL
99	95	35	30	27	40	20	A-6(12)	CL
99	90	33	27	25	40	17	A-6(11)	CL
99	91	42	35	31	51	27	A-7-6(17)	CH
99	92	40	32	27	47	26	A-7-6(16)	CL
99	82	20	17	15	33	10	A-4(8)	ML-CL
100	85	20	18	17	33	9	A-4(8)	ML-CL
99	94	35	27	23	41	18	A-7-6(11)	CL
99	93	39	32	27	50	28	A-7-6(17)	CL
99	93	35	29	26	44	24	A-7-6(14)	CL

<sup>3</sup> Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 8): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-59 (1).

<sup>4</sup> Based on MIL-STD-619B (17).

blowing; soil texture; content of stones; accumulation 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.

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

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

**Engineering test data**

Table 5 contains engineering test data for some of the major soil series in Fremont County. These tests were made to help evaluate the soils 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.

Moisture-density data are important in earthwork. If a soil material is compacted at successively higher moisture content, 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 tests is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

The liquid limit and the plasticity index indicate the effect of moisture on the consistence of the soil material. As the moisture content of a dry clayey soil is increased, the material changes from a semisolid to a plastic. As the moisture content is further increased, the material changes from a plastic to a liquid. The plastic limit is the moisture content at which the material passes from a semisolid to a plastic. The liquid limit is the moisture content at which the material passes from a plastic to a liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

### **Special features affecting highway work <sup>7</sup>**

Most of the upland soils in Fremont County formed in loess that overlies glacial till. The loess ranges from about 100 feet thick in parts of the Ida-Monona-Hamburg soil association to about 30 feet thick in the Marshall association in the southeastern part of the county. In some stream valleys, soils that formed in loess are on benches and are underlain by alluvium. In places where streams have dissected the landscape, glacial till is exposed. The soils of the Nodaway-Kennebec-Colo, McPaul-Napier, Luton-Lakeport-Salix-Keg, and Haynie-Albaton-Onawa associations formed in alluvium and occupy about 35 percent of the county. The soils in many small stream valleys and drainageways in the uplands also formed in alluvium.

Monona, Ida, Hamburg, and Marshall are the most extensive loess-derived soils in the county. They are nearly level to very steep. Monona and Marshall soils are typically classified as A-6 or A-7-6(ML-CL) and have group index numbers of 9 to 15. Ida soils are typically A-6 or A-4(ML-CL), and Hamburg soils A-4 (ML or ML-CL). Group index numbers are generally 8 to 10. These soils erode easily where runoff is concentrated. Sodding, paving, or check dams may be needed in gutters and ditches to check excessive erosion. Nearly vertical black slopes in the drier Hamburg soils are stable, and ditch drainage is good.

The clayey Malvern soils also formed in older loess. These soils were once buried but have since been re-exposed on ridges and the lower part of side slopes. They are typically classified as A-7-6 (CH) and have group index numbers of 18 to 20.

In the soils derived from loess, the seasonal high water table is generally above the glacial till-loess contact. In these areas, because the in-place density of the loess is

relatively low, the soil has a high moisture content and subdrains may be needed in the backslope to intercept seepage. This high moisture content may cause instability in embankments unless moisture-density control is exercised to permit compaction to high density.

The Shelby and Steinauer soils formed in glacial till. They are mainly on side slopes adjacent to stream valleys. Their classification primarily is A-6 (CL) but ranges to A-7-6. Where this material is in or along grading projects, it is generally placed in the upper subgrade in unstable areas. Because of their high in-place density, these glacial till soils generally do not have excessively high moisture content and are more stable and more easily compacted than soils that formed in loess. The Adair soils formed in highly weathered glacial till that also is on side slopes. They have a subsoil of highly weathered clay that is classified as A-7-6 (15-20). This layer is too expansive to be used for a highway subgrade and should not be used within 5 feet of the finished grade. If this clay material occurs at grade in roadcuts, it should be replaced with a backfill of less weathered glacial till such as is found in Shelby and Steinauer soils.

Pockets and lenses of sand and gravel are commonly interspersed throughout the till and are often water bearing. Where the road grade is only a few feet above such a deposit, and loess or silty till overlies it, frost heaves are likely to develop unless the deposit is drained, or the soil above it is replaced with granular backfill or clay till.

The soils on bottom lands along the Missouri River, on bottoms of smaller streams, and in drainageways formed in alluvium. A number of soils on bottom lands along the Missouri River are clayey throughout most of the profile and are classified as A-7-6(20)(CH). Most of these are high in organic matter in the upper part. They are in the Albaton, Blend, Solomon, Luton, Woodbury, and other series. The clayey material should not be placed within 5 feet of grade in embankments. Where these soils occupy visible old oxbows of the river, they may be soft and unable to support an embankment more than 5 feet high. They should also be investigated for stability against sliding and for consolidation. A number of soils have these clayey materials to a depth of about 2 feet and have coarser textures below. These soils are in the Blake, Blencoe, Onawa, Percival, and other series. Modale, Merville, and Waubonsie soils have clay beginning at a depth of about 2 feet and a coarser texture above.

Colo, Kennebec, Nishna, Spillville, Zook, Judson, and Napier soils have a thick surface layer that is high in organic matter. These soils are on bottom lands and in upland drains throughout the county. The soil material in the surface layer may consolidate erratically under the load of a heavy embankment. For an embankment more than 15 feet high, these soils should be carefully investigated to be sure that they have sufficient strength to support it. Road embankments through bottom lands should be constructed on a continuous embankment that extends above the level reached by frequent floods.

Many of the soils on bottom lands have a seasonally high water table. A number of the soils, especially those that formed in recent alluvial sediments near the Missouri River, have strata of fine sandy sediments, and are dominantly sandy throughout. These soils are in the Grable, Cott, Percival, Sarpy, Carr, and other series. If an embankment is constructed only a few feet above the

<sup>7</sup> By DONALD A. ANDERSON, soils engineer, Iowa State Highway Commission.

water table in these soils, frost heaving may result unless proper drainage is established or unless materials not susceptible to frost action are used in the subgrade. Some of the soils that are better sources of borrow available for road construction are on the flood plain.

The bedrock in Fremont County is buried so deeply by other deposits that it is seldom a factor in road work. A few outcrops of limestone and shale occur near Thurman.

Ratings in table 4 show the suitability of the soils in Fremont County as a source of topsoil to promote the growth of vegetation on embankments, on cut slopes, and in ditches, and as a source of borrow for road construction. At many construction sites there are major variations in the soil within the depth of the proposed excavation, and several soils occur within short distances.

The soil maps, profile descriptions, and the engineering data given in this section should be used in planning detailed surveys of soils at construction sites. By using the information in soil surveys, the soil engineer can concentrate on the most important soil units. Then he can obtain a minimum number of soil samples for laboratory testing, and an adequate soil investigation can be made at minimum cost.

## **Formation and Classification of the Soils**

In this section the factors that have affected the formation of the soils of Fremont County are discussed. Also discussed are the development of soil horizons and the classification of the soils. Table 6 gives the classification of all the soils mapped in the county.

### **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 soil 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 development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has 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 genesis 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 development are unknown.

### **Parent material**

The soils of Fremont County formed in loess of two ages, in alluvium, and in glacial till. Near Thurman, some limestone and shale are exposed at the base of the bluffs. These materials are Cretaceous in age, but no soils have formed in these materials, and they have had little or no effect on the surrounding soils.

Alluvium is the most extensive parent material in the county. It consists of sediments deposited along the major streams and then narrow upland drainageways. The texture of the alluvium ranges from sand to clay because of the difference in materials from which it came and the manner in which it was deposited. About half of the county is occupied by soils formed in alluvium. A large area is along the Missouri River, and areas near the Nishnabotna Rivers and the small upland streams and drainageways of the county account for more than half of the soils that formed in alluvium. Some of the alluvial material has been transported only a short distance and is called "local" alluvium. Such alluvium retains many of the characteristics of the soils from which it has been washed. Judson and Napier soils, for example, are generally at the base of slopes below soils that formed in loess. Terril soils are below soils that formed in glacial till. Castana soils formed partly in material that moved downslope by the action of gravity. That material, colluvium, is included with local alluvium in this discussion. All of the soils are similar in texture to the soils upslope.

There are about 30 series in the county that have alluvium as their parent material. Other alluvial soils can be placed in two broad groups. One group formed in alluvium that has been in place long enough that soil-forming factors have had an effect on the soils. Luton, Blencoe, Colo, Keg, Salix, Lakeport, and Cooper soils are among the soils in this group. The second group of soils formed in recent alluvium. Sarpy, Haynie, McPaul, Onawa, Blake, and Albaton soils are in this group. The most noticeable difference is that soils of the first group have a darker, deeper surface horizon because of the accumulation of organic matter.

The alluvium and the soils that have formed in it vary widely in texture. Luton, Solomon, and Albaton formed entirely in clayey alluvium. Sarpy soils are loamy sand or sand in texture. Keg, Haynie, McPaul, and Kennebec soils are silt loam. Colo and Lakeport soils are silty clay loam. Some soils formed in alluvium that has layers of different textures. Blencoe, Blake, Blend, Onawa, Modale, and Percival are among these soils. Nevin soils are on low stream benches or second bottoms along the Nishnabotna Rivers. They are silty clay loam in texture. They have more profile development and are not so subject to overflow as associated alluvial soils on the first bottoms.

Loess is the second most extensive parent material in the county. A number of persons have studied loess soils in western Iowa. Hutton (6) and White and others (19) characterized Monona and Ida soils as part of a regional or county-wide study. Daniels and Jordan (3) reported on physical and chemical characteristics of Monona, Ida, and Dow soils and the loess in which they formed. Davidson and associates (4) studied the physical and engineering properties of loess in western Iowa and elsewhere. Ulrich (12, 13) and Godfrey and Riecken (5) studied physical and chemical changes accompanying

TABLE 6.—*Soil series classified according to the current system*

Series	Family	Subgroup	Order
Adair <sup>1</sup>	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Albaton	Fine, montmorillonitic, calcareous, mesic	Vertic Haplaquolls	Entisols.
Blake	Fine-silty, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Blencoe	Clayey over loamy, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Blend	Fine, montmorillonitic, noncalcareous, mesic	Fluventic Haplaquolls	Mollisols.
Buckney <sup>1</sup>	Coarse-loamy, mixed, mesic	Entic Hapludolls	Mollisols.
Carr	Coarse-loamy, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Castana	Fine-silty, mixed, mesic	Entic Hapludolls	Mollisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Cooper <sup>1</sup>	Fine-silty over clayey, mixed, mesic	Aquic Hapludolls	Mollisols.
Corley	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Cott	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Dockery	Fine-silty, mixed, nonacid, mesic	Aquic Udifluvents	Mollisols.
Dow	Fine-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Grable	Coarse-silty over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Udifluvents	Entisols.
Hamburg	Coarse-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Haynie	Coarse-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Ida	Fine-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keg	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Knox	Fine-silty, mixed, mesic	Mollic Hapludolls	Alfisols.
Lakeport	Fine, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Luton	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.
Malvern <sup>1</sup>	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Marshall <sup>1</sup>	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
McPaul	Coarse-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Minden	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Modale	Coarse-silty over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Monona <sup>1</sup>	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Moville	Coarse-silty over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Napier	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Nevin	Fine-silty, mixed, mesic	Aquic Argiudolls	Mollisols.
Nishna	Fine, montmorillonitic, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Onawa	Clayey over loamy, montmorillonitic, calcareous, mesic	Mollic Haplaquolls	Entisols.
Percival	Clayey over sandy or sandy-skeletal, montmorillonitic, calcareous, mesic.	Aquic Udifluvents	Entisols.
Salix	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Solomon	Fine, montmorillonitic, calcareous, mesic	Vertic Haplaquolls	Mollisols.
Steinauer	Fine-loamy, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Vore	Fine-silty over sandy or sandy-skeletal, mixed, calcareous, mesic.	Aquic Udifluvents	Entisols.
Waubonsie	Coarse-loamy over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Woodbury	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.
Zook	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.

<sup>1</sup> In this county the following soils are taxadjuncts to the series for which they are named. Adair soils have a surface layer that is thinner or lighter colored. Buckney soils have a higher proportion of sand throughout the profile, and the colors in the upper part of the C horizon have lower chromas. Cooper soils have a higher proportion of sand in the silty and loamy alluvial underlying material. The severely eroded Malvern soil has a surface layer that is thinner or lighter colored. The severely eroded Marshall soil has a surface layer that is thinner or lighter colored. All the severely eroded Monona soils have a surface layer that is thinner or lighter colored.

soil profile formation in soils formed in loess in southwest Iowa. Physical and chemical data for loess soils of southwest Iowa including Ida and Hamburg soils in Fremont County have been published (16).

Loess is yellowish-brown, wind-deposited material that consists largely of silt particles. It has smaller amounts of clay and sand. Most of the upland is occupied by soils that formed in Wisconsin loess. Ida, Monona, and Marshall soils are the most extensive of these. Hamburg soils occupy the bluffs adjacent to the Missouri River Valley. The Wisconsin loess is believed to have blown mainly from the flood plain of the Missouri River during the Wisconsin glacial period, about 25,000 to 14,000 years

ago (8). The thickness of the loess and the differences between soils that formed in it are related to the distance from the source of the loess (6, 8). The loess is thickest in the bluffs in the northwestern part of the county, perhaps nearly 100 feet in places. In the southeastern part of the county, it thins to about 30 feet in thickness. In places, mainly on steep hillsides adjacent to stream valleys, the Wisconsin loess has been removed by geologic erosion. Here glacial till or, in places, another loess deposit, the Loveland Loess, is exposed.

The loess of southwestern and southern Iowa thins and becomes finer textured from west to east (6, 8). The change in texture is quite marked in Fremont County. The

Marshall soils in the eastern part of the county are considerably higher in content of clay than the Hamburg soils in the western part of the county. The Ida and Monona soils are intermediate between these two in their content of clay.

The Malvern soils formed in an older loess, the Loveland Loess, that is exposed in places on side slopes. This loess lies beneath the Wisconsin loess. It was deposited during the Illinoian glacial episode (8, 9). A reddish paleosol developed in this loess during the Sangamon interglacial period and was subsequently covered by Wisconsin loess. It is in this paleosol, where exposed by geologic erosion on the present land surface, that the Malvern soils have formed.

Glacial till is the parent material of only a few soils in the county. There are thick glacial till deposits throughout the uplands, but most are covered by loess. The main areas exposed are on upland hillsides near the Nishnabotna Rivers where the loess has been removed by erosion.

Most of the glacial till is considered to be from the Kansan Glaciation. There is some indication that a few exposures may be from the earlier Nebraskan Glaciation. The unweathered till is firm, calcareous clay loam. It contains pebbles, boulders, and sand as well as silt and clay. The till is a heterogeneous mixture and shows little evidence of sorting or stratification. The mineral composition of its components is also heterogeneous and is similar to that of particles in unweathered loess.

Soils formed on the Kansan till plain during the Yarmouth and Sangamon Interglacial Stages before the loess was deposited. The soils formed during this time period are called Yarmouth-Sangamon paleosols. In nearly level areas the soils are strongly weathered and have a gray, plastic subsoil called gumbotil (9). The gumbotil is several feet thick and very slowly permeable. A widespread erosion surface has cut below the Yarmouth Sangamon paleosol into Kansan Till and older deposits. The surface is characterized generally by a stone line or subjacent sediment and is surmounted by pedisodiment. A paleosol formed in the pedisodiment, stone line, and generally subjacent till. This surface is of Late Sangamon age. The paleosols are less strongly weathered, more reddish in color, and not so thick as those in nearly level areas.

The soils that formed in the Kansan Till during Yarmouth and Sangamon time were covered by loess. Geologic erosion has removed the loess from some slopes and has exposed these paleosols. In other places, erosion has removed all of the paleosol and has exposed till that is only slightly weathered at the surface.

The Yarmouth-Sangamon paleosol is strongly weathered, gray clay and is exposed only in small areas in the county. It is shown on the detailed soil map by a spot symbol for a gray clay soil. The Adair soils formed where the less strongly weathered, reddish paleosol is exposed. The Shelby and Steinauer soils formed in slightly weathered glacial till that has had the overlying paleosols removed by geologic erosion.

### **Climate**

According to recent evidence, the soils in Fremont County formed under variable climatic conditions. About 13,000 to 10,500 years ago, the climate in central Iowa was cool and the vegetation dominated by conifers

(18). During the period, 10,500 to 8,000 years before the present time, there was a warming trend when the vegetation changed from conifers to mixed forest, in which hardwoods were prominent. Beginning about 8,000 years ago, the climate became warmer and drier and herbaceous prairie vegetation became dominant. Studies of the forest-prairie transition in central Iowa show that there was a late change in postglacial climate from a relatively dry to a more moist climate (?). This change may have begun about 3,000 years ago. The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county. The general climate is modified locally by conditions in or near the developing soil. For example, on the very steep bluffs occupied by Hamburg soils, most of the water runs off or soaks rapidly into the soil. This results in a warmer and drier climate than the average of nearby areas. On south-facing slopes the effect is similar. On north- and east-facing slopes the climate tends to be cooler and more moist than on south-facing slopes, and in a climate such as that of Fremont County, natural stands of trees are more likely to grow. Low-lying or depressional, poorly drained or very poorly drained soils are wetter and colder than most soils around them.

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 differences in climate do account for some of the differences in soils.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soil and on the kinds of plants that grow.

Some variations in plant and animal life are caused by variation in temperature or by the action of other climatic forces on the soil material. To that extent, climate influences changes in soils that are brought about by differences in plant and animal populations.

### **Plant and animal life**

Several 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 Fremont County tall grasses were the dominant vegetation at the time of settlement, but there were about 57,000 acres of trees. These trees were mainly in steep areas within a few miles of the Missouri River valley, but they were also in other places in the county, mainly near streams. In Fremont County the thickest stands of timber are likely to be on north- and east-facing slopes.

Because grasses have many roots and tops that have decayed or are in the soil, soils that formed under prairie typically have a thicker, darker colored surface layer than do soils that formed under trees. Under trees the organic matter, derived principally from leaves, was deposited mainly on the surface of the soil. Soils that formed under trees generally are more acid than those formed under grass. Marshall and Monona soils are typical of soils that formed under prairie. Soils such as Knox, however, have

properties intermediate between soils formed entirely under trees and those formed under grass. Knox soils are believed to have developed first under prairie grasses and then later under trees. They are the only soils in the county that have been markedly influenced by trees. In other places, the stands of trees apparently have not been in place long enough to influence the soils to the extent that a different soil series can be recognized and mapped.

Man has had marked influence on soils because of changes that have taken place in them as a result of his use. Changes caused by water erosion are often the most apparent. On many soils in the county, cultivation has caused the loss of part or all of the original surface layer and in some places gullies have formed. Tillage alters the structure of the surface layer. Less obvious are chemical changes brought about by additions of lime and fertilizers 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 are the result largely of man's activities. In McPaul and Menville soils, which are on bottom lands, the original dark-colored soil has been covered by new parent material, which is light-colored and calcareous. This is material eroded from the uplands, largely because of man's farming operations.

### Relief

Relief, or lay of the land, ranges from nearly level to very steep in Fremont County. It is an important factor in soil formation because it affects drainage, runoff, the height of the water table, and erosion. A difference in relief is the basic reason for the differing soil properties of some of the soils in the county.

Even though soils have formed in the same kind of parent material, the influence of relief is seen in the color, thickness of solum, and the development of horizons. Ida and Monona soils are examples of those that formed in similar parent material but that differ in characteristics, mainly because of relief. The Monona soils are well drained and, in most places, have slopes where some of the water runs off. Ida soils are more sloping and are in positions where more of the water runs off and where erosion has occurred at such a rate that little soil formation has taken place. For these reasons, the Monona soils have a thicker and darker-colored surface layer than the Ida soils. They are leached of carbonates, but Ida soils are calcareous at or near the surface. That slope affects the thickness of the solum and the depth to carbonates can be seen in such soils as the Monona and Shelby soils, which have a wide range of slope. In these soils the depth to carbonates and the thickness of the solum decrease as the percentage of slope increases and the slopes are more convex.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. In a soil that has good drainage, the subsoil generally is brown because iron compounds are well distributed throughout the horizon and are oxidized, but in soils that have restricted drainage, it generally is grayish and mottled. This can be seen in soils on the bottom lands along the Missouri River, where the low-lying, poorly drained to very poorly drained Luton soils have a gray and olive-gray subsoil. In contrast, the Keg soils at slightly higher elevations are well drained and have a brownish subsoil. Generally, however, the

texture of the parent material on the bottom lands of the Missouri River varies with elevation, and the poor drainage of the Luton soils is caused partly by their clayey texture.

### Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Similar kinds of soil are produced from widely different kinds of parent material if other factors continue to operate over long periods of time. But soil development generally is interrupted by geologic events that expose new parent material.

In Fremont County the bedrock has been covered by glacial drift from two different glaciers, the Nebraskan and the Kansan. After a period of time, Loveland Loess was deposited. Later the present surface material, the Wisconsin Loess, was deposited. As a result the soils have been buried, and further development of those soils has stopped.

According to studies by R. V. Ruhe and others (9), the Adair soils have subsoil horizons that are the most weathered in the county. These soils formed in Kansan till, which began to weather in Late Sangamon time. Then they were covered by loess. More recently the upper part of this ancient subsoil was exposed to weathering again when the loess was removed by erosion. Soils such as Adair soils are called paleosols.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating late Pleistocene events. Loess deposition began about 25,000 years ago and continued to about 14,000 years ago. Based on these dates, the soil material in the surface of nearly level, loess-mantled divides in Iowa is about 14,000 years old. In Fremont County, among stable areas are the nearly level ridgetops or divides and benches and the more level parts of gently sloping ridgetops occupied mainly by Monona or Marshall soils. In much of Iowa, including Fremont County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediments downslope (9). The soil materials on the surfaces of nearly level upland divides are older than those on the slopes that have been beveled and that ascend to the divides. Thus, the side slopes are less than 14,000 years old.

The sediment stripped from side slopes accumulated to form local alluvium. The age of soil materials on side slopes is determined by the alluvial fill at the base of the slopes. Daniels and Jordan (3) found the alluvium in some stream valleys in western Iowa to be less than 1,800 years old. Studies by Ruhe, Daniels, and Cady (9) in Adair County in southwest Iowa indicated that the base of the alluvial fill was about 6,800 years old. Because the sediment from the side slopes accumulated to form the alluvium, the soil materials on the surface of the side slopes in these areas is as young or younger than these dates. Some of the soils that formed in similar alluvium in Fremont County are Judson, Napier, Terril, and Kennebec soils.

Some of the soils on the Missouri River bottoms formed in alluvium deposited since settlement by man. Others, such as Salix and Keg soils, have not been flooded since before the first settlers plowed them, and they are older. The difference in the time that the soil-forming factors

have operated is reflected in the characteristics of the soils.

The proportion of land surface that is about 14,000 years old and less than 14,000 years old can be obtained by extrapolating soil data by landscapes in counties where soil surveys have been completed. In Fremont County only about 10 percent of the soils are as old or older than 14,000 years. About 90 percent are younger than 14,000 years.

### Processes of Soil Horizon Differentiation

Horizon differentiation is caused by four basic kinds of changes. These changes are additions, removals, transfers, and transformations in the soil system. Each of these four kinds of changes affect many substances that make up 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 those changes within the profile.

Addition of organic matter is an early step in the process of horizon differentiation in most soils. In Fremont County the soils on flood plains are divided into two broad groups, based mainly on this feature. The soils that have a relatively thick, dark-colored surface layer are separated from those that do not. The dark color, or lack of it, is the most obvious difference between the Luton and Albaton soils, between the Keg and Haynie soils, and between the Blencoe and Onawa soils.

In some soils on uplands, the darkened surface layer is the only soil feature that reflects to any extent these basic processes. The Ida and Steinauer soils are examples.

The process of removal of substances from parts of the soil profile is very important in the differentiation of soil horizons in Fremont County. This process accounts for some of the most obvious differences among a number of soils in the county. The movement of calcium carbonates downward in the soil material as a result of leaching is an example. In soils such as Ida and Steinauer, little calcium carbonate has been removed, and they are calcareous at or near the surface. In many places there are lime concretions on the surface. No B horizon has developed in these soils. In Monona and Shelby soils, calcium carbonates have been moved from the upper part of their profiles by leaching. This removal, along with other processes, has resulted in the differentiation of a B horizon. The Monona and Ida soils formed in calcareous loess, and Shelby and Steinauer soils formed in glacial till.

A number of kinds of transfers of substances from one horizon to another are evident in the soils of Fremont County. Phosphorus, removed from the subsoil by plant roots, is 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. The clay minerals are carried downward in suspension in percolating water from the A horizon. They accumulate in the

B horizon in pores and root channels and as clay films on ped faces. In Fremont County, only in the Corley, Knox, Adair, and Shelby soils has this process had a marked influence on the soil profiles. In other soils the clay content of the A horizon is not markedly different from that of the B horizon, and other evidence of clay movement is minimal. Another kind of transfer that is minimal in most soils but occurs to some extent in very clayey soils is brought about by shrinking and swelling. The shrinking and swelling causes cracks to form and some materials from the surface layer to be incorporated into lower parts of the profile. Luton and Albaton soils are examples of soils that have a potential for this kind of physical transfer.

Transformations are physical and chemical. For example, soil particles are weathered to smaller sizes. The reduction of iron is another example of a 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 gray colors. Gleying is associated with poorly drained and very poorly drained soils such as Luton soils.

Another kind of transformation is the weathering of the primary apatite mineral, present 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. This kind of transformation is important in Fremont County, because it helps explain the differences in the level of available phosphorus among soils that formed from similar calcareous parent materials. For example, Ida soils are calcareous and very low in available phosphorus, but Monona soils that have been leached and are about neutral are low in available phosphorus but have a better supply than Ida soils.

### Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for the application of this knowledge on farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and revised later (11). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (15) and was adopted in 1965 (10). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in

families, may change as more precise information becomes available.

Table 6 shows the classification of each soil series of Fremont County by higher categories according to the current system. Following are brief descriptions of these categories.

**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 6 shows the three orders in Fremont County: Alfisols, Entisols, and Mollisols. Alfisols have clay-enriched B horizons that are high in base saturation. Entisols are recent soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols have thick, friable surface layers that have been darkened by organic matter.

**SUBORDER:** Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes having 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 the 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* for Mollisol).

**GREAT GROUPS:** Soil suborders are separated 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 the 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 syllables and are made by adding a prefix to the name of the suborder. An example is Hapludoll (*hapl* meaning simple, *ud* for humid, and *oll* for Mollisol).

**SUBGROUPS:** Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another 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:** Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils where 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 of texture, mineralogy, and the like that are used as family differentiae. An example is 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 having genetic horizons that, except for texture of the surface

soils, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

## General Nature of the County

The area that is now Fremont County was part of the Louisiana Purchase. The county was organized in 1849. The first deed was recorded at the county seat of Austin in 1849, but the county seat was moved to Sidney in 1851.

According to the Iowa annual farm census for 1969, the area in farms in Fremont County was 303,850 acres. Most farmland was used for crops, but 49,373 acres was used as pasture. The rest amounted to 96,268 acres and included idle cropland, land used for roads and buildings, wooded areas, and wasteland.

Beef cattle, hogs, dairy cattle, and poultry are the livestock most extensively raised in Fremont County. In 1969 there were marketed 24,255 grain-fed cattle and 63,045 hogs. Laying hens numbered 7,541, but only 400 commercial broilers were raised in the county. Beef cattle numbered 9,752, and milk cows 520. There were 1,074 lambs born in the county in 1969.

The number of beef cattle has slightly increased recently, but number of milk cows has decreased. The number of hogs raised has remained about the same, but there has been a decrease in poultry and sheep, especially poultry.

The largest acreage of cropland in Fremont County is used for corn, and the next largest is used for soybeans. In 1969, a total of 88,713 acres of corn was harvested for grain, and the average yield was 98.6 bushels per acre. A total of 52,483 acres was used for soybeans, and the average yield was 37.4 bushels per acre. Other crops and the acreages grown were hay, 7,667 acres; wheat, 3,654 acres; oats, 1,017 acres; sorghums, 1,309 acres; and popcorn, 2,139 acres. Nursery stock is grown quite extensively, and limited amounts of apples and other orchard crops are also grown.

In recent years there has been a steady decrease in the number of farms, but the size of farms has increased. In 1969 there were 3,218 people living on 895 farms in Fremont County. The farms averaged 339 acres in size. Owner-operated farmland made up 38.3 percent of the farmland in the county, which is lower than the 52.5 percent average for the State. Tenant farmers operated the remaining 61.7 percent, compared with the State average of 47.5 percent.

Beef and hogs are the most important livestock marketed. Many of the cattle and hogs are sold at the livestock market at Omaha and at local livestock auctions and buying stations. Some are sold at packing plants or other livestock markets in Iowa or adjacent states. Milk, cream, and eggs are picked up at the farms and hauled to creameries, dairies, and produce houses, mainly outside the county.

Corn and soybeans are the main crops marketed. Much of the grain is sold at local elevators and then trucked to larger terminal grain markets.

U.S. Highways 275 and 59 serve north-south traffic along the eastern edge and through the center of the county. These highways are connected with all parts of

the county by State Highways 2, 42, 145, 174, 184, and 333 and by county roads. Almost all farms have access to hard-surfaced or gravelled roads. One main line of the Chicago, Burlington, and Quincy Railroad goes through the western part of the county, and a branch line serves Sidney, Anderson, and Randolph. Another branch line goes from Shenandoah, on the county line, to Farragut and Riverton. A line of the Norfolk and Western Railroad goes through the northeast corner of Fremont County and through Imogene. The Shenandoah Municipal Airport is in the eastern part of the county, but it is not used for scheduled airline flights. Bus transportation is available on the main highways, and motor freight lines serve every trading center in the county.

## Topography

Three rather distinct topographic areas are recognized in the county. These are the rolling uplands, the steep bluffs along the Missouri River bottoms, and the broad, nearly level bottom lands along the Missouri and Nishnabotna Rivers. The more gently rolling upland areas are in the eastern part of the county in the Marshall soil association. In these areas, ridgetops are well rounded, the side slopes relatively smooth and regular, and the valleys wide.

A strip of very hilly land about  $\frac{1}{2}$  mile to  $2\frac{1}{2}$  miles wide occurs east of the bottom lands along the Missouri River and extends to within  $1\frac{1}{2}$  miles of the southern county line. In this area the west-facing bluffs rise from 150 to 250 feet above the bottom lands. This area is occupied by the Ida-Monona-Hamburg soil association. The bluffs near the bottom lands are occupied mainly by Hamburg soils and have characteristic catsteps formed by small earth slips on the very steep slopes. Narrow ridgetops, long steep or very steep side slopes, and deep raw gullies are characteristic features of this area.

The bottom lands along the Missouri River range from about 3 miles in width in the extreme northern part of the county to about 10 miles in width at the widest point. They are mainly nearly level, but a few areas bordering the river are undulating or hummocky. There are numerous old sloughs or swales and channels in the bottom land. Many have been drained by drainage ditches. Numerous nearly level benches occur along the Nishnabotna Rivers. Soils on these benches make up the Marshall-Nevin soil association.

## Drainage

The county is drained by the Missouri River and its tributaries. The main tributaries are the Nishnabotna River, the West Nishnabotna River, and the East Nishnabotna River. Some of the important minor streams in the county are Waubonsie Creek, Plum and Knox Creeks in the western part of the county; Camp Creek, Coon Creek, Brush Creek, Deer Creek, Honey Creek, Walnut Creek, and Hunters Creek, which are tributaries of the West Nishnabotna River in the central part of the county; Fisher Creek and Mill Creek, which are tributaries of the East Nishnabotna River in the east-central part of the county; and High Creek and Rock Creek which drain the southeastern part of the county.

Artificial drainage is needed in areas largely restricted to the bottom lands and narrower drainageways in the uplands. In places it is needed for soils on benches.

## Climate <sup>8</sup>

Fremont is in the extreme southwestern corner of Iowa. The county is drained toward the southwest, mainly by the Nishnabotna Rivers that empty into the Missouri River, which flows southward along the west side of the county.

Table 7 gives temperature and precipitation data based on records kept at the weather station at Sidney, which is in the central part of the county. The average dates when low temperatures can be expected in spring and fall are based on records kept at Glenwood, which is in adjacent Mills County. The records at Sidney are representative of Fremont County, and the records at Glenwood are fairly representative.

Annual precipitation ranges from 31 inches in the northwestern part of the county to about 32.3 inches in the southeastern part. About 70 percent of the precipitation falls during the growing season, April through September. A trace or more falls about 165 days a year, and 0.01 inch or more falls about 95 days; a tenth of an inch about 55 days, and half an inch or more about 25 days. Most of the heavier showers occur in spring and early in summer when the hazard of soil erosion is greatest in newly tilled fields and in fields where crops are newly emergent. On the average, the hour when rainfall is most frequent is about 5 a.m.

On 30 to 40 days each year, there is snow cover of an inch or more, and on these days, the average depth of snow is 4 inches. Between 1949 and December of 1961, the greatest depth of snow recorded was 18 inches. The season when there is an average of an inch or more of snow cover begins in early December and normally ends in early March. The average seasonal snowfall is about 28 inches of snow, which in terms of water is equivalent to less than 10 percent of annual precipitation.

At crop planting time, the surface layer of a soil should be relatively dry and the subsoil should have ample moisture. Following this, well-spaced, gentle showers throughout the rest of the growing season are desirable. These are optimum conditions of soil moisture, but in this country, variations from these conditions are frequent and occasionally extreme. Normally, showers are most abundant in May and June and the weather is drier in July and August. Except in the early stages of growth, corn requires about an inch of moisture per week for optimum growth, but the chances of receiving an inch or more of rain a week during the growing season in Fremont County is normally about 1 in 2 during the first half of June and about 1 in 4 during the later half of July.

During the past two decades, temperature has ranged from 22° F. below zero to 107° above. It is freezing or below on 136 days a year and 90° or higher on about 44 days during the growing season. According to data kept at Glenwood, the average date when the last 32° temperature occurs in spring is April 28 and the first in fall is October 10. The average growing season is 165 days. The growth of most plants is normally limited by temperatures

<sup>8</sup> By PAUL J. WAITE, climatologist for Iowa, National Weather Service, U.S. Dept. of Commerce.

TABLE 7.—*Temperature and precipitation data*

[Data from Sidney, Iowa]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average total	One year in 10 will have—		Number of days with snow of 1 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	° F.	° F.	° F.	° F.	Inches	Inches	Inches		Inches
January	35	14	54	-13	0.7	0.1	2.1	10	4
February	41	20	60	-6	1.2	.1	1.4	8	3
March	47	25	74	5	1.9	.1	4.7	6	4
April	65	40	88	28	2.5	.8	5.3	( <sup>1</sup> )	1
May	76	53	92	37	4.3	1.4	8.7		
June	84	62	94	49	5.1	1.9	10.0		
July	88	65	98	55	4.0	1.1	16.2		
August	87	64	96	51	4.9	1.9	9.3		
September	80	55	92	38	3.1	.9	8.0		
October	69	45	86	26	2.4	0	4.9		
November	52	30	71	10	1.1	.1	3.2	2	3
December	40	20	62	-3	.7	.2	1.6	6	4
Year	64	41	99	-15	31.9	22.0	49.2	32	4

<sup>1</sup> Less than 0.5 day.

of 90° or higher because the evapotranspiration on such hot days usually causes plant stress that limits growth and development.

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## Glossary

**Acidity.** See Reaction.

**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.

**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.

**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.

**Contour farming.** Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

**Drainage class (natural).** Drainage 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 horizon and upper part of the B horizon and have mottling in the lower part of the B horizon and in the C horizon.

*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; they are light gray and generally mottled from the surface downward, but some have few or no mottles.

*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.

**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.

**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.

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

**Parent material.** Disintegrated and partly weathered rock from which soil has formed.

**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*.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. In words, the degrees of acidity or alkalinity are expressed thus:

	<i>pH</i>
Extremely acid.....	Below 4.5
Very strongly acid.....	4.5 to 5.0
Strongly acid.....	5.1 to 5.5
Medium acid.....	5.6 to 6.0
Slightly acid.....	6.1 to 6.5
Neutral.....	6.6 to 7.3
Mildly alkaline.....	7.4 to 7.8
Moderately alkaline.....	7.9 to 8.4
Strongly alkaline.....	8.5 to 9.0
Very strongly alkaline.....	9.1 and higher

**Relief.** The elevations or inequalities of a land surface, considered collectively.

**Sand.** As a soil separate, individual rock or mineral fragments that range from 0.05 to 2.0 millimeters in diameter. Most sand grains consist of quartz, but the sand may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

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

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each

grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

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

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

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

**Terrace (geological).** An old alluvial plain, ordinarily flat or 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."

**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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