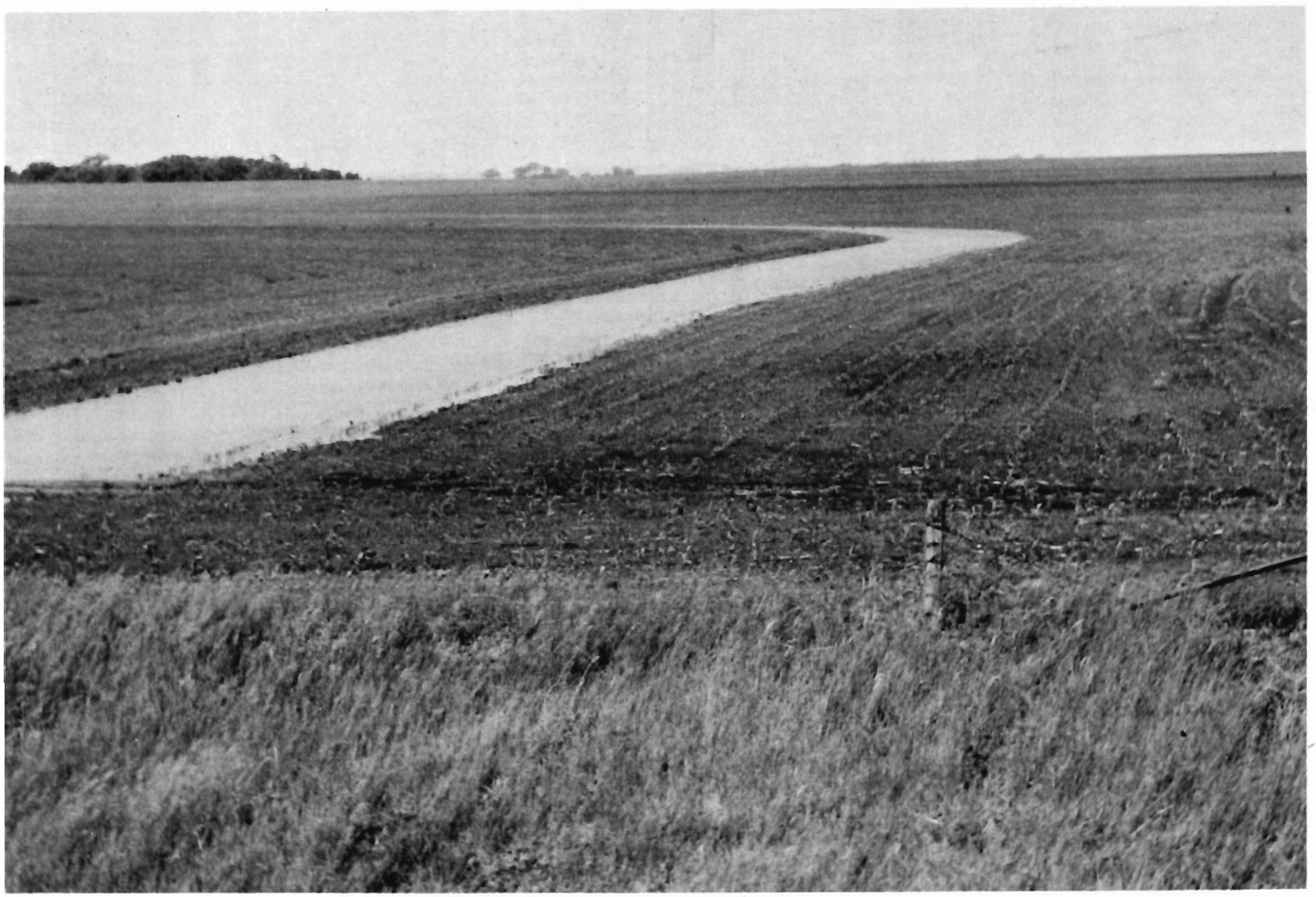
SOIL SURVEY OF

Lyon County, Iowa



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

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

Major fieldwork for this soil survey was completed in the period 1967–71. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service, the Iowa Agriculture and Home Economics Experiment Station and Cooperative Extension Service of Iowa State University, and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Lyon County Soil Conservation District. Funds appropriated by Lyon County were used to pay part of the cost of this survey.

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

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and wildlife areas; 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 Lyon County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in numerical order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit and the environmental planting 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 having a slight limitation for a given use can be colored green, those having a moderate limitation can be colored yellow, and those having 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 environmental planting groups.

Foresters and others can refer to the section "Environmental Plantings" where the soils of the county are grouped according to their suitability for trees and shrubs.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife Habitat."

Community planners and others can read about soil properties that affect the choice of sites for recreation areas in the section "Recreational Development."

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 the soils in the section "Formation and Classification of the Soils."

Newcomers in Lyon 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: Level terrace on Moody silty clay loam, 5 to 9 percent slopes, moderately eroded. Water held by the terrace will soak into the soil.

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Issued February 1978

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SOIL SURVEY OF LYON COUNTY, IOWA

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LYON COUNTY is in the northwestern part of Iowa (fig. 1). It has a total area of about 376,320 acres, or 588 square miles. The county seat is Rock Rapids, which had a population of 2,632 in 1970.

Most of the land in the county is used for farming. The average size of farms is about 250 acres. Corn is the major crop. Soybeans, oats, pasture, and hay combined are grown on about as much acreage as is used for corn. These crops are used mainly for the production of livestock and dairy products.

The climate is subhumid and continental. Variation in precipitation from year to year results in variation in crop yields. Water supplies adequate for irrigation are not available in most of the county.

How This Survey Was Made

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

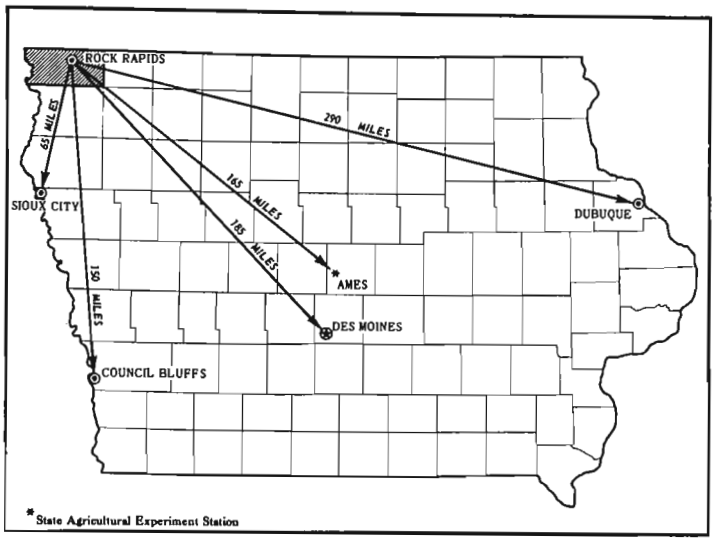

Figure 1.—Location of Lyon County in Iowa.

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. Galva and Primghar, 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, Galva silty clay loam, 2 to 5 percent slopes, is one of several phases within the Galva series.

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

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

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

A soil complex consists of areas of two or more soils so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Estherville-Salida complex, 5 to 9 percent slopes, is an example.

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

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

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

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is useful as a general guide for broad planning on a watershed, a wooded tract, or a wildlife area, or for broad planning of recreational facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey area are described on the pages that follow.

1. Calco-Spillco-Dempster association

Nearly level to moderately sloping, moderately fine textured and medium textured, poorly drained to well drained soils

This association is adjacent to the major streams in the county. The soils in this association are on flood plains that are about ¼ to 1 mile in width and are on stream benches adjacent to the flood plains. In most places the benches are 5 to 15 feet above the flood plain, but in places they are as low as 3 or 4 feet.

This association makes up about 11 percent of the county. Calco soils make up about 23 percent of the association, and Spillco and Dempster soils, each, make up about 11 percent. Colo and Ackmore soils, each, make up about 9 percent, Galva and Moody soils, together, about 9 percent, and other minor soils about 28 percent.

Calco soils formed in silty alluvium on flood plains. These nearly level soils are poorly drained. The surface layer is moderately alkaline, calcareous silty clay loam. In most places these soils are moderately alkaline, calcareous silt loam or silty clay loam below the surface layer.

Spillco soils formed in loamy alluvium on flood plains. They are nearly level and moderately well drained or somewhat poorly drained. The surface layer is neutral loam in the upper part and mildly alkaline or moderately alkaline, calcareous loam in the lower part. These soils are moderately alkaline loam below the surface layer in most places.

Dempster soils formed in silty deposits that are underlain by loamy sand or sand and gravel. These soils are nearly level to moderately sloping and well drained. They are on stream benches between the flood plains and the uplands. The surface layer and subsoil are neutral or slightly acid silt loam or silty clay loam.

Colo and Ackmore soils formed in silty alluvium on flood plains, Galva and Moody soils formed in silty loess that is underlain by water-deposited sand and gravel, Estherville and Salida soils are on stream benches, and Alluvial land and Millington and Davis soils are on flood plains.

This association is used mainly for cultivated crops. Some of the soils that are susceptible to frequent flooding, that have poor drainage, or that have sand or gravel at or near the surface are used for hay or pasture. Trees border the streams in places, but they are

not managed for commercial use. Most of the sand and gravel used in the county is mined from the stream benches in areas of this association. Some of the abandoned gravel pits are used for waste disposal. The sewage disposal lagoons for most of the towns in the county are on soils of this association.

The soils on flood plains in this association are susceptible to flooding and in some places need artificial drainage if they are to be used for cultivated crops. The poorly drained soils are sometimes plowed in fall after harvest; when this is done, soil blowing early in spring is a serious hazard. The sloping soils are susceptible to erosion, especially where they receive runoff from soils higher on the landscape. The soils that have sand and gravel at a shallow depth commonly have a sparse plant cover, which increases their susceptibility to erosion.

Soils in this association have the potential to continue to be important in the production of cultivated crops. The acreage used for hay and pasture will probably be increased on the soils that have sand and gravel at a depth shallow enough to cause a serious hazard of drought and be decreased on the soils on flood plains. Areas of this association are a major source of sand and gravel used in the county.

The roads generally follow section lines, but bridges do not cross the major streams on every section line. Most roads are graveled, and a few are paved.

2. Moody association

Nearly level to strongly sloping, moderately fine textured, well drained soils

This association has gently sloping convex ridgetops and gently sloping to moderately sloping hillsides. There are some nearly level ridgetops. Near the streams are some strongly sloping hillsides. The drainageways are about 100 feet wide at the upper end and are as wide as 800 feet near the streams. A few stream benches that are nearly level and gently sloping are in this association.

This association makes up about 41 percent of the county. Moody soils make up about 84 percent of the association. Soils in drainageways make up about 12 percent and other minor soils on uplands about 4 percent.

Moody soils formed in loess on convex ridgetops, hillsides, and stream benches. These nearly level to strongly sloping soils are well drained. The surface layer is neutral or slightly acid silty clay loam. The subsoil is slightly acid or neutral silty clay loam in the upper part and grades to mildly alkaline or moderately alkaline silt loam in the lower part. The underlying material is moderately alkaline, calcareous silt loam. These soils have glacial till at a depth of 42 to 48 inches in many places in the northern part of the association. The till generally is at a depth of 60 inches or more in the southern part.

The most extensive of the minor soils in the association, Trent soils, formed in loess. These soils are gently sloping in drainageways and are nearly level on lower side slopes below areas of Moody soils. In a few places they are upslope from Moody soils.

Ackmore, Colo, Calco, Marcus, and Afton soils are the major soils in the lower parts of drainageways. Marcus and Afton soils formed mainly in loess. Ackmore, Colo, and Calco soils formed in alluvial sediment. All of these soils have a surface layer of silty clay loam, and all are poorly drained, except Ackmore soils, which are somewhat poorly drained.

A few areas of Steinauer and Egan soils are in this association. Steinauer soils formed in till and are on uplands near the streams. Egan soils formed in loess and have glacial till at a depth of less than 40 inches. They are mainly in the northern part of the association.

This association is used mainly for row crops. Oats and hay are grown on a minor acreage. Most farms have some pasture for feeder cattle or dairy herds. The areas of pasture are generally small and occupy the major drainageway, on farms. Some farms in the western part of the association, where the soils are more sloping, have beef cattle herds.

Except for the nearly level soils, all the upland soils in the association are subject to erosion. The soils on hillsides are particularly subject to erosion because the slopes are long. Most of the soils in this association have a high available water capacity, but they are seldom filled to capacity because not enough water infiltrates. Reducing runoff increases the amount of water that is stored in these soils and is available to plants. Where the drainageways are farmed, a line of tile is generally installed to allow more timely tillage.

Soils in this association have the potential to continue to be important in the production of cultivated crops. The soils are suited to intensive row crops if they are managed to control runoff and erosion. Livestock operations help to maintain farm income in years of below normal precipitation.

Roads are on most section lines. Most are graveled or paved.

3. Galva-Primghar association

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

This association has broad, nearly level and gently sloping ridgetops and long, gently sloping and moderately sloping hillsides. In most places the moderately sloping part of the hillsides is not extensive. The drainageways are gently sloping and about 100 feet wide at the upper end. They are nearly level and are more than 300 feet wide at the lower end.

This association makes up about 23 percent of the county. Galva soils make up about 57 percent of this association and Primghar soils about 18 percent. Poorly drained and somewhat poorly drained soils in drainageways make up about 18 percent and minor soils on uplands and stream benches about 7 percent.

Galva soils formed in loess on convex ridgetops and hillsides. They have glacial till at a depth of 40 to 48 inches in many places in the northern part of the association and generally at a depth of more than 60 inches in the southern part. Galva soils are well drained and nearly level to moderately sloping. They are upslope from Primghar soils in some places and downslope in others. The surface layer is neutral or slightly acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part and neutral to mod-

erately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Primghar soils formed in loess in plane and convex upland areas and on the upper end of concave drainageways. These soils are somewhat poorly drained and are nearly level and gently sloping. They are upslope from Galva soils in places and downslope in other places. The surface layer is neutral to medium acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part and neutral to moderately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Afton, Calco, Colo, Marcus, and Ackmore soils are in the drainageways. Calco, Colo, and Ackmore soils formed in alluvium, and Afton and Marcus soils formed mainly in loess. All of these soils have a surface layer of silty clay loam.

Of the minor soils on uplands, Sac soils are the most extensive. The upper part of Sac soils formed in loess, and the lower part formed in glacial till.

This association is used mainly for cultivated crops. Corn and soybeans are the major crops, but some acreage is used for alfalfa, oats, and pasture. Most farm operators use the corn to fatten cattle or hogs. Areas of pasture are small and are used for grazing during only part of the growing season on some farms.

The sloping soils in this association are subject to erosion. Adequate erosion control normally can be obtained by the use of terraces. Generally, tile has been installed in drainageways that are in cultivated fields.

Soils in this association have the potential to continue to be important in the production of crops. The soils are suited to intensive row crops if management practices are used that control erosion and maintain soil fertility.

Roads are on most section lines. Most are graveled or paved.

4. Egan-Trent-Moody association

Nearly level to strongly sloping, moderately fine textured, well drained and moderately well drained soils

This association has gently sloping ridgetops and mainly gently sloping hillsides, but it has some moderately sloping hillsides and a few strongly sloping hillsides. An area of nearly level soils is in the north-central part of the association. The association has nearly level and gently sloping drainageways. They are about 100 feet wide at the upper end and as wide as 800 feet near the permanent streams.

This association makes up about 7 percent of the county. Egan soils make up about 47 percent of the association, Trent soils about 20 percent, and Moody soils about 20 percent. Poorly drained and somewhat poorly drained soils in drainageways make up about 7 percent, and minor soils on uplands and stream benches about 6 percent. (fig. 2).

Egan soils formed in loess and glacial till on convex ridgetops and hillsides. The glacial till is about 36 inches below the surface in most places. These well drained soils are gently sloping to strongly sloping. They are upslope from Moody and Trent soils where they are on ridgetops and downslope from Moody soils where they are on hillsides. The surface layer and subsoil are neutral to medium acid and are mainly silty clay loam. The underlying glacial till is moderately alkaline, calcareous clay loam.

Trent soils formed in loess in plane and convex upland areas and at the upper end of concave drainageways. These moderately well drained soils are nearly level and gently sloping. They are upslope from Egan and Moody soils in places and downslope in other places. The surface layer is neutral or slightly acid silty clay loam, and the subsoil is slightly acid to mildly alkaline silty clay loam and silt loam. The underlying material is moderately alkaline, calcareous silt loam.

Moody soils formed in loess on convex ridgetops and hillsides. Glacial till is at a depth of 42 to 48 inches in many places. These well drained soils are nearly level to strongly sloping. The surface layer is neutral or slightly acid silty clay loam. The subsoil is slightly acid to neutral silty clay loam in the upper part and mildly alkaline or moderately alkaline silt loam in the lower part. The underlying material is moderately alkaline, calcareous silty loam.

Afton, Calco, Colo, and Marcus soils are in the drainageways. Afton and Marcus soils formed mainly in loess, and Calco and Colo soils formed in alluvium. All of these soils have a surface layer of silty clay loam.

This association is used mainly for cultivated crops. Corn and soybeans are the main crops. Oats are commonly grown as a companion crop to new alfalfa seedings. Much of the corn, oats, and alfalfa is fed to livestock on the farm. Dairy cattle and feeder cattle utilize pasture forage.

The sloping soils of this association are subject to erosion. The nearly level and gently sloping soils in drainageways and plane upland areas remain wet longer than the adjoining well drained soils. Where the soils are farmed together, tile generally is installed in the drainageways.

Soils in this association have the potential to continue to be important in the production of crops. A large part of the association is suitable for intensive row crops if erosion is controlled. Dairying and hog and cattle feeding help to maintain farm income in years of below normal precipitation.

Roads are on most section lines. Most are graveled or paved.

5. Primghar-Marcus-Galva association

Nearly level to moderately sloping, moderately fine textured, poorly drained to well drained soils

This association has very broad, nearly level and gently sloping ridgetops and long, gently sloping and moderately sloping hillsides. The moderately sloping part of the hillsides is small. The very broad ridgetops have concave, plane, and convex areas. In places there are depressions that pond water. The concave areas connect with drainageways downslope. Many drainageways become narrower rather than wider downslope and become wider again near the lower end.

This association makes up about 6 percent of the county. Primghar soils make up about 44 percent of the association, Marcus soils about 20 percent, and Galva soils about 16 percent. Minor soils on uplands and the upper parts of drainageways make up about

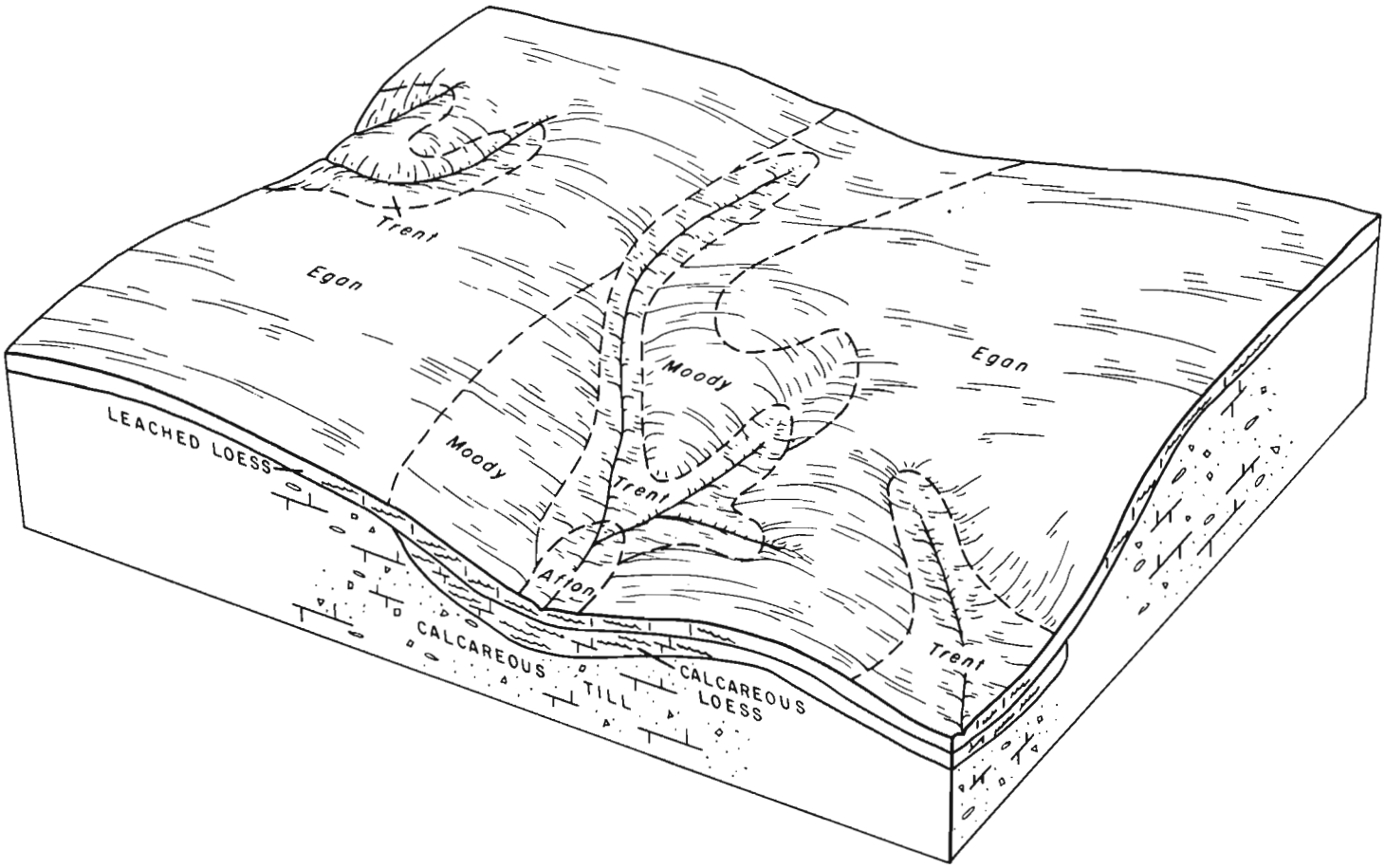

Figure 2.—**Typical pattern of soils and underlying material in the Egan-Trent-Moody association.**

11 percent, and other minor soils, in lower drainageways, about 9 percent (fig. 3).

Primghar soils formed in loess in plane and convex upland areas and on the upper end of concave drainageways. These somewhat poorly drained soils are nearly level and gently sloping. In upland areas they are generally upslope from Galva soils on the landscape, and in concave drainageways they are downslope from Galva soils. The surface layer is neutral to medium acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part and neutral to moderately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Marcus soils formed in loess in plane and concave upland areas and in concave drainageways. These poorly drained soils are nearly level. They are generally downslope from Primghar soils on the landscape. The surface layer is neutral or mildly alkaline silty clay loam or light silty clay. The subsoil is neutral or mildly akaline silty clay loam or light silty clay in the upper part and mildly alkaline or moderately alkaline silty clay loam or silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Galva soils formed in loess in plane and convex ridgetops and on convex hillsides. These well drained soils are nearly level to moderately sloping. They are upslope from Primghar and Marcus soils that are in drainageways, and they are downslope from Primghar and Marcus soils that are on very broad upland ridgetops. The soils are neutral or slightly acid silty clay loam in the upper part and neutral to moderately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Sperry soils formed in loess in small depressions, or, in a few places, in upland drainageways. These soils are nearly level and very poorly drained to poorly drained. Afton soils are poorly drained, nearly level soils that formed mainly in loess in drainageways. Sac soils formed in loess and glacial till on uplands. They are well drained.

This association is used mainly for cultivated crops. Corn and soybeans are the major crops. Oats, alfalfa, and pasture grasses are grown on a minor acreage. Most farm operators use some or all of the corn grown to fatten cattle or hogs, but a few sell their grain and do not feed livestock.

The sloping soils in this association are subject to erosion. Some of the nearly level soils remain wet for long periods where they are not artificially drained. Tile normally are used for drainage, and they generally are effective.

Soils in this association have the potential to con-

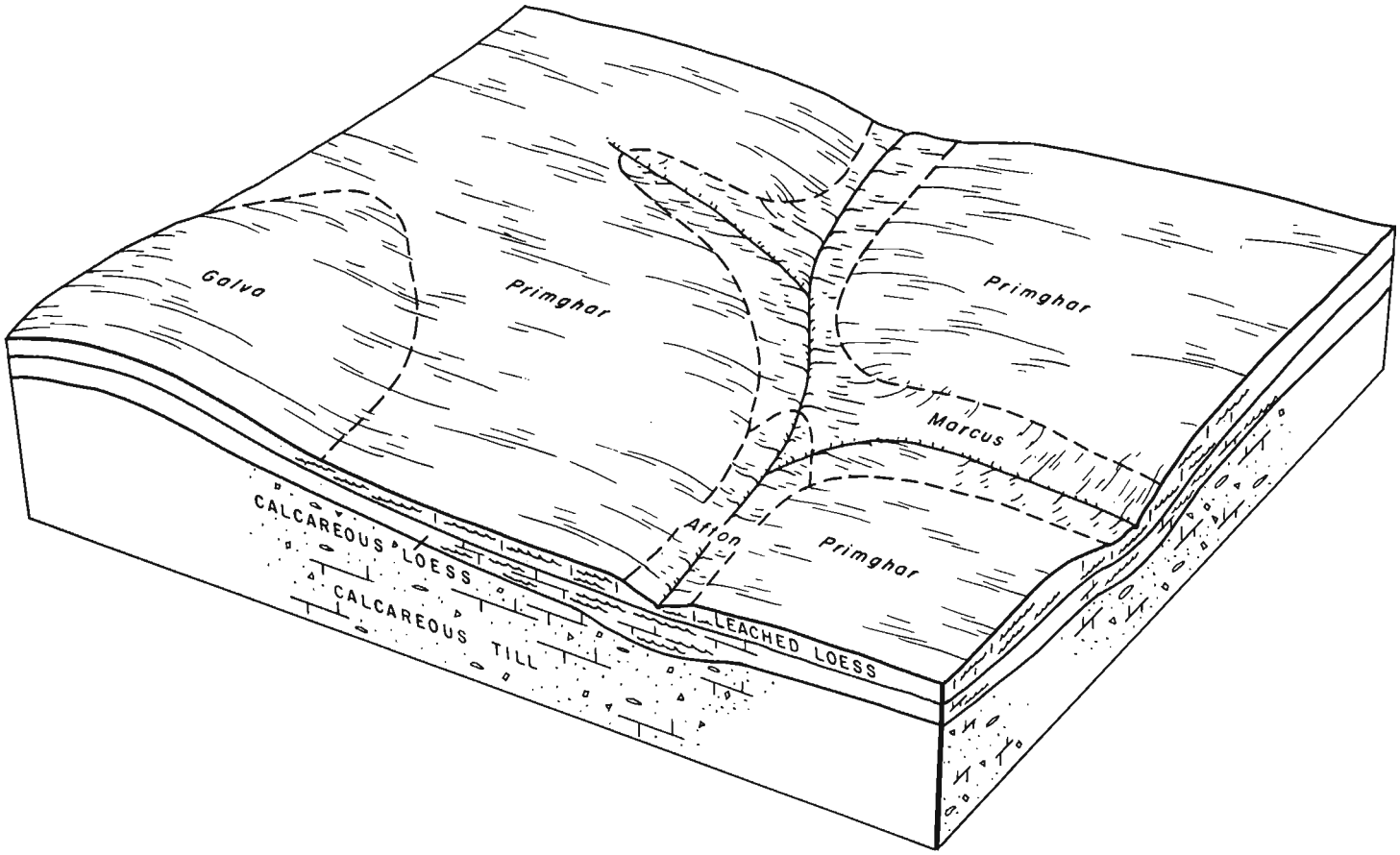

Figure 3.—**Typical pattern of soils and underlying material in the Primghar-Marcus-Galva association.**

tinue to be important in the production of row crops, and the small acreage of pasture in this association probably will be further reduced. If management is used to control erosion and artificial drainage is used where it is needed, the soils of this association are suited to intensive row crops. Corn and crop residues are used widely for livestock feeding.

Roads are on all section lines. Most are graveled or paved.

6. Sac-Galva-Primghar association

Nearly level to strongly sloping, moderately fine textured, well drained and somewhat poorly drained soils

This association has nearly level and gently sloping ridgetops and moderate to long, gently sloping and moderately sloping hillsides. A few hillsides have strongly sloping soils on the lower part. The drainageways typically are 100 to 400 feet wide. The loess is thinner in this association than in other parts of the county.

This association makes up about 5 percent of the county. Sac soils make up about 69 percent of the association, Galva soils about 11 percent, and Primghar soils about 7 percent. Minor soils on uplands and benches make up about 10 percent, and soils in drainageways about 3 percent (fig. 4).

Sac soils formed in loess and the underlying glacial till on convex ridgetops and hillsides. These well drained soils are gently sloping to strongly sloping. The surface layer is neutral to medium acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part. The underlying glacial till is moderately alkaline clay loam. It is at a depth of about 30 inches.

Galva soils formed in loess on convex ridgetops and hillsides. The loess ranges from 40 inches to more than 60 inches in thickness. These well drained soils are nearly level to moderately sloping. The surface layer is neutral or slightly acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part and neutral to moderately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Primghar soils formed in loess in plane and convex upland areas and on the upper end of concave drainageways. These somewhat poorly drained soils are nearly level and gently sloping. The surface layer is neutral to medium acid silty clay loam. The subsoil is neutral or slightly acid silty clay loam in the upper part and neutral to moderately alkaline silt loam in the lower part. The underlying loess is moderately alkaline silt loam.

Marcus soils are the most extensive of the minor

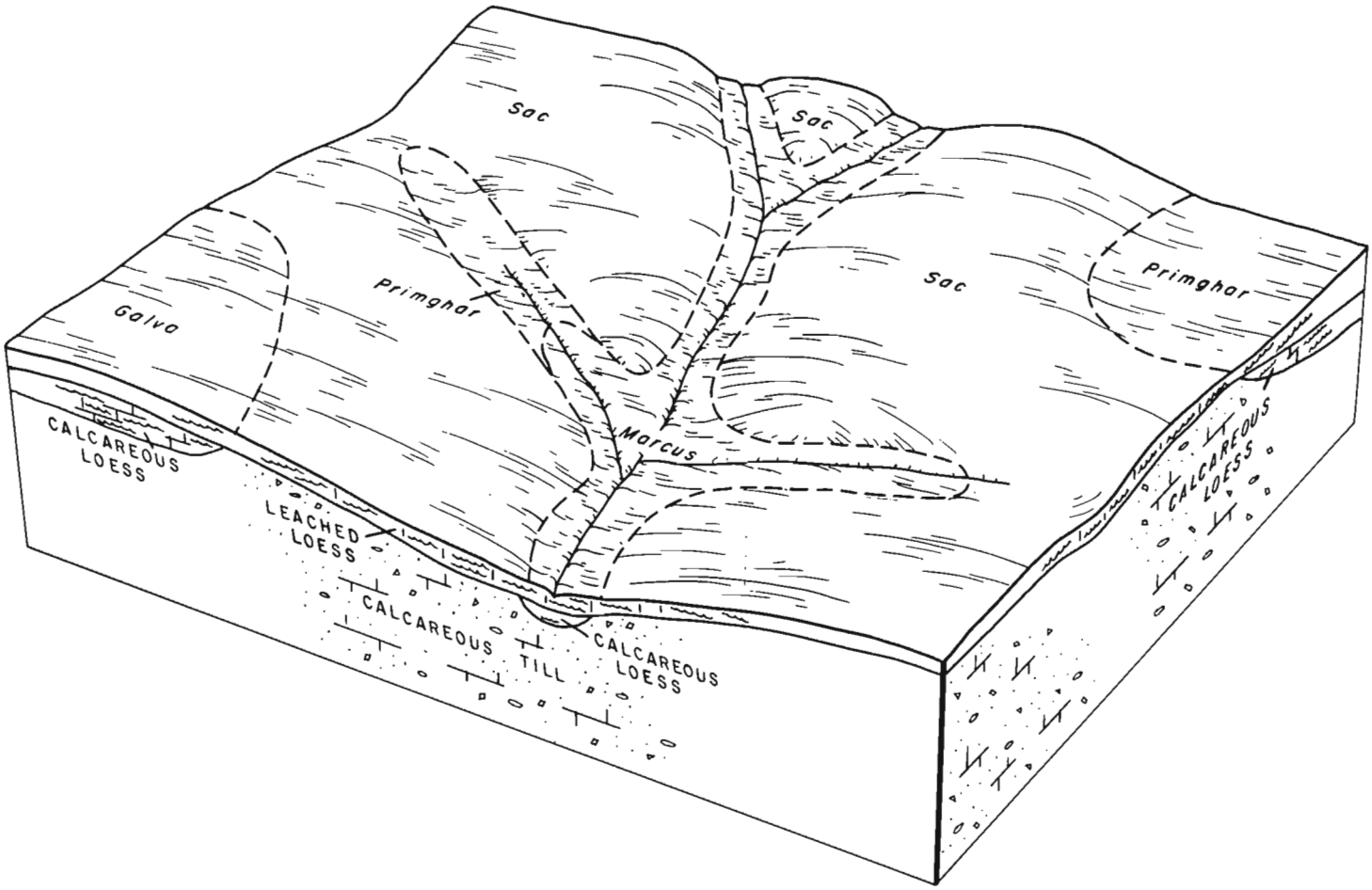

Figure 4.—Typical pattern of soils and underlying material in the Sac-Galva-Primghar association.

soils on uplands. They formed in loess and are poorly drained. Everly soils, in a small area in the vicinity of Little Rock, are similar to Sac soils, but they have a higher content of sand in the upper part, and the glacial till is at a shallower depth. Some minor soils are on stream benches and bottom land. Dempster soils on stream benches are the most extensive of these. They are moderately deep or deep to sand or gravel.

Corn and soybeans are the major crops. Some oats and alfalfa are also grown. Some of the more sloping soils and some of the wet soils in this association are used for pasture. Almost all farm operators feed livestock. Feeding cattle or hogs are the major livestock enterprises. Some farm operators keep dairy herds.

The sloping soils in this association are subject to erosion. Most areas of soils have adequate natural drainage, but some of the nearly level soils are wet and need artificial drainage to permit timely tillage. Terraces commonly are built to control runoff. The relatively shallow depth to glacial till influences their design, because the till is less permeable than the loess. Tile drains generally are used where artificial drainage is needed.

Soils in this association have the potential to continue to be used mainly for the production of row crops. This is a suitable use if adequate erosion control is provided on the sloping soils and fertility is maintained on all the soils. Livestock feeding will likely continue to be important.

Roads are on all section lines. Most are graveled or paved.

7. Ocheyedan-Bolan-Dickman association

Nearly level to strongly sloping, medium textured and moderately coarse textured, well drained and somewhat excessively drained soils

This association has nearly level and gently sloping ridgetops and gently sloping to strongly sloping hillsides. It occupies a strip ½ mile to 2 miles wide on the eastern and southern sides of the Rock and Little Rock Rivers. It includes some areas of nearly level soils on stream benches. Soils in this association formed mainly in loamy and sandy eolian material. The proportion of sand in these soils generally decreases as distance from the stream increases. In the normal pattern of the major soils the Dickman soils are nearest to the stream and Ocheyedan soils are at the greatest distance from the stream.

This association makes up about 4 percent of the county. Ocheyedan soils make up about 29 percent of the association, Bolan soils about 21 percent, and Dickman soils about 11 percent. Minor soils on stream

benches make up about 20 percent and minor soils on uplands about 19 percent (fig. 5).

Ocheyedan soils formed mainly in loamy eolian material on convex ridgetops and hillsides. These well drained soils are nearly level to strongly sloping. The surface layer is neutral or slightly acid loam. The subsoil is neutral or slightly acid sandy loam, loam, or light clay loam in the upper part and neutral to moderately alkaline sandy loam, loam, or silt loam in the lower part. The underlying material is moderately alkaline silt loam or loam.

Bolan soils formed mainly in loamy eolian material. These soils are well drained and are generally downslope from areas of Ocheyedan soils. The surface layer is neutral or slightly acid loam. The subsoil is neutral or slightly acid; the upper part of the subsoil is loam, and the lower part is fine sandy loam or loamy fine sand. The underlying material is neutral to moderately alkaline loamy sand or sand.

Dickman soils formed in loamy and sandy eolian material. They are somewhat excessively drained upland soils that are next to the stream benches or flood plains. They are generally downslope from Bolan or Ocheyedan soils. The surface layer and upper part of the subsoil is neutral or slightly acid fine sandy loam or sandy loam. The lower part of the subsoil is loamy sand or sand, and the underlying material is sand.

Dempster soils are on stream benches. These soils are underlain by sand or gravel at a depth of 24 to 40 inches. Of the minor soils on uplands, Everly soils are the most extensive.

Corn, soybeans, oats, and alfalfa are the major crops. There is proportionately more area in pasture in this association than in most other associations in the county. The major limitation to crops is available water capacity, which is lower than in other soils in the county.

The soils in this association are subject to soil blowing if the surface is unprotected, and all of the sloping soils are susceptible to water erosion. Also, the lack of adequate available water in the soil hinders plant growth during dry periods. Conservation practices, such as mulch tillage and other practices that reduce runoff and evaporation and protect the surface, are important in management. Terraces generally are not built on the sandier soils, because they are not stable.

Soils in this association have the potential to continue to be important in the production of cultivated crops, but they may be used more extensively for pasture in the future. Although almost all farm operators now raise or fatten livestock, the number of livestock is likely to increase.

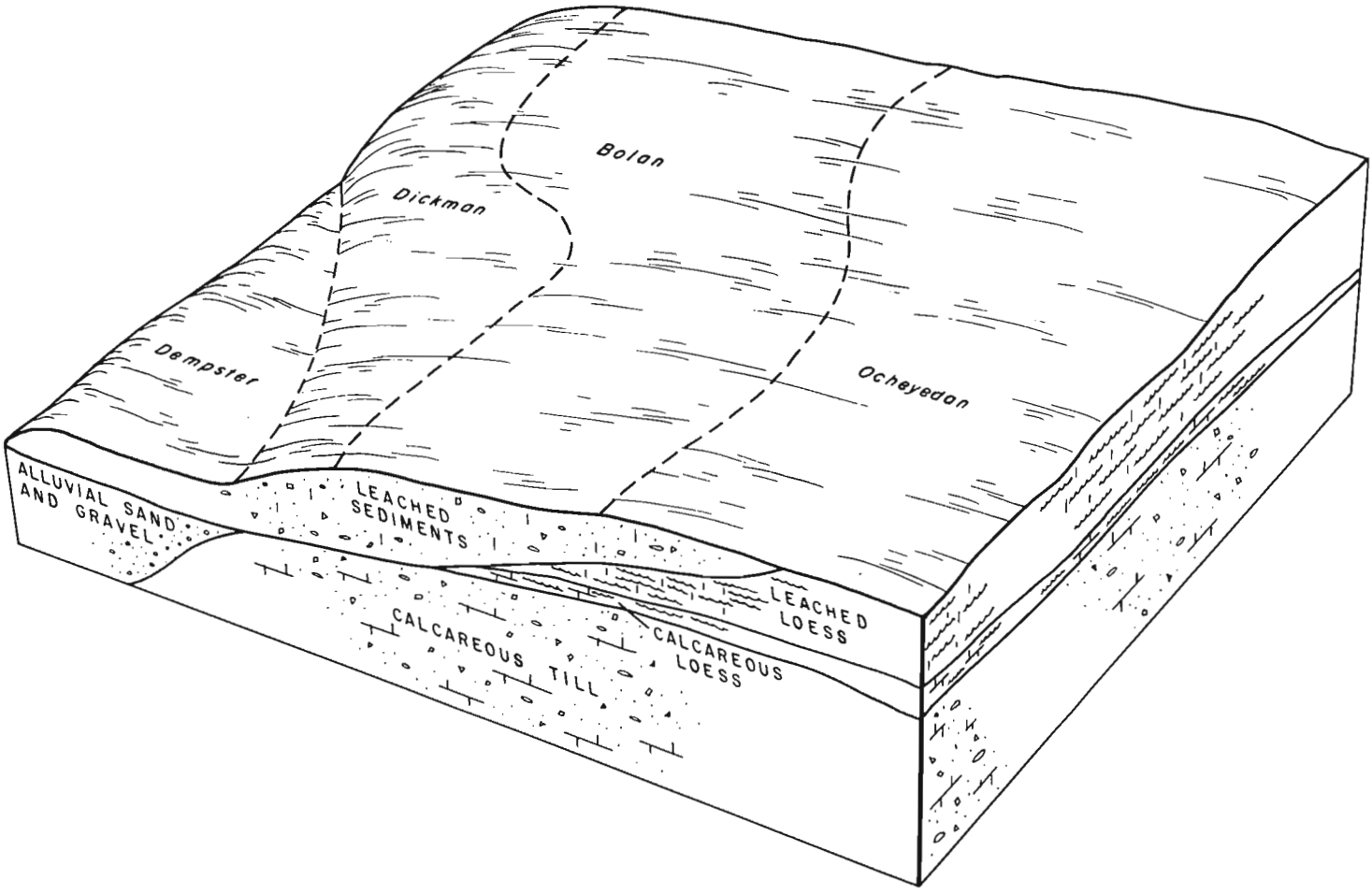

Figure 5.—Typical pattern of soils and underlying material in the Ocheyedan-Bolan-Dickman association.

Roads are on most section lines. Most are graveled or paved.

8. Steinauer-Moody association

Gently sloping to very steep, moderately fine textured, well drained soils

This association is on the upland adjacent to the Big Sioux River. It has gently sloping or moderately sloping ridgetops and strongly sloping to very steep hillsides. The gently sloping to strongly sloping drainageways typically are 100 to 300 feet wide near the lower end, but near the upper end they narrow to 50 to 100 feet. Some drainageways that are on very steep hillsides and in the upper part of narrow valleys are too deeply channeled to be crossable with farm machinery.

This association makes up about 3 percent of the county. Steinauer soils make up about 53 percent of the association and Moody soils about 22 percent. The soils in drainageways and on foot slopes make up about 17 percent of the association, and Crofton soils and other soils on the uplands make up the other 8 percent (fig. 6).

Steinauer soils formed in glacial till on convex hillsides. These well drained soils are strongly sloping to very steep. The surface layer is moderately alkaline clay loam that is commonly calcareous. The underlying material is moderately alkaline, calcareous clay loam.

Moody soils formed in loess on convex ridgetops and hillsides. These well drained soils are gently sloping to strongly sloping. The surface layer and subsoil are slightly acid or neutral silty clay loam. The underlying material is moderately alkaline, calcareous silt loam.

Crofton soils formed in loess. They are mostly in narrow bands on hillsides upslope from Steinauer soils and downslope from Moody soils. The surface layer is calcareous silt loam. Terril soils are on foot slopes. They formed in sediment from Steinauer soils. Colo, Ackmore, and Davis soils are mainly in the drainageways. They formed in alluvium from the surrounding Steinauer, Moody, and Crofton soils. A few areas of Egan soils are between Moody and Steinauer soils in places where the thickness of loess over glacial till is 20 to 40 inches.

This association is used mainly for pasture, but the wider ridgetops and drainageways are used for row crops. Some hillsides are planted to row crops, but they are better suited to hay or pasture. Stands of trees are common in this association, but they are seldom used for commercial products.

The upland soils in this association are more sloping than the upland soils in any of the other associations

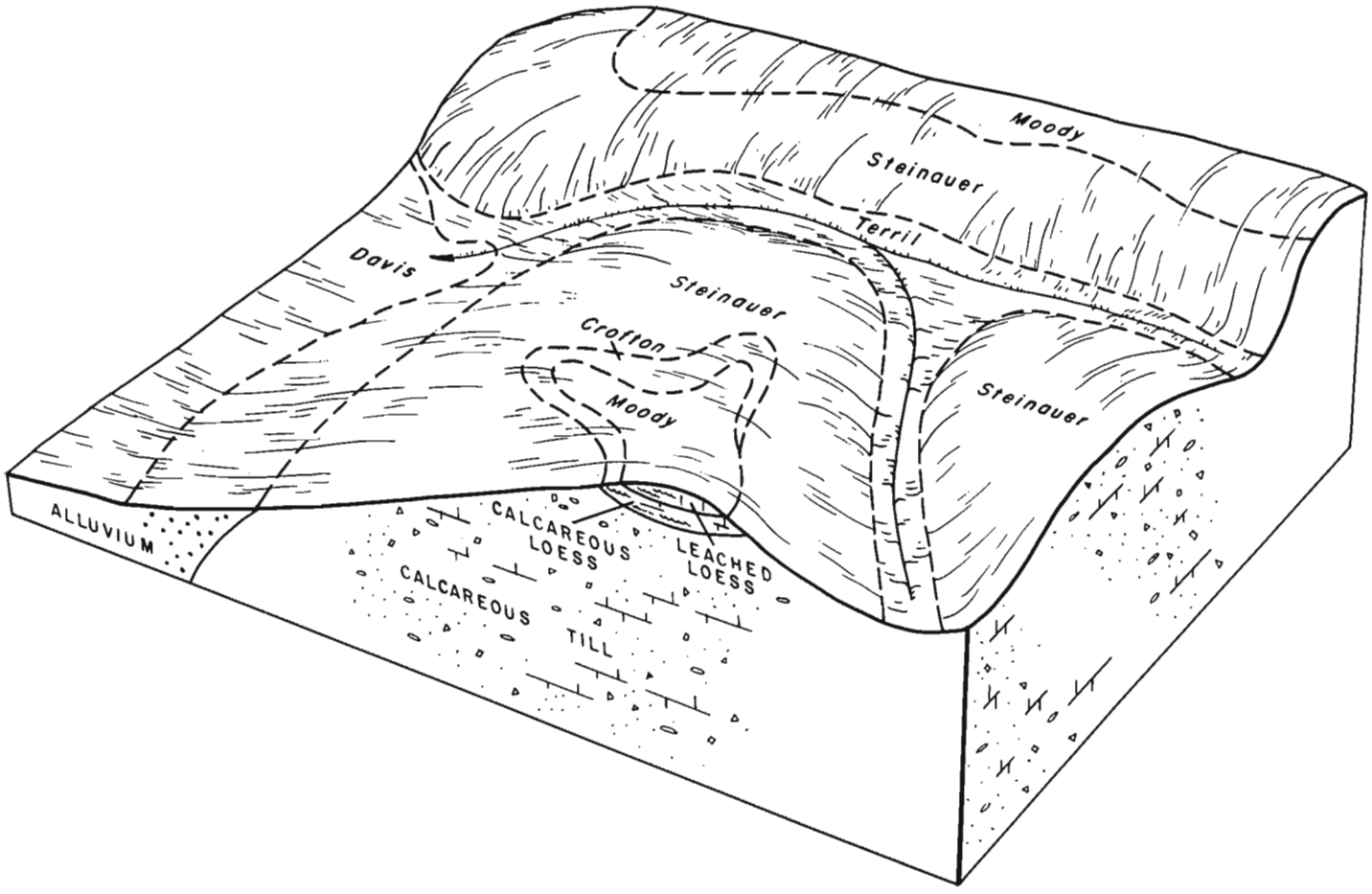

Figure 6.—Typical pattern of soils and underlying material in the Steinauer-Moody association.

in the county (fig. 7). They are very susceptible to erosion, and because runoff is rapid they are somewhat droughty. Most areas of gently sloping soils on ridgetops are too small or irregular in shape for efficient production of row crops. Areas of gently sloping soils in drainageways are long and narrow. They are subject to flooding.

This association is less well suited to cultivated crops than the other associations in the county. It is well suited to pasture and forage production. A program to increase the productivity of the native grasses will make this practice more competitive with row crops.

There are fewer roads in this association than in the others. Roads generally follow ridgetops and valleys. Most are graveled.

Descriptions of the Soils

This section describes the soil series and mapping units in Lyon 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 the soils. Color terms are for moist soil unless otherwise stated. The profile described in the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

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

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the

Figure 7.—Rolling Moody soils in the Steinauer-Moody association.

detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed and the environmental planting group. The page numbers for the descriptions of the capability units and the number of the environmental planting 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 at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*14*).[1] For example, soil reaction, which is defined in the Glossary, was measured in the field using indicator dyes, which are discussed in the Soil Survey Manual.

The location of the State boundaries shown on the soil maps is approximate.

Ackmore Series

This series consists of deep, nearly level to gently sloping, somewhat poorly drained, moderately fine textured soils on flood plains and in upland drainageways. These soils formed in alluvium.

In a representative profile the surface layer is very dark gray silty clay loam about 7 inches thick. The underlying material, to a depth of 30 inches, is stratified, friable, very dark gray silty clay loam and dark grayish brown silt laminae. The lower part of the underlying material, to a depth of 60 inches, is the surface layer of a buried soil. It is black silty clay loam.

Ackmore soils have moderate permeability in the upper part of the profile and have moderately slow permeability in the buried soil. Available water capacity is high. Organic-matter content is high. Available phosphorus in the underlying material is low, and available potassium is low. Reaction is neutral or mildly alkaline in the surface layer.

Ackmore soils are used mainly for cultivated crops. They are also used for hay and pasture, especially in the upland drainageways. Runoff from surrounding soils is the main limitation for cultivated crops.

Representative profile of Ackmore silty clay loam, 1 to 3 percent slopes, in pasture, 1,150 feet south and 360 feet east of the northwest corner of sec. 36, T. 99 N., R. 47 W.:

A—0 to 7 inches; very dark gray (10YR 3/1) silty clay loam; weak thin platy structure parting to weak very thin platy and granular; friable; mildly alkaline; gradual boundary.

C—7 to 30 inches; very dark gray (10YR 3/1) silty clay loam; very thin dark grayish brown (10YR 4/2) silt laminae; common fine dark brown (7.5YR 3/2) stains and few fine dark reddish brown (5YR 3/3) stains; weak medium platy structure parting to moderate thin and very thin platy and fine granular; friable; mildly alkaline; clear boundary.

IIA11b—30 to 38 inches; black (10YR 2/1) silty clay loam; weak fine subangular blocky structure parting to weak very fine granular; friable; neutral; gradual boundary.

IIA12b—38 to 45 inches; black (10YR 2/1, tends to N 2/0) silty clay loam; weak medium subangular blocky structure parting to moderate very fine granular; friable; neutral; gradual boundary.

IIA13b—45 to 52 inches; black (N 2/0) silty clay loam; weak medium subangular blocky structure parting to moderate very fine granular; friable; neutral; gradual boundary.

IIA3b—52 to 60 inches; black (10YR 2/1) silty clay loam; weak medium subangular blocky and prismatic structure parting to weak very fine subangular blocky and granular; friable; mildly alkaline.

The material above the buried soil is 20 to 40 inches thick. It is light silty clay loam or heavy silt loam and is stratified except where the soil has been cultivated frequently enough to mix the soil material as deposition progressed.

In most places the A horizon is very dark brown (10YR 2/2) or very dark gray (10YR 3/1) and is 6 to 20 inches thick. It is neutral or mildly alkaline.

The C horizon has color similar to that of the A horizon except that dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) colors are commonly present in the thin silty laminae. This horizon is neutral or mildly alkaline.

The IIAb horizon grades to very dark gray (10YR 3/1) at a depth above 60 inches in some profiles. It is generally medium or heavy silty clay loam and ranges from neutral to moderately alkaline.

Ackmore soils are associated with Afton, Colo, and Marcus soils, which are in similar landscape positions. Ackmore soils have more than 20 inches of lighter colored alluvium over the black layer, whereas the other soils lack the lighter colored alluvium or only have a thin layer.

430—Ackmore silty clay loam, 1 to 3 percent slopes. This nearly level soil is on flood plains and in upland drainageways. The areas of this soil are commonly much longer than they are wide and are 10 acres to more than 50 acres in size.

Included with this soil in mapping are gently sloping Ackmore soils near the upper end of upland drainageways. Also included are small areas of Afton and Colo soils that have 12 to 20 inches of overwash. In places the lighter colored overwash is moderately alkaline and is calcareous.

This soil is suited to row crops if flooding is controlled. Flooding causes limitations of erosion, siltation, and wetness. Where this soil is used for hay or pasture, these limitations are minimized.

Management concerns for row crops are reduced when runoff and erosion on the adjoining upland soils are controlled. Capability unit IIw–2; environmental planting group 1.

Afton Series

This series consists of deep, nearly level, poorly drained, moderately fine textured soils in upland drainageways. These soils formed in loess and local alluvium.

In a representative profile the surface layer is black silty clay loam about 29 inches thick. The subsoil is about 17 inches thick. It is friable, olive gray silty clay loam in the upper part and friable, olive gray silt loam in the lower part. The underlying material, to a depth of 60 inches, is light brownish gray silt loam. The subsoil and underlying material have very dark gray, strong brown, yellowish brown, and brownish yellow mottles.

Afton soils have moderately slow permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is low, and available potassium is low. Reaction is generally neutral or mildly alkaline in the surface layer.

[1] Italic numbers in parentheses refer to Literature Cited, p. 88.

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

Soil	Acres	Percent
Ackmore silty clay loam, 1 to 3 percent slopes	8,695	2.3
Afton silty clay loam, 0 to 2 percent slopes	4,980	1.3
Alluvial land	1,985	.5
Benclare silty clay loam, 0 to 2 percent slopes	750	.2
Biscay clay loam, deep, 0 to 2 percent slopes	315	.1
Bolan loam, 0 to 2 percent slopes	215	.1
Bolan loam, 2 to 5 percent slopes	2,530	.7
Bolan loam, 5 to 9 percent slopes, moderately eroded	840	.2
Bolan loam, 9 to 14 percent slopes, moderately eroded	185	(1)
Calco silty clay loam, 0 to 2 percent slopes	12,960	3.4
Colo silty clay loam, 0 to 2 percent slopes	6,025	1.6
Crofton silt loam, 5 to 9 percent slopes	825	.2
Crofton silt loam, 9 to 14 percent slopes	760	.2
Crofton silt loam, 9 to 14 percent slopes, severely eroded	2,065	.6
Crofton silt loam, 14 to 20 percent slopes, severely eroded	250	.1
Cylinder silty clay loam, deep, 0 to 2 percent slopes	1,745	.5
Davis loam, 0 to 2 percent slopes	1,475	.4
Davis silt loam, 0 to 2 percent slopes	1,680	.4
Dempster silt loam, deep, 0 to 2 percent slopes	2,865	.8
Dempster silt loam, deep, 2 to 5 percent slopes	1,075	.3
Dempster silt loam, moderately deep, 0 to 2 percent slopes	1,825	.5
Dempster silt loam, moderately deep, 2 to 5 percent slopes	1,430	.4
Dempster silt loam, moderately deep, 5 to 9 percent slopes, moderately eroded	565	.2
Dickman fine sandy loam, 2 to 5 percent slopes	205	.1
Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded	1,465	.4
Dickman fine sandy loam, 9 to 14 percent slopes, moderately eroded	320	.1
Egan silty clay loam, 2 to 5 percent slopes	7,660	2.0
Egan silty clay loam, 2 to 5 percent slopes, moderately eroded	5,810	1.5
Egan silty clay loam, 5 to 9 percent slopes, moderately eroded	3,930	1.0
Egan silty clay loam, 9 to 14 percent slopes, moderately eroded	220	.1
Estherville loam, 0 to 2 percent slopes	565	.1
Estherville-Salida complex, 5 to 9 percent slopes	335	.1
Estherville-Salida complex, 9 to 14 percent slopes	480	.1
Everly clay loam, 2 to 5 percent slopes	1,730	.5
Galva silty clay loam, 0 to 2 percent slopes	6,840	1.8
Galva silty clay loam, 2 to 5 percent slopes	33,760	9.0
Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	10,305	2.7
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	2,480	.7
Galva silty clay loam, stratified substratum, 0 to 2 percent slopes	4,785	1.3
Galva silty clay loam, stratified substratum, 2 to 5 percent slopes	675	.2
Gravel pit	350	.1
Kennebec silty clay loam, 0 to 2 percent slopes	1,225	.3
Kennebec silty clay loam, 2 to 5 percent slopes	395	.1
Marcus silty clay loam, 0 to 2 percent slopes	8,685	2.3
Mayer loam, 0 to 2 percent slopes	810	0.2
Millington loam, somewhat poorly drained, 0 to 2 percent slopes	1,960	.5
Moody silty clay loam, 0 to 2 percent slopes	1,080	.3
Moody silty clay loam, 2 to 5 percent slopes	59,025	15.7
Moody silty clay loam, 2 to 5 percent slopes, moderately eroded	32,595	8.7
Moody silty clay loam, 5 to 9 percent slopes, moderately eroded	31,610	8.4
Moody silty clay loam, 9 to 14 percent slopes, moderately eroded	10,610	2.8
Moody silty clay loam, benches, 0 to 2 percent slopes	1,435	.4
Moody silty clay loam, benches, 2 to 5 percent slopes	1,205	.3
Moody silty clay loam, loamy substratum, 2 to 5 percent slopes	1,660	.4
Moody silty clay loam, loamy substratum, 2 to 5 percent slopes, moderately eroded	2,030	.5
Moody silty clay loam, loamy substratum, 5 to 9 percent slopes, moderately eroded	1,325	.4
Ocheyedan loam, 0 to 2 percent slopes	280	.1
Ocheyedan loam, 2 to 5 percent slopes	2,505	.7
Ocheyedan loam, 2 to 5 percent slopes, moderately eroded	945	.8
Ocheyedan loam, 5 to 9 percent slopes, moderately eroded	1,210	.3
Ocheyedan loam, 9 to 14 percent slopes, moderately eroded	180	(1)
Omadi silt loam, occasionally flooded, 0 to 2 percent slopes	755	.2
Primghar silty clay loam, 0 to 2 percent slopes	18,105	4.8
Primghar silty clay loam, 2 to 5 percent slopes	7,080	1.9
Primghar silty clay loam, calcareous variant, 0 to 2 percent slopes	305	.1
Sac silty clay loam, 2 to 5 percent slopes	11,925	3.2
Sac silty clay loam, 2 to 5 percent slopes, moderately eroded	1,015	.3
Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	1,575	.4
Sac silty clay loam, 9 to 14 percent slopes, moderately eroded	120	(1)
Salida sandy loam, 18 to 40 percent slopes	290	.1
Sperry silt loam, 0 to 1 percent slopes	335	.1
Spicer silty clay loam, 0 to 2 percent slopes	1,005	.3
Spillco loam, 0 to 2 percent slopes	4,960	1.3
Steinauer clay loam, 5 to 9 percent slopes	425	.1
Steinauer clay loam, 9 to 14 percent slopes	1,405	.4
Steinauer clay loam, 14 to 18 percent slopes	965	.3
Steinauer clay loam, 18 to 25 percent slopes	3,435	.9
Steinauer clay loam, 25 to 40 percent slopes	5,940	1.3
Terril loam, 2 to 5 percent slopes	1,470	.4
Terril loam, 5 to 9 percent slopes	655	.2
Terril loam, 9 to 14 percent slopes	205	.1
Trent silty clay loam, 0 to 2 percent slopes	4,805	1.3
Trent silty clay loam, 2 to 5 percent slopes	8,295	2.2
Wentworth silty clay loam, 0 to 2 percent slopes	910	.2
Wentworth silty clay loam, 2 to 5 percent slopes	670	.2
Wentworth silty clay loam, 5 to 9 percent slopes, moderately eroded	650	.2
Zook silty clay loam, 0 to 2 percent slopes	160	(1)
Cut and fill land	55	(1)
Pond and sewage lagoon	80	(1)
Total	376,320	100.0

[1] Less than 0.05 percent.

Afton soils are used for cultivated crops, hay, and pasture. Where these soils have tile drainage, they are generally cultivated. Where they have no tile drainage, they remain wet for long periods. Flooding is a limitation. Soil blowing is a limitation, especially if the soils are plowed in the fall.

Representative profile of Afton silty clay loam, 0 to 2 percent slopes, in a cultivated field, 600 feet north and 250 feet east of the southwest corner of the SE¼ sec. 18, T. 99 N., R. 44 W., in a concave area where the slope is less than 1 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; weak fine granular structure; friable; mildly alkaline; abrupt boundary.

A12—7 to 12 inches; black (10YR 2/1) silty clay loam; few very thin pale brown (10YR 6/3) dry silt laminae; moderate fine granular and very fine subangular blocky structure; friable; few worm castings; mildly alkaline; gradual boundary.

A13—12 to 23 inches; black (N 2/0) silty clay loam; few fine strong brown (1.5YR 4/6) organic stains, very dark gray (2.5Y 3/1) mixing in lower part; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; mildly alkaline; gradual boundary.

A3—23 to 29 inches; black (2.5Y 2/1) and very dark gray (2.5Y 3/1) silty clay loam, grayish brown (2.5Y 5/2) mixing in lower part; weak medium subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; mildly alkaline; gradual boundary.

B21g—29 to 35 inches; olive gray (5Y 5/2, tending to 2.5Y) silty clay loam; very dark gray (2.5Y 3/1) worm castings; few fine strong brown (7.5Y 5/8) mottles; weak fine prismatic structure parting to moderate very fine subangular blocky; friable; mildly alkaline; gradual boundary.

B22g—35 to 40 inches; olive gray (5Y 5/2) silty clay loam, very dark gray (2.5Y 3/1) coatings in root channels; common fine brownish yellow (10YR 6/6) mottles; weak medium prismatic structure parting to weak fine and very fine subangular blocky; friable; mildly alkaline; gradual boundary.

B3g—40 to 46 inches; olive gray (5Y 5/2) silt loam; many fine yellowish brown (10YR 5/6) and strong brown (7.5YR 5/8) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few very fine segregations of iron and manganese; mildly alkaline; gradual boundary.

Cg—46 to 60 inches; light brownish gray (2.5Y 6/2) silt loam; many fine brownish yellow (10YR 6/6) mottles; massive; friable; few segregations of iron and manganese; few lime concretions and segregations; slight effervescence; moderately alkaline.

The A horizon is medium to heavy silty clay loam. In places, peds of very dark gray (10YR 3/1) to grayish brown (2.5Y 5/2) are mixed in the lower part. This horizon is neutral or mildly alkaline and is 24 to 32 inches thick.

The B2g horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 or less. Mottles in the B2g horizon have hue of 7.5YR or 10YR, value of 5 or 6, and chroma of more than 2. The B2g horizon is neutral or mildly alkaline and is 11 to 20 inches thick. The B3g horizon has colors similar to those of the B2g horizon. It is silt loam or light silty clay loam and is 4 to 10 inches thick. It is neutral to moderately alkaline.

The Cg horizon has colors similar to those of the Bg horizon, but the value ranges to 6. It is silt loam, loam, or clay loam. It has slight to strong effervescence.

Afton soils are associated with Marcus, Primghar, and Trent soils. They are more poorly drained than Primghar and Trent soils. They have a thicker dark colored surface layer than Marcus soils.

31—Afton silty clay loam, 0 to 2 percent slopes. This nearly level soil is on drainageways on uplands. Areas are generally longer than wide and are 10 acres to 30 acres or more in size.

Included with this soil in mapping are Afton soils that have as much as 12 inches of recent deposition on the surface. The deposited material is generally lighter in color than the black surface layer beneath it and is light silty clay loam in texture. Also included are small areas of calcareous soils.

This soil is suited to row crops. Flooding of short duration and excessive wetness are the main limitations to use of this soil for row crops. The soil becomes cloddy if it is tilled when it is too wet. Capability unit IIw–2; environmental planting group 2.

Alluvial Land

315—Alluvial land. Alluvial land is on bottom land adjacent to the major streams in the county. It is generally associated with Spillco, Millington, and Davis soils and is at a slightly lower elevation than these soils. The surface topography is irregular, and abandoned stream channels are in many places. This land has variable texture. Most of it is stratified sand, loamy sand, sandy loam, or loam.

Included with this land in mapping are small areas of Spillco, Millington, and Davis soils.

Alluvial land is suited to pasture, trees, and wildlife habitat. Areas that have a sandy surface layer produce only a small yield of grass. Areas that have a less sandy surface layer produce usable forage. The main limitations to the use of this land for pasture are frequent flooding and removal or deposition of soil material. Only a small acreage is cultivated. Capability unit Vw–1; environmental planting group 4.

Benclare Series

This series consists of deep, nearly level, moderately well drained, moderately fine textured to fine textured soils on stream terraces. These soils formed in alluvium.

In a representative profile the surface layer is about 24 inches thick. It is black silty clay loam in the upper part and very dark grayish brown silty clay in the lower part. The subsoil is about 39 inches thick. It is firm, dark grayish brown or olive brown silty clay in the upper part; firm, olive brown to light olive brown light silty clay in the middle part; and firm, dark grayish brown or olive brown silty clay loam in the lower part. Below the subsoil is a buried surface layer. This layer is very dark brown silty clay loam to a depth of 72 inches.

Benclare soils have slow permeability. Available water capacity is high. Organic-matter content in the surface layer is high. Available phosphorus in the subsoil is low, and available potassium is low. Reaction is neutral to medium acid in the surface layer.

Benclare soils are used mainly for cultivated crops. Wetness and flooding are slight limitations.

Representative profile of Benclare silty clay loam, 0 to 2 percent slopes, in a cultivated field, 1,260 feet south and 300 feet west of the northeast corner of sec. 36, T. 98 N., R. 49 W., on a plane slope of less than 1 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; weak fine granular structure; friable; medium acid; clear boundary.

A12—7 to 15 inches; black (10YR 2/1) silty clay loam; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual boundary.

A3—15 to 24 inches; very dark grayish brown (2.5Y 3/2) silty clay; faces of peds are black (10YR 2/1), very dark brown (10YR 2/2) kneaded; moderate fine and very fine subangular blocky and angular blocky structure; firm; neutral; gradual boundary.

B21—24 to 33 inches; dark grayish brown to olive brown (2.5Y 4/3) silty clay, faces of some peds are very dark grayish brown (2.5Y 3/2); weak fine prismatic structure parting to strong fine angular blocky and subangular blocky; firm; sheen on faces of peds; neutral; clear boundary.

B22—33 to 49 inches; dark grayish brown or olive brown (2.5Y 4/3) to grayish brown or light olive brown 2.5Y 5/3) heavy silty clay loam; weak medium prismatic structure parting to moderate fine subangular blocky; firm; sheen on faces of peds; common fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

B23—49 to 57 inches; olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4) light silty clay; weak medium prismatic structure parting to moderate fine angular blocky and subangular blocky; firm; sheen on faces of peds; few fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

B3—57 to 63 inches; dark grayish brown to olive brown (2.5Y 4/3) silty clay loam; weak medium prismatic structure; firm; few very fine black oxide segregations; common fine lime concretions and segregations; strong effervescence; moderately alkaline; clear boundary.

Ab—63 to 72 inches; very dark brown (10YR 2/2) silty clay loam; weak medium prismatic structure; friable; strong effervescence; mildly alkaline.

The solum typically extends to a depth of 60 inches or more and overlies a buried soil. Free lime is at a depth of 30 to 50 inches in most places.

The Ap or A1 horizon is medium or heavy silty clay loam. It is 10 to 20 inches thick. It is neutral to medium acid. The A3 horizon is very dark brown (10YR 2/2) or very dark grayish brown (2.5Y 3/2) heavy silty clay loam or silty clay. It is neutral or slightly acid and is 4 to 10 inches thick.

The B2 horizon has hue of 2.5Y or 5Y; value of 3, 4, or 5; and chroma of 3 or 4. In some places the B2 horizon has a hue of 2.5Y and a chroma of 2. The pH increases as depth increases and reaction is neutral or mildly alkaline in the upper part and mildly alkaline or moderately alkaline in the lower part. The B3 horizon has color similar to that of the B2 horizon. It ranges from silty clay loam to light silty clay. It is mildly alkaline or moderately alkaline. The buried soil has texture similar to that of the solum.

Benclare soils are similar to Zook soils in texture but are better drained than the Zook soils.

64—Benclare silty clay loam, 0 to 2 percent slopes. This nearly level soil is on concave and plane positions on stream benches. Most areas are 10 to 40 acres in size.

Included with this soil in mapping are small areas of soils that are similar to this soil, but are poorly drained. These areas are in the concave depressions.

This soil is suited to row crops. Soils that are in the concave areas and have no artificial drainage remain wet too long for timely tillage. Flooding from the Big Sioux River is a limitation in many areas of this soil, but average flooding is less than one time per year. Capability unit IIw–1; environmental planting group 1.

Biscay Series

This series consists of poorly drained, nearly level, moderately fine textured soils on low stream benches and in narrow channels. These soils have sand and gravel at a depth of about 32 to 40 inches. They formed in alluvium.

In a representative profile the surface layer is black clay loam that grades to very dark gray in the lower part. It is about 27 inches thick. The subsoil is friable, dark gray loam in the upper part and very friable, dark grayish brown sandy loam in the lower part. It is about 10 inches thick. The underlying material is grayish brown gravelly sand and sand.

Biscay soils have moderate permeability in the upper part and rapid permeability in the underlying material. Available water capacity is moderate, and organic-matter content is high. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is neutral or slightly acid in the surface layer.

Biscay soils in wider valleys are used mainly for cultivated crops, but many areas in the narrow valleys are used for pasture and hay. The major limitation is wetness.

Representative profile of Biscay clay loam, deep, 0 to 2 percent slopes, in a cultivated field, 1,300 feet south and 620 feet west of the northeast corner of the NW¼ of sec. 1, T. 98 N., R. 44 W., on a plane slope of about 0.5 percent:

Ap—0 to 7 inches; black (10YR 2/1) clay loam; weak fine granular structure; friable; slightly acid; clear boundary.

A12—7 to 21 inches; black (10YR 2/1) light clay loam; weak medium subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual boundary.

A3—21 to 27 inches; very dark gray (10YR 3/1) light clay loam; weak medium subangular blocky structure parting to weak very fine subangular blocky; friable; neutral; gradual boundary.

B2—27 to 32 inches; dark gray (2.5Y 4/1) loam; few very fine olive brown (2.5Y 4/4) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; a few fine gravel; neutral; clear boundary.

B3—32 to 37 inches; dark grayish brown (2.5Y 4/2) sandy loam; few fine olive brown (2.5Y 4/4) mottles; weak medium prismatic structure; very friable; about 10 percent gravel; mildly alkaline; clear boundary.

IIC1—37 to 40 inches; grayish brown (2.5Y 5/2) gravelly sand; single grained; loose; mildly alkaline; clear boundary.

IIC2—40 to 60 inches; grayish brown (2.5Y 5/2) sand; single grained; loose; slight effervescence; mildly alkaline.

The A horizon is light clay loam, silty clay loam, or heavy loam. It is 16 to 30 inches thick.

The B horizon is dark gray (2.5Y or 5Y 4/1), dark grayish brown (2.5Y 4/2), or olive gray (5Y 4/2). It is clay loam or loam in the upper part and light clay loam to sandy loam in the lower part. It has few or common mottles that have hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 4 or 6. It is neutral or mildly alkaline.

The IIC horizon is at a depth of 32 to 40 inches. This horizon is mixed sand and gravel in most profiles, but in some profiles it is predominantly sand.

In most places the A horizon is thicker than the range defined for the series. This difference does not significantly affect the use or behavior of the soils.

Biscay soils are associated on low stream benches with Cylinder and Estherville soils. They have a thicker dark colored A horizon and are more poorly drained than Cylinder and Estherville soils.

259—Biscay clay loam, deep, 0 to 2 percent slopes. This nearly level soil is on low stream benches. Areas in narrow stream valleys are long and narrow. Areas in the valleys of major streams are irregular in shape.

Included with this soil in mapping are a few areas of Biscay soils that have sand and gravel at a depth of less than 32 inches and some areas of soils that have sand and gravel at a depth greater than 40 inches. Also included are some areas that have a calcareous surface layer, a few areas that have a gravelly surface layer, and a few areas that pond water.

This soil is suited to row crops, but it remains wet for long periods when the water table is high. Tile drains reduce the time this soil is too wet for tillage, but caving of ditchbanks makes tile installation difficult in some places. Where the water level in the adjacent stream controls the water table, the benefit of tiling is reduced. Capability unit IIw–3; environmental planting group 2.

Bolan Series

This series consists of deep, nearly level to strongly sloping, well drained, medium textured soils on uplands and stream benches. These soils formed in sandy and loamy material deposited by wind and water.

In a representative profile the surface layer is very dark grayish brown loam about 8 inches thick. The subsoil is about 31 inches thick. It is dark brown loam in the upper part, brown loam in the middle part, and brown and yellowish brown fine sandy loam in the lower part. The underlying material is yellowish brown and light yellowish brown loamy sand to a depth of 69 inches.

Bolan soils have moderate permeability in the upper part and rapid permeability in the lower part. Available water capacity is moderate. Organic-matter content is moderate. Available phosphorus in the subsoil is very low, and the available potassium is very low. Reaction is generally neutral or slightly acid in the surface layer.

Bolan soils are used mainly for cultivated crops. In many places strongly sloping areas are used for pasture. These soils are somewhat droughty, and erosion is a serious limitation unless the soil surface is protected by a crop or crop residue.

Representative profile of Bolan loam, 2 to 5 percent slopes, in a cultivated field, 330 feet north and 250 feet west of the southeast corner of sec. 31, T. 98 N., R. 45 W., on a convex slope of 3 percent:

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) loam; weak fine granular structure; friable; slightly acid; clear boundary.

B1—8 to 12 inches; dark brown (10YR 3/3) loam, faces of peds very dark grayish brown (10YR 3/2); few very dark grayish brown (10YR 3/2) worm castings; weak fine subangular blocky structure; friable; neutral; clear boundary.

B21—12 to 23 inches; brown (10YR 4/3) loam, faces of peds dark brown (10YR 3/3); weak medium subangular blocky structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

B22—23 to 29 inches; brown (10YR 4/3) fine sandy loam, faces of peds dark brown (10YR 3/3); weak fine prismatic structure parting to weak fine subangular blocky; very friable; neutral; clear boundary.

B3—29 to 39 inches; yellowish brown (10YR 5/4) light fine sandy loam; weak medium prismatic structure; very friable; neutral; gradual boundary.

C1—39 to 48 inches; yellowish brown (10YR 5/4) loamy sand; single grained; loose; neutral; gradual boundary.

C2—48 to 69 inches; light yellowish brown (2.5Y 6/4) loamy sand; single grained; loose; strong effervescence; moderately alkaline.

The A horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). It is loam or silt loam that has a high content of sand. It is neutral or slightly acid and is 8 to 14 inches thick.

The B2 horizon typically is brown (10YR 4/3 or 5/3), but the upper part is dark brown (10YR 3/3) in many profiles. It is neutral or slightly acid and is 16 to 24 inches thick. The B3 horizon has value of 4 or 5 and chroma of 4, 5, or 6. It is fine sandy loam or loamy fine sand. It is neutral or slightly acid and is 6 to 13 inches thick.

The C horizon has value of 4 to 6 and chroma of 3 to 6. It is commonly loamy sand or sand, but in some profiles it is stratified and in some it is silt loam below a depth of 48 inches. It ranges from neutral to moderately alkaline.

Bolan soils in the county are outside the range defined for the series, because they are less acid in the lower part of the profile and have free lime above a depth of 60 inches. They also have a slightly thinner A1 horizon, and the mean annual precipitation is about 5 inches less.

Bolan soils are associated with Dickman and Ocheyedan soils on uplands. They are less sandy than Dickman soils and more sandy than Ocheyedan soils.

174—Bolan loam, 0 to 2 percent slopes. This nearly level soil is on upland ridgetops and on stream benches. Areas are commonly about 10 to 40 acres in size, but a few are less than 5 acres. This soil has a profile similar to the one described as representative of the series, but the surface layer is thicker and darker colored. It is about 14 inches thick and is very dark brown.

Included with this soil in mapping are small areas of Ocheyedan soils and small areas of soils that are similar to Bolan soils, but have a surface layer more than 14 inches thick.

This soil is well suited to row crops. Soil blowing is a limitation, particularly early in spring, but the major limitation is droughtiness. Capability unit IIs–1; environmental planting group 1.

174B—Bolan loam, 2 to 5 percent slopes. This gently sloping soil is on hillsides and stream benches. Most areas are 10 to 50 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are some moderately eroded Bolan soils, some small areas of Ocheyedan soils, some areas of Bolan soils that are underlain by silt loam below a depth of 40 inches, and areas of nearly level Bolan soils. Also included are a few areas of soils that have a sandy surface layer.

This soil is well suited to row crops. Soil blowing and erosion are the main limitations to the use of this soil for row crops. Crop yields are often reduced by droughtiness. Capability unit IIe–3; environmental planting group 1.

174C2—Bolan loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides. Most areas are less than 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the upper part of the underlying material is moderately alkaline and contains free lime. Some of the dark brown subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are Bolan soils that are underlain by silt loam below a depth of 40

inches. Also included are small areas of Ocheyedan and Dickman soils and a few small areas of other soils that are sandy or calcareous in the surface layer.

This soil is suited to row crops. Where this soil is adjacent to strongly sloping and moderately steep soils it is used for pasture, to which it is well suited. Careful management is required to control erosion. Crop yields are reduced by droughtiness except in years of very favorable moisture. Capability unit IIIe–2; environmental planting group 1.

174D2—Bolan loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on hillsides. Most areas are on short slopes adjacent to bottom lands and stream benches. Areas are generally small, mostly less than 10 acres in size. This soil has a profile similar to the one described as representative of the series, but the upper part of the underlying material is moderately alkaline and contains free lime. Some of the dark brown subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are severely eroded Bolan soils and Bolan soils that are underlain by silt loam below a depth of 40 inches. Also included are small areas of Ocheyedan and Dickman soils, and a few small areas of other soils that are calcareous or that formed in glacial till.

This soil is well suited to hay and pasture. It is used for pasture in places where it adjoins soils on bottom lands that are used for pasture. Some of this soil is cultivated. Slopes are not too steep for safe tillage, but the hazard of erosion is high and crop yields are reduced by droughtiness. Capability unit IVe–1; environmental planting group 1.

Calco Series

This series consists of deep, nearly level, poorly drained, moderately fine textured soils on flood plains and upland drainageways. These soils formed in alluvium.

In a representative profile the surface layer is black silty clay loam about 38 inches thick. The subsoil is about 16 inches thick. It is friable, very dark gray silty clay loam in the upper part and friable mottled dark grayish brown, very dark gray, and gray silty clay loam in the lower part. The underlying material is mottled dark gray, grayish brown, and very dark grayish brown silt loam to a depth of 60 inches.

Calco soils have moderately slow permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the lower part of the surface layer is very low, and available potassium is low. The surface layer is generally moderately alkaline and has strong effervescence.

The Calco soils on bottom lands are used mainly for cultivated crops. Much of the acreage in upland drainageways is used for pasture. The major limitations to the use of these soils for crops are flooding and wetness.

Representative profile of Calco silty clay loam, 0 to 2 percent slopes, in pasture, 1,060 feet west and 170 feet south of the northeast corner of sec. 36, T. 98 N., R. 44 W., on a plane slope of less than 1 percent:

A11—0 to 10 inches; black (N 2/0) light silty clay loam; weak very fine subangular blocky structure parting to weak very fine granular; friable; strong effervescence; moderately alkaline; gradual boundary.

A12—10 to 20 inches; black (N 2/0) silty clay loam; weak fine subangular blocky structure parting to weak very fine granular; friable; strong effervescence; moderately alkaline; gradual boundary.

A13—20 to 32 inches; black (10YR 2/1) silty clay loam; weak fine prismatic structure parting to weak medium and fine granular; friable; strong effervescence; moderately alkaline; gradual boundary.

A3—32 to 38 inches; black (10YR 2/1) silty clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; slight effervescence; moderately alkaline; clear boundary.

B2g—38 to 48 inches; very dark gray (10YR 3/1) silty clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual boundary.

B3g—48 to 54 inches; mottled dark grayish brown (2.5Y 4/2), very dark gray (10YR 3/1), and gray (2.5Y 5/1) silty clay loam, very dark gray (2.5Y 3/1) kneaded; weak medium prismatic structure; friable; strong effervescence; moderately alkaline; gradual boundary.

Cg—54 to 60 inches; mottled dark gray (2.5Y 4/1), grayish brown (2.5Y 5/2), and very dark grayish brown (2.5Y 3/2) silt loam, dark gray (2.5Y 4/1) kneaded; massive with vertical parting; friable; slight effervescence; moderately alkaline.

The A horizon is silty clay loam or heavy silt loam and is very dark gray (10YR 3/1) in the lower part in some profiles. It is mildly alkaline or moderately alkaline and is 30 to 40 inches thick.

The B horizon has hue of 10YR or 2.5Y or is neutral; value of 3 or 4; and chroma of 1 or less. In many profiles it has mottled colors that have higher value and chroma than these. This horizon is silty clay loam or silt loam. It is mildly alkaline or moderately alkaline.

The C horizon has hue of 10YR or 2.5Y or is neutral; value of 3 to 5; and chroma of 2 or less. In many profiles it has mottled colors that have higher value and chroma than these. This horizon is silty clay loam or silt loam in most places, but in some places it is loam or clay loam or silty clay below a depth of 36 inches.

Calco soils are associated with Spillco and Millington soils on flood plains and with Spicer soils in upland drainageways. All of these soils are calcareous in at least part of the profile. Calco soils are calcareous in the upper part of the A horizon, whereas Spillco soils are noncalcareous. They have more clay throughout than Millington soils. They are darker colored deeper in the profile than Spicer soils.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level soil is on flood plains and in drainageways on uplands. Areas are long and narrow in drainageways and irregular in shape on flood plains. Most areas are between 20 and 100 acres in size.

Included with this soil in mapping are areas of similar soils that are calcareous in the surface layer but are not calcareous below. Also included are areas of Calco soils that have as much as 15 inches of recently deposited sediment on the surface, a few areas of soils that are sandy or gravelly, and a few that pond water.

This soil is suited to row crops. In some places it remains wet in spring for long periods. Generally, where it is on flood plains, it is flooded at least one time a year. In drainageways, water from upslope commonly runs across this soil. The alkaline reaction of this soil causes fertility deficiency in some crops. Capability unit IIw–1; environmental planting group 2.

Colo Series

This series consists of deep, nearly level, poorly drained, moderately fine textured soils on flood plains and in narrow upland drainageways. These soils formed in alluvium.

In a representative profile the surface layer is black silty clay loam, about 39 inches thick. The subsoil and underlying material are very dark gray, firm or friable silty clay loam to a depth of 64 inches.

Colo soils have moderately slow permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is low, and available potassium is low. These soils are neutral or slightly acid to a depth of 3 feet or more except where calcareous overwash is on the surface or where a horizon directly above the water table is calcareous.

Colo soils are used mainly for cultivated crops, but a sizeable acreage is used for pasture. The major limitations to the use of these soils for crops are flooding and seasonal wetness. If these soils are plowed in fall, soil blowing is a limitation.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a cultivated field, 100 feet west and 450 feet south of the northeast corner of the SE¼ of sec. 18, T. 99 N., R. 46 W., on a plane slope of less than 1 percent:

Ap—0 to 7 inches; black (N 2/0) silty clay loam; moderate fine granular structure; friable; slightly acid; abrupt boundary.

A12—7 to 18 inches; black (N 2/0) silty clay loam; weak medium subangular blocky structure parting to moderate fine granular; friable; neutral; gradual boundary.

A12—18 to 31 inches; black (10YR 2/1) heavy silty clay loam; weak fine prismatic structure parting to moderate fine and very fine subangular blocky and granular; firm; few fine oxide segregations; neutral; gradual boundary.

A3—31 to 39 inches; black (10YR 2/1) heavy silty clay loam; few fine sand grains; weak medium prismatic structure parting to moderate very fine prismatic and subangular blocky; firm; few fine oxide segregations; neutral; gradual boundary.

Bg—39 to 53 inches; very dark gray (10YR 3/1) heavy silty clay loam, faces of peds black (10YR 2/1); few fine sand grains; weak medium prismatic structure parting to weak fine subangular blocky; firm; few fine oxide segregations; neutral; gradual boundary.

Cg—53 to 64; very dark gray (10YR 3/1) silty clay loam; common fine dark grayish brown (2.5Y 4/2) mottles; few fine sand grains; weak medium prismatic structure; friable; few fine oxide segregations; neutral.

The surface layer is black (N 2/0 or 10YR 2/1) except in places that have received recent deposition of sediment. In places this sediment is as much as 15 inches thick. It is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or very dark brown (10YR 2/2). It is generally light silty clay loam, but in a few places it is heavy silt loam.

The A horizon is 36 to 48 inches thick and is slightly acid or neutral. In the lower part in some profiles it has few or common reddish, brownish, or yellowish mottles.

The B horizon is very dark gray (10YR 3/1) or dark gray (10YR 4/1). It is lacking in some places.

The C horizon ranges in color from very dark gray (10YR 3/1) to dark grayish brown (10YR or 2.5Y 4/2).

Colo soils are associated on bottom land and in upland valleys with Ackmore, Kennebec, and Afton soils. They are finer textured than Kennebec soils. They have a thicker dark colored A horizon than Afton soils and a thinner layer of recent sediment, if present, than Ackmore soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level soil is on flood plains and in drainageways on uplands. Individual areas are irregular in shape on flood plains and long and narrow in drainageways. Most areas are 10 to 40 acres in size.

Included with this soil in mapping are areas of Colo soils that have as much as 15 inches of recently deposited sediment, and soils that have some calcareous horizons or that are more clayey or contain more sand than Colo soils. Also included are a few small areas of soils that are sandy or calcareous in the surface layer and a few that pond water.

This soil is suited to row crops. In some places it remains wet in spring for long periods. In most places it is susceptible to flooding, but this does not prevent production of row crops. Wetness is a limitation. This soil gets cloddy if worked when it is wet. Capability unit IIw–1; environmental planting group 2.

Crofton Series

This series consists of deep, moderately sloping to moderately steep, medium textured soils on convex upland ridgetops and hillsides. These soils formed in calcareous silty loess.

In a representative profile the surface layer is very dark grayish brown silt loam about 5 inches thick. The surface layer is underlain by very dark grayish brown and dark grayish brown silt loam about 3 inches thick. The underlying material is grayish brown in the upper part and light olive brown in the lower part. It is friable silt loam to a depth of 60 inches.

Crofton soils have moderate permeability. Available water capacity is high. Organic-matter content in the surface layer is moderately low. Available phosphorus below the surface layer is very low, and available potassium is low. Reaction is commonly mildly alkaline or moderately alkaline in the surface layer.

Moderately sloping Crofton soils are used mainly for cultivated crops. Strongly sloping and moderately steep soils are used mostly for pasture. Erosion is a limitation if the soils are cultivated. The more sloping soils are somewhat droughty if they are not managed to reduce runoff.

Representative profile of Crofton silt loam, 9 to 14 percent slopes, in bromegrass pasture, 260 feet south and 260 feet east of the northwest corner of sec. 1, T. 98 N., R. 48 W., on a convex slope of 11 percent:

Ap—0 to 5 inches; very dark grayish brown (10YR 3/2) heavy silt loam; weak very fine granular structure; friable; slight effervescence; mildly alkaline; clear boundary.

AC—5 to 8 inches; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) heavy silt loam, dark grayish brown (10YR 4/2, tending to 2.5Y) kneaded; weak very fine subangular blocky and fine granular structure; friable; few fine and medium lime concretions and segregations; strong effervescence; moderately alkaline; clear boundary.

C1—8 to 13 inches; grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/3) kneaded; very weak fine subangular blocky structure; friable; common fine and medium

lime concretions and segregations; strong effervescence; clear boundary.

C2—13 to 22 inches; light olive brown (2.5Y 5/3) silt loam; massive; friable; common fine and medium lime concretions and segregations; strong effervescence; moderately alkaline; gradual boundary.

C3—22 to 60 inches; light olive brown (2.5Y 5/3) silt loam; few fine gray (2.5Y 6/1) mottles; massive; friable; common very fine dark oxide segregations; few fine and very fine lime concretions and segregations; strong effervescence, moderately alkaline.

The A horizon typically is very dark grayish brown (10YR 3/2) silt loam to light silty clay loam. It is 3 to 4 inches thick and is neutral to moderately alkaline. In severely eroded places it is generally dark grayish brown (10YR 4/2). Where the soil is cultivated, thickness of the A horizon is the same as that of the plowing depth.

The AC horizon is commonly dark grayish brown (10YR 4/2) silt loam. It is less than 8 inches thick, and it is absent in most severely eroded areas. It is mildly alkaline or moderately alkaline.

The C horizon is grayish brown (2.5Y 5/2 or 5/3) or light olive brown (2.5Y 5/4). Hue tends toward 10YR in some places.

Crofton soils are mostly associated with Moody and Steinauer soils. They have a thinner A horizon than Moody soils, and they lack a B horizon, which Moody soils have. They formed in loess, whereas Steinauer soils formed in glacial till.

401C—Crofton silt loam, 5 to 9 percent slopes. This moderately sloping soil is on hillsides where the associated soils are gently sloping or moderately sloping and on ridgetops where the associated soils are sloping. Most areas are 5 to 20 acres in size and are long and narrow. This soil has a profile similar to the one described as representative of the series, but lime is leached to a depth of about 6 inches.

Included with this soil in mapping are small areas of Crofton soils that have a thinner or lighter colored surface layer or that have lime at the surface and some soils in which the lime has been leached to a depth of 1 or 2 feet. Also included are some areas of soils that formed in glacial till and soils that have a sandy or gravelly surface layer.

This soil is suited to row crops. Erosion is a serious limitation. If soil material containing lime is exposed at the surface, the availability of phosphorus and other plant nutrients is reduced. This soil is generally managed the same as adjoining soils because areas are small. Capability unit IIIe–3; environmental planting group 3.

401D—Crofton silt loam, 9 to 14 percent slopes. This strongly sloping soil is on convex ridgetops and hillsides. Most areas are 5 to 20 acres in size and are generally long and narrow. This soil has the profile described as representative of the series.

Included with this soil in mapping are severely eroded Crofton soils. Also included are small areas of soils that have gravelly and sandy material and soils that have glacial till at the surface.

This soil is well suited to hay or pasture. Some areas are used for row crops part of the time. This use is suitable if erosion is controlled, but careful management is needed to control erosion and runoff if this soil is used for row crops. The use of adjoining soils generally determines the use of this soil. Capability unit IIIe–4; environmental planting group 3.

401D3—Crofton silt loam, 9 to 14 percent slopes, severely eroded. This strongly sloping soil is on convex ridgetops and hillsides. Most areas are 5 to 20 acres in size and are generally long and narrow. This soil has a profile similar to the one described as representative of the series, but the surface layer is lighter colored and more alkaline.

Included with this soil in mapping are less eroded Crofton soils, small areas of soils that have gravelly and sandy material, and areas of soils that have glacial till at the surface.

This soil is well suited to hay and pasture. It is suited to row crops if erosion and runoff are controlled. The use of the adjoining soils generally determines how this soil is used. Capability unit IIIe–4; environmental planting group 3.

401E3—Crofton silt loam, 14 to 20 percent slopes, severely eroded. This moderately steep soil is on narrow, convex ridgetops above Steinauer soils on hillsides and on hillsides below less sloping Moody or Crofton soils. Most areas are long and narrow and are 5 to 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner and more alkaline.

Included with this soil in mapping are small areas of soils that are similar to Crofton soils but have clay loam glacial till within 36 inches of the surface, and some small areas of steep Crofton soils. Also included are a few areas of soils that have glacial till or sandy material at the surface.

This soil is well suited to hay or pasture. Most areas are adjacent to more sloping soils and are managed as pasture. Row crops can be grown occasionally, and machinery can be safely used. Some areas have scattered trees, but little marketable timber is produced. Accelerated erosion is a limitation if this soil is cultivated or overgrazed, and gullies develop in travel lanes. Capability unit IVe–1; environmental planting group 3.

Cylinder Series

This series consists of somewhat poorly drained, nearly level, moderately fine textured soils on stream benches. These soils formed in predominantly silty alluvium that has moderate amounts of sand. Sand and gravel are below a depth of 32 to 40 inches.

In a representative profile the surface layer is about 20 inches thick. It is black in the upper part and mixed very dark gray and dark grayish brown in the lower part. It is silty clay loam that has a high content of sand. The subsoil is about 19 inches thick. It is friable, dark grayish brown clay loam in the upper part; friable, dark grayish brown loam in the middle part; and very friable, olive brown loam in the lower part. The underlying material is olive brown gravelly loamy sand to a depth of 60 inches.

Cylinder soils have moderate permeability. Available water capacity is moderate to high. Organic-matter content is high. Available phosphorus in the subsoil is very low, and available potassium is low. Typically, reaction is neutral or slightly acid in the layers above the underlying material.

Cylinder soils are used mainly for cultivated crops. Some Cylinder soils that receive runoff from adjacent soils are used for hay or pasture.

Representative profile of Cylinder silty clay loam, deep, 0 to 2 percent slopes, in pasture, 90 feet south

and 430 feet west of the northeast corner of the SE¼ of sec. 7, T. 100 N., R. 45 W., 560 feet south of State line, on a plane slope of less than 1 percent:

A11—0 to 6 inches; black (10YR 2/1) silty clay loam high in sand; weak very thin platy structure and weak very fine granular; friable; slightly acid; clear boundary.

A12—6 to 15 inches; black (10YR 2/1) silty clay loam high in sand; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear boundary.

A3—15 to 20 inches; mixed very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) silty clay loam high in sand, very dark grayish brown (2.5Y 3/2) kneaded; weak fine subangular blocky structure; friable; slightly acid; clear boundary.

B21—20 to 24 inches; dark grayish brown (2.5Y 4/2) clay loam, 15 percent very dark gray (10YR 3/1), dark grayish brown (2.5Y 4/2) kneaded; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

B22—24 to 30 inches; dark grayish brown (2.5Y 4/2) loam; weak medium prismatic structure; friable; few worm castings; few fine gravel; neutral; clear boundary.

IIB3—30 to 39 inches; olive brown (2.5Y 4/4) loam; weak medium prismatic structure; very friable; 15 percent fine gravel; neutral; clear boundary.

IIC—39 to 60 inches; olive brown (2.5Y 4/4) gravelly loamy sand; single grained; loose; strong effervescence; moderately alkaline.

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

The B horizon has value of 3 to 5 and chroma of 2 or 3, but in the middle and lower parts of many profiles there are mottles that have higher or lower chroma than this. The upper part of this horizon is silty clay loam that is high in sand, light clay loam, or heavy loam. The horizon grades to loam in the lower part. It is more than 10 percent gravel in the lower part in many profiles. It is 10 to 20 inches thick and is slightly acid or neutral.

The IIC horizon has value of 3 to 5 and chroma of 2 or 3. It is loamy sand or sand that has a variable amount of gravel. It is stratified with other textures below a depth of 48 inches in some places. Its upper boundary is at a depth of 32 to 40 inches.

The Cylinder soils in the county have slightly less sand in the material above the IIC horizon than allowed in the range defined for the series. This difference does not significantly affect the use and behavior of the soils.

Cylinder soils are associated with Biscay and Dempster soils. They are not so well drained as Dempster soils and are better drained than Biscay soils.

203—Cylinder silty clay loam, deep, 0 to 2 percent slopes. This nearly level soil is on stream benches. Areas are irregular in shape. Most areas are 5 to 20 acres in size.

Included with this soil in mapping are areas of soils that are similar to this soil but that have sand and gravel at a depth of more than 40 inches and areas of Cylinder soils that have sand and gravel at a depth of less than 32 inches. Also included are a few areas of soil that are calcareous in the surface layer, a few small wet areas, and a few small gravel pits.

This soil is well suited to row crops. Some areas receive runoff from adjoining soils. This soil is somewhat droughty in dry years, particularly where the depth to gravel is less than 3 feet. Capability unit I–2; environmental planting group 1.

Davis Series

This series consists of deep, nearly level, moderately well drained, medium textured soils on high bottom lands. These soils formed in alluvium.

In a representative profile the surface layer is about 27 inches thick. The upper part is black silt loam, and the lower part is very dark brown silt loam and loam. The subsoil is friable, very dark grayish brown loam about 20 inches thick. The underlying material is loam in the upper part and silt loam in the lower part. It is dark grayish brown to a depth of 60 inches.

Davis soils have moderate permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is low, and available potassium is low. Reaction is generally neutral or slightly acid to a depth of 30 inches or more.

Davis soils are used mainly for crops. Some areas that are associated with soils that are more susceptible to flooding are used for pasture. Flooding is a limitation on Davis soils.

Representative profile of Davis silt loam, 0 to 2 percent slopes, in a cultivated field, 400 feet south and 67 feet west of the northeast corner of the NW¼ of sec. 36, T. 98 N., R. 46 W., on a plane slope of less than 1 percent:

Ap—0 to 7 inches; black (10YR 2/1) silt loam high in sand; cloddy parting to weak fine granular structure; friable; slightly acid; abrupt boundary.

A12—7 to 13 inches; black (10YR 2/1) silt loam high in sand; weak fine and very fine subangular blocky and granular structure; friable; slightly acid; clear boundary.

A13—13 to 19 inches; very dark brown (10YR 2/2) silt loam high in sand, faces of peds black (10YR 2/1); few black (10YR 2/1) worm castings; weak medium prismatic structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual boundary.

A14—19 to 27 inches; very dark brown (10YR 2/2) loam low in sand, faces of peds black (10YR 2/1); weak medium prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual boundary.

B2—27 to 40 inches; very dark grayish brown (10YR 3/2) loam, faces of peds very dark brown (10YR 2/2); weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine gravel fragments; neutral; gradual boundary.

B3—40 to 47 inches; very dark grayish brown (10YR 3/2) loam low in sand, faces of peds very dark brown (10YR 2/2); weak medium prismatic structure parting to weak medium subangular blocky; friable; common very fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

C1—47 to 55 inches; dark grayish brown (10YR 4/2) loam low in sand; weak medium prismatic structure; friable; common very fine lime segregations; strong effervescence; moderately alkaline; clear boundary.

C2—55 to 60 inches; dark grayish brown (10YR 4/2) silt loam, common fine dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure; friable; common very fine lime segregations; strong effervescence; moderately alkaline.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 12 to 28 inches thick. It is silt loam or loam and is slightly acid or neutral.

The B horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 or 2. It is loam, silt loam, or light clay loam. It is 18 to 30 inches thick. The upper part is slightly

acid or neutral, and the lower part is neutral to moderately alkaline.

The C horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. It is commonly loam or silt loam, but in some places it is stratified with layers ranging in texture from sandy loam to clay loam or silty clay loam. It is calcareous and mildly alkaline or moderately alkaline.

Davis soils are associated with Kennebec and Spillco soils on bottom lands. They contain more sand than Kennebec soils and are leached of lime to a shallower depth. They contain less sand than Spillco soils.

486—Davis loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands adjacent to small streams. Areas vary in shape and range from 10 acres to 40 acres or more in size. This soil has a profile similar to the one described as representative of the series, but the texture is loam throughout.

Included with this soil in mapping are small areas of Davis silt loam, Millington soils, Spillco soils, and soils that are similar to this soil but are poorly drained. Also included are a few small areas of soils that have a sandy surface layer and soils that pond water intermittently.

This soil is suited to row crops. Many areas are flooded one time or more each year. Areas that are frequently flooded are used for pasture, a use to which this soil is well suited. Capability unit IIw–1; environmental planting group 1.

899—Davis silt loam, 0 to 2 percent slopes. This nearly level soil is on flood plains and high bottom land. Areas are irregular in shape and are generally 20 to 100 acres in size. In many places this soil is intermingled with soils in lower positions on the flood plain. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that are similar to this soil but have lime at a depth of less than 30 inches, and soils that have lighter colored underlying material, contain more sand, and are better drained than this Davis soil. Also included are a few soils that are sandy, gravelly, or calcareous at the surface.

This soil is well suited to row crops. The frequency of flooding is generally less than one time per year, and some areas are flooded less than 1 time in 10 years. Capability unit I–1; environmental planting group 1.

Dempster Series

This series consists of well drained, nearly level to moderately sloping, medium textured soils on stream benches. These soils formed in silty sediment. They have sand or gravel below a depth of 24 to 40 inches.

In a representative profile the surface layer is very dark brown silt loam in the upper part and very dark grayish brown silty clay loam in the lower part. It is about 14 inches thick. The subsoil is friable, dark brown and brown silty clay loam and silt loam about 22 inches thick. The underlying material is yellowish brown loamy sand and sand and gravel.

Dempster soils have moderate permeability in the upper part of the profile and rapid permeability in the underlying material. Available water capacity is moderate to high. Organic-matter content is moderate. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is generally neutral or slightly acid in the surface layer.

Dempster soils are used mainly for crops. Erosion is a limitation where the soils are gently sloping and moderately sloping. These soils are somewhat droughty, especially where sand or gravel is at a depth of less than 32 inches.

Representative profile of Dempster silt loam, deep, 0 to 2 percent slopes, in a cultivated field, 300 feet south and 40 feet east of the northwest corner of the SW¼ of sec. 8, T. 98 N., R. 46 W., on a plane slope of less than 1 percent:

Ap—0 to 7 inches; very dark brown (10YR 2/2) heavy silt loam; weak fine granular structure; friable; slightly acid; abrupt boundary.

A12—7 to 14 inches; very dark grayish brown (10YR 3/2) silty clay loam; weak very fine subangular blocky structure; friable; slightly acid; clear boundary.

B1—14 to 18 inches; dark brown (10YR 3/3) silty clay loam, faces of peds very dark grayish brown (10YR 3/2); weak fine and medium subangular blocky structure; friable; slightly acid; gradual boundary.

B21—18 to 25 inches; brown (10YR 4/3) silty clay loam, faces of peds dark brown (10YR 3/3); weak fine and medium subangular blocky structure; friable; neutral; gradual boundary.

B22—25 to 31 inches; brown (10YR 4/3) silty clay loam, faces of peds dark brown (10YR 3/3); weak medium subangular blocky structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

B3—31 to 36 inches; brown (10YR 4/3) silt loam; weak medium subangular blocky structure; friable; neutral; clear boundary.

IIC1—36 to 43 inches; yellowish brown (10YR 5/4) loamy sand; single grained; loose; few coarse fragments in lower part; slight effervescence; mildly alkaline; gradual boundary.

IIC2—43 to 60 inches; yellowish brown (10YR 5/4) sand and gravel; single grained; loose; lime crusts on undersides of gravel; strong effervescence; moderately alkaline.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 10 to 16 inches thick. It is silt loam or silty clay loam and is slightly acid or neutral.

The B horizon has value of 3 to 5 and chroma of 2 to 4. It is silt loam or silty clay loam.

The IIC horizon has value of 4 or 5 and chroma of 3 or 4. It is generally loamy sand or sand that has varying amounts of gravel. It is mildly alkaline or moderately alkaline and calcareous. Some profiles have a C horizon of silt loam or loam above the IIC horizon.

Dempster soils are associated with Estherville, Moody, and Salida soils on stream benches. They have sand and gravel at a shallower depth than Moody soils on benches, and at a greater depth than Estherville and Salida soils. They also have less sand in the upper part of the profile than Estherville and Salida soils.

808—Dempster silt loam, deep, 0 to 2 percent slopes. This nearly level soil is on stream benches. Most areas are 10 to 40 acres in size; a few areas are more than 100 acres. This soil has the profile described as representative of the series.

Included with this soil in mapping are soils that are similar to this soil but have sand and gravel at a depth greater than 40 inches or less than 32 inches, have more sand and gravel in the surface layer, or formed in loess. Also included are small areas of gently sloping Dempster soils.

This soil is well suited to row crops. It is slightly droughty in years of below normal moisture. Capability unit I–2; environmental planting group 1.

808B—Dempster silt loam, deep, 2 to 5 percent slopes. This gently sloping soil is on stream benches.

Most areas are between 10 and 40 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 12 inches thick.

Included with this soil in mapping are soils that are similar to this soil but have sand or gravel at a depth greater than 40 inches and less than 32 inches, have more sand in the surface layer, or formed in loess. Also included are small areas of nearly level and moderately sloping Dempster soils.

This soil is suited to row crops. It is susceptible to erosion especially where it receives runoff from adjoining soils. It is slightly droughty in years of below normal moisture. Capability unit IIe–2; environmental planting group 1.

608—Dempster silt loam, moderately deep, 0 to 2 percent slopes. This nearly level soil is on stream benches. Most areas are between 10 and 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the underlying sand and gravel are at a depth of about 28 inches.

Included with this soil in mapping are soils that are similar to this soil but have sand or gravel at a depth greater than 32 inches or less than 24 inches, have more sand in the surface layer, or formed in loess. Also included are small areas of gently sloping Dempster soils.

This soil is suited to row crops, but it is droughty. Capability unit IIs–1; environmental planting group 1.

608B—Dempster silt loam, moderately deep, 2 to 5 percent slopes. This gently sloping soil is on stream benches. Most areas are between 10 and 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the underlying sand and gravel are at a depth of about 28 inches and the surface layer is about 12 inches thick.

Included with this soil in mapping are soils that are similar to this soil but have sand or gravel at a depth greater than 32 inches or less than 24 inches, have more sand or gravel in the surface layer, or formed in loess. Also included are small areas of nearly level Dempster soils.

This soil is suited to row crops. Droughtiness and water erosion are limitations. Capability unit IIs–2; environmental planting group 1.

608C2—Dempster silt loam, moderately deep, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is at the edge of stream benches. In most places it is below other Dempster soils. Most areas are between 5 and 15 acres in size and are longer than they are wide. This soil has a profile similar to the one described as representative of the series, but the underlying sand and gravel is at a depth of about 28 inches and the surface layer is about 10 inches thick. Some of the dark brown subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are soils that are similar to this soil but have sand or gravel at a depth greater than 32 inches or less than 24 inches, have more sand in the surface layer, or formed in loess. Also included are small areas of gently sloping and strongly sloping Dempster soils.

This soil is suited to row crops and is well suited to pasture and hay. It is droughty. Erosion is a serious limitation, especially where this soil receives runoff from adjacent soils. Capability unit IIIe–2; environmental planting group 1.

Dickman Series

This series consists of deep, gently sloping to strongly sloping, somewhat excessively drained, moderately coarse textured soils on uplands and stream benches. These soils formed in sandy and loamy materials deposited by wind and water.

In a representative profile the surface layer is very dark grayish brown, dark brown, and brown fine sandy loam about 10 inches thick. The subsoil is about 22 inches thick. It is very friable, brown fine sandy loam in the upper part; very friable, dark yellowish brown loamy fine sand in the middle part; and loose, brown loamy fine sand in the lower part. The underlying material is brown and pale brown sand to a depth of 60 inches.

Dickman soils have rapid permeability. Available water capacity is low to moderate. Organic-matter content is low. Available phosphorus in the lower part of the subsoil is very low, and available potassium is very low. The surface layer is generally neutral or slightly acid.

Dickman soils are used mainly for cultivated crops. The moderately sloping and strongly sloping areas are commonly used for pasture. These soils are droughty. Soil blowing and water erosion are limitations if the surface is not protected by a crop or crop residue.

Representative profile of Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded, in a cultivated field, 440 feet north and 85 feet east of the southwest corner of the SE¼ sec. 22, T. 100 N., R. 45 W., on a convex slope of 8 percent:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) heavy fine sandy loam; weak fine granular structure; very friable; neutral; abrupt boundary.

A3—7 to 10 inches; dark brown (10YR 3/3) and brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) kneaded; weak medium subangular blocky structure parting to weak fine granular; very friable; neutral; clear boundary.

B21—10 to 15 inches; brown (10YR 4/3) fine sandy loam; weak medium subangular blocky structure parting to weak fine subangular blocky; very friable; slightly acid; gradual boundary.

B22—15 to 22 inches; dark yellowish brown (10YR 4/4) heavy loamy fine sand, faces of peds brown (10YR 4/3); weak fine prismatic structure parting to very weak fine subangular blocky; very friable; slightly acid; gradual boundary.

B3—22 to 32 inches; brown (10YR 5/3) loamy fine sand; very weak medium prismatic structure; loose; slightly acid; gradual boundary.

C1—32 to 40 inches; brown (10YR 5/3) sand; single grained; loose; slightly acid; gradual boundary.

C2—40 to 60 inches; pale brown (10YR 6/3) sand; single grained; loose; strong effervescence; moderately alkaline.

The Ap horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) fine sandy loam or sandy loam. The A horizon is neutral or slightly acid and is 10 to 14 inches thick.

The B horizon has value of 3 to 5 and chroma of 3 or 4. It is fine sandy loam or sandy loam in the upper part, grading to loamy fine sand or loamy sand in the lower part. It is neutral or slightly acid and is 16 to 24 inches thick.

The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 or 4. It is loamy fine sand, loamy sand, fine sand, or sand. It has stratified texture in some places. It

ranges from slightly acid to moderately alkaline and from noncalcareous to calcareous.

Some of these soils are neutral to moderately alkaline in the C horizon and are outside the range defined for the Dickman series. This difference, however, does not significantly affect the use or behavior of the soils.

Dickman soils are associated with Bolan and Ocheyedan soils. They are more sandy than Bolan and Ocheyedan soils.

28B—Dickman fine sandy loam, 2 to 5 percent slopes. This gently sloping soil is on hillsides. A few areas are on stream benches. Most areas are less than 10 acres in size. This soil has a profile similar to the one described as representative of the series, but the dark surface layer is about 12 inches thick.

Included with this soil in mapping are small areas of Bolan soils, some areas of nearly level Dickman soils, and small areas where the surface layer is more sandy or less sandy than that of this Dickman soil. Also included are a few small areas of glacial till.

This soil is suited to row crops. It is droughty and susceptible to soil blowing and erosion. In years of normal rainfall, crop yields are reduced because available water capacity is a limitation. Capability unit IIs–2; environmental planting group 4.

28C2—Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides. A few areas are on stream benches. Most areas are less than 20 acres in size. This soil has the profile described as representative of the series. Some of the dark brown subsoil has been mixed into the plow layer in many places.

Included with this soil in mapping are areas of soils that are similar to this soil but have less sand or more sand in the surface layer, Dickman soils that have little or no erosion, and severely eroded Dickman soils. Also included are a few small areas of soils that have gravel in the surface layer.

This soil is suited to row crops. It is well suited to pasture. It is droughty. Water erosion and soil blowing are serious limitations if this soil is cultivated. Capability unit IIIe–2; environmental planting group 4.

28D2—Dickman fine sandy loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on hillsides. Most areas are less than 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the upper part of the underlying material is moderately alkaline. Some dark brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of Bolan soils, moderately steep Dickman soils, and severely eroded Dickman soils. Also included are a few small areas of glacial till.

This soil is well suited to hay or pasture. Erosion and soil blowing are serious limitations. Row crops can be grown, but available water capacity is a limitation to plant growth, and establishing plant cover to help control erosion is difficult. Capability unit IVe–2; environmental planting group 4.

Egan Series

This series consists of deep, gently sloping to strongly sloping, well drained, moderately fine textured soils on uplands. These soils formed in silty loess that is 20 to 40 inches thick and in the underlying clay loam glacial till.

In a representative profile the surface layer is black silty clay loam about 7 inches thick. The subsoil is about 33 inches thick. It is friable, very dark brown and dark brown silty clay loam in the upper part; friable, brown and grayish brown silt loam in the middle part; and firm, mottled yellowish brown, light brownish gray, and olive brown clay loam in the lower part. A transition layer of light gray gravelly sandy loam about 3 inches thick is between the middle part and lower part of the subsoil. The underlying material is mottled yellowish brown and light olive brown clay loam to a depth of 60 inches.

Egan soils have moderate permeability in the silty clay loam and silt loam upper material and moderately slow permeability in the clay loam lower material. Available water capacity is high. Organic-matter content is low to moderate. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is neutral to mildly acid in the surface layer.

Egan soils are used mainly for cultivated crops. Erosion is a limitation on all Egan soils.

Representative profile of Egan silty clay loam, 2 to 5 percent slopes, in a cultivated field, 1,000 feet west and 70 feet south of the northeast corner of sec. 26, T. 100 N., R. 47 W., on a convex slope of 2.5 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; cloddy parting to weak fine granular structure; friable; medium acid; abrupt boundary.

B21—7 to 12 inches; very dark brown (10YR 2/2) and dark brown (10YR 3/3) silty clay loam, very dark grayish brown (10YR 3/2) kneaded; weak medium prismatic structure parting to moderate fine and very fine subangular blocky and granular; friable; slightly acid; clear boundary.

B22—12 to 18 inches; brown (10YR 4/3) silty clay loam, faces of peds very dark grayish brown (10YR 3/2), brown (10YR 4/3) kneaded; weak medium prismatic structure parting to weak very fine subangular blocky; friable; few black (10YR 2/1) worm castings; slightly acid; clear boundary.

B23—18 to 28 inches; brown (10YR 4/3) heavy silt loam, common thin dark brown (10YR 3/3) coatings on peds, brown (10YR 4/3) kneaded; weak medium prismatic structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

IIB31—28 to 31 inches; brown (10YR 4/3) and grayish brown (2.5Y 5/2) silt loam high in sand; few thin dark brown (10YR 3/3) coatings on peds; common fine prominent brownish yellow (10YR 6/6) and gray (2.5Y 6/1) mottles; weak medium prismatic structure; friable; neutral; clear boundary.

IIB32—31 to 34 inches; light gray (10YR 7/2) sandy loam; 20 percent gravel; single grained; loose; neutral; abrupt boundary.

IIB33—34 to 40 inches; mottled yellowish brown (10YR 5/6), light brownish gray (2.5Y 6/2), and olive brown (2.5Y 4/4) clay loam; few fine faint yellowish brown (10YR 5/8) mottles; weak coarse prismatic structure; firm; many very fine dark concretions of iron and manganese; few fine lime concretions; weak effervescence; mildly alkaline; gradual boundary.

IIC—40 to 60 inches; mottled yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/4) clay loam; few fine distinct light gray (2.5Y 6/1) and strong brown (7.5Y 5/8) mottles; massive; firm; few very fine concretions of iron and manganese; few fine lime concretions; weak effervescence; moderately alkaline.

The A horizon is black (10YR 2/1), very dark brown

(10YR 2/2), or very dark gray (10YR 3/1). It is neutral to medium acid and is 4 to 10 inches thick.

The B2 horizon is 11 to 22 inches thick. It has hue of 10YR that tends to 2.5Y in some places, value of 3 or 4 and chroma of 2 to 4. It is silty clay loam or silt loam. Most profiles have the maximum clay in the upper part of the B2 horizon, but some have the maximum clay in the middle part of this horizon. The B3 horizon has color and texture similar to those of the lower part of the B2 horizon in some places. In other places the B3 horizon is partly or wholly clay loam or loam and has color similar to that of the C horizon. It ranges from slightly acid to moderately alkaline.

The IIC horizon has hue of 2.5Y, 10YR, and 7.5YR; value of 4 to 6; and chroma of 2 to 8. The high and low chroma are generally present in mottles. The horizon is clay loam or loam and is mildly alkaline or moderately alkaline.

The Egan soils in this county are leached of carbonates to a greater depth than is defined in the range for the series. Also, they lack a B3ca or Cca horizon. These differences do not significantly affect the use and behavior of the soils.

Egan soils are associated with Moody soils and are similar to Sac soils. They have glacial till above a depth of 40 inches, whereas Moody soils have silt loam loess to a depth of more than 40 inches. They have a lower average moisture content than Sac soils.

411B—Egan silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas are 20 to 100 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of moderately eroded Egan soils that have a lighter colored surface layer than this Egan soil and small areas of Moody soils. Also included are a few small areas of glacial till.

This soil is suited to row crops. It is susceptible to erosion, especially on long hillsides. Capability unit IIe–3; environmental planting group 1.

411B2—Egan silty clay loam, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on ridgetops and hillsides. Most areas are 20 to 100 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown and the upper part of the subsoil is dark brown. Some dark brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of moderately sloping Egan soils and small areas where erosion has removed most of the original surface layer. Also included are small areas of glacial till.

This soil is suited to row crops. It is more susceptible to erosion than the Egan soil described as representative of the series. Adequate erosion control can be obtained with reasonable care. Capability unit IIe–3; environmental planting group 1.

411C2—Egan silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides. Most areas are from 10 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown. Some dark brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are areas of Egan soils that have a darker colored surface layer than this soil. Also included are small areas of severely eroded Egan soils and soils that have a loamy or gravelly surface layer.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

411D2—Egan silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on the lower part of hillsides below less sloping Egan and Moody soils. Most areas are less than 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown and clay loam glacial till is at a depth of only about 24 inches. Some dark brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are areas of Egan soils that have a darker colored surface layer than this soil. Also included are a few small areas of severely eroded Egan soils.

This soil is suited to row crops. It is well suited to hay and pasture. Careful management is needed to control erosion if this soil is used for row crops. Capability unit IIIe–4; environmental planting group 1.

Estherville Series

This series consists of somewhat excessively drained, nearly level to strongly sloping, medium textured soils on stream benches and near the base of short slopes bordering stream valleys. These soils are underlain by sand and gravel below depths of about 15 to 30 inches. They formed in alluvium from melting glaciers.

In a representative profile the surface layer is black loam in the upper part and black, very dark grayish brown, and dark brown sandy loam in the lower part. It is about 18 inches thick. The subsoil is loose, brown gravelly sandy loam about 4 inches thick. The underlying material is brown in the upper part and yellowish brown in the lower part. It is gravelly sand to a depth of 60 inches.

Estherville soils have moderately rapid permeability in the surface layer and subsoil and rapid permeability in the underlying material. Available water capacity is low. Available phosphorus and available potassium in the lower part of the surface layer are very low. Organic-matter content of the surface layer is moderate or moderately low. The surface layer is commonly slightly acid.

The nearly level and gently sloping Estherville soils are used mainly for cultivated crops. The more sloping Estherville soils are used for cultivated crops, pasture, or hayland, depending on the use of adjoining soil areas. A major limitation to all uses of these soils is droughtiness. Erosion is a limitation where sloping areas of these soils are cultivated.

Representative profile of Estherville loam, 0 to 2 percent slopes, in a cultivated field, 210 feet west and 130 feet north of the southeast corner of sec. 35, T. 98 N., R. 46 W., on a plane slope of less than 1 percent:

Ap—0 to 6 inches; black (10YR 2/1) loam; cloddy parting to weak fine and very fine granular structure; friable; slightly acid; clear boundary.

A12—6 to 13 inches; black (10YR 2/1) sandy loam; weak fine subangular blocky structure parting to weak

fine and very fine granular; very friable; slightly acid; clear boundary.

A3—13 to 18 inches; mixed very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) light sandy loam, very dark grayish brown (10YR 3/2) kneaded; weak fine subangular blocky structure; very friable; neutral; clear boundary.

IIB—18 to 22 inches; brown (10YR 4/3) gravelly light sandy loam; weak medium subangular blocky structure; loose; few lime coats on under sides of gravel in lower part, neutral; clear boundary.

IIC1—22 to 30 inches; brown (10YR 4/3) gravelly sand; single grained; loose; lime coats on under sides of gravel; strong effervescence; moderately alkaline; gradual boundary.

IIC2—30 to 60 inches; yellowish brown (10YR 5/4) gravelly sand; single grained; loose; strong effervescence; moderately alkaline.

The A1 horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). It is 6 to 15 inches thick. It is generally loam, but in a few places it is sandy loam. It is generally slightly acid, but ranges to neutral. The A3 horizon is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) loam or sandy loam. It is 3 to 6 inches thick. It is neutral or slightly acid.

The B horizon has value of 3 or 4 and chroma of 3 or 4. It ranges from loam to gravelly light sandy loam. It is 4 to 12 inches thick, but that part of the horizon that is transitional in texture to the IIC horizon is less than 5 inches thick. It ranges from slightly acid to mildly alkaline.

The IIC horizon has value of 4 or 5 and chroma of 3, 4, or 5. Colors are often variegated. It ranges from medium sand that has no gravel to gravel that has less than 30 percent sand. It is generally moderately alkaline and calcareous, but in some profiles the upper few inches is neutral or mildly alkaline.

Estherville soils in this county are in an area that receives slightly less rainfall than is in the range defined for the series. This does not significantly affect the use or behavior of the soils.

Estherville soils are associated with Salida and Dempster soils. They have sand or gravel at a shallower depth than Dempster soils. They have sand or gravel at a greater depth than Salida soils.

72—Estherville loam, 0 to 2 percent slopes. This nearly level soil is on low stream benches. Most areas are more than 10 acres in size and a few are more than 100 acres. Areas are irregular in shape but generally are longest in the direction parallel to nearby streams. This soil has the profile described as representative of the series (fig. 8).

Included with this soil in mapping is a soil covering an area of about 120 acres in sec. 17, T. 99 N., R. 43 W., that has more clay and less sand in the material above the sand and gravel than this soil. A soil that has only dark colors above the sand and gravel and is calcareous throughout the profile is in sec. 25, T. 98 N., R. 46 W. Also included are soils in places where the depth to sand and gravel and the texture of the

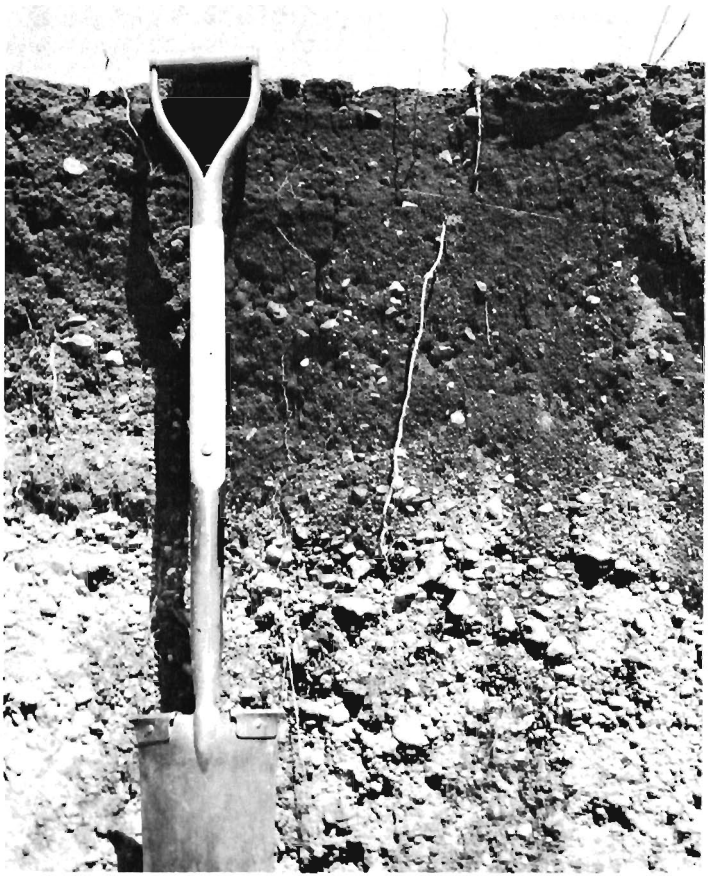

Figure 8.—Profile of Estherville loam, 0 to 2 percent slopes.

overlying material are too variable to separate in mapping and a few areas of gently sloping Estherville soils.

This soil is suited to row crops. It is droughty. Soil blowing occurs during dry, windy periods unless the soil surface is protected by crop residue or a growing crop. Crops that are drought-tolerant or that mature before the usual dry periods produce acceptable yields more consistently than do crops that require a long growing season. Capability unit IIs–1; environmental planting group 4.

541C—Estherville-Salida complex, 5 to 9 percent slopes. These moderately sloping soils are downslope from nearly level and gently sloping soils on benches and uplands. In the northeastern part of the county these soils are on small knobs above gently sloping and moderately sloping soils on uplands. Most areas of these soils are about 60 percent Estherville loam and about 40 percent Salida sandy loam. In most places Salida sandy loam is upslope from Estherville loam; it is more convex and, in many places, more steeply sloping than Estherville loam. Most areas are less than 10 acres in size. These soils have profiles similar to the ones described as representative of their respective series, but the surface layer of Estherville loam is neutral.

Included with these soils in mapping are narrow soil areas adjacent to bottom land that have sand and gravel at a depth of 24 inches or more and have only dark colored soil material above the gravel. Also included are a few small areas of soils that formed in glacial till.

These soils are suited to row crops. They are well suited to hay and pasture. They are droughty, and water erosion and soil blowing are serious limitations. Rocks in the surface layer in some places make effective tillage difficult. Most areas of these soils are too small to be managed differently than adjoining soil areas. Capability unit IIIe–2; environmental planting group 4.

541D—Estherville-Salida complex, 9 to 14 percent slopes. These strongly sloping soils are at the edge of stream benches and on short side slopes between soils on bottom lands and soils on uplands. In the northeastern part of the county these soils are on small knobs above gently sloping and moderately sloping soils on uplands. Most areas of these soils are about 50 percent Estherville loam and about 50 percent Salida sandy loam. Salida sandy loam is typically more convex and more steeply sloping than Estherville loam. Most areas are less than 10 acres in size.

These soils have profiles similar to the ones described as representative of their respective series, but the surface layer of Estherville loam is neutral.

Included with these soils in mapping are some severely eroded areas of these soils and areas, near the boundary between these soils and soils on bottom lands, of a soil that has sand or gravel at a depth of more than 24 inches. Also included are some areas of moderately steep Salida soils.

These soils are well suited to pasture or hay crops. They are droughty, and water erosion and soil blowing are severe limitations. Stones are in the surface layer of these soils in many places. Capability unit IVe–2; environmental planting group 4.

Everly Series

This series consists of deep, gently sloping, well drained, moderately fine textured soils on uplands. These soils formed in loamy material about 20 to 36 inches thick and in the underlying glacial till.

In a representative profile the surface layer is black and very dark brown and dark brown clay loam about 16 inches thick. The subsoil is friable, very dark grayish brown, brown and yellowish brown clay loam in the upper part and firm, mottled, yellowish brown clay loam in the lower part. It is about 26 inches thick. The underlying material to a depth of 60 inches is mottled dark yellowish brown, yellowish brown, and light gray clay loam.

Everly soils have moderate permeability in the upper part and moderately slow permeability in the lower part. Available water capacity is high. Organic-matter content in the surface layer is moderate. Available phosphorus and potassium in the subsoil are very low. Reaction is neutral to medium acid in the surface layer.

The Everly soils are used mainly for cultivated crops, but a few areas are in pasture. Erosion is the major limitation if these soils are cultivated.

Representative profile of Everly clay loam, 2 to 5 percent slopes, 300 feet south and 70 feet west of the northeast corner of sec. 27, T. 98 N., R. 44 W., on a convex slope of 2.5 percent:

Ap—0 to 6 inches; black (10YR 2/1) light clay loam; weak very fine granular structure; friable; medium acid; abrupt boundary.

A12—6 to 12 inches; black (10YR 2/1) light clay loam; weak fine subangular blocky structure parting to weak very fine granular; friable; slightly acid; clear boundary.

A3—12 to 16 inches; very dark brown (10YR 2/2) and dark brown (10YR 3/3) light clay loam, very dark grayish brown (10YR 3/2) kneaded; weak fine subangular blocky structure parting to weak very fine granular; friable; slightly acid; clear boundary.

B21—16 to 22 inches; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) light clay loam, brown (10YR 4/3) kneaded; weak medium subangular blocky structure parting to weak fine granular; friable; common black (10YR 2/1) worm castings; neutral; clear boundary.

IIB22—22 to 28 inches; yellowish brown tending to light olive brown (10YR 5/4, tending to 2.5Y hue) clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; few black (10YR 2/1) worm castings; upper part of horizon has very dark grayish brown (10YR 3/2) coatings on peds; neutral; clear boundary.

IIB23—28 to 33 inches; yellowish brown tending to light olive brown (10YR 5/4, tending to 2.5Y) clay loam; common fine strong brown (7.5YR 5/6) and yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; thin discontinuous clay films on faces of prisms; mildly alkaline; clear boundary.

IIB3—33 to 42 inches; yellowish brown tending to light olive brown (10YR 5/4, tending to 2.5Y) clay loam; few fine strong brown (7.5Y 5/6) mottles common fine yellowish brown (10YR 5/4) mottles, and common fine and medium light gray (10YR 6/1) mottles; weak medium prismatic structure parting to moderate fine subangular blocky; firm; thin discontinuous clay films on faces of prisms; common fine lime segregations and concretions; slight effervescence; moderately alkaline, clear boundary.

IIC1—42 to 48 inches; mottled yellowish brown (10YR 5/4), dark yellowish brown (10YR 4/4), and light gray

(10YR 6/1) clay loam; weak medium prismatic structure parting to moderate fine angular blocky; firm; thin discontinuous clay films on faces of prisms; common fine and medium lime segregations; strong effervescence; moderately alkaline, clear boundary.

IIC2—48 to 60 inches; mottled dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and light gray (10YR 6/1) clay loam; weak coarse prismatic structure parting to massive; firm; common medium and large lime segregations and concretions; strong effervescence; moderately alkaline.

The Everly soils in the northeastern part of the county have more silt and less sand in the upper part of the profile than those in the southeastern part of the county.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2). It is heavy loam, clay loam, or silty clay loam. It is 10 to 16 inches thick where the soil is not eroded or only slightly eroded.

The B2 horizon is brown (10YR 4/3 to 10YR 5/3) or yellowish brown (10YR 5/4) in most profiles, although the upper part is very dark grayish brown (10YR 3/2) in some profiles. It is clay loam or silty clay loam. In most profiles the lower part of the B2 horizon or the B3 horizon extends into clay loam glacial till. The B horizon is generally 10YR, but tends toward 2.5Y in many profiles. The B horizon is about 20 to 32 inches thick and is neutral to moderately alkaline.

The IIC horizon has a matrix color of dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4) and has few to common mottles in some profiles. In other profiles, it is mottled dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and light gray (10YR 6/1). It is mildly alkaline or moderately alkaline.

Everly soils are associated with Galva and Sac soils. They formed partly in glacial till, whereas Galva soils formed in 40 inches or more of loess over till. They have more sand and less silt in the upper part of the profile than Sac soils.

577B—Everly clay loam, 2 to 5 percent slopes. This gently sloping soil is on uplands. In many places it is adjacent to Ocheyedan soils. Areas are large; some are more than 160 acres in size.

Included with this soil in mapping are small areas of moderately eroded Everly soils and areas of Ocheyedan soils. Also included are small areas of soils that have a surface layer of sandy loam and small areas of moderately sloping and strongly sloping Everly soils.

This soil is well suited to row crops. Erosion is a limitation where slopes are long. Management that controls erosion also reduces runoff. Capability unit IIe-3; environmental planting group 1.

Galva Series

This series consists of deep, nearly level to moderately sloping, well drained, moderately fine textured soils on uplands and stream benches. Sand and gravel, ranging in thickness from a few inches to many feet, underlie most areas of Galva, stratified substratum, soils. These soils formed in silty loess that is underlain at a depth of more than 40 inches by clay loam glacial till or by stratified sediment.

In a representative profile the surface layer is silty clay loam that is very dark brown in the upper part and very dark grayish brown in the lower part. This layer is about 12 inches thick. The subsoil is about 32 inches thick. It is friable, brown silty clay loam in the upper part; friable brown silt loam in the middle part; and friable, yellowish brown silt loam in the lower part. The underlying material is yellowish brown silt loam to a depth of 64 inches and yellowish brown clay loam between the depths of 64 and 72 inches.

Galva soils have moderate permeability. Available water capacity is high. Organic-matter content is moderate. Available phosphorus in the subsoil is very low, and available potassium is low. The surface layer is generally neutral or slightly acid.

Galva soils are used mainly for cultivated crops. Erosion is a limitation on the gently sloping and moderately sloping Galva soils.

Representative profile of Galva silty clay loam, 2 to 5 percent slopes, in a cultivated field, 1,330 feet south and 800 feet east of the northwest corner of sec. 10, T. 98 N., R. 44 W., on a convex slope of 3 percent:

Ap—0 to 8 inches; very dark brown (10YR 2/2) silty clay loam; cloddy parting to weak fine and very fine granular structure; friable; slightly acid; abrupt boundary.

A3—8 to 12 inches; very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) kneaded; weak fine subangular blocky structure; friable; slightly acid; clear boundary.

B21—12 to 18 inches; brown (10YR 4/3) silty clay loam, faces of peds dark brown (10YR 3/3); weak medium subangular blocky structure parting to moderate fine and very fine subangular blocky; friable; slightly acid; gradual boundary.

B22—18 to 24 inches; brown (10YR 4/3) light silty clay loam; weak fine prismatic structure parting to moderate very fine prismatic and fine subangular blocky; friable; neutral; gradual boundary.

B23—24 to 30 inches; brown (10YR 4/3) heavy silt loam; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; neutral; gradual boundary.

B31—30 to 38 inches; yellowish brown (10YR 5/4) silt loam; few very fine light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; neutral; abrupt boundary.

B32—38 to 44 inches; yellowish brown (10YR 5/4) silt loam; common fine light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine prismatic; friable; common fine and very fine lime concretions and segregations; slight effervescence; moderately alkaline gradual boundary.

C1—44 to 64 inches; yellowish brown (10YR 5/4) silt loam; common fine light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; friable; common fine and very fine lime concretions and segregations; strong effervescence; moderately alkaline; abrupt boundary.

IIC2—64 to 72 inches; yellowish brown (10YR 5/4) clay loam; common fine light brownish gray (2.5Y 6/2) and strong brown (7.5Y 5/6) mottles; massive; few very fine lime segregations; strong effervescence; moderately alkaline.

The Ap or A1 horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). The A3 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A horizon is generally neutral or slightly acid and is 10 to 16 inches thick.

The B horizon is 24 to 34 inches thick. The B2 horizon is brown (10YR 4/3 or 5/3) or yellowish brown (10YR 5/4). It ranges from light to medium silty clay loam in the upper part and from light silty clay loam to silt loam in the lower part. It is neutral or slightly acid. The B3 horizon has color similar to that of the B2 horizon. It generally is silt loam, but the upper part is light silty clay loam in some places. It ranges from neutral to moderately alkaline.

The C horizon has hue of 10YR tending to 2.5Y in some profiles, value of 4 or 5, and chroma of 3 or 4. It is silt loam to a depth of 60 inches or more in some places and silt loam over clay loam or stratified sediment below a depth of 40 inches in other places.

Galva soils are similar to Moody soils. They have a higher average moisture content than Moody soils.

310—Galva silty clay loam, 0 to 2 percent slopes. This nearly level soil is on ridgetops above gently sloping Galva soils and on convex areas above nearly level Marcus and Primghar soils. Areas vary greatly in size, but most are between 20 and 100 acres. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 15 inches thick.

Included with this soil in mapping are a few small areas of soils that formed in glacial till.

This soil is well suited to row crops. Water erosion is not a serious limitation, but the soil is most productive where runoff is minimized. Capability unit I–3; environmental planting group 1.

310B—Galva silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas are 50 acres to 200 acres or more in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of gently sloping Sac soils, some areas of moderately eroded Galva soils, and narrow areas of Primghar soils in drainageways. Also included are a few small areas of glacial till or calcareous soils.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long, which is common for this soil. Capability unit IIe–3; environmental planting group 1.

310B2—Galva silty clay loam, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas are 50 acres to 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 very dark grayish brown in the upper part. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of slightly eroded Galva soils. Also included are a few areas of soils that have glacial till or gravelly or calcareous soil material in the surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long, which is common for this soil. Capability unit IIe–3; environmental planting group 1.

310C2—Galva silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is mostly on hillsides; a small acreage is at the edge of stream benches. Most areas are 10 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is lighter colored in the upper part. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are areas of severely eroded Galva soils and areas of slightly eroded Galva soils. Also included are a few small areas of soils that have glacial till or gravelly or calcareous soil material in the surface layer.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

311—Galva silty clay loam, stratified substratum, 0 to 2 percent slopes. This nearly level soil is on plane uplands or on stream benches. Most areas are large; some are more than 300 acres in size. The profile of this soil differs from the representative profile in having a stratified substratum and a thicker dark colored surface layer.

Included with this soil in mapping are some areas of Galva silty clay loam, 0 to 2 percent slopes.

This soil is well suited to row crops. Lime is leached to a greater depth in this soil than in the other well drained soils on uplands in the county. Crop response to liming generally is greater on this soil than on other well drained soils in the county. Capability unit I–3; environmental planting group 1.

311B—Galva silty clay loam, stratified substratum, 2 to 5 percent slopes. This gently sloping soil is on stream benches that are 5 to 15 feet above the flood plain. In most places this soil is downslope from nearly level Galva soils on benches. Most areas are 10 to 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the subsoil is thicker and is underlain by sand and gravel.

Included with this soil in mapping are nearly level Galva soils and soils that are similar to this soil but formed in silty material that is stratified. Also included are a few small areas of soils that have a gravelly or calcareous surface layer.

This soil is suited to row crops. Water erosion is a limitation, especially where this soil receives runoff from adjacent soils. In places rooting depth is a limitation to deep-rooted crops because of the underlying sand and gravel. Capability unit IIe–3; environmental planting group 1.

Gravel Pit

501—Gravel pit. Gravel pits are areas currently used and formerly used as sources of gravel and sand. Some gravel pits pond water.

Where mining activity has been completed and some plant cover is present, these areas provide good wildlife habitat (fig. 9). Where gravel pit areas are small, they are often reclaimed for pasture or for cultivated crops. The material left after mining is completed is high in sand and gravel. Large stones are common in many pits. Stockpiling of the topsoil is important if the pits are to be reclaimed for cropland. Capability unit VIIs–1; environmental planting group 4.

Kennebec Series

This series consists of deep, nearly level and gently sloping, moderately well drained, moderately fine textured soils on bottom lands and foot slopes. These soils formed in alluvium.

In a representative profile the surface layer is black, very dark gray and very dark grayish brown. The upper part is silty clay loam, and the lower part is silt loam. It is about 45 inches thick. The underlying material is dark grayish brown loam to a depth of 60 inches.

Kennebec soils have moderate permeability. Available water capacity is high. Organic-matter content is

Figure 9.—A gravel pit area that has partly revegetated.

high. Available phosphorus in the lower part of the surface layer is low, and available potassium is low. The surface layer is generally neutral or slightly acid.

Kennebec soils are used mostly for cultivated crops. Some areas are used for pasture. Flooding is a limitation on most Kennebec soils on bottom lands, but this generally does not hinder row crop production. Erosion is a limitation on gently sloping Kennebec soils.

Representative profile of Kennebec silty clay loam, 0 to 2 percent slopes, in a cultivated field, 350 feet south and 280 feet west of the northeast corner of the SE¼ of sec. 15, T. 99 N., R. 45 W., on a plane slope of less than 1 percent:

A11—0 to 12 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; slightly acid; clear boundary.

A12—12 to 20 inches; very dark gray (10YR 3/1) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual boundary.

A13—20 to 30 inches; very dark grayish brown (2.5Y 3/2) light silty clay loam, faces of peds black (10YR 3/1); few fine brown (7.5Y 4/4) iron stains; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual boundary.

A14—30 to 45 inches; very dark grayish brown (2.5Y 3/2) silt loam, faces of peds very dark gray (10YR 3/1); few fine brown (7.5Y 4/4) iron stains; weak medium prismatic structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

C—45 to 60 inches; dark grayish brown (2.5Y 4/2) loam; common fine dark yellowish brown (10YR 4/4) iron stains; weak medium prismatic structure; friable; strong effervescence; moderately alkaline.

The A horizon is silty clay loam or silt loam. It ranges from slightly acid to mildly alkaline and is 36 to 48 inches thick.

The C horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. It is silt loam, loam, or silty clay loam. It is commonly moderately alkaline and calcareous, but in some places it is mildly alkaline or neutral and noncalcareous.

Kennebec soils are associated with Colo and Davis soils on bottom lands. They have less clay than Colo soils and less sand than Davis soils.

26—Kennebec silty clay loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands and foot slopes. Most areas are 10 to 30 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are soils that are similar to this soil but moderately alkaline and calcareous within a depth of 40 inches or less. Also included are small areas of Colo and Davis soils and a few small areas of soils that have a gravelly or calcareous surface layer.

This soil is well suited to row crops, but flooding is a slight limitation to this use in some places. The surface layer is easily tilled, and good seedbeds are not difficult to prepare. Capability unit I–1; environmental planting group 1.

26B—Kennebec silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on foot slopes. Some

areas are between soils on uplands and soils on terraces. Most areas are 5 to 15 acres in size.

Included with this soil in mapping are soils that are similar to this soil but are moderately alkaline and calcareous within a depth of 40 inches or less. Also included are areas of soils that are similar but well drained and mainly on toe slopes between bottom lands and uplands.

This soil is suited to row crops, but erosion and siltation are limitations to this use where this soil receives runoff from adjacent soils. Capability unit IIe–1; environmental planting group 1.

Marcus Series

This series consists of deep, nearly level, poorly drained, moderately fine textured soils in plane areas on uplands and in concave areas on upland drainageways. These soils formed in loess.

In a representative profile the surface layer is black silty clay loam and silty clay about 19 inches thick. The subsoil is about 26 inches thick. It is firm, very dark gray and olive gray silty clay in the upper part; firm, dark gray, olive, olive gray, light brownish gray, and brownish yellow silty clay loam in the middle part; and friable, olive gray silt loam in the lower part. The underlying material is gray and brownish yellow silt loam to a depth of 60 inches.

Marcus soils have moderately slow permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is low, and available potassium is low. The surface layer is generally neutral or mildly alkaline.

Marcus soils are used for cultivated crops, hay, and pasture. Where this soil has tile drainage, it is commonly cultivated except in grassed waterways. If tile drainage is not provided, this soil remains wet for long periods and is generally used for pasture.

Representative profile of Marcus silty clay loam, 0 to 2 percent slopes, in a cultivated field, 1,160 feet north and 120 feet west of the southeast corner of the NE¼ of sec. 9, T. 98 N., R. 43 W., on a plane slope of less than 1 percent:

Ap—0 to 7 inches; black (N 2/0) silty clay loam; cloddy parting to weak fine and very fine granular structure; friable; mildly alkaline; clear boundary.

A12—7 to 15 inches; black (N 2/0) heavy silty clay loam; weak coarse granular structure parting to moderate fine and very fine granular; friable; neutral; clear boundary.

A3—15 to 19 inches; black (10YR 2/1) light silty clay; weak fine prismatic structure parting to moderate fine and very fine subangular blocky and granular; firm; neutral; clear boundary.

B21g—19 to 23 inches; mixed very dark gray (2.5Y 3/1) and olive gray (5Y 5/2) light silty clay, dark gray (2.5Y 4/1) kneaded; few fine light olive brown (2.5Y 5/4) mottles; weak medium prismatic structure parting to moderate very fine subangular blocky; firm; shiny coatings on faces of peds; neutral; clear boundary.

B22g—23 to 30 inches; mixed dark gray (5Y 4/1) and olive (5Y 5/3) heavy silty clay loam; common fine yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate fine and very fine subangular blocky; firm; few very fine dark segregations of iron and manganese; mildly alkaline; clear boundary.

B23g—30 to 39 inches; mottled olive gray (5Y 5/2), light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6) light silty clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine dark segregations of iron and manganese; mildly alkaline; clear boundary.

B3g—39 to 45 inches; olive gray (5Y 5/2) silt loam; common fine yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; friable; few fine and very fine dark iron and manganese segregations; few fine lime concretions; strong effervescence; moderately alkaline; gradual boundary.

C—45 to 60 inches; mottled gray (5Y 6/1) and brownish yellow (10YR 6/8) silt loam; massive; friable; few fine and very fine iron and manganese segregations; few very fine lime concretions; strong effervescence; moderately alkaline.

The A horizon is 14 to 22 inches thick.

The B2g horizon has hue of 2.5Y or 5Y, value of 3 to 5, and chroma of 2 or less where the hue is 2.5Y and 3 or less where the hue is 5Y. It has mottles that have hue of 2.5Y, 10YR, or 7.5YR; value of 6 or less; and chroma of more than 2. It is 16 to 28 inches thick. The B3g horizon has color similar to that of the B2g horizon. It is silty clay loam or silt loam. It is mildly alkaline or moderately alkaline and is about 6 to 14 inches thick.

The C horizon is variable in color where it has strata of sandy material or is clay loam glacial till.

Marcus soils are associated with Afton, Primghar, and Trent soils. They are more poorly drained than Primghar and Trent soils. They have a thinner dark colored surface layer than Afton soils.

92—Marcus silty clay loam, 0 to 2 percent slopes. This nearly level soil is on plane positions and in concave areas in drainageways on uplands. Areas in drainageways are much longer than they are wide. Most areas are 10 to 30 acres in size. Some plane areas are larger than 30 acres.

Included with this soil in mapping are small areas of Afton, Primghar, Spicer, and Sperry soils. Also included are some areas of soils, mostly in T. 100 N., R. 43 W., that are similar to this Marcus soil but have glacial material within a depth of 40 inches or less.

This soil is well suited to row crops. Excess wetness is the main limitation to this use. Soil blowing is a limitation if large areas are fall plowed. Capability unit IIw–2; environmental planting group 2.

Mayer Series

This series consists of nearly level, somewhat poorly drained, medium textured soils on flood plains. These soils are underlain by sand and gravel at a depth below 20 to 40 inches. They formed in loamy alluvium.

In a representative profile the surface layer is black loam about 30 inches thick. The underlying material is dark gray and light brownish gray gravelly sand.

Mayer soils have moderate permeability in the surface layer and very rapid permeability in the underlying material. Available water capacity is moderate. Organic-matter content is high. Available phosphorus in the lower part of the surface layer is very low, and available potassium is very low. Reaction ranges from neutral to moderately alkaline in the surface layer.

Mayer soils are used mainly for hay and pasture, but some areas are used for cultivated crops. The major limitations are flooding and, in years of below normal rainfall, droughtiness.

Representative profile of Mayer loam, 0 to 2 percent slopes, in pasture, 320 feet west and 310 feet north of

the southeast corner of the SW¼ of sec. 33, T. 99 N., R. 43 W., on a plane slope of less than 1 percent:

A11—0 to 7 inches; black (10YR 2/1) loam low in sand; weak fine and very fine granular structure; friable; mildly alkaline; clear boundary.
A12—7 to 11 inches; black (10YR 2/1) loam; weak fine granular structure; very friable; slight effervescence; moderately alkaline; clear boundary.
A13—11 to 20 inches; black (10YR 2/1) loam; weak fine subangular blocky structure parting to weak fine granular; very friable; very few coarse fragments; strong effervescence; moderately alkaline; clear boundary.
A14—20 to 30 inches; black (10YR 2/1) light loam; weak medium subangular blocky structure parting to weak fine granular; very friable; few coarse fragments; strong effervescence; moderately alkaline; clear boundary.
IIC1—30 to 36 inches; dark gray (10YR 4/1) gravelly sand; single grained; loose; strong effervescence; moderately alkaline; clear boundary.
IIC2—36 to 60 inches; light brownish gray (2.5Y 6/2) gravelly sand; single grained; loose; few small shells; strong effervescence; moderately alkaline.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR or 2.5Y 3/2). It is typically loam, but in some profiles the upper part is recent deposition that ranges from sandy loam to silt loam. It ranges from neutral to moderately alkaline in the upper 20 inches. It is 24 to 36 inches thick.

The IIC horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 1 to 3. It is loamy sand or sand that has variable amounts of gravel. In some profiles as depth increases, stratification is indicated by changes in color and texture.

Mayer soils in the county are not within the range defined for the series. They lack a B horizon or have a B horizon that is weakly developed. They are somewhat poorly drained and are commonly noncalcareous at the surface. Also, they have a dark surface layer that is thicker than the range defined for the series. These differences, however, do not significantly affect the use and behavior of the soils.

Mayer soils are associated with Spillco, Millington, and Davis soils on bottom lands. They have sand and gravel at a depth of 24 to 36 inches, whereas Spillco, Millington, and Davis soils have sand and gravel, if present, below a depth of 48 inches.

658—Mayer loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands adjacent to streams. Most areas of this soil are in the valleys of the Rock River or the Little Rock River, are less than 10 acres in size, and are irregular in shape.

Included with this soil in mapping are areas of soils that are similar to this soil but have sand or gravel at a depth of more than 36 inches or less than 24 inches. Also included are a few small areas of soils that have gravel in the surface layer.

This soil is suited to row crops. Many areas are flooded one time or more each year. This soil is droughty in dry periods. The old stream channels commonly associated with this soil prevent tillage during wet periods. Capability unit IIw–3; environmental planting group 3.

Millington Series

This series consists of deep, nearly level, somewhat poorly drained, medium textured soils on flood plains. These soils formed in calcareous, loamy alluvium.

In a representative profile the surface layer is about 24 inches thick. It is black loam in the upper part and very dark gray loam in the lower part. The subsoil is very friable, very dark gray loam about 7 inches thick. The underlying material is very dark grayish brown sandy loam to a depth of 60 inches.

Millington soils have moderate permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is very low, and available potassium is very low. Reaction is mildly alkaline or moderately alkaline in the surface layer.

Millington soils are used for cultivated crops, hay, and pasture. The major limitation is flooding.

Representative profile of Millington loam, somewhat poorly drained, 0 to 2 percent slopes, in a cultivated field, 800 feet west and 150 feet south of the northeast corner of sec. 33, T. 99 N., R. 45 W.:

Ap—0 to 6 inches; black (10YR 2/1) loam; weak fine granular structure; friable; slight effervescence, moderately alkaline; clear boundary.
A12—6 to 10 inches; black (10YR 2/1) loam; weak medium subangular blocky structure parting to weak fine granular; friable; slight effervescence; moderately alkaline; gradual boundary.
A13—10 to 18 inches; very dark gray (10YR 3/1) loam; weak medium subangular blocky structure parting to weak fine granular; friable; strong effervescence; moderately alkaline; gradual boundary.
A14—18 to 24 inches; very dark gray (10YR 3/1) loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual boundary.
B—24 to 31 inches; very dark gray (10YR 3/1) loam; weak medium prismatic structure parting to weak fine subangular blocky; very friable; strong effervescence; moderately alkaline; gradual boundary.
C1—31 to 55 inches; very dark grayish brown (10YR 3/2) sandy loam; weak coarse subangular blocky structure; very friable; few thin strata of fine sand; strong effervescence; moderately alkaline; clear boundary.
C2—55 to 60 inches; very dark grayish brown (10YR 3/2) sandy loam; single grained; loose; few small shells; strong effervescence; moderately alkaline.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It is loam or silt loam that has a high content of sand. It is 18 to 36 inches thick and is mildly alkaline or moderately alkaline.

The B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. It is loam or silt loam that is high in content of sand. It is 6 to 15 inches thick and is mildly alkaline or moderately alkaline.

The C horizon has color similar to that of the B horizon. It ranges from sandy loam to silty clay loam that is high in content of sand. Some profiles have sand or gravel below a depth of 48 inches.

Millington soils in the county are outside the range defined for the series. They are somewhat poorly drained and generally lack mottles in the B and C horizons. They have a dark colored surface layer that is thicker than the range defined for the series. These differences, however, do not significantly affect the use and behavior of the soils.

Millington soils are associated with Spillco and Davis soils on bottom lands and are similar to these soils. They are calcareous in the surface layer, whereas Spillco and Davis soils are noncalcareous.

458—Millington loam, somewhat poorly drained, 0 to 2 percent slopes. This nearly level soil is on bottom lands adjacent to streams. Areas are generally 10 to 50 acres in size.

Included with this soil in mapping are small areas of Spillco and Mayer soils, soils that are similar to this soil but lack lime in the subsoil, soils that are poorly drained or very poorly drained, and soils that contain less sand.

This soil is suited to row crops. Many areas of this soil flood one time or more each year. Areas that flood frequently are used for pasture, to which this soil is well suited. Capability unit IIw–1; environmental planting group 3.

Moody Series

This series consists of deep, nearly level to strongly sloping, well drained, moderately fine textured soils on uplands and stream benches. These soils formed in loess.

In a representative profile the surface layer is very dark brown silty clay loam about 8 inches thick. The subsoil is about 32 inches thick. It is friable, very dark grayish brown silty clay loam in the upper part; friable, brown silty clay loam in the middle part; and friable, yellowish brown silty clay loam and silt loam in the lower part. The underlying material, to a depth of 60 inches, is yellowish brown silt loam.

Moody soils have moderate permeability. Available water capacity is high. Organic-matter content is moderate. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is generally neutral or slightly acid in the surface layer.

Moody soils are used mainly for cultivated crops. Erosion is a limitation on the sloping Moody soils.

Representative profile of Moody silty clay loam, 2 to 5 percent slopes, in a cultivated field, 900 feet east and 65 feet north of the southwest corner of sec. 3, T. 99 N., R. 48 W.:

Ap—0 to 8 inches; very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) kneaded; cloddy parting to weak thin subangular blocky and granular structure; friable; slightly acid; clear boundary.

B1—8 to 14 inches; very dark grayish brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) coatings on peds; many very dark brown (10YR 2/2) worm castings; weak fine and medium subangular blocky structure that has weak vertical parting; friable; neutral; gradual boundary.

B21—14 to 19 inches; brown (10YR 4/3) silty clay loam; weak fine and medium subangular blocky structure that has weak vertical parting; friable; few worm castings; neutral; gradual boundary.

B22—19 to 27 inches; yellowish brown (10YR 5/4) light silty clay loam; weak medium prismatic structure partings to weak fine and medium subangular blocky; friable; very few worm castings; many fine tubular pores; neutral; gradual boundary.

B23—27 to 33 inches; yellowish brown (10YR 5/4) silt loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; many fine tubular pores; neutral; clear boundary.

B3—33 to 40 inches; yellowish brown (10YR 5/4) silt loam, few fine gray (10YR 6/1) mottles; weak coarse and medium subangular blocky structure; friable; common fine tubular pores; common fine lime concretions and segregations; strong effervescence; moderately alkaline; gradual boundary.

C—40 to 60 inches; yellowish brown (10YR 5/4) silt loam, common fine faint gray (10YR 6/1) mottles and common fine distinct yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5Y 5/8) mottles; massive; friable; many fine dark segregations of iron and manganese; few fine lime segregations; strong effervescence; moderately alkaline.

Free lime is generally at a depth of 30 to 42 inches, but it is at a depth of only 30 to 36 inches in steeper areas.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). It is 6 to 12 inches thick. It is generally neutral or slightly acid, but it is medium acid in some places.

The B1 horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is neutral or slightly acid and is about 4 to 7 inches thick. The B2 horizon has value of 3 to 5 and chroma of 2 to 4. It is neutral or mildly alkaline and is 12 to 20 inches thick. The B3 horizon has color similar to that of the B2 horizon. It is light silty clay loam or silt loam and is 6 to 10 inches thick. It is neutral to moderately alkaline.

The C horizon has color similar to that of the lower part of the B2 horizon. Typically, it is silt loam, but depth to clay loam glacial till is as little as 40 inches in places, especially in the northern part of the county.

In Moody soils that have a loamy substratum, the lower part of the B horizon and the C horizon are loam or light clay loam, which is outside the range defined for the series. This difference does not significantly affect the use and behavior of the soils.

Moody soils are associated with Trent and Egan soils and are similar to Galva soils. They are better drained than Trent soils. They lack clay loam texture above a depth of 40 inches, whereas Egan soils have clay loam till above that depth. They have a lower average moisture content than Galva soils.

410—Moody silty clay loam, 0 to 2 percent slopes. This nearly level soil is on ridgetops. It is upslope from Afton, Marcus, and Trent soils and from gently sloping Moody soils. Most areas range from 20 and 100 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 12 inches thick.

Included with this soil in mapping are small areas of gently sloping Moody soils.

This soil is well suited to row crops. It is most productive when runoff is minimized, because lack of available water often is the factor limiting yields. Capability unit I–3; environmental planting group 1.

410B—Moody silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas range from 50 acres to 200 acres or more in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately eroded Moody soils, small areas of Trent soils in the drainageways, and small areas of Crofton, Sperry, and Steinauer soils. Also included are areas of severely eroded Moody soils.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long. Capability unit IIe–3; environmental planting group 1.

410B2—Moody silty clay loam, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas range from 50 acres to 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 very dark grayish brown. Some of the brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of slightly eroded Moody soils and small areas of Crofton and Steinauer soils. Also included are areas of soils that have a loamy or sandy surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long. Capability unit IIe–3; environmental planting group 1.

410C2—Moody silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is

mainly on hillsides, and in a few places is on the edge of stream benches. Most areas are 10 to 50 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown. Some of the brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are areas of less eroded Moody soils that have a darker colored surface layer than this soil, small areas of Crofton and Steinauer soils, and areas of soils that have a loamy or sandy surface layer. Also included are areas of soils that have gravel on the surface.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

410D2—Moody silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on the lower part of hillsides in most areas and is downslope from gently sloping and moderately sloping Moody soils. It is upslope from steep and very steep Steinauer soils in the western part of the county. Areas commonly are long and narrow and are about 5 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is lighter colored and the lime is not leached to such a great depth. The surface layer is very dark grayish brown, and the lime is at a depth of about 30 inches. Some of the brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping in places are slightly eroded Moody soils, especially along the lower edge of the slope, and small areas of Crofton and Steinauer soils. Also included are areas of severely eroded Moody soils.

This soil is suited to row crops. It is well suited to hay and pasture. Where this soil is used for row crops, the hazard of erosion is serious. Capability unit IIIe–4; environmental planting group 1.

T410—Moody silty clay loam, benches, 0 to 2 percent slopes. This nearly level soil is on stream benches. Most of the stream benches are along the larger streams and are about 5 to 15 feet above the flood plains. Areas are as much as 100 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 12 inches thick, free lime is deeper, and sand or gravel are below the silt loam underlying material.

Included with this soil in mapping are areas of soils that have more clay in the subsoil and that are leached of lime to a greater depth than this soil, small areas of gently sloping Moody soils, and areas, mostly in the northern part of the county, that have sand or gravel at a depth of 40 to 48 inches. Also included are a few small areas of soils that have a loamy or sandy surface layer.

This soil is well suited to row crops. In places it receives runoff from adjacent, higher lying soils. The underlying sand or gravel slightly reduces the available water capacity. Capability unit I–2; environmental planting group 1.

T410B—Moody silty clay loam, benches, 2 to 5 percent slopes. This gently sloping soil is on stream benches. In places it is downslope from nearly level Moody soils and is 5 to 15 feet above the flood plain. In other places it is upslope from Dempster soils that are on the edge of benches. Most areas are 10 to 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 10 inches thick, and sand or gravel is below the silt loam underlying material.

Included with this soil in mapping are small areas of soils that are similar to this soil, but they have sand or gravel at a depth as little as 36 inches, and small areas of nearly level Moody soils. Also included are a few small areas of Crofton soils.

This soil is suited to row crops. Erosion is a limitation, especially where this soil receives runoff from adjacent soils. In places the underlying sand and gravel limit the rooting depth of crops and slightly reduce the available water capacity of the soil. Capability unit IIe–3; environmental planting group 1.

890B—Moody silty clay loam, loamy substratum, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. It commonly is in areas with other gently sloping Moody soils and moderately sloping Moody soils. Most areas are 10 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but it is higher in content of sand, especially in the lower part of the subsoil and in the underlying material.

Included with this soil in mapping are areas of nearly level Moody soils and small areas of soils that are more sandy than this Moody soil. Also included are some areas of soils that have a gravelly or sandy surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long. The higher content of sand in this soil causes it to have slightly lower available water capacity than Moody soils that have less sand. Capability unit IIe–3; environmental planting group 1.

890B2—Moody silty clay loam, loamy substratum, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on convex ridgetops and hillsides on uplands. It commonly is in areas with other gently sloping Moody soils and with moderately sloping Moody soils. Most areas are 10 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but it is higher in content of sand, especially in the lower part of the subsoil and in the underlying material. Also, the surface layer is lighter colored; generally it is very dark grayish brown and is mixed with some material from the brown subsoil.

Included with this soil in mapping are small areas of soils that are more sandy than this Moody soil. Also included are areas of soils that have a gravelly or sandy surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially where slopes are long. The higher content of sand in this soil causes it to have slightly lower available water capacity than Moody soils that have less sand. Also, the lower content of organic matter in this soil tends to increase puddling, which results in less infiltration of water. Capability unit IIe–3; environmental planting group 1.

890C2—Moody silty clay loam, loamy substratum, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex hillsides. Most areas

are between the soils in the valley and the gently sloping Moody soils upslope on the ridgetop. Areas generally are 5 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but it is higher in content of sand, especially in the lower part of the subsoil and in the underlying material. Also, the surface layer is lighter colored; generally, it is very dark grayish brown and is mixed with some material from the brown subsoil.

Included with this soil in mapping are areas of soils that are more sandy than this Moody soil. Also included are areas of soils that have a gravelly or sandy surface layer.

This soil is suited to row crops, but careful management is needed to control erosion. The higher content of sand in this soil causes it to have a slightly lower available water capacity than Moody soils that have less sand. Also, the lower content of organic matter in this soil tends to increase puddling, which results in less infiltration of water. Capability unit IIIe–3; environmental planting group 1.

Ocheyedan Series

This series consists of deep, nearly level to strongly sloping, well drained, medium textured soils on uplands. A relatively small acreage is on stream benches. These soils formed in loamy material that was deposited by wind or water.

In a representative profile the surface layer is about 12 inches of loam that is low in sand content. It is black in the upper 7 inches and very dark grayish brown in the lower 5 inches. The subsoil is about 30 inches thick. It is friable, brown loam in the upper part; very friable, dark yellowish brown loam and sandy loam in the middle part; and very friable, yellowish brown sandy loam in the lower part. The underlying material is yellowish brown silt loam to a depth of 60 inches.

Ocheyedan soils have moderate permeability. Available water capacity is high. Organic-matter content is moderate. Available phosphorus in the subsoil is very low, and available potassium is very low. The surface layer is generally neutral or slightly acid.

Ocheyedan soils are used mainly for cultivated crops, but the strongly sloping areas are commonly used for hay or pasture. Erosion is a limitation on the sloping Ocheyedan soils.

Representative profile of Ocheyedan loam, 2 to 5 percent slopes, in a cultivated field, 1,210 feet west and 130 feet south of the northeast corner of sec. 23, T. 100 N., R. 45 W., on a convex slope of 2.5 percent:

Ap—0 to 7 inches; black (10YR 2/1) loam low in sand; weak fine and very fine subangular blocky structure; friable; neutral; clear boundary.

A12—7 to 12 inches; very dark grayish brown (10YR 3/2) loam low in sand, faces of peds very dark grayish brown (10YR 3/2); few very dark grayish brown (10YR 3/2) worm castings; weak fine and very fine subangular blocky structure; friable; slightly acid; clear boundary.

B1—12 to 19 inches; brown (10YR 4/3) loam low in sand, faces of peds very dark grayish brown (10YR 3/2); few very dark grayish brown (10YR 3/2) worm castings; weak fine and very fine subangular blocky structure; friable; slightly acid; clear boundary.

B21—19 to 22 inches; dark yellowish brown (10YR 4/4) loam, faces of peds dark brown (10YR 3/3); weak fine subangular blocky structure; friable; slightly acid; gradual boundary.

B22—22 to 31 inches; dark yellowish brown (10YR 4/4) heavy sandy loam; weak fine subangular blocky structure; very friable; neutral; clear boundary.

B3—31 to 42 inches; yellowish brown (10YR 5/4, tending to 2.5Y) heavy sandy loam; weak medium subangular blocky structure; very friable; neutral; clear boundary.

IIC—42 to 60 inches; yellowish brown (10YR 5/4, tending to 2.5Y) silt loam; few fine yellowish brown (10YR 5/8) and grayish brown (2.5Y 5/2) mottles; massive; friable; common fine lime segregations; strong effervescence; moderately alkaline.

Free lime is generally at a depth of 30 to 46 inches, but it is at a depth of 30 to 36 inches in strongly sloping areas.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is neutral or slightly acid, but in a few profiles the Ap horizon is medium acid. It is 10 to 15 inches thick.

The B horizon is 20 to 32 inches thick. It has value of 3 to 5 and chroma of 3 or 4. It ranges from light clay loam to sandy loam. In some places it contains a layer of loamy sand as much as 6 inches thick. The lower part of the B2 horizon or the B3 horizon is silt loam in many places. The B1 and B2 horizons are neutral to slightly acid, and the B3 horizon is neutral to moderately alkaline.

The IIC horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 6; the high and low chroma are generally present in mottles. It is commonly silt loam or loam, but in places there are sandy loam strata.

Ocheyedan soils are associated with Bolan soils. They contain less sand than Bolan soils. They lack glacial till in their solum, whereas Everly soils have glacial till at a depth of about 30 inches.

878—Ocheyedan loam, 0 to 2 percent slopes. This nearly level soil is on uplands. Most areas are upslope from gently sloping Bolan or Ocheyedan soils and downslope from gently sloping Galva soils. Most areas are less than 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 15 inches thick.

Included with this soil in mapping are small areas of gently sloping Ocheyedan soils.

This soil is well suited to row crops. Reducing runoff increases crop yields, especially in years of below normal precipitation. Capability unit I–3; environmental planting group 1.

878B—Ocheyedan loam, 2 to 5 percent slopes. This gently sloping soil is on uplands. Many areas are upslope from Bolan soils and downslope from Galva soils. Most areas are 10 to 40 acres in size, but a few are larger than 100 acres. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of nearly level Ocheyedan soils and moderately eroded Ocheyedan soils. Also included are small areas of Crofton and Dickman soils.

This soil is suited to row crops. The management needed to control erosion is not difficult. Capability unit IIe–3; environmental planting group 1.

878B2—Ocheyedan loam, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on uplands. In most places it is more sloping or on more convex positions than gently sloping Ocheyedan soils that are less eroded. Areas are generally 10 to 40 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is not so thick. Some brown material from

the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of Bolan soils and areas of soils that are similar to this soil but have a surface layer of silty clay loam high in sand.

This soil is suited to row crops. It is susceptible to erosion, but control of erosion is not difficult. Capability unit IIe–3; environmental planting group 1.

878C2—Ocheyedan loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides downslope from less sloping Ocheyedan soils. In many places it is upslope from Bolan and Dickman soils. Most areas are 10 to 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer and subsoil are thinner and the surface layer is very dark grayish brown. Some brown material from the subsoil has been mixed into the plow layer in most places. This soil is about 34 inches thick over the underlying material.

Included with this soil in mapping are less eroded Ocheyedan soils. Also included are small areas of Crofton, Dickman, and Steinauer soils.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

878D2—Ocheyedan loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on hillsides. Areas vary greatly in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 10 inches thick and the subsoil is only about 20 inches thick. Some dark brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are soils that are calcareous just under the surface layer. Also included are small areas of Crofton, Dickman, and Steinauer soils and severely eroded Ocheyedan soils.

This soil is suited to row crops, but careful management is needed to control erosion. It is well suited to hay and pasture. Capability unit IIIe–4; environmental planting group 1.

Omadi Series

This series consists of deep, nearly level, well drained and moderately well drained, medium textured soils on bottom lands adjacent to the Big Sioux River. These soils formed in alluvium.

In a representative profile the surface layer is very dark gray silt loam about 5 inches thick. The underlying material is very dark gray silt loam that has lenses of dark grayish brown to grayish brown very fine sand to a depth of 60 inches.

Omadi soils have moderate permeability. Available water capacity is high. Organic-matter content is low. Available phosphorus is low, and available potassium is low. The surface layer is mildly alkaline or moderately alkaline.

Omadi soils are used for cultivated crops and pasture. Areas that flood frequently are used for pasture.

Representative profile of Omadi silt loam, occasionally flooded, 0 to 2 percent slopes, in a wooded pasture, 1,300 feet north and 600 feet east of the southwest corner of sec. 18, T. 98 N., R. 48 W., on a plane slope of less than 1 percent:

A—0 to 5 inches; very dark gray (10YR 3/1) silt loam; weak medium platy structure; friable; strong effervescence; moderately alkaline; clear boundary.

C—5 to 60 inches; very dark gray (10YR 3/1) silt loam, very dark grayish brown (10YR 3/2) kneaded; numerous thin dark grayish brown (10YR 4/2) to grayish brown (2.5Y 5/2) very fine sand lenses; few dark reddish brown (5YR 3/4) oxide stains; massive; friable; strong effervescence; moderately alkaline.

The A horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) silt loam that is low to high in content of sand. It is mildly alkaline or moderately alkaline and is 5 to 10 inches thick.

The C horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2), but it has strata that have value of 2 to 4 in places. It is dominantly silt loam, but strata as coarse as very fine sandy loam are present in places, and typically there are thin lenses of sandy loam to sand. It has slight or strong effervescence.

The strata just below the A horizon are outside the range defined for the series. This difference, however, does not significantly affect the use and behavior of the soils.

Omadi soils are associated with Ackmore and Spillco soils. They have less clay and more sand than the Ackmore soils. They have less sand than the Spillco soils.

189—Omadi silt loam, occasionally flooded, 0 to 2 percent slopes. This nearly level soil is on bottom land adjacent to the Big Sioux River. Most areas are long and narrow and are 5 to 30 acres in size.

Included with this soil in mapping are small areas of Alluvial land, many shallow channels, and a few areas of soils in which the surface layer is loamy or sandy.

This soil is suited to row crops; flooding is a serious limitation. Tree removal and use of grass species tolerant to siltation make pastures more productive. Capability unit IIw–1; environmental planting group 3.

Primghar Series

This series consists of deep, somewhat poorly drained, moderately fine textured soils that formed in loess. Nearly level Primghar soils are in broad, plane, upland areas and on lower slopes of hillsides. Gently sloping Primghar soils are in the upper reaches of drainageways.

In a representative profile the surface layer is silty clay loam about 20 inches thick. It is black and very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is friable, dark grayish brown and olive brown silty clay loam in the upper part and friable, light olive brown silt loam in the lower part. It is about 15 inches thick. The underlying material is light olive brown silt loam to a depth of 60 inches.

Primghar soils have moderate permeability to moderately slow permeability. Available water capacity is high. Organic-matter content of the surface layer is high. Available phosphorus in the subsoil is very low, and available potassium in the lower part of the surface layer is low. Reaction is generally medium acid in the surface layer, but in places it is slightly acid or neutral.

Primghar soils are used mainly for cultivated crops. Some areas in swales are used for hay and pasture.

Representative profile of Primghar silty clay loam,

0 to 2 percent slopes, in bromegrass pasture, 800 feet east and 410 feet south of the northwest corner of sec. 12, T. 99 N., R. 44 W., on a plane slope of 0.5 percent:

Ap—0 to 9 inches; black (10YR 2/1) silty clay loam; weak fine granular structure; friable; medium acid; abrupt boundary.

A12—9 to 15 inches; very dark gray (10YR 3/1) silty clay loam; moderate fine and very fine granular structure; friable; slightly acid; gradual boundary.

A3—15 to 20 inches; very dark grayish brown (2.5Y 3/2) silty clay loam; moderate very fine subangular blocky structure; friable; neutral; gradual boundary.

B21—20 to 26 inches; dark grayish brown (2.5Y 4/2) silty clay loam; moderate very fine subangular blocky structure; friable; few fine dark oxide concretions; neutral; gradual boundary.

B22—26 to 30 inches; olive brown (2.5Y 4/3) silty clay loam; weak very fine subangular blocky structure; friable; few fine dark oxide segregations; neutral; gradual boundary.

B3—30 to 35 inches; light olive brown (2.5Y 5/3) silt loam; weak coarse prismatic structure parting to weak very fine subangular blocky; friable; few fine dark oxide segregations; common fine and medium lime concretions; strong effervescence; moderately alkaline; gradual boundary.

C1—35 to 48 inches; light olive brown (2.5Y 5/4) silt loam; common fine yellowish brown (10YR 5/6), dark yellowish brown (10YR 4/4), and light gray (2.5Y 7/1) mottles; massive; friable; few fine dark oxide segregations; few fine and medium lime concretions; strong effervescence; moderately alkaline; gradual boundary.

C2—48 to 60 inches; light olive brown (2.5Y 5/3) silt loam; common fine light gray (2.5Y 7/1) and strong brown (7.5Y 5/6) mottles; massive; friable; common fine dark oxide segregations; few fine lime segregations; strong effervescence; moderately alkaline.

The A horizon is black (10YR 2/1 or N 2/0) or very dark brown (10YR 2/2). Where this soil occurs in concave positions that receive deposition from the surrounding soils, the upper part of the A horizon is generally very dark brown (10YR 2/2). The A horizon is 16 to 22 inches thick. It is medium acid to neutral.

The B horizon has value of 4 or 5 and chroma of 2 or 3. In some profiles hue is 10YR in the upper part or chroma is 4 in the lower part. High- and low-chroma mottles are present in most profiles. The upper part ranges from heavy to light silty clay loam, and the lower part ranges from light silty clay loam to silt loam. This horizon is 15 to 30 inches thick. It is slightly acid or neutral in the upper part and neutral and noncalcareous to moderately alkaline and calcareous in the lower part.

The C horizon has value of 4 or 5 and chroma of 3 or 4. Where this horizon is mottled, colors have value of 6 and chroma of 2 to 6. This horizon is commonly silt loam to a depth of 60 inches in the southern part of the county. Clay loam glacial till is commonly within a depth of 42 to 48 inches in the northern part of the county.

Primghar soils are associated with Galva and Marcus soils. They have a thicker A horizon than Galva soils, and their B horizon is not so gray as the B horizon in Marcus soils.

91—Primghar silty clay loam, 0 to 2 percent slopes. This nearly level soil is on broad flats on uplands and on lower side slopes of hills. Most areas are large; a few are more than 640 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Galva and Marcus soils. Also included are a few small areas of Primghar variant soils, Sperry soils, and soils that have gravel in the surface layer.

This soil is well suited to row crops. It remains wet longer than the adjoining Galva soils. Long delays in tillage occur only in periods of above average precipitation. This soil is often tiled where it is associated with poorly drained soils or where more timely tillage is desired in years of above-normal precipitation. Capability unit I–3; environmental planting group 1.

91B—Primghar silty clay loam, 2 to 5 percent slopes. This gently sloping soil is in shallow concave swales on hillsides. Areas are relatively long and narrow. Most are 5 to 15 acres in size, but a few are larger than 20 acres. This soil has a profile similar to the one described as representative of the series, but the dark colored surface layer is thicker. Some of this soil has recent deposition as much as 12 inches thick over the original surface layer.

Included with this soil in mapping are some Marcus and Afton soils. Also included are a few small areas of Primghar variant soils and Sperry soils.

This soil is suited to row crops. Some areas are used for hay or pasture because the poor drainage of the included soils makes timely cultivation difficult. In many places runoff from adjoining soils causes rilling, sheet erosion, and siltation. Capability unit IIe–1; environmental planting group 1.

Primghar Variant

This variant consists of deep, nearly level, somewhat poorly drained, moderately fine textured soils on lower side slopes of hills, low convex ridges between swales, and in concave swales. These soils formed in loess.

In a representative profile the surface layer is black, very dark gray, and dark grayish brown silty clay loam about 18 inches thick. The subsoil is about 16 inches thick. The upper part is dark gray and grayish brown, friable, silty clay loam; and the lower part is friable, grayish brown to light olive brown silt loam. The underlying material is mottled yellowish brown and gray silt loam to a depth of 60 inches.

Primghar variant soils have moderate to moderately slow permeability. Available water capacity is high. Organic-matter content in the surface layer is high. Available phosphorus in the subsoil is very low, and available potassium in the lower part of the surface layer is low. Reaction is mildly alkaline or moderately alkaline in the surface layer.

Most areas of these soils are used for cultivated crops, but some are used for pasture and hay. These soils are commonly managed with the adjoining soils.

Representative profile of Primghar silty clay loam, calcareous variant, 0 to 2 percent slopes, in cultivated field, 780 feet east and 300 feet south of the northwest corner of sec. 14, T. 98 N., R. 43 W., on a plane slope of less than 1 percent:

Ap—0 to 9 inches; black (N 2/0) silty clay loam; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear boundary.

A12—9 to 13 inches; black (10YR 2/1) silty clay loam, some mixing of dark grayish brown (2.5Y 4/2) in lower part; weak fine subangular blocky structure parting to moderate fine and very fine granular; friable; strong effervescence; moderately alkaline; gradual boundary.

A3—13 to 18 inches; very dark gray (10YR 3/1) and dark grayish brown to olive brown (2.5Y 4/3) silty clay loam, very dark grayish brown (2.5Y 3/2) kneaded; weak medium subangular blocky structure parting

to weak very fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual boundary.

B2—18 to 24 inches; dark gray (10YR 4/1) and grayish brown to light olive brown (2.5Y 5/3) light silty clay loam, dark grayish brown (2.5Y 4/2) kneaded; weak medium prismatic structure parting to weak fine subangular blocky; friable; few very fine lime concretions; strong effervescence; moderately alkaline; gradual boundary.

B3—24 to 34 inches; grayish brown to light olive brown (2.5Y 5/3) silt loam, few dark grayish brown (2.5Y 4/2) peds; few very fine yellowish brown (10YR 5/6) mottles; weak medium prismatic structure; friable; few very fine lime concretions; few very dark oxide segregations; strong effervescence; moderately alkaline; gradual boundary.

C—34 to 60 inches; mottled yellowish brown (10YR 5/4) and gray (5Y 5/1) silt loam; massive; friable; few very fine lime concretions; common very fine dark oxide segregations; strong effervescence; moderately alkaline.

The solum generally has free lime in all horizons, but some profiles lack free lime in the lower part of the B horizon.

The A1 or Ap horizon is 10 to 16 inches thick. The A3 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2 or 2.5Y 3/2). In some profiles it is partly dark grayish brown (2.5Y 4/2) or very dark grayish brown to olive brown (2.5Y 4/3), and if kneaded it is not lighter in color than very dark grayish brown (2.5Y 3/2 or 10YR 3/2).

The B2 horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 to 4. Where hue is 10YR, chroma is 2 or less, except where mottles of higher and lower chroma are present. This horizon is silty clay loam or silt loam and is 6 to 12 inches thick. The B3 horizon has color similar to that of the B2 horizon. It is silt loam or light silty clay loam and is 6 to 12 inches thick.

The C horizon has hue of 2.5Y or, if colors are mottled, of 10YR to 5Y; value of 4 or 5; and chroma of 3 or 4, except where mottles of higher and lower chroma are present. The C horizon is silt loam, loam, or clay loam.

Primghar variant soils are associated with Galva, Marcus, and Primghar soils. They differ from these soils in being calcareous in the upper part of the solum.

791—Primghar silty clay loam, calcareous variant, 0 to 2 percent slopes. This nearly level soil is on lower slopes of hillsides; on low, convex ridges between swales; and in concave swales on uplands. Most areas are less than 10 acres in size.

Included with this soil in mapping are soils that are similar to this soil, but not calcareous throughout the profile, and small areas of Spicer soils. Also included are a few small areas of soils that have a loamy or sandy surface layer.

This soil is well suited to row crops. Some crop varieties show symptoms of plant nutrient deficiencies if they are grown on this soil. Most areas of this soil are farmed with the adjacent noncalcareous soils. Capability unit I–3; environmental planting group 3.

Sac Series

This series consists of deep, gently sloping to strongly sloping, well drained, moderately fine textured soils on uplands. These soils formed in loess and clay loam glacial till. The loess is 24 to 40 inches thick.

In a representative profile the surface layer is black in the upper part, very dark brown in the middle part, and very dark grayish brown in the lower part. It is silty clay loam about 15 inches thick. The subsoil is about 26 inches thick. It is friable, brown silty clay loam in the upper part and friable, yellowish brown clay loam in the lower part. The underlying material is yellowish brown clay loam to a depth of 60 inches.

Sac soils have moderate permeability. Available water capacity is high. Organic-matter content is low to moderate. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is neutral to medium acid in the surface layer.

Sac soils are used mainly for cultivated crops. Erosion is a limitation.

Representative profile of Sac silty clay loam, 2 to 5 percent slopes, in cultivated field, 1,314 feet south and 1,290 feet east of the northwest corner of sec. 13, T. 99 N., R. 43 W., on a convex slope of 3 percent:

Ap—0 to 6 inches; black (10YR 2/1) silty clay loam; cloddy parting to weak fine granular structure; friable; slightly acid; clear boundary.

A12—6 to 11 inches; very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) kneaded; moderate very fine subangular blocky and fine granular structure; friable; slightly acid; gradual boundary.

A13—11 to 15 inches; very dark grayish brown (10YR 3/2) silty clay loam, many surfaces of peds very dark brown (10YR 2/2); weak to moderate very fine and fine subangular blocky structure; friable; slightly acid; gradual boundary.

B1—15 to 21 inches; brown (10YR 4/3) silty clay loam, few surfaces of peds very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2); weak fine subangular blocky structure; friable; neutral; gradual boundary.

B2—21 to 32 inches; brown (10YR 4/3) silty clay loam, weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few thin patchy clay films on faces of prisms; neutral; clear boundary.

IIB31—32 to 37 inches; yellowish brown (10YR 5/4) light clay loam; few fine faint yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few thin patchy clay films on faces of prisms and in root channels; common fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

IIB32—37 to 41 inches; yellowish brown (10YR 5/4) clay loam; common fine distinct strong brown (7.5YR 5/8) mottles and few fine distinct red (2.5YR 4/8) mottles; weak medium subangular blocky structure; friable; few thin patchy clay films in root channels; common fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

IIC—41 to 60 inches; yellowish brown (10YR 5/4) clay loam; massive; firm; common fine and medium lime concretions; few fine dark oxide segregations; strong effervescence; moderately alkaline.

The A horizon is neutral to medium acid. It is 8 to 15 inches thick.

The B horizon is 18 to 30 inches thick. The B1 horizon is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3). The B2 horizon is brown (10YR 4/3 or 5/3) or yellowish brown (10YR 5/4). In some places it is silt loam in the lower part. It is neutral or slightly acid. The B3 horizon has color similar to that of the B2 horizon. It is silt loam, loam, or clay loam in the upper part, and it is loam or clay loam in the lower part. It is neutral to moderately alkaline.

The IIC horizon has hue of 2.5Y, 10YR, and 7.5YR; value of 4 to 6, and chroma of 2 to 8; the high and low chroma are generally present in mottles. It is clay loam or loam. It is mildly alkaline or moderately alkaline.

Sac soils are associated with Galva and Primghar soils and are similar to Egan soils. They have glacial till above a depth of 40 inches, whereas Galva and Primghar soils have loess to a depth of 40 inches or more. They have a higher average moisture content than Egan soils.

77B—Sac silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas are 20 to 100 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are nearly level Sac soils, small areas of moderately eroded Sac soils, and small areas of Galva soils. Also included are a few small areas of Steinauer soils and soils that have gravel in the surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially when slopes are long. Capability unit IIe–3; environmental planting group 1.

77B2—Sac silty clay loam, 2 to 5 percent slopes, moderately eroded. This gently sloping soil is on ridgetops and hillsides. Most areas are 20 to 100 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 10 inches thick and is very dark grayish brown. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of moderately sloping Sac soils and small areas where erosion has removed most of the surface layer. Also included are a few small areas of Steinauer soils and soils that have gravel in the surface layer.

This soil is suited to row crops. It is more susceptible to erosion than the Sac soil described as representative of the series. Adequate erosion control can be obtained with careful management. Capability unit IIe–3; environmental planting group 1.

77C2—Sac silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides. Most areas are 10 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 10 inches thick and is very dark grayish brown. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of Sac soils that are slightly eroded and areas that are severely eroded. Also included are a few small areas of Crofton and Steinauer soils and soils that have gravel in the surface layer.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

77D2—Sac silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on the lower part of hillsides below less sloping Sac and Galva soils. Most areas are less than 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 10 inches thick and is very dark grayish brown, and depth to free lime is only about 28 inches. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are areas of slightly eroded and severely eroded Sac soils. Also included are a few small areas of strongly sloping Galva soils, of Crofton and Steinauer soils, and of soils that have gravel in the surface layer.

This soil is suited to row crops. It is well suited to pasture and hay crops. Careful management is needed to control erosion if this soil is used for row crops. Capability unit IIIe–4; environmental planting group 1.

Salida Series

This series consists of moderately sloping to very steep, excessively drained soils that have about 10 inches or less of moderately coarse textured material over sand and gravel. These soils formed in gravelly glacial deposits. They are on the edges of alluvial benches, on lower side slopes adjacent to streams in the uplands, and on small knobs on uplands in the northeastern part of the county. The acreage of these soils on knobs is minor and they are mapped only as complexes with Estherville soils.

In a representative profile the surface layer is black sandy loam about 5 inches thick. Below the surface layer is a transitional layer about 4 inches thick. It is very friable, very dark brown gravelly sandy loam. The underlying material is dark yellowish brown gravel and sand to a depth of 60 inches.

Salida soils have very rapid permeability. Available water capacity is very low. Organic-matter content in the surface layer is low. Available phosphorus and available potassium in the transitional layer are very low. The surface layer is commonly neutral or mildly alkaline.

Salida soils are used mainly for pasture. Some areas of moderately sloping and strongly sloping Salida soils are used for crops where the adjoining soil areas are cultivated. Erosion is a major limitation where these soils are cultivated. Droughtiness is a major limitation to crops or pasture.

Representative profile of Salida sandy loam, 18 to 40 percent slopes, in pasture, 124 feet west and 6 feet north of the southeast corner of sec. 16, T. 99 N., R. 48 W., on a convex slope of 34 percent:

A1—0 to 5 inches; black (10YR 2/1) sandy loam, very dark brown (10YR 2/2) kneaded; weak fine granular structure; very friable; neutral; clear boundary.

AC—5 to 9 inches; very dark brown (10YR 2/2) gravelly sandy loam; weak fine granular structure; very friable; strong effervescence; moderately alkaline; gradual boundary.

IIC—9 to 60 inches; dark yellowish brown (10YR 3/4) gravel and sand; some cobbles and stones; single grained; loose; lime coatings on undersides of coarse fragments; violent effervescence; moderately alkaline.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 4 to 7 inches thick. It is generally sandy loam or loamy sand that has variable amounts of gravel. It is neutral or mildly alkaline. The AC horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is gravelly sandy loam or gravelly loamy sand and is 0 to 6 inches thick. It is neutral to moderately alkaline.

The C horizon has value of 3 to 6 and chroma of 2, 3, or 4. It has variegated color in many places. It is sand that has varying amounts of gravel and cobbles.

Salida soils are similar to Estherville soils. They have sand and gravel at a shallower depth than Estherville soils.

73F—Salida sandy loam, 18 to 40 percent slopes. This steep to very steep soil is on the edge of stream benches. A few areas are on the lower part of side slopes on uplands. Areas are long in relation to width and generally less than 10 acres in size.

Included with this soil in mapping are soils that have

less sand in the surface layer and soils that have a very gravelly surface layer. Also included are soils that are deeper to sand and gravel, particularly on lower side slopes.

This soil is suited to permanent pasture. Most slopes are too steep for safe operation of farm machinery. This soil is droughty, and the hazard of erosion is high where vegetation is sparse. Capability unit VIIe–1; environmental planting group 4.

Sperry Series

This series consists of deep, nearly level, very poorly drained to poorly drained, medium textured soils in concave closed depressions on uplands. These soils formed in loess. They have a clayey layer in the subsoil. In places the upper part of this soil formed in local alluvium.

In a representative profile the surface layer is black silt loam about 9 inches thick. The subsurface layer is very dark gray silt loam about 14 inches thick. The subsoil is about 35 inches thick. The upper 5 inches is firm, dark gray silty clay loam; the next 6 inches is firm, brown silty clay; the next 12 inches is firm, light olive gray silty clay loam; and the lower 12 inches is friable, mottled olive gray and strong brown silty clay loam. The underlying material is mottled gray and strong brown silt loam.

Sperry soils have slow permeability. Available water capacity is high. Organic-matter content is moderate to high. Available phosphorus in the subsoil is very low, and available potassium is very low. Reaction is neutral to medium acid in the surface layer.

Sperry soils are used mainly for cultivated crops. The duration of ponding and depth to water table vary from place to place, but field operations often are difficult because of excess wetness.

Representative profile of Sperry silt loam, 0 to 1 percent slopes, in cultivated field, 640 feet north and 60 feet west of the southeast corner of the NE¼ of sec. 35, T. 98 N., R. 43 W., on a concave slope in a depression:

Ap—0 to 9 inches; black (10YR 2/1) heavy silt loam; weak very thin platy and weak, fine granular structure; friable; neutral; clear boundary.

A21—9 to 13 inches; very dark gray (10YR 3/1) silt loam; few fine dark brown (7.5YR 3/2) stains; weak thin platy and weak very fine subangular blocky structure; friable; neutral; gradual boundary.

A22—13 to 23 inches; very dark gray (10YR 3/1) tending to dark gray (10YR 4/1) silt loam, few fine brown (7.5YR 4/2) stains; weak thin platy structure and weak very fine subangular blocky; friable; neutral; clear boundary.

B21—23 to 28 inches; dark gray (10YR 4/1) silty clay loam; thin continuous very dark gray (10YR 3/1) coatings on peds; common fine strong brown (7.5YR 5/6) mottles; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; slightly acid; gradual boundary.

B22—28 to 34 inches; brown (10YR 4/3) light silty clay, dark grayish brown (10YR 4/2) kneaded; moderately thick continuous very dark gray (10YR 3/1) coatings on peds; common fine strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to strong very fine subangular blocky; firm; slightly acid; gradual boundary.

B23—34 to 46 inches; olive gray (5Y 5/2) heavy silty clay loam; thin continuous very dark gray (10YR 3/1) coatings on peds; many fine strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to moderate very fine subangular blocky; firm; slightly acid; gradual boundary.

B3—46 to 58 inches; mottled light olive gray (5Y 6/2) and strong brown (7.5YR 5/6) silty clay loam; thin continuous very dark grayish brown (2.5Y 3/2) coatings on peds; weak medium prismatic structure parting to moderate fine subangular blocky; friable; few fine dark segregations and concretions of iron and manganese; neutral; gradual boundary.

C—58 to 75 inches; mottled gray (2.5Y 6/1) and strong brown (7.5YR 5/6) silt loam; weak medium prismatic structure; friable; few fine dark segregations and concretions of iron and manganese; neutral.

The solum generally lacks free lime to a depth of 60 inches or more. The thickness of local alluvium varies from place to place, but it is generally 12 inches or less. Development of the solum is commonly greatest in the lowest part of depressions.

The A1 or Ap horizon is black (10YR 2/1 or N 2/0) or very dark gray (10YR 3/1). It is silt loam or silty clay loam. It is 8 to 12 inches thick. The A2 horizon is very dark gray (10YR 3/1) or dark gray (10YR 4/1) and is 6 to 15 inches thick.

The B2 horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 to 3. It is 20 to 30 inches thick. Common to many mottles of higher chroma are present in most places.

The B3 and C horizons have color similar to that of the B2 horizon. The B3 horizon is light to medium silty clay loam or silt loam. The C horizon in most places is silt loam, but in some it is clay loam or loam.

Sperry soils are associated with Marcus, Primghar, and Trent soils. They have an A2 horizon, which the other soils lack, and they are more poorly drained than the other soils.

505—Sperry silt loam, 0 to 1 percent slopes. This nearly level soil is in concave depressions on uplands. Most areas are less than 10 acres in size.

Included with this soil in mapping are soils that are similar to this soil but that have a surface layer less than 8 inches thick, that have most of the subsurface layer incorporated into the plow layer, or that have dark colors extending to a depth of more than 24 inches. Also included and associated with Galva silty clay loam, stratified substratum, is a soil that is similar to this Sperry soil but has a browner and less clayey subsoil and is not so wet.

This soil is suited to row crops if excess water is removed by surface or tile drainage. Areas are too small to be managed separately for surrounding soils. Capability unit IIIw–1; environmental planting group 2.

Spicer Series

This series consists of deep, nearly level, poorly drained, moderately fine textured soils in plane upland areas and in concave upland drainageways. These soils formed in loess.

In a representative profile the surface layer is black in the upper part and very dark gray in the lower 6 inches. It is silty clay loam about 20 inches thick. The subsoil is about 19 inches thick. It is friable, dark gray silty clay loam in the upper part; friable, olive gray silt loam in the middle part; and friable, mottled yellowish brown and light olive gray silt loam in the lower part. The underlying material is light olive gray silt loam to a depth of 46 inches and brownish yellow clay loam between depths of 46 and 72 inches.

Spicer soils have moderate permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the subsoil is very low, and

available potassium is low. Reaction is mildly alkaline or moderately alkaline in the surface layer.

Spicer soils are used for cultivated crops, hay, and pasture. Where the soils have tile drainage, they are generally cultivated except in grassed waterways. If tile drainage is not provided, the soils remain wet for long periods.

Representative profile of Spicer silty clay loam, 0 to 2 percent slopes, in cultivated field, 790 feet south and 480 feet west of the northeast corner of the SE¼ of sec. 31, T. 100 N., R. 43 W., on a plane slope of 1 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; cloddy parting to weak fine granular structure; friable; slight effervescence; mildly alkaline; clear boundary.

A12—7 to 14 inches; black (10YR 2/1) silty clay loam; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear boundary.

A3—14 to 20 inches; very dark gray (2.5Y 3/1) silty clay loam; few black (10YR 2/1) peds; weak fine subangular blocky structure parting to weak very fine granular; friable; common very fine lime segregations; strong effervescence; moderately alkaline; clear boundary.

B21g—20 to 26 inches; dark gray (5Y 4/1) light silty clay loam; few very dark gray (2.5Y 3/1) peds; weak medium prismatic structure parting to weak very fine subangular blocky; friable; strong effervescence; moderately alkaline; clear boundary.

B22g—26 to 34 inches; olive gray (5Y 5/2) silt loam; common fine yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine dark colored segregations of iron and manganese; common fine lime segregations; strong effervescence; moderately alkaline; clear boundary.

B3g—34 to 39 inches; mottled yellowish brown (10YR 5/6) and light olive gray (5Y 6/2) silt loam; weak medium prismatic structure; friable; common very fine dark colored segregations of iron and manganese; common fine lime segregations; strong effervescence; moderately alkaline; clear boundary.

C1—39 to 46 inches; light olive gray (5Y 6/2) silt loam; common medium yellowish brown (10YR 5/6) mottles; massive; friable; common fine segregations of iron and manganese; common fine lime segregations; few coarse fragments in lower part; strong effervescence; moderately alkaline; clear boundary.

IIC2—46 to 72 inches; brownish yellow (10YR 6/6) clay loam; common fine and medium light olive gray (5Y 6/2) mottles; massive; firm; few lime concretions; strong effervescence; moderately alkaline.

The solum generally has free lime in all horizons, but some profiles lack free lime in the lower part of the B horizon.

The A horizon is 12 to 24 inches thick.

The Bg horizon is generally mottled throughout, but some profiles lack mottles in the upper part of the horizon. The B2g horizon has hue of 2.5Y or 5Y, value of 3 to 5, and chroma of 2 or less where hue is 2.5Y and 3 or less where hue is 5Y. It has mottles that have hue of 10YR and 7.5YR, value of 5 or 6, and chroma higher than 2. It is 12 to 24 inches thick. The B3g horizon has color similar to that of the B2g horizon, but value of 6 is within the range. It is silt loam or light silty clay loam. It is mildly alkaline or moderately alkaline. It is generally about 4 to 12 inches thick but is absent in some profiles.

The C horizon has color similar to that of the B2g horizon, but value of 6 is within the range. It is silt loam in the upper part and clay loam or loam in the lower part. In some profiles it has stratified material.

Spicer soils are associated with Primghar and Trent soils. They are calcareous, and the other soils are noncalcareous.

32—Spicer silty clay loam, 0 to 2 percent slopes. This nearly level soil is in plane areas and in concave drainageways on uplands. Areas in drainageways are long and narrow. Most areas are 10 to 30 acres in size.

Included with this soil in mapping are Spicer soils that are underlain by sand and gravel at a depth of 42 to 48 inches in drainageways on uplands, mostly in T. 100 N., R. 43 W. Also included are small areas of soils that are similar to this Spicer soil but are calcareous in the surface layer and noncalcareous in most of the subsoil. There are a few small areas of Sperry soils.

This soil is suited to row crops. Excess wetness is the main limitation to this use. Some crop varieties are sensitive to plant nutrient deficiencies caused by the excessive lime in this soil. Capability unit IIw–2; environmental planting group 2.

Spillco Series

This series consists of deep, nearly level, moderately well drained to somewhat poorly drained, medium textured soils on bottom lands. These soils formed in alluvium.

In a representative profile the surface layer is about 50 inches thick. The upper part is black loam, and the lower part is very dark gray loam. The underlying material is very dark grayish brown loam to a depth of 60 inches.

Spillco soils have moderate permeability. Available water capacity is high. Organic-matter content is high. Available phosphorus in the lower part of the surface layer is low, and available potassium is very low. These soils are generally neutral to a depth of 20 inches.

Spillco soils are used for crops and pasture. Most areas of these soils are flooded at least one time a year. Areas that are flooded frequently are used for pasture.

Representative profile of Spillco loam, 0 to 2 percent slopes, in a cultivated field, 550 feet south and 60 feet west of the northeast corner of sec. 9, T. 99 N., R. 46 W.:

Ap—0 to 8 inches; black (10YR 2/1) loam; weak fine granular structure; friable; neutral; clear boundary.

A12—8 to 13 inches; black (10YR 2/1) loam; weak fine subangular blocky and granular structure; friable; common worm castings; neutral; gradual boundary.

A13—13 to 23 inches; black (10YR 2/1) loam; weak medium subangular blocky structure parting to weak fine subangular blocky and granular; friable; common worm castings; neutral; gradual boundary.

A14—23 to 28 inches; very dark gray (10YR 3/1) loam, faces of peds very dark brown (10YR 2/2); weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few worm castings; strong effervescence; mildly alkaline; gradual boundary.

A15—28 to 38 inches; very dark gray (10YR 3/1) loam; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few worm castings; few small snail shells; strong effervescence; moderately alkaline; gradual boundary.

AC—38 to 50 inches; very dark gray (10YR 3/1) loam, tending to very dark grayish brown (2.5Y 3/2), very dark grayish brown (10YR 3/2) kneaded; weak medium prismatic and subangular blocky structure; friable; strong effervescence; moderately alkaline; gradual boundary.

C—50 to 60 inches; very dark grayish brown (10YR 3/2, tending to 2.5Y 3/2) loam; massive with vertical

parting; friable; strong effervescence; moderately alkaline.

The A horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in the lower part. It is 36 to 50 inches thick. It is loam or silt loam that is high in content of sand. The AC horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is loam or silt loam that is high in content of sand. It is 8 to 16 inches thick.

The C horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 2 or 3. It is generally loam or silt loam, but in places it is loamy sand, sandy loam, or light clay loam.

Spillco soils are associated with Mayer and Millington soils on bottom lands and have somewhat similar profiles. They are neutral and noncalcareous in the upper part of the surface layer, whereas Millington soils are moderately alkaline and calcareous in the surface layer. They lack sand and gravel above a depth of 40 inches, whereas Mayer soils have sand and gravel above a depth of 36 inches.

785—Spillco loam, 0 to 2 percent slopes. This nearly level soil is on flood plains. Areas are irregular in shape and are generally 10 to 100 acres in size.

Included with this soil in mapping are small areas of Mayer, Millington, and Davis soils and soils that are similar to this soil but are poorly drained. Also included are small areas of soils that have sand or gravel in the surface layer.

This soil is suited to row crops. Flooding causes delays in tillage, and there is crop damage in some years. Capability unit IIw–1; environmental planting group 1.

Steinauer Series

This series consists of deep, moderately sloping to very steep, well drained, moderately fine textured soils on hillsides on uplands. These soils formed in calcareous clay loam glacial till.

In a representative profile the surface layer is very dark gray clay loam about 4 inches thick. The next layer is friable, dark grayish brown and light olive brown clay loam about 7 inches thick. The underlying material, to a depth of 60 inches, is light olive brown and olive brown clay loam that has strong brown and reddish yellow mottles.

Steinauer soils have moderate permeability. Available water capacity is high. Organic-matter content is low. Available phosphorus in the upper part of the underlying material is very low, and available potassium is very low. Reaction is moderately alkaline in the surface layer.

Steinauer soils are used mainly for pasture. Some of the moderately sloping and strongly sloping Steinauer soils are used for cultivated crops. Erosion is a serious limitation.

Representative profile of Steinauer clay loam, 25 to 40 percent slopes, in pasture, 350 feet west and 160 feet south of the northeast corner of sec 21. T. 98 N., R. 48 W., on a convex slope of 31 percent:

A1—0 to 4 inches; very dark gray (10YR 3/1) clay loam; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear boundary.

AC—4 to 11 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5YR 5/4) clay loam, olive brown (2.5YR 4/3) kneaded, few very dark gray (10YR 3/1) peds; weak fine and medium subangular blocky structure parting to weak very fine subangular blocky; friable; few fine lime segregations and concretions; strong effervescence; moderately alkaline; gradual boundary.

C1—11 to 19 inches; light olive brown (2.5Y 5/4) light clay loam, few dark grayish brown (2.5Y 4/2) peds; few fine strong brown (7.5YR 5/8) mottles; weak medium prismatic structure; friable; few fine lime segregations and concretions; strong effervescence; moderately alkaline; gradual boundary.

C2—19 to 33 inches; light olive brown (2.5Y 5/4) clay loam, common fine and medium strong brown (7.5YR 5/6) and reddish yellow (7.5YR 6/8) mottles; moderate coarse blocky structure; firm; common fine lime segregations and concretions; strong effervescence; moderately alkaline; gradual boundary.

C3—33 to 60 inches; light olive brown (2.5Y 5/4) and olive brown (2.5Y 4/3) clay loam; common fine and medium strong brown (7.5YR 5/6) and reddish yellow (7.5YR 6/8) mottles; moderate coarse blocky structure; firm; few fine and medium lime segregations and concretions; strong effervescence; moderately alkaline.

The solum ranges from 8 to 18 inches in thickness. Lime is at a depth of 14 inches or less.

The A horizon is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark grayish brown (10YR 4/2) light clay loam or heavy loam. It is 4 to 7 inches thick. It has no effervescence to strong effervescence.

The AC horizon is 7 to 14 inches thick. It is dark grayish brown (10YR 4/2), grayish brown (10YR 5/2), or brown (10YR 5/3). It is mildly alkaline or moderately alkaline.

The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 6; the high and low chroma are generally present as mottles. It is commonly clay loam, but it is loam in places. In a few places there are pockets of sand and gravel.

Steinauer soils are associated with Crofton, Egan, and Sac soils. They formed in glacial till, whereas those soils formed partly in loess.

33C—Steinauer clay loam, 5 to 9 percent slopes. This moderately sloping soil is on hillsides. A few areas are on ridgetops. Most areas are less than 10 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer in many places is dark grayish brown.

Included with this soil in mapping are areas of severely eroded Steinauer soils. Also included are a few small areas of Crofton and Salida soils.

This soil is suited to row crops. It is well suited to hay and pasture. Careful management is needed to control erosion. Capability unit IIIe–4; environmental planting group 3.

33D—Steinauer clay loam, 9 to 14 percent slopes. This strongly sloping soil is on hillsides. In most places this soil is downslope from less sloping Egan, Galva, Moody, or Sac soils. Most areas are more than 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer in many places is dark grayish brown.

Included with this soil in mapping are areas of severely eroded Steinauer soils. Also included are a few small areas of Salida soils and soils that have a sandy surface layer.

This soil is well suited to hay and pasture. It is occasionally suited to row crops if erosion is controlled. Capability unit IVe–1; environmental planting group 3.

33E—Steinauer clay loam, 14 to 18 percent slopes. This moderately steep soil is on hillsides. Most areas are more than 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is dark grayish brown in plowed areas.

Included with this soil in mapping are areas of severely eroded Steinauer soils. Also included are a few small areas of Crofton soils and soils that have a sandy surface layer.

This soil is well suited to hay and pasture. It is occasionally suited to row crops if erosion is controlled. Capability unit IVe–1; environmental planting group 3.

33F—Steinauer clay loam, 18 to 25 percent slopes. This steep soil is on hillsides. Areas range from 5 acres to more than 40 acres in size and are long and narrow in many places. This soil has a thicker or darker colored surface layer on north-facing hillsides than on south-facing hillsides.

Included with this soil in mapping are areas of soils that have a thicker, darker colored surface layer. Also included are a few small areas of Salida soils.

This soil is suited to pasture and hay. Erosion is not a serious limitation to these uses if grass cover is maintained. This soil is not too steep for safe operation of most farm machinery if care is exercised. Capability unit VIe–1; environmental planting group 3.

33G—Steinauer clay loam, 25 to 40 percent slopes. This very steep soil is on hillsides. Areas range from about 5 acres to more than 40 acres in size. This soil has the profile described as representative of the series. This soil has a thicker or darker colored surface layer on north-facing hillsides than on south-facing hillsides.

Included with this soil in mapping are areas of soils that have a thicker, darker colored surface layer than Steinauer soils. Also included are a few small areas of Crofton soils.

This soil is suited to pasture, recreational areas, and wildlife habitat. Erosion is not a serious limitation to these uses if a grass cover is maintained. Where vegetation is sparse the soil erodes rapidly. This soil is too steep for safe operation of most farm machinery. Capability unit VIIe–1; environmental planting group 3.

Terril Series

This series consists of deep, gently sloping to strongly sloping, moderately well drained, medium textured soils on foot slopes and alluvial fans. These soils formed in local alluvium.

In a representative profile the surface layer is black in the upper part and very dark gray and very dark grayish brown in the lower part. This layer is loam and silt loam that is high in sand content and is about 26 inches thick. The subsoil is about 29 inches thick. It is friable, very dark grayish brown loam in the upper part; friable, grayish brown to olive brown clay loam in the middle part; and friable, light olive brown clay loam in the lower part. The underlying material is light olive brown clay loam.

Terril soils have moderate permeability. Available water capacity is high. Organic-matter content in the surface layer is moderate to high. Available phosphorus in the subsoil is low, and available potassium is medium. Reaction is commonly neutral or slightly acid in the surface layer.

Terril soils are used for cultivated crops, hay, and pasture. Because individual areas are relatively long and narrow, these soils are managed with the adjacent soils, especially where they are moderately sloping or strongly sloping.

Representative profile of Terril loam, 5 to 9 percent slopes, in cultivated field, 1,090 feet west and 60 feet north of the southeast corner of sec. 1, T. 99 N., R. 48 W., on a concave slope of 8 percent:

Ap—0 to 7 inches; black (10YR 2/1) loam high in silt; weak fine granular structure; friable; slightly acid; abrupt boundary.

A12—7 to 12 inches; black (10YR 2/1) silt loam high in sand; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear boundary.

A13—12 to 20 inches; mixed black (10YR 2/1) and very dark gray (10YR 3/1) silt loam high in sand, very dark gray (10YR 3/1) kneaded; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; neutral; clear boundary.

A3—20 to 26 inches; mixed very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) heavy loam, very dark gray (10YR 3/1) kneaded; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

B21—26 to 32 inches; very dark grayish brown (2.5Y 3/2) heavy loam, faces of peds very dark gray (10YR 3/1); weak coarse subangular blocky structure parting to weak fine subangular blocky; friable; neutral; clear boundary.

B22—32 to 42 inches; grayish brown to olive brown (2.5Y 4/3) light clay loam; continuous thin very dark grayish brown (2.5Y 3/2) coatings on peds; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; neutral; clear boundary.

B3—42 to 55 inches; light olive brown (2.5Y 5/3) light clay loam; many thin dark grayish brown (2.5Y 4/2) coatings on peds; weak medium prismatic structure parting to weak fine prismatic; friable; neutral; gradual boundary.

C—55 to 65 inches; light olive brown (2.5Y 5/3) light clay loam; common thin grayish brown (2.5Y 4/3) coatings on peds; weak coarse prismatic structure parting to weak fine prismatic; friable; many very fine lime segregations; strong effervescence; moderately alkaline.

The solum is generally free of lime to a depth of 4 feet or more.

The A horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark brown (10YR 2/2) or very dark gray (10YR 3/1) in the lower part. It is loam or silt loam high in sand. It is neutral or slightly acid and is 24 to 36 inches thick.

The B horizon is very dark grayish brown (10YR or 2.5Y 3/2), dark grayish brown (10YR 4/2), or grayish brown to brown (2.5Y 4/3) in the upper part and grayish brown to olive brown (2.5Y 4/3) or light olive brown (2.5Y 5/3) in the lower part. It is slightly acid to neutral in the upper part and neutral to moderately alkaline in the lower part. It is 10 to 40 inches thick.

The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. A few mottles that have high and low chroma are present in many places.

Terril soils are associated with Steinauer soils. They have a B horizon and formed in local alluvium, whereas Steinauer soils lack a B horizon and formed in glacial till.

27B—Terril loam, 2 to 5 percent slopes. This gently sloping soil is on foot slopes and alluvial fans. Most areas are less than 15 acres in size and are long and narrow in shape.

Included with this soil in mapping are soils that are similar to this soil but are somewhat poorly drained. Also included are a few small areas of Steinauer soils and soils that have a calcareous surface layer.

This soil is well suited to row crops. Runoff from soils

higher on the landscape damages emerging crops and causes erosion in places. Most areas of this soil are managed with the adjoining soils. Capability unit IIe–1; environmental planting group 1.

27C—Terril loam, 5 to 9 percent slopes. This moderately sloping soil is on foot slopes. Most areas are less than 15 acres in size and relatively long and narrow. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Terril soils that have a surface layer of silt loam. Also included are a few small areas of Steinauer soils.

This soil is suited to row crops. Erosion is a limitation, especially where this soil receives runoff from adjacent soils. Most areas of this soil are managed with the adjoining soils. Capability unit IIIe–1; environmental planting group 1.

27D—Terril loam, 9 to 14 percent slopes. This strongly sloping soil is on foot slopes. Most areas are long and narrow. This soil has a profile similar to the one described as representative of the series, but calcareous material is at a depth of only about 40 inches.

Included with this soil in mapping are small areas of soils that are similar to this soil but have a surface layer less than 24 inches thick.

This soil is suited to row crops, hay, and pasture. The hazard of erosion is severe. Most areas of this soil are managed with the adjoining soils. Capability unit IIIe–1; environmental planting group 1.

Trent Series

This series consists of deep, nearly level and gently sloping, moderately well drained, moderately fine textured soils on broad plane upland areas, swales, and lower side slopes of hills. These soils formed in loess.

In a representative profile the surface layer is black silty clay loam about 17 inches thick. The subsoil is friable, very dark grayish brown and dark grayish brown silty clay loam in the upper part and friable, dark grayish brown and light olive brown silt loam in the lower part. It is about 31 inches thick. The underlying material is mottled grayish brown, light brownish gray, and yellowish brown silt loam to a depth of 60 inches.

Trent soils have moderate permeability. Available water capacity is high. Organic-matter content in the surface layer is high. Available phosphorus in the subsoil is low, and available potassium in the lower part of the surface layer is low. Reaction is generally slightly acid in the surface layer.

These soils are used mainly for cultivated crops, but areas in swales and adjacent to valleys are commonly used for hay and pasture.

Representative profile of Trent silty clay loam, 0 to 2 percent slopes, in meadow, 507 feet north and 70 feet west of the southeast corner of the SW¼ of sec. 14, T. 99 N., R. 46 W., on a plane slope of 2 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; weak fine granular structure; friable; slightly acid; abrupt boundary.

A12—7 to 17 inches; black (10YR 2/1) silty clay loam; weak fine subangular blocky structure parting to moderate fine granular; friable; slightly acid; clear boundary.

B1—17 to 24 inches; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) silty clay loam, few black (10YR 2/1) peds, very dark grayish brown (2.5Y 3/2) kneaded; moderate fine subangular blocky granular structure; friable; neutral; gradual boundary.

B21—24 to 30 inches; dark grayish brown (2.5Y 4/2) silty clay loam; few very dark grayish brown (2.5Y 3/2) peds and coats on peds; few very fine yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure parting to moderate fine subangular blocky; friable; few very fine dark colored oxide segregations; neutral; gradual boundary.

B22—30 to 36 inches; dark grayish brown (2.5Y 4/2) heavy silt loam; few very fine light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/4) mottles; moderate medium prismatic structure parting to moderate fine subangular blocky; friable; few thin clay films on faces of peds; few very fine dark colored oxide segregations; neutral; gradual boundary.

B23—36 to 43 inches; dark grayish brown (2.5Y 4/2) heavy silt loam; few very fine gray (2.5Y 6/1) and strong brown (7.5Y 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; common thin clay films on faces of peds; few very fine dark colored oxide segregations; neutral; gradual boundary.

B3—43 to 48 inches; light olive brown (2.5Y 5/4) silt loam; common fine gray (2.5Y 6/1) mottles and few fine yellowish brown (10YR 5/6) mottles; weak coarse and medium prismatic structure parting to weak fine subangular blocky; friable; common very fine dark colored oxide segregations and concretions; neutral; clear boundary.

C1ca—48 to 54 inches; mottled grayish brown (2.5Y 5/2) light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) silt loam; massive with vertical parting; friable; common very fine dark colored oxide segregations and concretions; common fine lime concretions and segregations; strong effervescence; moderately alkaline; clear boundary.

C2ca—54 to 60 inches; mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/8) silt loam; massive; friable; common very fine dark colored oxide concretions and segregations; common fine lime concretions and segregations; strong effervescence; moderately alkaline.

The A horizon generally is 12 to 20 inches thick. The upper part is black (10YR 2/1) or very dark brown (10YR 2/2), and the horizon is slightly thicker than 20 inches where this soil is on concave positions and receives deposition from surrounding soils. It is generally neutral or slightly acid.

The B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1, 2, or 3 in the upper part. The value of 3 extends to a depth of 20 inches or deeper. In the lower part colors have value of 4 or 5 and chroma of 2 to 4. Mottles of both high and low chroma are present below a depth of 24 inches. This horizon ranges from heavy to light silty clay loam in the upper part and from light silty clay loam to silt loam in the lower part. It is 24 to 36 inches thick. It ranges from neutral to slightly acid in the upper part and from neutral to mildly alkaline in the lower part. The lower part is calcareous in some profiles.

The C horizon has hue of 2.5Y, value of 5 or 6, and chroma of 2 or 3. Generally it has mottles that have chroma greater than 3. It is generally silt loam to a depth of 60 inches, but clay loam glacial till commonly is within a depth of 48 inches in the northern part of the county. It is mildly alkaline or moderately alkaline and calcareous.

Trent soils are associated with Moody soils. They have an A horizon that is thicker and contains more clay than Moody soils, and they are not so well drained.

910—Trent silty clay loam, 0 to 2 percent slopes. This nearly level soil is on broad flats on uplands and on lower side slopes of hills. Some areas on upland flats are more than 100 acres in size. On lower side slopes most areas range from less than 5 acres to about

20 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Moody and Marcus soils, a few areas that have a thicker, dark colored surface layer than is typical of Trent soils, and a few small areas of Sperry soils. Also included are soils that have a calcareous surface layer and soils that have gravel in the surface layer.

This soil is well suited to row crops. Some areas remain wet slightly longer than the adjoining Moody and Egan soils. Where this soil is in concave areas adjacent to swales, it is often tiled at the same time tile is installed in the poorly drained soils in the swales. Capability unit I–3; environmental planting group 1.

910B—Trent silty clay loam, 2 to 5 percent slopes. This gently sloping soil is in shallow concave swales on hillsides. Areas are relatively long and narrow. Most areas are 5 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the dark colored surface layer is about 22 inches thick. Some areas of this soil have recent deposition as much as 12 inches thick over the original surface.

Included with this soil in mapping are some areas of Marcus and Afton soils. Also included are a few small areas of Sperry soils, soils that have a calcareous surface layer, and soils that have gravel in the surface layer.

This soil is suited to row crops. Some areas are used for hay or pasture because the poorly drained adjoining soils make timely cultivation difficult. Because this soil is in swales, runoff from the adjoining soils causes erosion. Capability unit IIe–1; environmental planting group 1.

Wentworth Series

This series consists of deep, nearly level to moderately sloping, well drained, moderately fine textured soils on uplands and stream benches. These soils formed in silty glacial drift and loess.

In a representative profile the surface layer is black and very dark brown silty clay loam about 11 inches thick. The subsoil is about 29 inches thick. It is friable, brown silty clay loam in the upper part; friable, dark yellowish brown silty clay loam in the middle part; and friable, yellowish brown silt loam in the lower part. The underlying material is mottled light gray and yellowish brown silt loam to a depth of 60 inches.

Wentworth soils have moderate permeability. Available water capacity is high. Organic-matter content in the surface layer is low to moderate. Available phosphorus in the subsoil is very low, and available potassium is low. Reaction is neutral to medium acid in the surface layer.

These soils are used mainly for cultivated crops. Erosion is a limitation on the sloping Wentworth soils.

Representative profile of Wentworth silty clay loam, 2 to 5 percent slopes, in cultivated field, 1,640 feet east and 2,350 feet south of the northwest corner of sec. 28, T. 100 N., R. 48 W., on a convex slope of 3 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; weak fine granular structure; friable; slightly acid; clear boundary.

A3—7 to 11 inches; very dark brown (10YR 2/2) silty clay loam, faces of peds black (10YR 2/1); weak medium subangular blocky structure parting to moderate fine subangular blocky and granular; friable; neutral; clear boundary.

B21—11 to 17 inches; brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) coatings on peds; weak fine prismatic structure parting to moderate fine subangular blocky; friable; neutral; clear boundary.

B22—17 to 24 inches; brown (10YR 4/3) silty clay loam; weak fine and medium prismatic structure parting to moderate fine subangular blocky; friable; continuous thin clay films on faces of prisms; neutral; gradual boundary.

B23—24 to 35 inches; dark yellowish brown (10YR 4/4) silty clay loam high in sand; weak medium prismatic structure parting to weak fine subangular blocky; friable; many thin clay films on faces of prisms; mildly alkaline; clear boundary.

B3—35 to 40 inches; yellowish brown (10YR 5/4) silt loam high in sand; common fine light gray (2.5Y 6/1) and few fine dark yellowish brown (10YR 4/4) mottles; weak medium prismatic structure; friable; few thin clay films on faces of prisms; common fine lime concretions; few very fine lime segregations; strong effervescence; moderately alkaline; gradual boundary.

C—40 to 60 inches; mottled light gray (2.5Y 6/1) and yellowish brown (10YR 5/4 and 5/6) silt loam; common fine strong brown (7.5YR 5/8) mottles; massive; friable; common very fine lime concretions and segregations; strong effervescence; moderately alkaline.

The solum ranges from 24 to 43 inches in thickness. Depth to free lime ranges from 24 to about 40 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 8 to 15 inches thick and is neutral to medium acid.

The B horizon is 16 to 36 inches thick. The B21 horizon has value of 3 or 4 and chroma of 2 or 3. The lower part of the B2 horizon has hue of 10YR and 2.5Y, value of 4 or 5, and chroma of 3 or 4. The B2 horizon ranges from slightly acid to mildly alkaline. The B3 horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 6. The high and low chromas, where present, are in mottles or mottled colors. The B3 horizon is silty clay loam or silt loam. It is mildly alkaline or moderately alkaline.

The C horizon has color similar to that of the B3 horizon, but colors are generally more mottled. It is typically silt loam or silty clay loam but has strata of sand, sandy loam, or loam in places.

A depth to lime of more than 30 inches is outside the range defined for the series. This difference, however, does not significantly affect the use and behavior of the soils.

Wentworth soils are associated with Moody soils. They contain more sand and more clay in the lower part of the B2 horizon than Moody soils.

710—Wentworth silty clay loam, 0 to 2 percent slopes. This nearly level soil is on stream benches near the Big Sioux River. Most areas are larger than 10 acres and a few are larger than 50 acres. This soil has a profile similar to the one described as representative of the series, but the upper part of the subsoil is darker colored; it is very dark grayish brown between depths of 12 and 20 inches. Also, the underlying material is stratified.

Included with this soil in mapping are soils that have sand and gravel below the silt loam underlying material and soils that have a thicker, dark colored surface layer. Also included are some areas of gently sloping Wentworth soils.

This soil is well suited to row crops. It receives runoff from adjacent soils on uplands in places. Erosion is not a serious limitation, but practices that reduce runoff are beneficial because of the extra water

available to plants. Capability unit I–2; environmental planting group 1.

710B—Wentworth silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops and hillsides on uplands. Most areas are 10 to 60 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of gently sloping Wentworth soils that are moderately eroded. Also included are areas of soils that have clayey material in the subsoil and a few small areas of soils that have clayey material in the surface layer.

This soil is suited to row crops. It is susceptible to erosion, especially on long side slopes of hills. Capability unit IIe–3; environmental planting group 1.

710C2—Wentworth silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on hillsides. Most areas are 10 to 40 acres in size and relatively long in relation to width. This soil has a profile similar to the one described as representative of the series, but the surface layer is only about 9 inches thick and depth to free lime is only about 26 inches. Some brown material from the subsoil has been mixed into the plow layer in most places.

Included with this soil in mapping are small areas of severely eroded Wentworth soils and small areas of Moody soils. Also included are a few small areas of Crofton and Steinauer soils and soils that have clayey material in the subsoil.

This soil is suited to row crops, but careful management is needed to control erosion. Capability unit IIIe–3; environmental planting group 1.

Zook Series

This series consists of deep, nearly level, poorly drained, moderately fine textured to fine textured soils on bottom lands. These soils formed in alluvium.

In a representative profile the surface layer is black silty clay loam in the upper part and black silty clay in the lower part. This layer is about 32 inches thick. The subsoil is about 23 inches thick. It is firm, very dark gray silty clay in the upper part and firm, dark gray silty clay in the lower part. The underlying material is gray clay loam to a depth of about 63 inches.

Zook soils have slow permeability. Available water capacity is high. Organic-matter content in the surface layer is high. Available phosphorus in the subsoil is low, and available potassium is low. Reaction is neutral or slightly acid in the surface layer.

Zook soils are used for cultivated crops, hay, and pasture. Most individual areas are too small to be managed separately from adjacent soils. The major limitation to use of these soils for cultivated crops is excessive wetness.

Representative profile of Zook silty clay loam, 0 to 2 percent slopes, in cultivated field, 1,700 feet west and 1,300 feet north of the southeast corner of sec. 25, T. 100 N., R. 43 W., on a concave slope of less than 1 percent:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; moderate fine and very fine granular structure; friable; neutral; clear boundary.

A12—7 to 17 inches; black (N 2/0) heavy silty clay loam; weak fine subangular blocky structure parting to moderate fine granular; friable; neutral; gradual boundary.

A3—17 to 32 inches; black (N 2/0) light silty clay; weak medium subangular blocky structure parting to moderate fine subangular blocky; firm; sheen on faces of peds; neutral; gradual boundary.

B2g—32 to 50 inches; very dark gray (10YR 3/1) light silty clay; weak coarse prismatic structure parting to strong fine angular blocky; firm; sheen on faces of peds; neutral; gradual boundary.

B3g—50 to 55 inches; dark gray (10YR 4/1) silty clay; weak coarse prismatic structure parting to moderate medium subangular blocky; firm; slight effervescence in lower part; mildly alkaline; clear boundary.

Cg—55 to 63 inches; gray (2.5Y 5/1) clay loam; massive; friable; few coarse fragments; common very fine lime segregations; strong effervescence; moderately alkaline.

The solum is 38 to 60 inches thick, and depth to free lime is typically greater than 48 inches.

The A horizon is neutral or slightly acid and is 26 to 40 inches thick.

The Bg horizon is very dark gray (10YR 3/1), dark gray (10YR 4/1), or gray (10YR or 5Y 5/1) silty clay. It has colors that have value of 3 or less to a depth of 36 inches or more. It is neutral or mildly alkaline and is 12 to 24 inches thick.

The Cg horizon has color similar to that of the Bg horizon. It is neutral to moderately alkaline and calcareous. It is silty clay, silty clay loam, or clay loam.

Zook soils are similar to Colo soils and are associated with Spillco and Colo on bottom lands. They have more clay than Colo soils. They have more clay and less sand than Spillco soils.

54—Zook silty clay loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands. Most areas are in backwater areas of major streams and are less than 15 acres in size.

Included with this soil in mapping are small areas of Zook soils that have as much as 12 inches of recent overwash on the surface. Also included are areas of Zook soils that have a surface layer of silty clay.

This soil is suited to row crops. Excess wetness is the main limitation to its use. Tile generally does not function as efficiently on this soil as it does in other poorly drained soils in the county. Soil blowing is a limitation, especially if the soil is fall plowed. Capability unit IIw–1; environmental planting group 2.

Use and Management of the Soils

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

Crops and Pasture

About 77 percent of the acreage in Lyon County is used for cultivated crops. Corn and soybeans are the major row crops. The value of most farms in the county is related to the suitability of the major soils for growing these two crops. Oats and alfalfa or alfalfa-bromegrass hay are also important. Some other crops that are grown less extensively are grain sorghum and forage sorghums.

On about 75 percent of the cropland, erosion is the major limitation; on about 9 percent, wetness is the major limitation; and on about 1 percent, low to mod-

erate available water capacity is the major limitation. The other 15 percent of the cropland is nearly level and has no serious limitations to use.

The erosion control practices used in the county include minimum tillage, contour tillage, terraces and diversions, grassed waterways, cropping systems that include grasses and legumes, and fertility management. On most farms a combination of these practices is used. The hazard of erosion in Lyon County is highest in spring and the early part of summer. About 40 percent of the annual precipitation comes in April, May, and June before crop growth is sufficient to protect the soil. Level terraces can be used on the soils in Lyon County that need terraces for erosion control. The water that stands in the terrace channels generally percolates into the soil before crop damage occurs. Tillage practices that leave crop residue on the surface also reduce runoff and erosion early in the growing season. Well managed crops reduce runoff and erosion. Where changes in practices are needed to reduce erosion, they can generally be made without reducing net returns.

Soil blowing is a limitation on all cropland in the county. It varies from year to year, depending on the weather. The soils that are plowed in fall are often subject to soil blowing the following spring. Some fields are plowed in fall because they consist of poorly drained soils that are difficult to till in spring. Fall plowing of soils that are not normally too wet in spring has little advantage except for better distribution of labor.

Most of the soils that have a wetness limitation are in drainageways and on bottom lands. Tile can be used to improve the drainage of these soils. In a few places adequate drainage can be obtained by surface drainage. Some of the soils on bottom lands are managed effectively by preventing overflow.

On well managed farms in the county, crop yields are limited by the supply of soil moisture in most years. Farming practices that control runoff and erosion also tend to increase the supply of soil moisture. A few farms adjoining the Rock and Big Sioux Rivers could use irrigation to increase soil moisture. There is no water supply available for irrigation on most of the farms in Lyon County.

About 11 percent of the county is in pasture. There are two general types: pasture on uplands and pasture in broad drainageways and on bottom lands.

Most of the pasture on uplands is near the Big Sioux River valley in the western part of the county. Smaller areas of pasture on uplands are scattered throughout the county along stream valleys.

The vegetation in the pasture on uplands is mainly native grasses. The relative proportion of individual grass species has been affected by overgrazing in many areas. Generally the proportion of tall grasses, such as big bluestem, switchgrass, and indiangrass, has decreased and the proportion of short and mid grasses, such as little bluestem, side-oats grama, and blue grama has increased. Pasture on soils near the Big Sioux River have stands of trees in places. Most of the trees are bur oak and are not large enough to supply merchantable timber. These areas are managed as pasture rather than as woodland.

Grazing management is the most important practice for the pasture on uplands. Controlling vegetation that competes with forage-producing species is needed in some pastures. Pasture that has been severely overgrazed can be reseeded if the area is suited to the use of farm machinery. Upland pasture that is reseeded with native grasses generally remains productive over a longer period than those that are reseeded with bromegrass or bromegrass-alfalfa.

Pasture in broad drainageways and on bottom lands are near the major streams throughout the county. Small areas of pasture on farms on uplands have vegetation similar to and are managed like the pasture on broad drainageways and bottom lands. The original vegetation was mainly native tall and mid grasses. The present vegetation is predominantly bluegrass. Reseeding with cool season grasses such as bromegrass, or with bromegrass-alfalfa, is practical where overflow can be controlled. Reed canarygrass is well suited where flooding occurs or where the soil remains wet for long periods. The acreage of this kind of pasture has been decreasing in Lyon County. The trend has been to convert the areas that can be protected from flooding from pasture to crops. Stream channel improvement is a common practice.

The total acreage of pasture in Lyon County has decreased about 20 percent in the last 10 years. Most of the pasture converted to cropland is in broad drainageways and on bottom lands. This is most commonly done after tiling and drainageway channel improvement.

Seeding permanent pasture on soils on uplands has been done on several farms in the county in the last few years. Generally, a combination of warm-season native grasses is planted. These grasses are deep rooted and are relatively productive on deep soils that have moderate or low available water capacity, such as Bolan and Dickman soils. These soils are also well suited to pasture of introduced cool-season grasses.

Capability grouping

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

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

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numer-

als 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 require moderate conservation practices.
Class III soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.
Class IV soils have very severe limitations that reduce the choice of plants or 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 or range, woodland, or wildlife habitat.
Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.
Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.
Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (No class VIII soils in Lyon County.)

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

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 or range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crop 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–3 or IIIe–4. 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.

In the following pages each capability unit in the county is described. To find the names of all soils in a given capability unit, refer to the "Guide to Mapping Units" at the back of this survey. For a complete explanation of the capability classification, see Agriculture Handbook No. 210, Land Capability Classification (*12*).

CAPABILITY UNIT I–1

This unit consists of nearly level, moderately well drained, silty soils on bottom lands. These soils are not subject to damaging floods in most years.

These soils have a surface layer of friable light silty clay loam or silt loam. Permeability is moderate. Organic-matter content is high, and available water capacity is high. Reaction is typically slightly acid or neutral in the surface layer.

These soils are only rarely subject to flooding during the growing season, but they are subject to flooding late in winter and early in spring in some years. The management required for sustained productivity is less difficult on soils of this unit than on soils of other units.

The soils are well suited to row crops, hay, and pasture. Corn and soybeans are the main crops. A few areas associated with soils that are flooded more often or are wetter are used for pasture.

CAPABILITY UNIT I–2

This unit consists of nearly level, somewhat poorly drained to well drained, silty soils on stream benches.

These soils have a surface layer of friable silty clay loam or silt loam. Permeability is moderate. Organic-matter content is moderate to high, and the available water capacity is high. Reaction ranges from medium acid to neutral in the surface layer.

These soils are underlain by sand and gravel at a depth as shallow as 32 inches in some places. Crops are affected by extended periods of drought, especially on the soils that have sand and gravel within a depth of 32 to 40 inches.

The soils of this unit are well suited to row crops, and this is the most common use. Corn and soybeans are the major crops. Oats, hay, and pasture crops are minor.

CAPABILITY UNIT I–3

This unit consists of nearly level, somewhat poorly drained to well drained, silty and loamy soils on uplands.

These soils have a friable surface layer. Permeability is moderate. Organic-matter content is moderate to high, and available water capacity is high. Reaction ranges from medium acid to neutral in the surface layer.

Most of these soils are in slightly convex positions. Some are in plane and concave positions, and these receive additional surface and subsurface water from adjacent soils. Some of the soils, especially those in concave positions, are artificially drained with tile. Where tile is used the soils are more easily managed together with adjacent well drained soils. Artificial drainage is generally not needed on the soils in other positions.

The soils of this unit are well suited to row crops, and this is the most common use. Corn and soybeans are the major crops. Oats, hay, and pasture are grown on a minor acreage.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping, moderately well drained to somewhat poorly drained, silty and loamy soils in narrow upland drainageways and on lower side slopes adjacent to valleys.

These soils have a surface layer of friable silty clay loam or loam. Permeability is moderate to moderately slow. Organic-matter content is moderate to high, and available water capacity is high. Reaction ranges from medium acid to neutral in the surface layer.

These soils receive runoff from adjacent soils. Water erosion is a major hazard early in the growing season. These soils are generally managed with adjacent soils because the areas are long and narrow. Where the adjacent soils are managed to reduce runoff, the hazards of erosion and crop damage from siltation are reduced on soils of this unit. Installing tile drains in the somewhat poorly drained soils allows more timely tillage.

The soils of this unit are suited to row crops, and this is the most common use. In some drainageways they are used for hay. Where they are adjacent to steeper soils that are used for pasture, they are also used for pasture. Pasture and hay are suited to these soils.

CAPABILITY UNIT IIe-2

Dempster silt loam, deep, 2 to 5 percent slopes, is the only soil in this unit. This soil is well drained and gently sloping. It has layers of sand or gravel at a depth of 32 to 40 inches.

Permeability is moderate in the layers above the sand and gravel and rapid in the sand and gravel. Organic-matter content is moderate and available water capacity is moderate to high. Reaction is typically neutral or slightly acid in the surface layer.

This soil is subject to erosion. It receives runoff from adjacent soils in most places. In many places the adjoining soils are nearly level on stream benches. Erosion is not a hazard on the adjoining soils, but practices that reduce runoff from these adjoining soils reduce the hazard of erosion and increase the amount of available water on the Dempster soil.

This soil is suited to row crops. Corn and soybeans are the major crops. Oats, hay, and pasture crops are minor. The underlying sand and gravel limits rooting depth on this soil.

CAPABILITY UNIT IIe-3

This unit consists of gently sloping, well drained, silty and loamy soils on uplands and stream benches.

These soils have a surface layer of friable silty clay loam or loam. Permeability is moderate in the upper part of the profile and ranges from moderately slow to moderately rapid in the lower part. Organic-matter content is moderate. Available water capacity is high except in one soil that has moderate available water capacity. Reaction is typically neutral or slightly acid in the surface layer.

These soils are subject to erosion. They are on ridgetops and hillsides. The main concern in managing these soils is controlling erosion on the long, sloping hillsides. The usual methods of erosion control are contouring, with or without terracing, and using tillage methods that keep crop residue on the surface.

These soils are suited to row crops, and corn and soybeans are grown intensively. A minor acreage is used for oats, hay, and pasture. These soils occupy large enough areas on many farms to be managed as a unit.

CAPABILITY UNIT IIw-1

This unit consists of nearly level, well drained to poorly drained, silty and loamy soils on bottom lands.

These soils have a surface layer of friable loam or silty clay loam. Permeability is moderate to slow. Organic-matter content is high in most places, but in places it is low. Available water capacity is high. Reaction ranges from medium acid to moderately alkaline in the surface layer.

These soils are subject to flooding during the growing season, but in most years crops are not severely damaged. Inadequate internal drainage is not as great a hazard as flooding, but some require artificial drainage for timely tillage of row crops. Tile drainage is normally used, but surface drainage is more efficient on the soils that have clayey layers.

These soils are suited to row crops. Corn and soybeans are grown on a considerable acreage. Areas that are frequently flooded during the growing season are used for hay and pasture. Farmers who need hay and pasture often use these soils for forage production, and thereby reduce costs of drainage and flood control.

CAPABILITY UNIT IIw-2

This unit consists of nearly level, somewhat poorly drained or poorly drained, silty soils in upland drainageways and small valleys.

These soils have a surface layer of friable silty clay loam. Permeability is moderately slow or moderate. Organic-matter content is high, and available water capacity is high. Reaction is neutral to medium acid in the surface layer of most of the soils, but in a few it is mildly alkaline or moderately alkaline.

These soils receive runoff from adjacent soils. In small valleys they are subject to floods of short duration during most of the year. They have a seasonal high water table. These soils are more easily cultivated where artificial drainage has been installed.

These soils are suited to row crops. Corn and soybeans are the main crops, but a sizeable acreage of these soils is used for hay and pasture. Many individual areas are managed separately from the adjoining better drained soils. Since the areas generally are too narrow to plant to row crops, they are left in pasture or hayland.

CAPABILITY UNIT IIw-3

This unit consists of nearly level, somewhat poorly drained and poorly drained, loamy soils on low stream terraces and high bottom lands.

These soils have a surface layer of friable loam or clay loam and are underlain by sand or gravel at a depth of 24 to 40 inches. Permeability is moderate in the upper part of the profile and rapid or very rapid

in the underlying material. Organic-matter content is high, and available water capacity is moderate. Reaction is neutral to moderately alkaline in the surface layer.

These soils are subject to flooding, but crop damage from floods is rare. The water table is normally controlled by the water level in the associated stream.

These soils are suited to row crops. Corn and soybeans are grown extensively in areas that are not subject to frequent flooding. Where these soils are subject to frequent overflow or are associated with soils that are, they are used for hay and pasture. In a few places the rooting depth is shallow enough to reduce productivity in dry years.

CAPABILITY UNIT IIs–1

This unit consists of nearly level, well drained or somewhat excessively drained, silty and loamy soils that are typically on stream benches but are on uplands in some places.

These soils have a surface layer of silt loam or loam. They are underlain by loamy sand, sand, or gravel at a depth of about 2 or 3 feet. Permeability is moderately rapid to moderate in the upper part of the profile and rapid in the underlying material. Organic-matter content is moderately low to moderate, and available water capacity is low to moderate. Reaction is neutral to medium acid in the surface layer.

These soils are subject to little or no water erosion, and, ordinarily, establishing a seedbed is not difficult. The soils are droughty, and the rooting depth of crops is limited by the sandy or gravelly underlying material.

Corn and soybeans are grown extensively on soils of this unit. Oats and annual forage crops are grown more intensively on these soils than on soils of most other capability units. These soils are suited to these uses.

CAPABILITY UNIT IIs–2

This unit consists of gently sloping, well drained and somewhat excessively drained, silty and loamy soils on stream benches and upland hillsides.

These soils have a surface layer of friable silt loam or fine sandy loam and are underlain by loamy sand, sand, or gravel. Permeability is moderate to rapid in the upper part of the profile and rapid in the underlying material. Organic-matter content is low to moderate, and available water capacity is low to moderate. Reaction is typically neutral or slightly acid in the surface layer.

These soils are subject to erosion, but the main limitation to most uses of these soils is droughtiness. Frequent rains are needed during the growing season to maintain crop growth. Crop establishment is not difficult; however, the surface layer of the fine sandy loam dries rapidly, which makes establishment of good stands of small-seeded crops difficult.

Corn and soybeans are grown on these soils, but oats and forage crops are also important, especially on farms that have sufficient acreage of soils that have adequate available water capacity.

CAPABILITY UNIT IIIe–1

This unit consists of moderately sloping and strongly sloping, moderately well drained, loamy soils that are mainly on lower side slopes at the base of upland hillsides and on convex alluvial fans.

These soils have a surface layer of friable loam. Permeability is moderate. Organic-matter content is moderate to high, and available water capacity is high. Reaction is neutral or slightly acid in the surface layer.

These soils receive runoff from soils that are higher on the landscape. Where these soils are used for hay or pasture, erosion is not a hazard unless grazing removes too much of the grass cover. Where grass cover is good these soils trap local alluvium washed from soils higher on the landscape. Most areas of these soils are managed together with adjoining soils.

The soils of this unit are suited to row crops if adequate erosion control measures are used. Corn and soybeans are not often grown on these soils because the steeper, adjoining soils are less suitable for row crops. These soils are well suited to hay and pasture and are easily managed for these uses.

CAPABILITY UNIT IIIe–2

This unit consists of moderately sloping, well drained to excessively drained, silty and loamy soils on stream benches and upland hillsides.

These soils have a surface layer of loam, silt loam, or sandy loam and are underlain by loamy sand, sand, or gravel. Permeability is moderate to rapid in the upper part of the profile and rapid or very rapid in the underlying material. Organic-matter content is mainly moderate to moderately low, but it is low in the soils that have a surface layer of sandy loam. Available water capacity is moderate to very low. Reaction generally is neutral or slightly acid in the surface layer, but in places it is moderately alkaline.

These soils are subject to erosion. Cultivated crops give less protection than on soils that have a greater available water capacity. Terraces are not practical on these soils because the underlying sandy or gravelly material is too close to the surface. Contour tillage is effective in most places. Practices that reduce runoff from soils higher on the landscape or that keep runoff from crossing the soils of this unit help to control erosion.

Corn and soybeans are grown on these soils where they are grown on adjoining soils. The soils of this unit are suited to row crops if adequate erosion control measures are used. Oats, hay, and pasture crops are also commonly grown.

CAPABILITY UNIT IIIe–3

This unit consists of moderately sloping, well drained, silty and loamy soils on hillsides on uplands.

These soils have a surface layer of friable loam, silt loam, or silty clay loam. Permeability is generally moderate in these soils, but in places it is moderately slow in the lower part of the profile. Organic-matter content is low to moderate, depending on the amount of erosion that has taken place. Available water capacity is high. Reaction is slightly acid to moderately alkaline in the surface layer.

These soils are subject to erosion. In many places they are managed together with gently sloping soils, although practices used to control erosion on the gently

sloping soils do not adequately control erosion on the moderately sloping soils.

The soils of this unit are suited to intensive row cropping if erosion is controlled. Corn and soybeans are the main crops. A small acreage is used for oats, hay, and pasture.

CAPABILITY UNIT IIIe–4

This unit consists of moderately sloping and strongly sloping, well drained, silty and loamy soils on hillsides on uplands.

These soils have a surface layer of friable loam, silt loam, silty clay loam, or clay loam. Permeability is moderate or moderately slow. Organic-matter content is low to moderate, depending on the amount of erosion that has taken place. Available water capacity is high. Reaction is slightly acid to moderately alkaline in the surface layer.

These soils are very susceptible to erosion. Accelerated erosion occurs where row crops are grown without adequate erosion control measures. Effective erosion control measures, such as terraces, are needed where these soils are frequently in row crops. Cropping systems that include hay and pasture a large part of the time also adequately control erosion.

The soils of this unit are suited to frequent row crops if erosion is controlled. They are well suited to hay and pasture. These soils are generally managed with the soils to which they are associated.

CAPABILITY UNIT IIIw–1

Sperry silt loam, 0 to 1 percent slopes, is the only soil in this unit. This silty soil is in depressions on uplands and is poorly drained to very poorly drained.

The surface layer is friable silt loam. Permeability is slow. Organic-matter content is moderate to high, and available water capacity is high. Reaction is neutral to medium acid in the surface layer.

Runoff from surrounding soils becomes ponded on this soil. Cultivated crops are grown in areas where surface drains have been constructed to drain off ponded water. Tile with surface intakes are used in places where surface drainage is not feasible. This soil has a seasonal high water table. Tile drains are not so effective in this soil as in other soils in the county that need artificial drainage. The high clay content in the subsoil slows water movement, so that even when tiled this soil remains wet for considerable periods.

This soil is suited to intensive row crops if adequate drainage is provided. Corn and soybeans are the major crops on the surrounding soils and are grown on this soil if adequate drainage is provided. If drained, this soil is also suited to other crops commonly grown in the county.

CAPABILITY UNIT IVe–1

This unit consists of strongly sloping to moderately steep, well drained, silty to loamy soils on hillsides on uplands.

These soils have a surface layer of friable loam, silt loam, or clay loam. Permeability is moderate in the upper part of the profile and rapid to moderate in the lower part. Organic-matter content is low to moderate, partly depending on the amount of erosion that has taken place. Available water capacity is moderate to high. Reaction is slightly acid to moderately alkaline in the surface layer.

These soils are very susceptible to erosion. Row crops can be grown occasionally without excessive soil loss if effective erosion control practices are used. Terraces are effective on the soils that have a surface layer of silt loam but are less effective on the other soils of this unit, because soil material that has low fertility and is in poor physical condition is exposed when terrace channels are cut. A more economical and equally effective method of erosion control is a cropping system that has hay and pasture as the dominant crops.

The soils of this unit are well suited to hay and pasture. They are suited to occasional row crops if erosion is controlled. In places where these soils are adjacent to steeper soils, they are generally used for pasture. These soils are easily managed for pasture because slopes are not too steep for farm machinery to be used safely.

CAPABILITY UNIT IVe–2

This unit consists of strongly sloping, somewhat excessively drained to excessively drained, loamy soils on hillsides and on side slopes at the edge of stream benches.

These soils have a surface layer of friable to very friable loam or sandy loam and are underlain by sandy or gravelly material. Permeability is moderately rapid to very rapid in the surface layer and rapid to very rapid in the underlying material. Organic-matter content is moderately low to low, and available water capacity is low to very low. Reaction is slightly acid to moderately alkaline in the surface layer.

These soils are very susceptible to erosion, and they are droughty. Row crops can be grown occasionally without excessive soil loss if effective erosion control practices are used. Where these soils occupy areas large enough to manage separately, hay and pasture crops are generally more feasible.

The soils of this unit are well suited to hay and pasture. They are suited to occasional row crops, and are most commonly used for row crops where they are next to areas of less sloping and less droughty soils. Tillage is hampered in places by stones in the surface layer.

CAPABILITY UNIT Vw–1

This unit consists of Alluvial land. The soils that make up Alluvial land are too intermingled on the landscape to be separated in mapping. These soils are nearly level and mostly sandy and loamy, but a few are silty. They are on bottom lands next to major streams.

The soils have a wide range of properties. The surface layer is recently deposited sandy alluvium in many places, but in areas of old channels it commonly has less sand.

The soils are seldom cultivated. Nearly all areas are in pasture or in trees and brush. Most areas are managed as pasture. Some areas could be used for crops if the old channels were filled and flooding were controlled. To use many areas for crops, it would be necessary to straighten the main channel of the stream. Generally it is more feasible to use the areas as pasture than to develop them for cultivation.

These soils are suited to pasture and wildlife habitat and for recreational uses. Pasture can be improved by removing undesirable brush, by planting grass and legume species that tolerate frequent overflow and deposition, and by fertilizing in some places.

CAPABILITY UNIT VIe–1

Steinauer clay loam, 18 to 25 percent slopes, is the only soil in this unit. It is a steep, loamy soil that is well drained. It is on hillsides.

This soil has a surface layer of friable clay loam. Permeability is moderate. Organic-matter content is low, and available water capacity is high. Reaction is moderately alkaline in the surface layer.

This soil is very susceptible to erosion. It receives runoff water from soils higher on the landscape. It generally is used for pasture. Farm machinery can be used in most places for pasture management and improvement. Pasture can be improved by controlling weeds, applying fertilizers, and planting more productive grass species.

This soil is well suited to pasture. The less sloping areas are also suited to hay.

CAPABILITY UNIT VIIe–1

This unit consists of steep and very steep, well drained to excessively drained soils on hillsides and at the edge of stream benches.

These soils have a surface layer of friable to very friable, sandy loam to clay loam. Some of the soils are underlain by sand and gravel. Permeability is moderate to very rapid. Organic-matter content is low, and available water capacity is high to very low. These soils have a mildly alkaline or moderately alkaline surface layer.

These soils are very susceptible to erosion. They are droughty because runoff is too rapid and, in some of the soils, because the soil has very low available water capacity. Controlled grazing reduces runoff and tends to make the soils less droughty. Farm machinery can be used in a few places, but most of these soils are too steep for safe operation of machinery.

The soils of this unit are suited to pasture, trees, and wildlife habitat and to recreational uses. Nearly all the areas are used for pasture. Stands of trees are common. Protecting trees from grazing, culling, and planting adapted tree species can be used to improve woodlands.

CAPABILITY UNIT VIIe–1

This unit consists of Gravel pits. Most areas are predominantly sandy and gravelly, and have scattered large rock on the surface. Many areas on low benches and bottom lands pond water. A few areas on high benches and uplands pond water.

Areas of Gravel pits are unsuited to farming. Some former areas have been reclaimed by hauling in cover material. Wildlife use of these areas varies, depending on the amount and kinds of plant cover and the distance to a surface water source. Many areas can be developed to improve wildlife habitat or developed for recreational uses.

Predicted yields

In table 2 the average acre yields of principal crops are predicted for a high level of management. The yields are those to be expected under a management system that controls erosion; provides for the level of fertility needed for each crop, as indicated by soil tests; controls the water level in wet soils; includes crop varieties that are suited to the area and to the soil; controls insect and disease losses; and provides for timely operations.

All available sources of information on yield were used in making these estimates, including data from the Federal census, Iowa farm census, Iowa experimental farms, and cooperative experiments with farmers and from information supplied by farmers, soil scientists, extension workers, and others.

The yield estimates are designed to serve as guides. They are approximate values for yields presently attainable. Of more value than the estimated yield on a particular soil, to many users, is the comparison of yields of different soils. This relationship is likely to remain fairly constant over a period of years. Yields on most soils have been increasing in past years. If this trend continues, the predicted yields in table 2 will soon be lower than commonly attained yields.

Environmental Plantings

In this section the soils of Lyon County are placed in four groups according to their suitability for growing trees and shrubs, some of the important soil characteristics for each group are presented, and hazards that may be encountered are discussed.

In table 3 suggested tree and shrub species are given for the following uses: shade trees, street trees, hedges and screens, woodland plantings, windbreaks, and wildlife plantings. The plants are not listed in order of preference, and the list does not include all suitable trees or shrubs. Individual preference and advice of specialists will determine which species will be used. Soils have been placed in four environmental planting groups as follows:

Environmental planting group 1.—In this group are soils that have properties generally favorable to good plant growth. Erosion is a hazard on the sloping soils. Plant-available water in most of the soils is less than optimum during dry periods, especially in the soils that are underlain by sand and gravel. Most of the bottom land soils are subject to flooding, but the floods are normally infrequent and of short duration. Reaction of the surface layer is typically neutral or slightly acid.

Environmental planting group 2.—In this group are wet soils and some soils that are subject to ponding or to flooding. Maximum duration of standing water is a few days to a week, except during unusually wet periods. Artificial drainage systems have been installed in many places to speed removal of excess water. Poor tilth is a problem at times. Reaction of the surface layer is typically slightly acid to moderately alkaline. Sperry soils tend to be more poorly drained and more acid than other soils in this group.

Environmental planting group 3.—The soils in this group generally are favorable for plant growth, but they have excess lime at or near the surface. This inhibits growth of many kinds of trees and shrubs. The soils on bottom lands are subject to flooding, but flood-

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

[Dashes indicate that the crop is not suited to the soil or is not generally grown on it. Hay and pasture are alfalfa-bromegrass]

Soil	Corn	Soybeans	Oats	Hay	Pasture
	Bu	*Bu*	*Bu*	*Tons*	*AUD* [1]
Ackmore silty clay loam, 1 to 3 percent slopes	91	35	77	3.8	190
Afton silty clay loam, 0 to 2 percent slopes	88	33	75	3.5	175
Alluvial land					25
Benclare silty clay loam, 0 to 2 percent slopes	86	33	73	3.6	180
Biscay clay loam, deep, 0 to 2 percent slopes	72	27	61	2.9	145
Bolan loam, 0 to 2 percent slopes	58	22	49	2.1	105
Bolan loam, 2 to 5 percent slopes	55	21	47	2.0	100
Bolan loam, 5 to 9 percent slopes, moderately eroded	47	18	39	1.8	90
Bolan loam, 9 to 14 percent slopes, moderately eroded	38	14	33	1.5	75
Calco silty clay loam, 0 to 2 percent slopes	83	32	71	3.3	165
Colo silty clay loam, 0 to 2 percent slopes	90	34	76	3.6	180
Crofton silt loam, 5 to 9 percent slopes	68	26	58	2.9	145
Crofton silt loam, 9 to 14 percent slopes	60	23	52	2.6	130
Crofton silt loam, 9 to 14 percent slopes, severely eroded	54	21	48	2.4	120
Crofton silt loam, 14 to 20 percent slopes, severely eroded	41	16	35	1.8	90
Cylinder silty clay loam, deep, 0 to 2 percent slopes	81	31	69	3.4	170
Davis loam, 0 to 2 percent slopes	91	35	77	3.8	190
Davis silt loam, 0 to 2 percent slopes	99	38	84	4.2	210
Dempster silt loam, deep, 0 to 2 percent slopes	74	28	63	3.0	150
Dempster silt loam, deep, 2 to 5 percent slopes	71	27	60	2.9	145
Dempster silt loam, moderately deep, 0 to 2 percent slopes	64	24	54	2.4	120
Dempster silt loam, moderately deep, 2 to 5 percent slopes	61	23	51	2.3	115
Dempster silt loam, moderately deep, 5 to 9 percent slopes, moderately eroded	53	20	45	2.0	100
Dickman fine sandy loam, 2 to 5 percent slopes	48	18	41	1.7	85
Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded	28	14	36	1.3	65
Dickman fine sandy loam, 9 to 14 percent slopes, moderately eroded				1.1	55
Egan silty clay loam, 2 to 5 percent slopes	78	30	66	3.3	165
Egan silty clay loam, 2 to 5 percent slopes, moderately eroded	75	29	63	3.2	160
Egan silty clay loam, 5 to 9 percent slopes, moderately eroded	71	28	59	2.9	145
Egan silty clay loam, 9 to 14 percent slopes, moderately eroded	62	24	50	2.7	135
Estherville loam, 0 to 2 percent slopes	40	15	34	1.4	70
Estherville-Salida complex, 5 to 9 percent slopes	35	14	29	1.7	75
Estherville-Salida complex, 9 to 14 percent slopes				1.6	60
Everly clay loam, 2 to 5 percent slopes	78	30	66	3.3	165
Galva silty clay loam, 0 to 2 percent slopes	92	36	78	3.9	195
Galva silty clay loam, 2 to 5 percent slopes	90	34	77	3.8	190
Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	87	33	74	3.6	180
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	82	32	70	3.4	170
Galva silty clay loam, stratified substratum, 0 to 2 percent slopes	92	36	78	3.9	195
Galva silty clay loam, stratified substratum, 2 to 5 percent slopes	90	34	77	3.8	190
Gravel pit					
Kennebec silty clay loam, 0 to 2 percent slopes	96	37	81	4.0	200
Kennebec silty clay loam, 2 to 5 percent slopes	95	37	79	4.0	200
Marcus silty clay loam, 0 to 2 percent slopes	92	36	78	3.7	185
Mayer loam, 0 to 2 percent slopes	60	23	51	2.4	120
Millington loam, somewhat poorly drained, 0 to 2 percent slopes	86	33	73	3.6	180
Moody silty clay loam, 0 to 2 percent slopes	87	33	74	3.6	180
Moody silty clay loam, 2 to 5 percent slopes	85	32	72	3.6	180
Moody silty clay loam, 2 to 5 percent slopes, moderately eroded	82	32	70	3.4	170
Moody silty clay loam, 5 to 9 percent slopes, moderately eroded	77	30	66	3.3	165
Moody silty clay loam, 9 to 14 percent slopes, moderately eroded	68	26	58	2.9	140
Moody silty clay loam, benches, 0 to 2 percent slopes	85	32	73	3.6	180
Moody silty clay loam, benches, 2 to 5 percent slopes	83	31	71	3.4	170
Moody silty clay loam, loamy substratum, 2 to 5 percent slopes	80	31	69	3.4	170
Moody silty clay loam, loamy substratum, 2 to 5 percent slopes, moderately eroded	77	30	66	3.3	165
Moody silty clay loam, loamy substratum, 5 to 9 percent slopes, moderately eroded	72	27	61	3.0	150
Ocheyedan loam, 0 to 2 percent slopes	79	30	68	3.3	165
Ocheyedan loam, 2 to 5 percent slopes	77	28	66	3.2	145
Ocheyedan loam, 2 to 5 percent slopes, moderately eroded	74	27	63	3.1	155
Ocheyedan loam, 5 to 9 percent slopes, moderately eroded	69	22	59	2.9	145
Ocheyedan loam, 9 to 14 percent slopes, moderately eroded	59	18	51	2.5	125
Omadi silt loam, occasionally flooded, 0 to 2 percent slopes	72	27	61	3.0	150
Primghar silty clay loam, 0 to 2 percent slopes	99	38	84	4.2	210
Primghar silty clay loam, 2 to 5 percent slopes	97	37	82	4.1	205
Primghar silty clay loam, calcareous variant, 0 to 2 percent slopes	97	37	82	4.1	205
Sac silty clay loam, 2 to 5 percent slopes	81	31	69	3.4	170
Sac silty clay loam, 2 to 5 percent slopes, moderately eroded	78	30	66	3.3	165

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

Soil	Corn	Soybeans	Oats	Hay	Pasture
	Bu	*Bu*	*Bu*	*Tons*	*AUD* [1]
Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	74	28	62	3.0	150
Sac silty clay loam, 9 to 14 percent slopes, moderately eroded	63	24	54	2.6	130
Salida sandy loam, 18 to 40 percent slopes					25
Sperry silt loam, 0 to 1 percent slopes	82	31	70	3.3	165
Spicer silty clay loam, 0 to 2 percent slopes	86	33	73	3.4	170
Spillco loam, 0 to 2 percent slopes	88	33	75	3.7	185
Steinauer clay loam, 5 to 9 percent slopes	67	26	57	2.8	140
Steinauer clay loam, 9 to 14 percent slopes	56	23	48	2.4	120
Steinauer clay loam, 14 to 18 percent slopes			36	2.0	100
Steinauer clay loam, 18 to 25 percent slopes				1.6	80
Steinauer clay loam, 25 to 40 percent slopes					50
Terril loam, 2 to 5 percent slopes	85	33	72	3.6	180
Terril loam, 5 to 9 percent slopes	81	31	69	3.4	170
Terril loam, 9 to 14 percent slopes	73	27	61	3.0	150
Trent silty clay loam, 0 to 2 percent slopes	97	37	83	4.0	200
Trent silty clay loam, 2 to 5 percent slopes	95	36	81	4.0	200
Wentworth silty clay loam, 0 to 2 percent slopes	85	32	72	3.6	180
Wentworth silty clay loam, 2 to 5 percent slopes	82	31	70	3.4	170
Wentworth silty clay loam, 5 to 9 percent slopes, moderately eroded	74	28	63	3.1	155
Zook silty clay loam, 0 to 2 percent slopes	80	30	68	3.2	160

[1] *Animal-unit-days* is the number of days that 1 acre will provide grazing for one animal unit, or 1,000 pounds of live weight, without damage to the pasture.

ing normally is of short duration. Available water for plants commonly is less than optimum during dry periods, especially on the sloping soils that face south or southwest. Also, the hazard of erosion is serious on the sloping soils. The use of machinery on Steinauer soils is limited by steep and very steep slopes. Reaction of the surface layer generally is mildly alkaline or moderately alkaline.

Environmental planting group 4.—Plant growth is limited in soils of this group by the lack of adequate available water during much of the growing season. Soil blowing is a hazard, and water erosion is a hazard on the sloping soils. Reaction of the surface layer generally is slightly acid to mildly alkaline.

Wildlife Habitat [2]

Wildlife is a product of the soil in the same respect that farm crops, forbs, shrubs, and trees are products of the soil. The kind of plant life that grows in an area and such characteristics of the soil as slope, permeability, and drainage, determine the type of wildlife habitat produced.

Many factors affect development of wildlife habitat and the resulting wildlife populations. In intensively farmed areas of Lyon County, personal preferences mainly determine the types of crops planted and other uses of the land. The type of vegetation produced, or lack of it, determines what type of wildlife can survive in the area.

Wildlife generally requires three things from the habitat for survival: (1) food, (2) cover for protection from enemies and weather, and (3) a suitable site to produce young. Fortunately, most farm crops provide these elements for some types of wildlife. Sometimes proper habitat is not enough. Other factors such as disease, extreme weather conditions, predation, and hunting pressure affect wildlife populations; therefore, good wildlife habitat does not guarantee abundant wildlife populations.

Table 4 shows the potential of each soil in Lyon County to produce seven elements of wildlife habitat. These elements are briefly described in the following paragraphs.

Grain and seed crops include corn, oats, soybeans, barley and rye. These plants provide food for many kinds of wildlife.

Grasses and legumes include bromegrass, switchgrass, indiangrass, big bluestem, alfalfa, red clover, and wild sweetclover. Such vegetation is important for nesting birds as well as for providing cover to escape from their predators.

Wild herbaceous plants provide both food and cover for many forms of wildlife. Examples of these plants are goldenrod, sunflower, pigweed, dock and ragweed.

Hardwood trees and shrubs lose their leaves each winter. Examples are oak, maple, elm, basswood, walnut, hickory, honeysuckle, dogwood, and ninebark. Their leaves, buds, or seeds provide important food for squirrels, deer and birds.

Coniferous trees and shrubs retain their leaves throughout the year. These include eastern white pine, eastern redcedar, Austrian pine, Norway spruce, Scotch pine, jack pine, and Pfitzer juniper. These plants furnish important winter cover for wild birds and mammals.

Wetland plants include smartweed, bulrush, cattail, and arrowhead. These plants provide both food and cover for the many kinds of waterfowl in Lyon County.

Shallow water areas are areas of soils that have the capacity to pond water to a maximum depth of 5 feet.

The soils in table 4 are rated good, fair, poor, or very poor. Generally, soils producing the most abundant

[2] BILL D. WELKER, biologist, Soil Conservation Service, assisted in the preparation of this section.

crop of grain, grass, or legume would be rated *good*. Soils providing the best conditions for growing conifers, hardwoods, wild herbaceous plants, or wetland plants or for holding water for impoundment are also rated good.

Soils that are artificially drained can produce different vegetation than the same soils when they are naturally poorly drained. Artificially drained soils in Lyon County are used to produce grain and seed crops or grasses and legumes. Therefore, poorly drained soils rated in table 4 for these two habitat elements are given a dual rating for drained and undrained conditions, respectively.

In table 4, the soils are also rated according to their potential for developing habitat for three general types of wildlife. These kinds of wildlife are briefly described in the following paragraphs.

Open-land wildlife includes pheasant, cottontail rabbit, and Hungarian partridge. Their habitat is composed of crop fields, pastures, road ditches and railroad rights-of-way. This habitat is found in Lyon County most often in the Moody and Galva-Primghar associations.

Woodland wildlife includes white-tailed deer, eastern fox, squirrel, red fox, and numerous songbirds. Their habitat is the natural timbered areas occurring mainly along the streams in Lyon County. An example of this habitat is that in the Steinauer-Moody association along the Big Sioux River.

Wetland wildlife includes mink, muskrat, beaver, raccoon, and many species of ducks and geese. Although there are no extensive wetland areas in Lyon County, some of the poorly drained soils in the Calco-Spillco-Dempster and the Primghar-Marcus-Galva associations provide wetland habitat.

Recreational Development

Knowledge of soils is needed in planning, developing, and maintaining areas used for recreation. In table 5 (p. 60) the soils of Lyon County are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails.

In table 5 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A severe limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these, is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rock and coarse fragments, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts and used mainly for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and have no slopes or stoniness that greatly increase cost of leveling sites or building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrop, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rock or stones on the surface.

Engineering Uses of the Soils [3]

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 degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

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

[3] VOLNEY H. SMITH, engineer, Soil Conservation Service, assisted in the preparation of this section.

TABLE 3.—*Kinds of plantings and suited trees and*

Environmental planting groups and map symbols	Shade trees	Street trees
Group 1: 26, 26B, 27B, 27C, 27D, 64, 77B, 77B2, 77C2, 77D2, 91, 91B, 174, 174B, 174C2, 174D2, 203, 310, 310B, 310B2, 310C2, 311, 311B, 410, 410B, 410B2, 410C2, 410D2, T410, T410B, 411B, 411B2, 411C2, 411D2, 430, 486, 577B, 608, 608B, 608C2, 710, 710B, 710C2, 785, 808, 808B, 878, 878B, 878B2, 878C2, 878D2, 890B, 890B2, 890C2, 899, 910, 910B.	American basswood, honeylocust, green ash, hackberry, sugar maple, silver maple.	Green ash, hackberry, pin oak, sugar maple.
Group 2: 31, 32, 54, 92, 133, 259, 505, 733	Silver maple, hackberry, sycamore, green ash.	Hackberry, American sycamore, green ash.
Group 3: 33C, 33D, 33E, 33F, 33G, 189, 401C, 401D, 401D3, 401E3, 458, 658, 791.	Green ash, hackberry, silver maple.	Green ash, hackberry
Group 4: 28B, 28C2, 28D2, 72, 73F, 315, 501, 541C, 541D	Scarlet oak, bur oak, hackberry, green ash, silver maple.	Hackberry, green ash

[1] These plants are not well suited for very poorly drained soils.

7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6, 7, and 8, (p. 62) which show, respectively, several estimated soil properties significant to engineering, interpretations for various engineering uses, and 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 6 and 7, and it also can be used to make other useful maps. This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 5 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have different meaning in soil science than in engineering. The Glossary defines many of these terms as they are commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*), used by the SCS engineers, Department of Defense, and others, and the AASHTO system (*1*), adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building material or for the support of structures other than highways. Soils are classified according to particle size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils that are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. There is one class of highly organic soils, Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL—ML.

The AASHTO 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 indi-

shrubs for environmental planting groups of soils

Hedges and screens	Woodland	Windbreaks	Wildlife
Lilac, American cranberrybush, Tatarian honeysuckle, silky dogwood, arrowwood viburnum, hawthorn.	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple, poplars.	Eastern white pine, red pine, blue spruce, Norway spruce, Scotch pine, white spruce, European larch, eastern redcedar, green ash, hackberry, eastern cottonwood, Douglas-fir, Tatarian honeysuckle, Austrian pine, ponderosa pine, pin oak, Russian-olive, silver maple, lilac.	Blackhaw, lilac, gray dogwood, alternate-leaf dogwood, autumn-olive, Tatarian honeysuckle, American plum, midwest Manchurian crabapple.
Northern white-cedar, silky dogwood, American cranberrybush, Lombardy poplar.	Eastern cottonwood	Silver maple, poplars, laurel, willow, American sycamore, green ash, hackberry [1], northern white-cedar, eastern redcedar [1], white spruce, Norway spruce.	Redosier dogwood, eastern, redcedar, northern white-cedar, silky dogwood, American cranberrybush.
Eastern redcedar, honeysuckle, Russian-olive, Siberian peashrub.	Ponderosa pine, Austrian pine, Scotch pine, hackberry, poplars, green ash.	Ponderosa pine, Austrian pine, green ash, hackberry, Russian-olive, eastern redcedar, northern white-cedar.	American plum, amur honeysuckle, Tatarian honeysuckle, Russian-olive, eastern redcedar.
Eastern redcedar, Russian-olive, honeysuckle, lilac, Siberian peashrub.	Eastern white pine, Scotch pine, European larch, eastern redcedar.	Red pine, eastern white pine, Scotch pine, eastern redcedar, green ash, hackberry, Austrian pine, ponderosa pine, Siberian peashrub.	Blackhaw, lilac, gray dogwood, alternate-leaf dogwood, autumn-olive.

cated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 8; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

Soil properties significant to engineering

Several estimated soil properties significant to engineering are given in table 6. These estimates are made by layers of representative soil profiles having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soils in other counties. Following are explanations of some of the columns in table 6.

Depth to bedrock is the distance from the surface of the soil to a rock layer within the depth of observation. This column is omitted in the table. Bedrock is below the depth normally investigated during the survey except in the extreme northwest corner of the county.

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

Soil texture is described in table 6 in the standard terms used by the U.S. Department of Agriculture (USDA). These terms are based on the percentages of sand, silt, and clay in the less than 2-millimeter fraction of the soil. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary at the back of this survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the water content of a clayey soil from which the particles coarser than 0.5 millimeter have been removed is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6, but in table 8 the data on liquid limit and plasticity index are based on tests of soil samples.

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

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly de-

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

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees and shrubs
Ackmore: 430	Good	Good	Good	Good
Afton: 31	Good-Fair [1]	Good-Fair [1]	Fair	Poor
Alluvial land: 315	Very poor	Very poor	Fair	Poor
Benclare: 64	Good	Good	Fair	Fair
Biscay: 259	Good-Fair [1]	Good-Fair [1]	Fair	Fair
Bolan:				
174, 174B	Good	Good	Good	Fair
174C2, 174D2	Fair	Good	Good	Fair
Calco: 733	Good-Fair [1]	Good-Fair [1]	Good	Fair
Colo: 133	Good-Fair [1]	Good-Fair [1]	Good	Fair
Crofton:				
401C, 401D, 401D3	Fair	Good	Good	Fair
401E3	Fair	Good	Good	Fair
Cylinder: 203	Good	Good	Good	Good
Davis: 486, 899	Good	Good	Good	Good
Dempster:				
808, 808B, 608, 608B	Good	Good	Good	Good
608C2	Fair	Good	Good	Fair
Dickman: 28B, 28C2, 28D2	Fair	Fair	Fair	Fair
Egan:				
411B, 411B2	Good	Good	Good	Good
411C2, 411D2	Fair	Good	Good	Good
Estherville:				
72	Fair	Fair	Fair	Fair
541C, 541D	Poor	Fair	Fair	Fair
Everly: 577B	Good	Good	Good	Good
Galva: 310, 310B, 310B2, 310C2, 311, 311B	Good	Good	Good	Good
Gravel pit: 501	Very poor	Very poor	Very poor	Very poor
Kennebec: 26, 26B	Good	Good	Good	Good
Marcus: 92	Good-Fair [1]	Good-Fair [1]	Good	Fair
Mayer: 658	Fair	Fair	Fair	Fair
Millington: 458	Fair	Good	Good	Good
Moody:				
410, 410B, 410B2, T410, T410B	Good	Good	Good	Good
410C2, 410D2	Fair	Good	Good	Good
890B, 890B2	Good	Good	Good	Good
890C2	Fair	Good	Good	Good

of wildlife habitat and for kinds of wildlife

Elements of wildlife habitat—Continued			Kinds of wildlife		
Coniferous trees and shrubs	Wetland plants	Shallow water areas	Open-land wildlife	Woodland wildlife	Wetland wildlife
Good	Fair	Fair	Good	Good	Fair.
Poor	Fair	Fair	Good-Fair[1]	Poor	Fair.
Very poor	Fair	Poor	Poor	Poor	Poor.
Fair	Fair	Fair	Good	Fair	Fair.
Poor	Good	Poor	Good-Fair[1]	Fair	Fair.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Poor	Good	Fair	Good-Fair[1]	Fair	Fair.
Poor	Good	Fair	Good-Fair[1]	Fair	Fair.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Poor	Very poor	Very poor	Good	Fair	Very poor.
Good	Fair	Poor	Good	Good	Poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Very poor	Good to very poor	Good to very poor	Very poor	Very poor	Good to very poor.
Good	Poor	Poor	Good	Good	Poor.
Poor	Good	Fair	Good-Fair[1]	Fair	Fair.
Poor	Fair	Poor	Fair	Fair	Poor.
Fair	Fair	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.

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

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees and shrubs
Ocheyedan:				
878, 878B, 878B2	Good	Good	Good	Good
878C2, 878D2	Fair	Good	Good	Fair
Omadi: 189	Good	Good	Good	Good
Primghar: 91, 91B, 791	Good	Good	Good	Good
Sac:				
77B, 77B2	Good	Good	Good	Good
77C2, 77D2	Fair	Good	Good	Good
Salida: 73F	Very poor	Poor	Fair	Fair
Sperry: 505	Good-Poor[1]	Good-Poor[1]	Good	Fair
Spicer: 32	Good-Fair[1]	Good-Fair[1]	Good	Fair
Spillco: 785	Good	Good	Good	Good
Steinauer:				
33C, 33D	Fair	Good	Good	Good
33E	Poor	Fair	Good	Good
33F, 33G	Very poor	Poor	Good	Good
Terril:				
27B	Good	Good	Good	Good
27C, 27D	Fair	Good	Good	Good
Trent: 910, 910B	Good	Good	Good	Good
Wentworth:				
710, 710B	Good	Good	Good	Good
710C2	Fair	Good	Good	Good
Zook: 54	Good-Fair[1]	Good-Fair[1]	Good	Fair

[1] Artificially drained condition and undrained condition, respectively.

fined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

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

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

Engineering interpretations

The estimated interpretations in table 7 are based on the estimated engineering properties of soils shown in table 6, 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 Lyon County. In table 6, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, pond and reservoir areas, embankments, and terraces and diversions. For these particular uses, table 6 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings, slight, moderate, and severe. *Slight* means soil properties generally favorable for the rated use or, in other words, limitations that are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties so unfavorable

wildlife habitat and for kinds of wildlife—Continued

Elements of wildlife habitat—Continued			Kinds of wildlife		
Coniferous trees and shrubs	Wetland plants	Shallow water areas	Open-land wildlife	Woodland wildlife	Wetland wildlife
Good	Poor	Poor	Good	Good	Poor.
Fair	Very poor	Very poor	Good	Fair	Very poor.
Fair	Poor	Very poor	Good	Good	Poor.
Good	Fair	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Poor	Fair	Very poor.
Poor	Good	Good	Good-Poor[1]	Poor	Good.
Poor	Good	Fair	Good-Fair[1]	Fair	Fair.
Fair	Fair	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Fair to poor	Good to fair	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Fair	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Good	Good	Good-Fair[1]	Fair	Good.

and so difficult to correct or overcome as to require major soil reclamation, special design, or intensive maintenance. 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 is so unfavorable for a 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, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 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 affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids (fig. 10, p. 82). 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 ma-

TABLE 5.—*Degree and kind of limitations for recreational development*

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Ackmore: 430	Severe: floods	Moderate: wet; floods.	Severe: floods	Moderate: wet.
Afton: 31	Severe: wet	Severe: wet	Severe: wet	Severe: wet.
Alluvial land: 315	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
Benclare: 64	Severe: floods	Moderate: wet; floods; too clayey.	Moderate: wet; slowly permeable; too clayey.	Moderate: too clayey.
Biscay: 259	Severe: wet	Severe: wet	Severe: wet	Severe: wet.
Bolan:				
174	Slight	Slight	Slight	Slight.
174B	Slight	Slight	Moderate: slope	Slight.
174C2	Slight	Slight	Severe: slope	Slight.
174D2	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Calco: 733	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: wet.
Colo: 133	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: wet.
Crofton:				
401C	Slight	Slight	Severe: slope	Slight.
401D	Moderate: slope	Moderate: slope	Severe: slope	Slight.
401D3	Moderate: slope	Moderate: slope	Severe: slope	Slight.
401E3	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Cylinder: 203	Moderate: wet	Slight	Moderate: wet	Moderate: wet.
Davis:				
486	Severe: floods	Moderate: floods	Severe: floods	Slight.
899	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Dempster:				
608, 808	Slight	Slight	Slight	Slight.
608B, 808B	Slight	Slight	Moderate: slope	Slight.
608C2	Slight	Slight	Severe: slope	Slight.
Dickman:				
28B	Slight	Slight	Moderate: slope	Slight.
28C2	Slight	Slight	Moderate: slope	Slight.
28D2	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Egan:				
411B, 411B2	Slight	Slight	Moderate: slope	Slight.
411C2, 411D2	Slight	Slight	Severe: slope	Slight.
Estherville:				
72	Slight	Slight	Slight	Slight.
541C	Slight	Slight	Severe: slope	Slight.
541D	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Everly: 577B	Slight	Slight	Moderate: slope	Slight.
Galva:				
310, 311	Slight	Slight	Slight	Slight.
311B, 310B, 310B2	Slight	Slight	Moderate: slope	Slight.
310C2	Slight	Slight	Severe: slope	Slight.
Gravel pit: 501	(1)	(1)	(1)	(1)
Kennebec:				
26	Severe: floods	Moderate: floods	Moderate: floods	Slight.
26B	Severe: floods	Moderate: floods	Moderate: floods; slope.	Slight.
Marcus: 92	Severe: wet	Severe: wet	Severe: wet	Severe: wet.
Mayer: 658	Severe: floods	Moderate: floods; wet.	Moderate: wet; floods.	Moderate: wet.

TABLE 5.—*Degree and kind of limitations for recreational development*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Millington: 458	Severe: floods	Moderate: floods; wet.	Moderate: wet; floods.	Moderate: wet.
Moody:				
410, T410	Slight	Slight	Slight	Slight.
T410B, 410B, 410B2, 890B, 890B2	Slight	Slight	Moderate: slope	Slight.
410C2, 890C2	Slight	Slight	Severe: slope	Slight.
410D2	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Ocheyedan:				
878	Slight	Slight	Slight	Slight.
878B, 878B2	Slight	Slight	Moderate: slope	Slight.
878C2	Slight	Slight	Severe: slope	Slight.
878D2	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Omadi: 189	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Primghar:				
91	Moderate: wet	Moderate: wet	Moderate: wet	Moderate: wet.
91B	Moderate: wet	Moderate: wet	Moderate: wet; slope.	Moderate: wet.
Primghar Variant: 791	Moderate: wet	Moderate: wet	Moderate: wet	Moderate: wet.
Sac:				
77B, 77B2	Slight	Slight	Moderate: slope	Slight.
77C2	Slight	Slight	Severe: slope	Slight.
77D2	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Salida: 73F	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Sperry: 505	Severe: wet	Severe: wet	Severe: wet	Severe: wet.
Spicer: 32	Severe: wet	Severe: wet	Severe: wet	Severe: wet.
Spillco: 785	Severe: floods	Moderate: floods	Moderate: floods	Moderate: floods.
Steinauer:				
33C	Slight	Slight	Severe: slope	Slight.
33D	Moderate: slope	Moderate: slope	Severe: slope	Slight.
33E	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
33F	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
33G	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Terril:				
27B	Slight	Slight	Moderate: slope	Slight.
27C	Slight	Slight	Severe: slope	Slight.
27D	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Trent:				
910	Moderate: wet	Moderate: wet	Moderate: wet	Moderate: wet.
910B	Moderate: wet	Moderate: wet	Moderate: wet; slope.	Moderate: wet.
Wentworth:				
710, 710B	Slight	Slight	Moderate: slope	Slight.
710C2	Slight	Slight	Severe: slope	Slight.
Zook: 54	Severe: wet; floods.	Severe: wet; floods.	Severe: wet	Severe: wet.

[1] Not rated.

terial as interpreted from the Unified soil classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

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

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular

TABLE 6.—*Estimated soil properties*

[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. to other series that appear in the first column. The

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Dominant USDA texture	Classification	
				Unified	AASHTO
	Ft	*In*			
Ackmore: 430	1–3	0–30	Silty clay loam	ML, CL or CH	A–7 or A–6
	1–3	30–60	Silty clay loam	CH	A–7
Afton: 31	1–3	0–23	Silty clay loam	CH	A–7
		23–40	Silty clay loam	CH or CL	A–7
		40–60	Silt loam	CL	A–6
Alluvial land: 315	(1)	0–60	(1)	(1)	(1)
Benclare: 64	3–5	0–15	Silty clay loam	CL or CH	A–7
		15–33	Silty clay	CH	A–7
		33–60	Silty clay loam and silty clay.	CL or CH	A–7
Biscay: 259	1–3	0–27	Clay loam	CL	A–7
		27–37	Loam and sandy loam	CL	A–6
		37–60	Gravelly sand and sand	SW, SP, or SW-SM	A–1 or A–3
Bolan: 174, 174B, 174C2, 174D2	>5	0–23	Loam	CL or ML	A–4 or A–6
		23–39	Fine sandy loam	SM-SC or SM	A–4
		39–60	Loamy sand	SM	A–2
Calco: 733	1–3	0–38	Silty clay loam	CH or CL	A–7
		38–60	Silty clay loam or silt loam	CH or CL	A–7
Colo: 133	1–3	0–39	Silty clay loam	CH or CL	A–7
		39–60	Silty clay loam	CH or CL	A–7
Crofton: 401C, 401D, 401D3, 401E3	>5	0–60	Silt loam	ML or CL	A–6
Cylinder: 203	3–5	0–20	Silty clay loam	CL	A–6 or A–7
		20–39	Clay loam and loam	CL	A–6
		39–60	Gravelly loamy sand	SP-SM or SM	A–1 or A–2
Davis: 486, 899	>5	0–19	Silt loam or loam	CL, ML or CL-ML	A–4 or A–6
		19–55	Loam	CL, ML or CL-ML	A–4 or A–6
		55–60	Silt loam or clay loam	CL	A–4 or A–6
Dempster:					
808, 808B	>5	0–31	Silty clay loam or silt loam	CL	A–7 or A–6
		31–36	Silt loam	CL	A–6
		36–43	Loamy sand	SM or SC	A–2
		43–60	Sand and gravel	SP or SP-SM	A–1
608, 608B, 608C2	>5	0–28	Silty clay loam or silt loam	CL	A–6 or A–7
		28–60	Sand and gravel	SP or SP-SM	A–1
Dickman: 28B, 28C2, 28D2	>5	0–15	Fine sandy loam	SM-SC or SC	A–2 or A–4
		15–60	Loamy fine sand and sand	SM	A–2
Egan: 411B, 411B2, 411C2, 411D2	>5	0–28	Silty clay loam or silt loam	CL or CH	A–7
		28–34	Silt loam	CL	A–6
		34–60	Clay loam	CL	A–6
*Estherville: 72, 541C, 541D	>5	0–6	Loam	CL	A–6 or A–4
For Salida part of 541C and 541D, see Salida series.		6–22	Sandy loam	SC, SM-SC	A–2 or A–4
		22–60	Gravelly sand	SP, SP-SM	A–1
Everly: 577B	>5	0–16	Clay loam	CL	A–6
		16–28	Clay loam	CL	A–6
		28–60	Clay loam	CL	A–6

significant in engineering

These soils may have different properties and limitations. Therefore, it is necessary to follow carefully the instructions for referring symbol > means more than; < means less than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
				Pct		*In per hr*	*In per in of soil*	*pH*	
100	100	100	95–100	35–50	15–30	0.6–2.0	0.21–0.23	7.4–7.8	Moderate.
100	100	100	95–100	50–65	30–40	0.2–0.6	0.21–0.23	6.6–7.8	High.
100	100	100	95–100	50–65	20–35	0.2–0.6	0.21–0.23	7.4–7.8	High.
100	100	100	95–100	45–65	20–35	0.2–0.6	0.18–0.20	7.4–7.8	High.
100	100	100	90–100	30–40	15–25	0.6–2.0	0.20–0.22	7.4–8.4	Moderate.
100	95–100	[1]	[1]	[1]	[1]	[1]	[1]	6.1–8.4	[1]
100	100	100	95–100	45–60	20–35	0.2–0.6	0.17–0.19	5.6–6.5	High.
100	100	100	95–100	50–70	30–45	0.06–0.2	0.14–0.16	6.6–7.3	High.
100	100	100	95–100	45–60	20–35	0.2–0.6	0.14–0.16	7.9–8.4	High.
95–100	95–100	70–90	50–60	41–50	15–25	0.6–2.0	0.17–0.19	6.1–7.3	Moderate.
90–100	90–100	60–80	50–60	30–40	11–20	0.6–2.0	0.13–0.17	6.6–7.8	Moderate.
65–90	60–80	20–45	2–12	[2] NP	[2] NP	>6.0	0.02–0.04	7.4–7.8	Low.
100	100	85–95	50–70	30–40	5–15	0.6–2.0	0.20–0.22	6.1–7.3	Low.
100	100	80–90	35–50	15–25	4–10	0.6–6.0	0.15–0.17	6.6–7.3	Low.
100	100	70–85	15–30	NP	NP	6.0–20	0.08–0.10	6.6–8.4	Low.
100	100	95–100	85–100	41–60	15–30	0.2–0.6	0.21–0.23	7.9–8.4	High.
100	100	90–100	80–100	41–55	15–30	0.2–0.6	0.18–0.20	7.9–8.4	High.
100	100	95–100	85–100	41–60	15–30	0.2–0.6	0.21–0.23	6.1–7.3	High.
100	100	90–100	80–100	41–60	15–30	0.2–0.6	0.18–0.20	6.6–7.3	High.
100	100	100	95–100	30–40	11–20	0.6–2.0	0.20–0.22	7.4–8.4	Low.
100	95–100	80–90	50–65	35–50	15–25	0.6–2.0	0.21–0.23	6.1–6.5	Moderate.
95–100	90–100	70–85	50–65	30–40	11–20	0.6–2.0	0.16–0.19	6.6–7.3	Moderate.
75–95	70–85	20–40	2–10	NP	NP	>6.0	0.05–0.07	7.9–8.4	Low.
100	100	80–95	50–70	25–40	5–15	0.6–2.0	0.20–0.23	6.1–7.3	Moderate.
100	100	70–85	50–65	25–40	5–15	0.6–2.0	0.17–0.19	6.6–8.4	Moderate.
100	100	75–85	50–70	30–40	8–20	0.6–2.0	0.18–0.20	7.9–8.4	Moderate.
100	100	95–100	70–85	35–50	15–30	0.6–2.0	0.21–0.23	6.1–7.3	Moderate.
100	100	90–100	65–75	30–40	11–20	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
95–100	90–100	80–90	35–50	<20	0–5	6.0–20	0.11–0.13	7.4–7.8	Low.
85–95	70–80	60–75	2–10	NP	NP	>6.0	0.02–0.04	7.9–8.4	Low.
100	100	95–100	65–80	35–50	20–30	0.6–2.0	0.20–0.23	6.1–7.3	Moderate.
85–95	70–80	60–75	2–10	NP	NP	>6.0	0.02–0.04	7.9–8.4	Low.
100	100	90–100	35–50	15–25	4–10	6.0–20	0.16–0.18	6.1–7.3	Low.
100	100	80–95	15–30	<20	NP-4	>6.0	0.05–0.10	6.1–8.4	Low.
100	100	100	95–100	41–55	20–30	0.6–2.0	0.21–0.23	5.6–7.3	High.
100	100	95–100	85–95	30–40	15–25	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
100	95–100	70–85	50–70	30–40	15–25	0.2–0.6	0.14–0.16	7.4–8.4	Moderate.
100	100	90–100	50–75	30–40	8–20	2.0–20	0.20–0.22	6.1–6.6	Moderate.
100	90–100	50–70	35–50	15–25	4–10	2.0–20	0.12–0.14	6.1–7.3	Low.
85–95	70–80	60–75	2–10	NP	NP	>6.0	0.02–0.04	7.9–8.4	Low.
100	95–100	80–90	60–75	30–40	11–20	0.6–2.0	0.17–0.19	5.6–6.5	Moderate.
100	95–100	80–90	55–70	30–40	11–20	0.6–2.0	0.15–0.19	6.6–7.3	Moderate.
100	90–100	70–85	50–70	30–40	11–20	0.2–0.6	0.14–0.16	7.4–8.4	Moderate.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Dominant USDA texture	Classification	
				Unified	AASHTO
	Ft	*In*			
Galva:					
310, 310B, 310B2, 310C2	>5	0–12	Silty clay loam	CH or CL	A–7
		12–38	Silty clay loam and silt loam	CL or CH	A–7
		38–60	Silt loam	CL	A–6
311, 311B	>5	0–12	Silty clay loam	CL or CH	A–7
		12–38	Silty clay loam and silt loam	CL or CH	A–7
		38–50	Silt loam	CL	A–6
		50–60	Sand and gravel	SM-SC or SC	A–1 or A–2
Gravel pit: 501	(1)	0–60	(1)	(1)	(1)
Kennebec: 26, 26B	2–5	0–30	Silty clay loam	CL	A–7
		30–45	Silt loam	CL	A–6 or A–7
		45–60	Loam	CL	A–6
Marcus: 92	1–3	0–19	Silty clay loam and silty clay	CH	A–7
		19–30	Silty clay loam and silty clay	CH	A–7
		30–60	Silty clay loam and silt loam	CL	A–6 or A–7
Mayer: 658	2–4	0–30	Loam	CL	A–4 or A–6
		30–60	Gravelly sand	SM-SC or SC	A–1 or A–2
Millington: 458	2–4	0–31	Loam	CL	A–4 or A–6
		31–60	Sandy loam	SM-SC or SM	A–2
Moody:					
410, 410B, 410B2, 410C2, 410D2, 890B, 890B2, 890C2	>5	0–8	Silty clay loam	CH	A–7
		8–27	Silty clay loam	CL or CH	A–7
		27–60	Silt loam or loam	CL	A–4 or A–6
T410, T410B	>5	0–8	Silty clay loam	CH	A–7
		8–27	Silty clay loam	CL or CH	A–7
		27–50	Silt loam	CL	A–4 or A–6
		50–60	Gravelly sand	SM-SC or SM	A–1 or A–2
Ocheyedan: 878, 878B, 878B2, 878C2, 878D2	>5	0–22	Loam	ML or CL	A–4 or A–6
		22–42	Sandy loam	SC or CL	A–4 or A–6
		42–60	Silt loam	CL or ML	A–4 or A–6
Omadi: 189	>5	0–60	Silt loam	CL or ML	A–4 or A–6
Primghar: 91, 91B	3–5	0–20	Silty clay loam	CH	A–7
		20–30	Silty clay loam	CH or CL	A–7
		30–60	Silt loam	CL	A–4 or A–6
Primghar Variant: 791	3–5	0–24	Silty clay loam	CH	A–7
		24–60	Silt loam	CL	A–4 or A–6
Sac: 77B, 77B2, 77C2, 77D2	>5	0–15	Silty clay loam	CL or CH	A–7
		15–32	Silty clay loam	CL or CH	A–7
		32–60	Clay loam	CL	A–6 or A–7
Salida: 73F	>5	0–9	Sandy loam and gravelly sandy loam.	SC	A–2
		9–60	Gravel and sand	SM, SM-SC, or SC	A–1 or A–2
Sperry: 505	0–3	0–23	Silt loam	ML or CL	A–4 or A–6
		23–46	Silty clay loam and silty clay	CH	A–7
		46–60	Silty clay loam and silt loam	CH or CL	A–6 or A–7
Spicer: 32	1–3	0–26	Silty clay loam	CH	A–7
		26–46	Silt loam	CL or ML	A–6
		46–60	Clay loam	CL	A–6

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
				Pct		*In per hr*	*In per in of soil*	*pH*	
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.21–0.23	6.1–6.6	Moderate.
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.18–0.20	6.1–7.3	Moderate.
100	100	95–100	90–100	30–40	15–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.21–0.23	6.1–6.6	Moderate.
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.18–0.20	7.9–8.4	Moderate.
100	100	95–100	90–100	30–40	15–20	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
80–90	75–90	50–70	5–12	>20	NP–4	>6.0	0.05–0.07	7.9–8.4	Low.
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
100	100	95–100	80–90	41–50	20–30	0.6–2.0	0.21–0.23	6.1–7.3	Moderate.
100	100	95–100	75–85	35–45	15–25	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
100	100	90–100	60–80	30–40	11–20	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
100	100	100	95–100	50–65	30–40	0.2–0.6	0.17–0.19	6.6–7.8	High.
100	100	100	95–100	50–65	30–40	0.2–0.6	0.14–0.16	6.6–7.8	High.
100	100	100	90–100	35–50	20–30	0.6–2.0	0.19–0.21	7.4–8.4	Moderate.
100	95–100	80–95	60–80	25–40	5–15	0.6–2.0	0.20–0.22	7.4–8.4	Moderate.
90–100	60–80	35–50	5–20	<20	4–10	>20	0.03–0.05	7.9–8.4	Low.
100	100	95–100	60–80	25–40	5–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
95–100	95–100	90–100	5–20	15–25	4–10	0.6–2.0	0.11–0.13	7.9–8.4	Low.
100	100	100	95–100	50–60	25–35	0.6–2.0	0.21–0.23	6.1–6.5	High.
100	100	100	95–100	41–55	20–30	0.6–2.0	0.18–0.20	6.6–7.3	Moderate.
100	100	95–100	60–95	30–40	5–15	0.6–2.0	0.20–0.22	6.6–8.4	Moderate.
100	100	100	95–100	50–60	25–35	0.6–2.0	0.21–0.23	6.1–6.5	High.
100	100	100	95–100	41–55	20–30	0.6–2.0	0.18–0.20	6.6–7.3	Moderate.
100	100	95–100	90–100	30–40	5–15	0.6–2.0	0.20–0.22	6.6–8.4	Moderate.
80–90	75–85	50–70	5–20	<20	NP–5	>6.0	0.03–0.05	7.9–8.4	Low.
100	100	75–90	65–80	25–40	5–15	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
100	100	60–80	40–60	25–40	5–15	0.6–6.0	0.13–0.16	6.6–7.3	Moderate.
100	100	85–95	75–90	25–40	5–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	90–100	75–90	25–40	5–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	100	95–100	50–65	30–40	0.2–2.0	0.21–0.23	5.6–7.3	High.
100	100	100	95–100	41–60	25–35	0.2–2.0	0.18–0.20	6.6–7.3	High.
100	100	95–100	90–100	25–40	8–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	100	95–100	50–65	30–40	0.2–2.0	0.21–0.23	7.4–8.4	High.
100	100	95–100	90–100	25–40	8–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	100	95–100	41–55	25–35	0.6–2.0	0.21–0.23	6.1–6.5	High.
100	100	95–100	90–100	41–55	25–35	0.6–2.0	0.18–0.20	6.6–7.3	High.
95–100	90–100	75–90	65–80	35–50	20–30	0.6–2.0	0.14–0.16	7.9–8.4	Moderate.
90–100	70–85	50–70	20–35	15–30	7–10	>20	0.10–0.12	6.6–8.4	Low.
75–90	60–80	40–60	5–25	<20	NP–10	>20	0.02–0.04	7.9–8.4	Low.
100	100	100	95–100	25–40	8–15	0.6–2.0	0.21–0.23	6.6–7.3	Moderate.
100	100	100	95–100	50–65	30–40	0.06–0.2	0.13–0.15	6.1–6.5	High.
100	100	100	90–100	41–55	25–35	0.2–2.0	0.19–0.21	6.6–7.3	Moderate.
100	100	100	95–100	50–65	25–35	0.6–2.0	0.21–0.23	7.4–8.4	High.
100	100	100	95–100	30–40	5–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
95–100	90–100	75–85	60–80	30–40	11–20	0.6–2.0	0.14–0.16	7.9–8.4	Moderate.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Dominant USDA texture	Classification	
				Unified	AASHTO
	Ft	*In*			
Spillco: 785	2–4	0–23	Loam	CL or ML	A–6 or A–4
		23–60	Loam	CL	A–6 or A–4
Steinauer: 33C, 33D, 33E, 33F, 33G	>5	0–60	Clay loam	CL	A–6
Terril: 27B, 27C, 27D	>5	0–26	Loam and silt loam	CL	A–4 or A–6
		26–60	Loam and clay loam	CL	A–4 or A–6
Trent: 910, 910B	2–4	0–17	Silty clay loam	CH	A–7
		17–48	Silty clay loam and silt loam	CH or CL	A–6 or A–7
		48–60	Silt loam	CL or ML	A–4 or A–6
Wentworth: 710, 710B, 710C2	>5	0–11	Silty clay loam	CH or CL	A–7
		11–24	Silty clay loam	CH or CL	A–7
		24–60	Silty clay loam and silt loam	CL	A–6
Zook: 54	1–3	0–17	Silty clay loam and silty clay	CH	A–7
		17–60	Silty clay and clay loam	CH	A–7

[1] Not rated.
[2] NP = Nonplastic.

traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 5 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. Even though reliable predictions can be made to a depth of 10 or 15 feet for some soils, every site should be investigated before it is selected.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep. Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and also the shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rock, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect both the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 7 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or 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 affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

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

Embankments, dikes and levees require soil material that is resistant to seepage and piping and has favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are unfavorable factors.

Drainage of cropland 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;

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
				Pct		*In per hr*	*In per in of soil*	*pH*	
100	95–100	90–100	55–80	25–40	8–20	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
100	95–100	90–100	55–80	25–40	8–20	0.6–2.0	0.17–0.19	7.4–8.4	Moderate.
95–100	90–100	70–90	60–80	30–40	11–25	0.6–2.0	0.15–0.19	7.4–8.4	Moderate.
100	95–100	70–90	60–80	25–40	8–15	0.6–2.0	0.21–0.23	6.1–7.3	Moderate.
100	90–100	70–90	60–80	25–40	8–15	0.6–2.0	0.15–0.18	6.6–8.4	Moderate.
100	100	100	95–100	50–65	25–35	0.6–2.0	0.21–0.23	6.1–6.5	High.
100	100	100	95–100	41–55	20–35	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
100	100	95–100	90–100	30–40	5–15	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.21–0.23	6.1–7.3	High.
100	100	95–100	90–100	41–55	20–35	0.6–2.0	0.18–0.20	6.6–7.3	High.
100	100	90–100	80–90	30–40	15–20	0.6–2.0	0.19–0.21	7.4–8.4	Moderate.
100	100	100	95–100	55–75	30–40	0.06–0.2	0.14–0.16	6.6–7.3	High.
100	100	90–100	90–100	50–70	30–40	0.06–0.2	0.13–0.15	6.6–8.4	High.

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 blowing; soil texture; content of stones; accumulations of salts and alkali; depth of rooting zone; rate of water intake at the surface; permeability of soil layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water 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.

Soil test data

Table 8 contains engineering test data for the Spillco series in Lyon County. These tests were made to help evaluate the soil for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or 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 test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material as has been explained for table 6.

Formation and Classification of the Soils

In this section the factors that have affected the formation of the soils in Lyon County are described. Also described is the classification of the soils by higher categories. Detailed descriptions of soil profiles considered representative for the series are given in the section "Descriptions of the Soils."

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic events. The characteristics of a specific soil are determined by (1) the physical and chemical properties of the parent material; (2) the climate that has existed since soil formation began; (3) the plant and animal life that has lived on and in the soil; (4) the relief, or lay of the land; and (5) the length of time that the parent material has been subject to the soil-forming processes.

Climate and plant and animal life are active factors of soil formation. Climate acts on soil and soil parent material directly and through its effect on the kinds of plants and animals that inhabit soils. These factors

TABLE 7.—*Interpretations of*

[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. fully the instructions for referring to other series

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
Ackmore: 430	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.	Severe: floods.
Afton: 31	Severe: wet	Severe: wet	Severe: wet	Severe: wet	Severe: wet; low strength; shrink-swell potential.
Alluvial land: 315	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Benclare: 64	Severe: slow permeability; floods.	Slight	Moderate: wet; floods; clayey.	Severe: wet	Severe: floods; low strength; high shrink-swell potential.
Biscay: 259	Severe[1]: wet	Severe: rapid permeability in substratum.	Severe: wet; sandy or gravelly substratum.	Severe: wet; rapid permeability in substratum.	Severe: wet; high shrink-swell potential; high susceptibility to frost action.
Bolan: 174, 174B, 174C2, 174D2	Slight[1]	Severe: rapid permeability in substratum; slopes of more than 2 percent; too steep.	Moderate: cutbanks cave.	Severe: rapid permeability in substratum.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or greater.
Calco: 733	Severe: wet; moderately slow permeability; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: floods; wet; low strength; high shrink-swell potential.

engineering properties

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

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: low strength; susceptible to frost action.	Unsuited	Good	Slopes of 1 to 3 percent; moderately slow permeability; floods.	Low strength; compressible; low compacted permeability.	Moderately slow permeability; floods; seasonal water table at a depth of 1 foot to 3 feet.	Slopes of 1 to 3 percent; moderately slow permeability.	Not needed.
Unsuited	Poor: wet	Poor: wet	Nearly level; moderately slow permeability.	Low strength; compressible; low compacted permeability; high shrink-swell potential.	Moderately slow permeability; seasonal water table at a depth of 1 foot to 3 feet.	Wet; moderately slow permeability; nearly level.	Not needed.
Varies from place to place.	Poor to unsuited.	Varies from place to place.	Nearly level; floods.	Varies from place to place.	Varies from place to place; floods.	Varies from place to place; floods; nearly level.	Not needed.
Poor: low strength; high shrink-swell potential.	Unsuited	Fair: clayey.	Nearly level; floods; slow permeability.	Low strength; compressible; low compacted permeability; high shrink-swell potential.	Slow permeability; floods; seasonal water table at a depth of 3 to 5 feet.	Slow permeability; floods; nearly level.	Not needed.
Poor: wet; moderate shrink-swell potential; high frost action.	Good below a depth of about 3 feet.	Poor: wet	Nearly level; rapid permeability in substratum.	Good compaction characteristics; low strength in upper 3 feet.	Sand and gravel below a depth of about 3 feet; seasonal water table at a depth of 1 foot to 3 feet.	Wet; rapid permeability in substratum; nearly level or level.	Not needed.
Good	Poor: excess fines.	Good	Rapid permeability in substratum; slopes as much as 14 percent.	Susceptible to piping; high compacted permeability; unstable fill.	Not needed	Slopes as much as 14 percent; rapid permeability in substratum.	Slopes as much as 14 percent; susceptible to piping.
Poor: wet; low strength; high shrink-swell potential; susceptible to frost action.	Unsuited	Poor: wet; excess lime.	Nearly level; moderately slow permeability; floods.	Low strength; compressible; low compacted permeability.	Moderately slow permeability; floods; seasonal water table at a depth of 1 foot to 3 feet.	Floods; wet; moderately slow permeability; nearly level.	Not needed.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
Colo: 133	Severe: wet; moderately slow permeability; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: floods.
Crofton: 401C, 401D, 401D3, 401E3	Slight if slopes are less than 9 percent. Moderate if slopes are 9 to 14 percent. Severe if slopes are 14 percent or more.	Severe: slope.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 to 14 percent. Severe if slopes are 14 percent or more.	Slight if slopes are less than 14 percent. Moderate if slopes are 14 percent or more.	Moderate if slopes are less than 14 percent. Severe if slopes are 14 percent or more.
Cylinder: 203	Moderate[1]: wet.	Severe: rapid permeability in substratum; wet.	Severe: sand and gravel below a depth of about 3 feet.	Severe: rapid permeability in substratum; wet.	Severe: susceptible to frost action.
Davis: 486, 899	Severe: floods.	Severe: floods; wet.	Severe: floods.	Severe: floods; wet.	Severe: floods.
Dempster: 808, 808B, 608, 608B, 608C2	Slight[1]	Severe: rapid permeability in substratum.	Severe: sand or gravel below a depth of 2 to 3 feet.	Severe: rapid permeability in substratum.	Slight
Dickman: 28B, 28C2, 28D2	Slight[1]	Severe: rapid permeability; slope.	Severe: sandy substratum.	Severe: rapid permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 to 14 percent.
Egan: 411B, 411B2, 411C2, 411D2	Slight if slopes are less than 9 percent. Moderate if slopes are 9 to 14 percent.	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Slight	Moderate: low strength; susceptible to frost action; moderate shrink-swell potential.

engineering properties—Continued

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: wet; low strength; high shrink-swell potential; susceptible to frost action.	Unsuited	Poor: wet	Nearly level; moderately slow permeability; floods.	Low strength; compressible; low compacted permeability.	Moderately slow permeability; floods; seasonal water table at a depth of 1 foot to 3 feet.	Floods; wet; moderately slow permeability; nearly level.	Not needed.
Fair: low strength; susceptible to frost action.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 to 14 percent. Poor if slopes are 14 percent or more.	Moderate permeability; slopes of 5 to 20 percent.	Low strength; susceptible to piping.	Not needed	Slopes of 5 to 20 percent; excess lime; erodes easily; moderate permeability.	Susceptible to piping; erodes easily; complex slopes.
Good	Good below a depth of about 3 feet.	Good	Rapid permeability in substratum; nearly level.	Good compaction characteristics; low strength in upper 3 feet.	Sand and gravel below a depth of about 3 feet; seasonal water table at a depth of 3 to 5 feet.	Nearly level; rapid permeability in substratum.	Not needed.
Poor: low strength; susceptible to frost action.	Unsuited	Good	Nearly level; moderate permeability.	Low strength; compressible; low compacted permeability.	Normally not needed; floods.	Nearly level; floods; moderate permeability.	Not needed.
Good	Good below a depth of 2 to 3 feet.	Good	Rapid permeability in substratum; slopes of 0 to 14 percent.	Sand and gravel at depth of 2 to 3 feet; upper part low strength; low compacted permeability.	Not needed	Slopes of 0 to 9 percent; rapid permeability in substratum; moderate or high available water capacity.	Sand and gravel below a depth of 2 to 3 feet; slopes of 0 to 14 percent.
Good	Poor: excess fines.	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Rapid permeability; slopes of 2 to 14 percent.	Medium strength; susceptible to piping.	Not needed	Slopes of 2 to 14 percent; rapid permeability, low to moderate available water capacity.	Slopes of 2 to 14 percent; susceptible to piping, erodes easily.
Fair: low strength; susceptible to frost action; moderate shrink-swell potential.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Slopes of 2 to 14 percent; moderately slow permeability.	Low strength; compressible; low compacted permeability.	Not needed	Slopes of 2 to 14 percent; moderately slow permeability.	Slopes of 2 to 14 percent; moderately slow permeability below a depth of about 2 feet.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
*Estherville: 72, 541C, 541D ---------- For the Salida part of 541C and 541D, see Salida series.	Slight[1] if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Severe: moderately rapid to rapid permeability; slopes of 0 to 14 percent.	Severe: sand and gravel at a depth of 1 foot to 2 feet.	Severe: moderately rapid to rapid permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.
Everly: 577B ----------	Slight --------	Moderate: slope.	Slight --------	Slight --------	Moderate: low strength: susceptible to frost action; moderate shrink-swell potential.
Galva: 310, 310B, 310B2, 310C2 ----------	Slight --------	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight --------	Slight --------	Severe: low strength: susceptible to frost action.
311, 311B ----------	Slight[1] -------	Severe: rapid permeability in substratum.	Moderate: stratified coarse textured substratum.	Severe: rapid permeability in substratum.	Severe: low strength; susceptible to frost action.
Gravel pit: 501 ----------	Slight[1] -------	Severe: rapid or very rapid permeability.	Severe: gravelly and stony.	Severe: rapid or very rapid permeability; gravel or sand texture.	([2]) ----------
Kennebec: 26, 26B ----------	Severe: floods.	Severe: floods; wet.	Severe: floods.	Severe: wet; floods.	Severe: low strength; floods; susceptible to frost action.
Marcus: 92 ----------	Severe: wet; moderately slow permeability.	Severe: wet --	Severe: wet --	Severe: wet --	Severe: wet; low strength; susceptible to frost action.

engineering properties—Continued

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Good	Good below a depth of 2 feet.	Good if slopes are 9 percent. Fair if slopes are 9 percent or more.	Moderately rapid to rapid permeability; slopes of 0 to 14 percent.	Medium strength; low compressibility; some large stones.	Not needed	Slopes of 0 to 14 percent; moderately rapid to rapid permeability; very low or low available water capacity.	Slopes of 0 to 14 percent; gravelly loam to sand; hard to vegetate.
Fair: low strength; susceptible to frost action; moderate shrink-swell potential.	Unsuited	Good	Slopes of 2 to 5 percent; moderately slow permeability.	Low strength; low compacted permeability.	Not needed	Slopes of 2 to 5 percent; moderately slow permeability.	Slopes of 2 to 5 percent; moderately slow permeability below a depth of about 2 feet.
Poor: low strength; susceptible to frost action.	Unsuited	Good	Slopes of 0 to 9 percent; moderate permeability.	Low strength; compressible; low compacted permeability.	Not needed	Slopes of 0 to 9 percent; moderate permeability.	Slopes of 0 to 9 percent; moderate permeability.
Poor: low strength; susceptible to frost action.	Good to poor below a depth of about 3 feet.	Good	Slopes of 0 to 5 percent; rapid permeability in substratum.	Low strength; compressible; low compacted permeability; stratified coarse material below a depth of about 4 feet.	Not needed	Slopes of 0 to 5 percent; moderate permeability.	Slopes of 0 to 5 percent; moderate permeability.
Good	Good to poor	Poor	[2]	[2]	[2]	[2]	[2].
Poor: low strength; susceptible to frost action.	Unsuited	Good	Slopes of 0 to 5 percent; moderate permeability; floods.	Low strength; medium compressibility; low compacted permeability.	Normally not needed; floods.	Slopes of 0 to 5 percent; floods; moderate permeability.	Slopes of 0 to 5 percent; floods; moderate permeability.
Poor: low strength; susceptible to frost action.	Unsuited	Poor: wet	Nearly level; moderately slow permeability.	Low strength; compressible; low compacted permeability.	Moderately slow permeability; seasonal water table at a depth of 1 foot to 3 feet.	Wet; nearly level; moderately slow permeability.	Not needed.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
Mayer: 658	Severe[1]: wet; floods.	Severe: floods; wet.	Severe: floods; wet; sand and gravel at a depth of about 2½ feet.	Severe: wet; floods.	Severe: floods.
Millington: 458	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: wet; floods.	Severe: floods.
Moody: 410, 410B, 410B2, 410C2, 410D2, 890B, 890B2, 890C2.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Slight	Severe: low strength; susceptible to frost action.
T410, T410B	Slight[1]	Severe: rapid permeability in sub-stratum.	Severe: sand and gravel below a depth of about 3 feet.	Severe: rapid permeability in sub-stratum.	Severe: low strength; susceptible to frost action.
Ocheyedan: 878, 878B, 878B2, 878C2, 878D2.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Slight	Severe: low strength; susceptible to frost action.
Omadi: 189	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods; susceptible to frost action.
Primghar: 91, 91B	Severe: wet; moderate to moderately slow permeability.	Severe: wet	Moderate: wet.	Severe: wet	Severe: low strength; susceptible to frost action.

engineering properties—Continued

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: wet; low strength; susceptible to frost action.	Fair to good below a depth of about 2½ feet.	Good	Nearly level; very rapid permeability in substratum; floods.	Sand and gravel below a depth of about 2½ feet; upper part low strength; low compacted permeability.	Not needed; gravel and sand below depth of about 2½ feet; floods.	Nearly level; floods; very rapid permeability in substratum; moderate available water capacity.	Not needed.
Fair: wet; low strength; susceptible to frost action.	Unsuited	Good	Nearly level; moderate permeability; floods.	Low strength; medium compressibility; low compacted permeability.	Moderate permeability; floods; seasonal water table at a depth of 2 to 4 feet.	Nearly level; floods; moderate permeability.	Not needed.
Poor: low strength; susceptible to frost action.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Slopes of 0 to 14 percent; moderate permeability.	Low strength; compressible; low compacted permeability.	Not needed	Slopes of 0 to 14 percent; moderate permeability.	Slopes of 0 to 14 percent; moderate permeability.
Poor: low strength; susceptible to frost action.	Fair to good below a depth of about 3 feet.	Good	Slopes of 0 to 5 percent; rapid permeability in substratum.	Low strength; compressible; low compacted permeability.	Not needed	Slopes of 0 to 5 percent; moderate permeability; rapid permeability in substratum.	Slopes of 0 to 5 percent; moderate permeability; sand and gravel below a depth of about 3 feet.
Poor: low strength; susceptible to frost action.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Slopes of 0 to 14 percent; moderate permeability.	Low strength; medium compressibility; low compacted permeability.	Not needed	Slopes of 0 to 14 percent; moderate permeability.	Slopes of 0 to 14 percent; moderate permeability.
Poor: low strength; susceptible to frost action.	Unsuited	Good	Nearly level; moderate permeability; floods.	Low strength; medium compressibility; low compacted permeability; susceptible to piping.	Not needed; floods.	Nearly level; floods; moderate permeability.	Not needed.
Poor: low strength; susceptible to frost action.	Unsuited	Good	Slopes of 0 to 5 percent; moderate to moderately slow permeability.	Low strength; compressible; low compacted permeability.	Moderate to moderately slow permeability; seasonal water table at a depth of 3 to 5 feet.	Slopes of 0 to 5 percent; moderate to moderately slow permeability.	Slopes of 0 to 5 percent; moderate to moderately slow permeability.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
Primghar Variant: 791	Severe: wet; moderate to moderately slow permeability.	Severe: wet	Moderate: wet.	Severe: wet	Severe: low strength; susceptible to frost action.
Sac: 77B, 77B2, 77C2, 77D2	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Slight	Moderate: low strength; susceptible to frost action.
Salida: 73F	Severe[1]: Slopes of 25 to 40 percent.	Severe: very rapid permeability; slopes of 25 to 40 percent.	Severe: slopes of 5 to 40 percent; gravelly and stony.	Severe: very rapid permeability; slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.
Sperry: 505	Severe: wet; slow permeability.	Severe: wet	Severe: wet; clayey.	Severe: wet	Severe: wet; low strength.
Spicer: 32	Severe: wet	Severe: wet	Severe: wet	Severe: wet	Severe: wet; low strength; susceptible to frost action.
Spillco: 785	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.	Severe: floods; wet.	Severe: floods.
Steinauer: 33C, 33D, 33E, 33F, 33G	Slight if slopes are less than 9 percent. Moderate if slopes are 9 to 14 percent. Severe if slopes are 14 percent or more.	Severe: slopes of 5 to 40 percent.	Moderate if slopes are less than 9 percent. Severe if slopes are 9 percent or more.	Slight if slopes are less than 14 percent. Moderate if slopes are 14 to 25 percent. Severe if slopes are 25 percent or more.	Moderate if slopes are less than 14 percent. Severe if slopes are 14 percent or more.

engineering properties—Continued

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: low strength; susceptible to frost action.	Unsuited	Good	Nearly level; moderate to moderately slow permeability.	Low strength; compressible; low compacted permeability.	Moderate to moderately slow permeability; seasonal water table at a depth of 3 to 5 feet.	Nearly level; moderate to moderately slow permeability.	Nearly level; moderate to moderately slow permeability.
Fair: low strength; susceptible to frost action.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Slopes of 2 to 14 percent; moderate permeability.	Low strength; medium compressibility; low compacted permeability.	Not needed	Slopes of 2 to 14 percent; moderate permeability.	Slopes of 2 to 14 percent; moderate permeability.
Poor: slopes of 25 to 40 percent.	Good to fair: excess fines.	Poor: slopes of 25 to 40 percent; gravelly sandy loam.	Slopes of 5 to 40 percent; very rapid permeability.	Medium to high strength; low compressibility; high compacted permeability.	Not needed	Slopes of 5 to 40 percent; very rapid permeability; very low available water capacity.	Slopes of 5 to 40 percent; very rapid permeability; gravelly and stony.
Poor: wet; low strength.	Unsuited	Poor: wet	Nearly level; slow permeability.	Low strength; compressible; high compacted permeability.	Slow permeability; seasonal water table at a depth of 3 feet or less; hard to get outlets.	Nearly level; wet; slow permeability.	Not needed.
Poor: wet; low strength; susceptible to frost action.	Unsuited	Poor: wet	Nearly level; moderate permeability.	Low strength; compressible; high compacted permeability.	Moderate permeability; seasonal water table at a depth of 1 foot to 3 feet.	Nearly level; wet; moderate permeability.	Not needed.
Fair: low strength; susceptible to frost action.	Unsuited	Good	Nearly level; moderate permeability; floods.	Low strength; medium compressibility; low compacted permeability.	Normally not needed; floods; seasonal water table at a depth of 2 to 4 feet.	Nearly level; floods; moderate permeability.	Not needed.
Fair if slopes are less than 25 percent. Poor if slopes are 25 percent or more.	Unsuited	Fair if slopes are less than 14 percent. Poor if slopes are 14 percent or more.	Slopes of 5 to 40 percent; moderate permeability.	Low strength; medium compressibility; low compacted characteristics.	Not needed	Slopes of 5 to 40 percent; moderate permeability.	Slopes of 5 to 40 percent; moderate permeability; small stones.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Sanitary landfill	Local roads and streets
Terril: 27B, 27C, 27D	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight if slopes are less than 9 percent. Moderate if slopes are 9 percent or more.	Slight	Moderate: low strength; susceptible to frost action; slopes of 2 to 14 percent.
Trent: 910, 910B	Severe: wet	Severe: wet	Moderate: wet.	Severe: wet	Severe: low strength; susceptible to frost action.
Wentworth: 710, 710B, 710C2	Slight	Moderate if slopes are less than 5 percent. Severe if slopes are 5 percent or more; moderate permeability.	Slight	Slight	Severe: low strength; susceptible to frost action.
Zook: 54	Severe: wet; floods; slow permeability.	Severe: wet; floods.	Severe: wet; floods; clayey.	Severe: wet; floods.	Severe: wet; floods; low strength.

[1] Danger of contamination of ground water because of rapid or very rapid permeability in substratum.
[2] Not rated.

slowly change soil parent material into a natural body, soil, that has genetically related horizons. The effects of climate and living organisms are conditioned by relief. The kind of parent material places limits on the kinds of soil that can be formed. An interval of time is required for parent material to be changed into soil. The amount of time is determined by the intensity of the soil-forming processes and by the physical and chemical properties of the parent material.

The factors of soil formation are interrelated. The effect of one factor cannot be specified unless conditions are specified for the other four.

Parent material

The soils of Lyon County formed in loess, alluvium, glacial till, and eolian sand or other sediment deposited by wind or water. In the northwest corner of the county, there are outcrops of quartzite bedrock. This area is very small, and no soil series have been mapped that formed in this material. The outcrops are shown by a special symbol.

The different parent materials of the soils in the survey are discussed briefly in the following paragraphs.

Loess is the most extensive parent material in the county. It is generally yellowish brown to light olive brown. It is a wind-deposited material containing a high proportion of silt. In Lyon County the loess normally contains from 18 to 25 percent clay and less than 12 percent sand. Stones and pebbles are not present in the loess in most places, except near the boundary between the loess and the underlying glacial drift. The loess does contain lime concretions that formed after the loess was deposited. The thickness of loess in the county decreases from the southwest to the northeast. In the southwestern part of the county, the loess is 10 feet or more in thickness on uneroded ridgetops. Near the northeast corner of the county, the loess is less than 3 feet thick on many ridgetops.

A number of people have studied the soils that formed in loess in Lyon County and the adjoining counties in northwest Iowa. The properties of Galva and Moody soils, the two major soils that formed in loess in Lyon County, were investigated by Foth and Riecken (*4*). A continuing investigation of the management responses of the soils that formed in loess in northwest Iowa is being carried out at the Galva-Primghar and Moody experimental farms. The results

engineering properties—Continued

Suitability as a source of—			Soil features affecting—				
Roadfill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: low strength; susceptible to frost action.	Unsuited	Good if slopes are less than 9 percent. Fair if slopes are 9 percent or more.	Slopes of 2 to 14 percent; moderate permeability.	Low strength; medium compressibility; low compacted permeability.	Not needed	Slopes of 2 to 14 percent; moderate permeability.	Slopes of 2 to 14 percent; moderate permeability.
Poor: low strength; susceptible to frost action.	Unsuited	Good	Slopes of 0 to 5 percent; moderate permeability.	Low strength; compressible; low compacted permeability.	Moderately permeable; seasonal water table at a depth of 2 to 4 feet.	Slopes of 0 to 5 percent; moderate permeability.	Slopes of 0 to 5 percent; moderate permeability.
Poor: low strength; susceptible to frost action.	Unsuited, except fair to good below a depth of 4 feet in unit 710.	Good	Slopes of 0 to 9 percent; moderate permeability.	Low strength; compressible; low compacted permeability.	Not needed	Slopes of 0 to 9 percent; moderate permeability.	Slopes of 0 to 9 percent; moderate permeability.
Poor: wet; low strength.	Unsuited	Poor: wet; clayey.	Nearly level; slow permeability; floods.	Low strength; compressible; low compacted permeability.	Slow permeability; floods; seasonal water table at a depth of 1 foot to 3 feet.	Nearly level; floods; wet; slow permeability.	Not needed.

of these investigations are reported annually by the Iowa Agriculture and Home Economics Experiment Station, Iowa State University.

Soils that formed in loess occupy most of the uplands and higher stream benches in Lyon County. These soils occupy about 77 percent of the total area of the county. Of the soils that formed in loess, about 82 percent of the acreage is well drained, 13 percent is somewhat poorly drained and 5 percent is poorly drained. The well drained Moody soils are the most extensive and are in the western part of the county. In the eastern part of the county the well drained Galva soils predominate.

The soils that formed in loess have deep rooting zones and high available water capacity. The physical and chemical properties are favorable for cultivated crops and for other farming and nonfarming uses. There are hazards and limitations associated with specific soils because of slope or restricted drainage.

Alluvium is the second most extensive parent material in the county. It consists of sediment deposited by water along streams and upland drainageways and on low stream benches. Of the soils that formed in alluvium, about 63 percent have silty clay loam texture, 29 percent have loam texture, and 8 percent have silt loam texture. A small acreage of soils on low stream benches have clay loam texture.

Most of the soils that formed in loam and silt loam alluvium are on flood plains of the major streams. The soils that formed in silty clay loam alluvium are mainly adjacent to the smaller streams and in upland drainageways, but some areas of these soils are near major streams.

Some alluvium was transported only a short distance. In places it extends from the upper slope of hillsides to the lower slope adjacent to drainageways. This is called local alluvium. The alluvium in upland drainageways was derived from the soils in the watershed of the drainageways. This alluvium typically has a silty clay loam texture because most of the soils on uplands in Lyon County have a surface layer of silty clay loam. Most of the alluvium on flood plains along streams has texture ranging from silty clay loam to loam. The amount of sand and clay in this alluvium varies because of position on the flood plains and because of differences in soil texture in the areas from which the alluvium came.

The gravel and sand that underlie the soils on

TABLE 8.—*Engineering*

[Tests performed by the Iowa State Highway Commission according to standard procedures

Soil name and location	Parent material	Report No. AAD4–	Depth	Moisture density [1]	
				Maximum dry density	Optimum moisture
				Lb per cu ft	
Spillco loam:	Alluvium.	3157	0–13	100	21
550 feet south and 60 feet west of northeast corner of sec. 9, T. 99 N., R. 45 W. (Modal)		3158	23–28	114	15
		3159	50–60	116	14

[1] Based on AASHTO Designation T 99–70, Method A (*1*).

[2] Mechanical analyses according to the AASHTO Designation T 88–70 (*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO 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 pi-

stream benches and on some of the flood plains are considered to have been deposited by water from melting glaciers.

Soils that formed in alluvium make up about 15 percent of Lyon County. Of these soils, about 28 percent of the acreage is well drained or moderately well drained, 33 percent is somewhat poorly drained, and 39 percent is poorly drained.

The well drained alluvial soils can generally be managed in the same way as the well drained soils on uplands where slopes are comparable. They are subject to flooding, but in most places this is not a serious limitation. The somewhat poorly drained and poorly drained alluvial soils are subject to flooding, and they have a high water table for part of the year.

Because the alluvial parent material varies so widely in texture and other properties, no general statement about the suitability for farm and nonfarm uses can be made.

Glacial till is the third most extensive parent material in the county. It covers the uplands of the county, but in most places it is mantled by 2 to 10 feet or more of loess. The most extensive exposures are in the more sloping areas near the Big Sioux River in the western part of the county. In these sloping areas, geologic erosion has removed the loess from the surface, so Steinauer soils have formed in the glacial till. Steinauer is the only soil series mapped in the county that formed entirely in glacial till. These soils make up about 4 percent of the county.

A large proportion of the glacial till in the county probably is of Kansan age. However, evidence that till from more recent glaciation is also present in the county was presented by Smith and Riecken (*11*), by Ruhe (*5*), and by Ruhe and Scholtes (*6*). The changes in thickness of the loess over short distances in the north-central part of the county indicate that glaciation probably occurred as recently as the Tazewell, about 20,000 years ago.

Records of wells that have been drilled into and through the glacial till indicate that strata of the till have varying texture in many places. Evidence of textural changes great enough to cause a perched water table can be observed in the road cut at the northeast corner of sec. 31, T. 98 N., R. 48 W. (fig. 11, p. 83).

Steinauer soils have a thin profile. The geological erosion that removed the loess and exposed the till also removed the soil almost as fast as it developed.

These soils have high available water capacity. Much water is lost by runoff, however, and the soil tends to be droughty. Slope, as well as other soil properties, generally is less favorable for crop production on these soils than on soils that formed in loess or alluvium.

Loamy or sandy sediment deposited on the uplands by wind and water is a minor parent material in the county. The texture of the soils that formed in this parent material varies from place to place and with depth from the surface. It is loam, sandy loam, or loamy sand in most places. These soils make up about 4 percent of the county.

This material is mostly in narrow strips adjacent to flood plains of the major streams, commonly to the east and south of the streams. It is thought that the wind carried this parent material from the flood plains and deposited it on adjacent uplands. The proportion of sand generally decreases as distance from the flood plains increases. In local areas there is evidence that water reworked some of this material.

The soils that formed in this sediment have a deep rooting zone, but they have a lower available water capacity than the soils that formed in loess, glacial till, or most alluvium. Most other properties of these soils are less favorable for cultivated crops than are the properties of the soils that formed in loess.

Bedrock outcrop is in a few small areas in the extreme northwest corner of Lyon County. This outcrop is Sioux Quartzite. It is of Precambrian age and is the oldest exposed bedrock in Iowa. No soils are mapped that formed in this material, and no water supplies are present.

test data

of the American Association of State Highway and Transportation Officials (AASHTO)]

Mechanical analysis[2]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—							
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHTO[3]	Unified[4]
100	99	98	76	63	40	21	15	37	13	A-6(9)	CL-ML
100	99	97	57	42	27	16	11	28	11	A-6(5)	CL
---	---	100	74	53	33	19	15	30	13	A-6(9)	CL

pette 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.

[3] Based on AASHTO Designation M 145-66 (*1*).

[4] Based on the Unified soil classification system (*2*).

The surficial bedrock under the loess and glacial till in all of Lyon County except the northwest corner is undifferentiated rock of Cretaceous age. This is the youngest surficial bedrock in Iowa. No outcrops of this bedrock were identified in mapping the soils of the county, and no effect on soil formation caused by this bedrock was observed. Some layers of this sedimentary rock are aquifers, and wells are drilled into the bedrock for water supplies.

Climate

Climate has a major influence on soil formation. Soils form more rapidly in a warm climate than in a cold climate, and more rapidly in a wet climate than in a dry climate. Except for differences because of topography, the soils in Lyon County formed under about the same climate. The climate has not, however, been the same during the entire period of soil formation.

Most of the present upland soils in Lyon County formed after glaciation in Iowa ended and the climate began a warming trend. This occurred about 13,000 years ago (*6*). The climate in Iowa since that time has varied considerably (*15*). From about 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers. From 10,500 to about 8,000 years ago the climate became warmer, changing the vegetation from conifers to a mixed forest dominated by hardwoods. About 8,000 years ago the climate became progressively warmer and drier, until about 3,000 years ago, and resulted in replacement of forest vegetation by herbaceous prairie vegetation. There is evidence that soil erosion during this period removed most of the soil that formed under forest vegetation. From about 3,000 years ago to the present, the climate has become more humid, but the predominance of prairie vegetation has continued, except for small areas of trees on the more sloping soils, particularly near the Big Sioux River in the western part of the county.

The present climate in Lyon County is midcontinental subhumid. There is very little difference in climate from one part of the county to another. There is only about 2 inches increase in annual precipitation from the northwest corner to the southeast corner of Lyon County, and less than 2 degrees increase in annual mean temperature from the northeast corner to the southwest corner of the county.

The effect of this general climate on soils is modified by relief. Other things being equal, the more sloping soils, such as Steinauer soils, have formed under a drier microclimate than the associated, nearly level or gently sloping Moody soils.

On steeply sloping Steinauer soils, however, the north-facing slopes have a cooler and moister microclimate than the south-facing slopes. Because of this, trees are part of the natural vegetation on north-sloping Steinauer soils but not on the south-sloping Steinauer soils. Poorly drained soils such as Afton, Colo, and Marcus soils have a cooler and wetter microclimate than the adjoining better drained soils.

Much of the effect of climate on soil formation in Lyon County is through the influence of climate on vegetation, but climate also directly influences soil formation. The depth to which calcium carbonates, soluble salts, and clay are moved is determined by the amount of precipitation, which also affects the depth to the water table in such poorly drained and somewhat poorly drained soils as Marcus and Primghar soils. In places that have a high water table for most of the growing season, the soil does not develop to so great a depth.

Plant and animal life

Many kinds of living organisms are important in the formation of soils. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. However, differences in the kind of vegetation commonly cause the most marked differences in soils. Soils that formed under grass typically accumulate more organic matter and have a

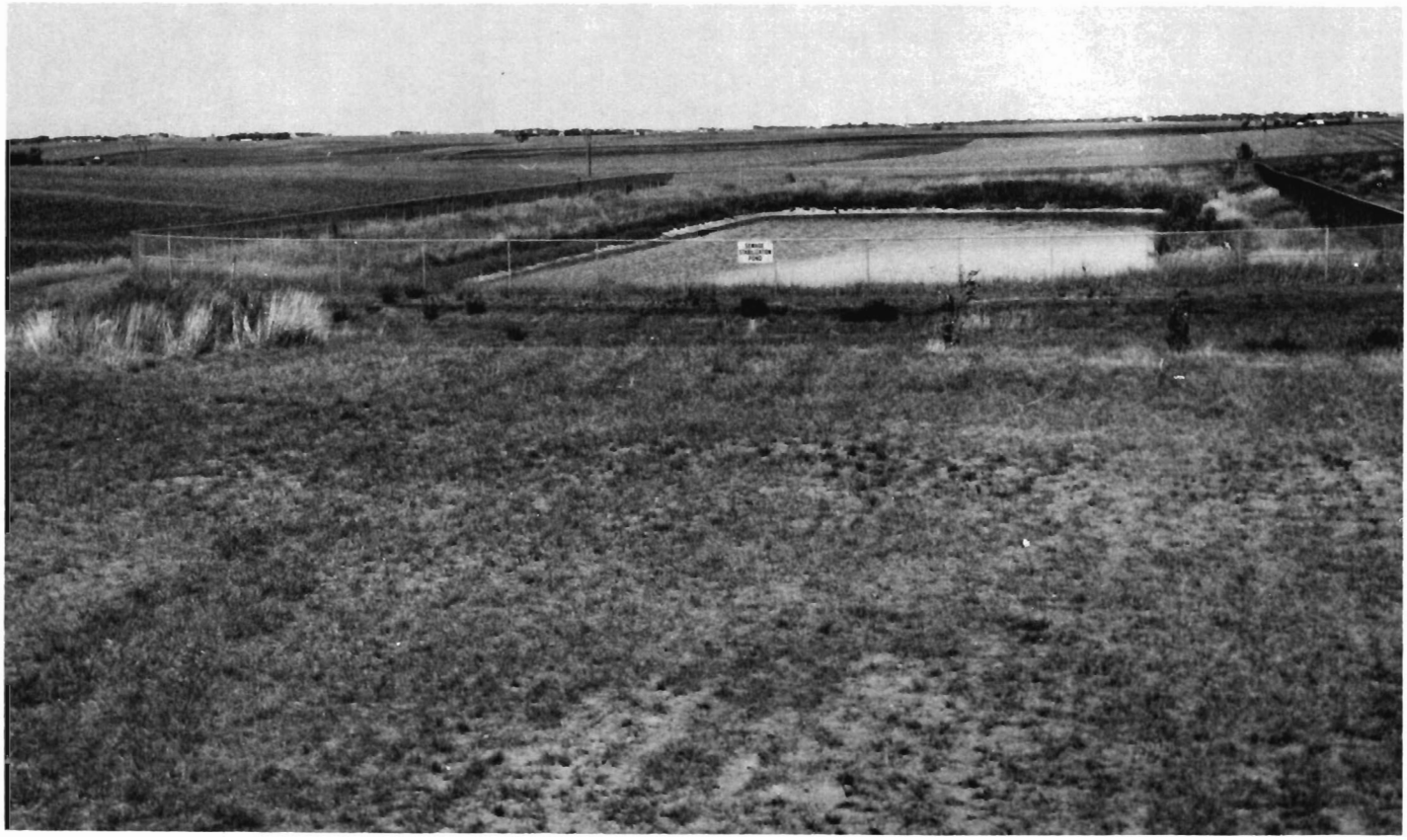

Figure 10.—Sewage lagoon in an area of Moody soils.

thicker, darker colored surface layer than soils that formed under trees. Also, soils that formed under grass normally have less downward movement of bases and clay-size particles and are less acid.

The soils of Lyon County formed mainly under the influence of prairie vegetation. As pointed out in the discussion of climate as a factor of soil formation, herbaceous prairie vegetation is presumed to have replaced timber vegetation about 3,000 years ago.

Although native trees are found on the steep soils near the Big Sioux River and at a few other locations in the county, soils that show the influence of trees were not observed during the survey of the county. The changes caused by trees on north- and east-sloping Steinauer soils are too slight to be significant or easily identified.

Such large burrowing animals as badgers, fox, and pocket gophers are the most obvious animals affecting the soil. They drastically affect soil development in small areas, but earthworms probably have a more widespread influence. As an example, when Moody and Galva soils are moist, most of the earthworm activity is in the upper horizons of these soils. As the upper horizons dry, the earthworms move deeper in the soil. This up and down movement in the soil as the moisture status changes mixes soil material of different horizons.

Despite the short time since settlement, most of the soils in Lyon County have been affected by man's activities. The Ackmore soil is one example. This soil is in upland drainageways and in some places on bottom lands. It formed in 20 to 40 inches of new parent material that has buried other soils. This new parent material eroded from the uplands largely because of man's farming operations.

Relief

Relief, or topography, refers to the lay of the land. Relief in the county ranges from nearly level on flood plains and upland drainage divides to very steep at the edge of uplands near major streams. Elevation above sea level ranges from about 1,230 feet on the flood plain of the Big Sioux River south of Beloit to about 1,470 feet on the uplands northeast of Little Rock. Most of the uplands in the county have nearly level to gently sloping soils. The greatest local variation in relief is on uplands in the western part of the county where the soils on ridgetops are nearly level to gently sloping and those on hillsides are moderately sloping to very steep.

Relief is an important factor in soil formation because of its effect on drainage, runoff, depth to the water table, and erosion. For soils that formed in the same kind of parent material, relief is the main reason properties differ from soil to soil. Differences in relief affect soils in the thickness of the profile, in the degree of development of horizons, and in the color. These differences can be shown by comparing Galva, Primghar, and Marcus soils.

Figure 11.—Road cut showing glacial till slumping because of a perched water table.

Galva soils are in convex areas and are nearly level to moderately sloping and well drained. Excess precipitation runs off and no water from runon or subsurface seepage collects on these soils. Primghar soils are in plane and concave areas and are nearly level to gently sloping and somewhat poorly drained. Primghar and Marcus soils generally receive runon from adjacent soils but are not sloping enough for runoff to occur. Primghar and Marcus soils have a seasonal water table at a depth of 1 foot to 3 feet because of topographic position and the presence of glacial till under the loess, which slows the downward percolation of water. Galva soils have no water table within a depth of 5 feet in most places. Erosion does not occur to any great extent on Primghar and Marcus soils, but most areas of Galva soils are subject to erosion.

According to the model developed by Runge (*8*), soil development is progressively slower in the order Marcus-Primghar-Galva. Marcus soils have the most water available for plant growth and production of organic matter. They are also moist enough for clay formation to occur over the longest interval each year. Most of the data accumulated on these soils indicate that Marcus soils have the highest organic-matter and clay contents in the upper parts of the horizon, and Galva soils have the least.

In thickness of profiles, the relationship among these three soils is not so consistent because the water table in many places restricts the depth of profile development in Marcus and Primghar soils. In Galva soils the amount of runoff controls the depth of water percolation by reducing the supply of water to the soil. Thus, Galva soils, having the most runoff, have the thinnest profiles.

Relief also affects the color of the B horizon through its effect on surface and subsurface drainage. The subsoil of Galva, a well drained soil, is brown because iron compounds are oxidized and distributed throughout the soil material. The subsoil of Marcus, a poorly drained soil, is grayish or olive, because iron compounds have been deoxidized and much of the iron has been removed.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in soil parent material. According to examples given by Simonson (*9*), only a few hundred years are needed to form the surface layer of a soil. Longer time intervals are needed to form a well developed subsoil. Similar soils are produced from different kinds of parent material if the other factors are active over long periods. The soils in Lyon County are relatively young because geologic events in the past interrupted soil develop-

ment, removed soil, and exposed new parent material.

There is evidence that there was considerable geologic erosion in central Iowa between 8,000 and 3,000 years ago (*15*). This geologic erosion probably also occured to some extent in Lyon County. Thus, although the present upland soils began developing when loess deposition ended about 14,000 years ago, the upper part of these soils may have been removed by geologic erosion in a later time period.

The nearly level upland areas would have been eroded less, so the nearly level soils in the county are probably older than the more sloping soils. The Crofton and Steinauer soils have comparatively little profile development because geologic erosion has kept pace with soil formation, allowing little time for soil development.

Most of the soils that formed in alluvium are no older than the youngest soils on the uplands, Steinauer and Crofton. Sediment from the soils on uplands accumulated to form alluvium. Based on data from studies in southwest Iowa (*5*), many of the soils that formed in alluvium probably began forming less than 1,800 years ago. These would include Colo, Davis, and Kennebec soils in Lyon County. The youngest soils are probably Ackmore soils, which formed in postsettlement alluvium, and Omadi soils, which formed in recent alluvium along the Big Sioux River.

Processes of Soil Horizon Differentiation

The five factors of soil formation produce soil horizon differentiation through their effect on the soil-forming processes. These processes have been defined (*9*) as additions, removals, transfers, and transformations within the soil system. The rate at which each of these processes occurs determines what kind of soil develops and how rapidly soil development progresses. For example, in most soil systems there are additions of organic matter, removal of soluble salts and carbonates, transfer of clay from the surface downward, and transformations of primary minerals into secondary minerals that can be used by plants.

In most soils these processes promote horizon differentiation. In some soils one or more retard or reduce soil formation. An example of this is a soil that is subject to rapid erosion. Organic matter is being removed faster than it is being added, and the horizon to which clay is being transferred comes closer to the surface as erosion removes the surface layer.

The addition of organic matter is one of the first evidences that horizon differentiation is progressing in soils. An example of this in Crofton and Steinauer soils is the darker color of the surface layer in comparison to the color of the layers beneath.

The removal of soluble salts and calcium carbonate from the surface layer of Crofton and Steinauer soils has progressed no faster than normal or accelerated erosion has removed the surface layer. In the other soils on uplands in Lyon County, however, soluble salts and calcium have been removed from the upper horizons. The soluble salts and calcium carbonates are moved downward by percolating water. The depth at which the calcium carbonate precipitates is an indication of the usual depth to which water percolates in the moist part of the year. A B horizon develops as carbonates are moved downward. This has occurred, for example, in Moody and Galva soils in the county.

Transfers are also important in the differentiation of horizons in Lyon County soils. The most apparent transfer is that of clay from the surface layer to the developing B horizon. The depth to which clay is moved is related to the depth of water percolation during the growing season (*7*). Transfers become removals when the substance is lost from the soil system. A significant transfer which takes place over the period of a cropping season is that of nitrate nitrogen. The nitrate is transferred downward by percolating water and removed in places from the soil system. Transfers also occur from lower horizons upward, as when plant roots take up nitrogen and other elements. There is evidence that elements such as zinc, which is relatively insoluble in soil water, are transferred from lower horizons to the surface by plants and transferred from the surface to the B horizon along with clay as horizon differentiation progresses. (*3*).

Transformations occur in all horizons of a soil, but the rate of transformation is greatest in the surface layer. During the growing season organic matter is transformed into mineral elements, and primary minerals are transformed into secondary mineral elements. Most transformations have the effect of making elements more available to plants. For example, near pH 7, the primary mineral apatite is weathered to secondary phosphorus compounds (*8*). Soils that have pH of more than 7, such as Crofton soils, are lower in available phosphorus than soils that have pH near 7, such as Moody or Galva soils.

Some elements must be transformed before they can be translocated by water in the soil. An example is iron. It is not soluble in the soil water in such well drained soils as Galva and Moody soils, but in such poorly drained soils as Marcus and Afton soils, the iron is transformed. It moves with the soil water, forming mottles, segregations, and concretions.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*10, 13*).

The current system of classification has six cate-

gories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 9, the soil series of Lyon County are placed in four categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol). Only the Entisols and the Mollisols are represented by the soils in Lyon County.

SUBORDER. Each order is subdivided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu,* meaning water or wet, and *oll,* from Mollisol).

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Haplaquoll (*Hapl,* meaning simple horizons, *aqu* for wetness or water, and *oll,* from Mollisols).

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and other called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplaquolls (a typical Haplaquoll).

FAMILY. Soil families are separated within a subgroup mainly on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 9). An example is the coarse-loamy, mixed, mesic family of Typic Haplaquolls.

SERIES. Soil series are groups of soils within families that formed from a particular kind or kinds of parent material, and have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

As knowledge about soils increases new series are established and concepts of some series, especially older ones that have been used little in recent years, are revised. Each soil survey adds to the information about soils. In the course of a soil survey it is often necessary to propose a new soil series. A new soil series becomes established when it has been reviewed and approved by State, regional, and national levels of responsibility for soil classification.

General Nature of the County

This section is mainly for those who are not familiar with Lyon County. It briefly discusses geology, climate, water supply, and natural vegetation. It also discusses transportation facilities, educational facilities, manufacturing and business services, and trends in land use.

Geology

The major geological formations in the county are flood plains, stream terraces where the soils are underlain by sands and gravels, and uplands mantled by loess that is underlain by glacial drift. All these formations are underlain by bedrock, which generally is at a considerable depth. The flood plains are best suited to and are generally used for farm and recreational enterprises. The stream terraces are less limited in the present and potential uses, but they generally are not suited to waste disposal without site modification. The stream terraces are the major source of sand and gravel. The uplands provide the best sites for confinement livestock operations because of the relative ease of safe waste disposal. They also provide favorable sites for nonfarm operations, as well as for farming.

Climate [4]

Weather data on Lyon County come primarily from Inwood. Tables 10 and 11 give the temperature, precipitation, and freeze data for that section. These data represent the county fairly well on temperature, although the extreme northern part is slightly colder. Inwood's annual precipitation is about 1 inch lower than for the eastern part of the county. During clear calm nights, river valleys and relatively low areas may have minimum temperatures several degrees lower than those in upland or urban areas. Maximum temperatures are representative for the county. In an average year, the number of days that have maximum

[4] By DR. ROBERT H. SHAW, professor of climatology, Department of Agronomy, Iowa State University using data from the National Weather Service, U.S. Department of Commerce.

TABLE 9.—*Classification of the soil series* [1]

Series	Family	Subgroup	Order
Ackmore	Fine-silty, mixed, nonacid, mesic	Aeric Fluvaquents	Entisols.
Afton	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Benclare	Fine, montmorillonitic, mesic	Pachic Haplustolls	Mollisols.
Biscay [2]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Haplaquolls	Mollisols.
Bolan [2]	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Calco	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Crofton	Fine-silty, mixed (calcareous), mesic	Typic Ustorthents	Entisols.
Cylinder [2]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Aquic Hapludolls	Mollisols.
Davis	Fine-loamy, mixed, mesic	Pachic Haplustolls	Mollisols.
Dempster	Fine-silty over sandy or sandy-skeletal, mixed, mesic	Udic Haplustolls	Mollisols.
Dickman	Sandy, mixed, mesic	Typic Hapludolls	Mollisols.
Egan [2]	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Estherville [2]	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Everly	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Galva	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Marcus	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols.
Mayer [2]	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic	Typic Haplaquolls	Mollisols.
Millington [2]	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Moody	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Ocheyedan	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Omadi [2]	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Primghar	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Primghar Variant	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Sac	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Sperry	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Spicer	Fine-silty, mixed (calcareous), mesic	Typic Haplaquolls	Mollisols.
Spillco	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Steinauer	Fine-loamy, mixed (calcareous), mesic	Typic Udorthents	Entisols.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Trent	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Wentworth [2]	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Zook	Fine, montmorillonitic, mesic	Cumulic Haplaquolls	Mollisols.

[1] The classification is that of 1973.
[2] This series is a taxadjunct in Lyon County. Reasons are discussed in the range of characteristics part of the soil description for each series.

temperatures of 90° F or higher has ranged from 23 at Rock Rapids to 27 at Inwood. These temperatures are too high for optimum crop production because of excessive water demand on those days.

The annual precipitation ranges from less than 25 inches in the west to over 26 inches in the east. Lyon County is one of the drier counties in Iowa. From 1951 to 1960, Inwood averaged 17 days with 0.5 inch or more of rainfall and 40 with 0.10 inch or more of rainfall. Heavy rains are important in determining the erosion potential.

Most of the heavy showers occur during the warmer part of the year, and May, June and August average 3 days each when showers occur. About 75 percent of the annual precipitation occurs as showers during the warm season from April through September. June is the wettest month of the year. Dry periods in the summer are mainly in July. The probability of receiving 1 inch or more of rainfall in a 1 week period is about 4 years out of 10 in June and decreases to almost 2 years out of 10 in July and August. Well developed crops use more than 1 inch of water a week during summer.

Soil moisture is also an important part of the moisture supply for crops. In the survey area a 5-inch reserve of available soil moisture is considered a critically low level in spring. There is almost a 50 percent chance of having less than 5 inches of plant-available water in the upper 5 feet of soil on April 15 and about a 10 percent chance of having more than 9 inches available at this time.

Water Supply

Water in amounts needed for domestic and farm use is obtained from shallow wells in most of the county. This water supply is dependent on annual rainfall, and if the wells are not chosen carefully the water is subject to pollution from runoff or seepage from farm lots. The water from shallow wells, both on uplands and near the streams, is low in salt content and generally is of good quality. Most of the towns in the county obtain at least part of their water supply from deep wells that are drilled through the glacial till into the bedrock. Some farms also obtain livestock and domestic water supplies from deep wells. Although water from the deep wells is higher in salt content than that from shallow wells, generally it is also of good quality. The cost of deep wells for individual farms is high, and there is interest in rural water districts to provide a dependable source of quality water to farmsteads in the county.

In some parts of the county it is practical to obtain water supplies by constructing pit ponds. Because sur-

TABLE 10.—*Temperature and precipitation*

[Data from Inwood]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average monthly total	One year in 10 will have—		Average number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F	°F	°F	°F	*Inches*	*Inches*	*Inches*		*Inches*
January	26	5	47	−21	0.5	0.1	1.1	24	6
February	30	9	50	−16	.9	.1	2.1	19	7
March	43	22	64	−3	1.5	.3	2.8	16	9
April	59	34	83	18	2.3	.8	4.1	1	3
May	71	46	89	27	3.2	1.1	6.3	0	0
June	80	56	94	41	4.3	1.9	7.6	0	0
July	86	61	97	48	2.9	.7	4.8	0	0
August	85	59	96	44	3.5	.4	7.1	0	0
September	76	50	91	31	2.7	.5	7.0	0	0
October	63	38	83	20	1.3	(1)	4.0	(2)	3
November	45	23	65	2	1.0	.1	2.5	4	3
December	31	11	51	−11	.7	.2	1.4	17	5
Year	58	35	99	−24	24.7	19.1	30.4	81	6

[1] Trace.
[2] Less than one-half.

face water is excluded, the water supply from a pit pond is of comparable quality to water that would be supplied from a shallow well at the same location.

Water supplies that could be economically used for irrigating cropland are only in the Rock and Big Sioux Rivers and nearby areas connected to these rivers by an underground aquifer.

Natural Vegetation

The natural vegetation in the county is dominantly prairie grasses. The Steinauer-Moody association in the western part of the county contains most of the remaining natural vegetation. Vegetation that is natural or becoming natural through plant succession is also found in old cemeteries and railroad rights-of-way in the county. Natural vegetation, whether remnants of the prairie or planted by man, generally requires less intensive management to maintain because the plant species that make up the natural vegetation are adapted to the soils and climate of the county.

Transportation Facilities

Transportation facilities are available to the residents of Lyon County in the form of rail, air, and road systems. Rail facilities are used mainly for transport of agricultural commodities, but there are some nonagricultural uses as well. Rail transport service in Lyon County has declined in the past several years.

Lyon County has no scheduled air service, but scheduled air service is available nearby at the Sioux Falls, South Dakota, and Sioux City, Iowa, airports. Facilities for small planes are available at airfields near Rock Rapids and Larchwood.

The road system in Lyon County has been improved as transportation needs have increased. U.S. Highway 75 crosses the county north to south near the middle of the county. Iowa Highway 9 crosses the county from west to east about 5 miles south of the northern boundary of the county. Other State highways and a number of hard-surfaced roads are in the county.

Educational Facilities

Educational facilities, through high school, are provided in the county. A number of colleges and a vocational school are in nearby counties in Iowa, South Dakota, and Minnesota.

Manufacturing and Business Services

Businesses in the county that are important in providing services, equipment, and supplies to the farm enterprises are those that manufacture farm equipment; that trade, store, and process farm commodities; and that produce concrete and gravel for construction. Farm equipment dealers, building contractors, and suppliers of construction materials and farm supplies are also in the county. Major livestock markets are nearby at Sioux Falls, South Dakota, and at Sioux City, Iowa.

Trends in Land Use

Trends in the use of land are important because of the effect they have on the soil and on the other related cultural features. Before settlement, the Sioux, Blackfeet, and other Indians who occupied what is now Lyon County used the soil much less intensively than it is used today. Soil use changed as Lyon County was settled, beginning with a homestead near Beloit in

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data from Inwood]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 12	April 26	May 5	May 13	May 24
2 years in 10 later than	April 6	April 20	April 30	May 8	May 19
5 years in 10 later than	March 27	April 9	April 19	April 28	May 9
Fall:					
1 year in 10 earlier than	October 18	October 13	October 3	September 23	September 14
2 years in 10 earlier than	October 23	October 18	October 9	September 28	September 19
5 years in 10 earlier than	November 3	October 29	October 20	October 9	September 29

1866. The most common crop the first settlers produced was reported to be spring wheat, sown the year following breaking of the prairie sod. Corn became the most extensively raised crop by the 1920's, followed by oats, alfalfa and hay crops, barley, and wheat. In 1971 corn was the dominant crop, followed by soybeans, oats, and alfalfa and legume-grass hay crops.

The dominant trend in soil use since the prairie sod was plowed has been a progressive increase in acreage used for row crops. Accompanying this trend has been a progressive increase in farm size. The number of farm families is expected to continue to decline in the near future. The continued increase in row crop acreage can be detrimental to long-term soil productivity unless it is accompanied by management practices that minimize erosion and compaction of the soil. One of these practices, reduced tillage systems, is encouraged by increases in farm size.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (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 moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

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

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pres-

sure 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; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, 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 classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

First bottom. The normal flood plain of a stream, subject to frequent flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil having one or more neutral gray horizons as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

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 a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded 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 of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to

2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Profile, soil. A vertical section of the soil extending through all its horizons and 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 described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. As a soil separate, individual rock or mineral fragments from 0.5 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a 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 soil 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 C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. 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 grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

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

Substratum. The part of the soil below the solum.

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 can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

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, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For complete information about a mapping unit, read both the description of the mapping unit and that of the soil series to which it belongs. The capability classification system is explained and general management of the soils is discussed in the section "Crops and Pasture." Environmental planting groups are defined and discussed in the section "Environmental Plantings."

Map symbol	Mapping unit	Page	Capability unit		Environmental planting group	
			Symbol	Page		Page
26	Kennebec silty clay loam, 0 to 2 percent slopes	28	I-1	46	1	50
26B	Kennebec silty clay loam, 2 to 5 percent slopes	28	IIe-1	47	1	50
27B	Terril loam, 2 to 5 percent slopes	41	IIe-1	47	1	50
27C	Terril loam, 5 to 9 percent slopes	42	IIIe-1	48	1	50
27D	Terril loam, 9 to 14 percent slopes	42	IIIe-1	48	1	50
28B	Dickman fine sandy loam, 2 to 5 percent slopes	22	IIs-2	48	4	52
28C2	Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded	22	IIIe-2	48	4	52
28D2	Dickman fine sandy loam, 9 to 14 percent slopes, moderately eroded	22	IVe-2	49	4	52
31	Afton silty clay loam, 0 to 2 percent slopes	13	IIw-2	47	2	50
32	Spicer silty clay loam, 0 to 2 percent slopes	39	IIw-2	47	2	50
33C	Steinauer clay loam, 5 to 9 percent slopes	40	IIIe-4	49	3	50
33D	Steinauer clay loam, 9 to 14 percent slopes	40	IVe-1	49	3	50
33E	Steinauer clay loam, 14 to 18 percent slopes	40	IVe-1	49	3	50
33F	Steinauer clay loam, 18 to 25 percent slopes	41	VIe-1	50	3	50
33G	Steinauer clay loam, 25 to 40 percent slopes	41	VIIe-1	50	3	50
54	Zook silty clay loam, 0 to 2 percent slopes	44	IIw-1	47	2	50
64	Benclare silty clay loam, 0 to 2 percent slopes	14	IIw-1	47	1	50
72	Estherville loam, 0 to 2 percent slopes	24	IIs-1	48	4	52
73F	Salida sandy loam, 18 to 40 percent slopes	37	VIIe-1	50	4	52
77B	Sac silty clay loam, 2 to 5 percent slopes	37	IIe-3	47	1	50
77B2	Sac silty clay loam, 2 to 5 percent slopes, moderately eroded	37	IIe-3	47	1	50
77C2	Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	37	IIIe-3	48	1	50
77D2	Sac silty clay loam, 9 to 14 percent slopes, moderately eroded	37	IIIe-4	49	1	50
91	Primghar silty clay loam, 0 to 2 percent slopes	35	I-3	46	1	50
91B	Primghar silty clay loam, 2 to 5 percent slopes	35	IIe-1	47	1	50
92	Marcus silty clay loam, 0 to 2 percent slopes	29	IIw-2	47	2	50
133	Colo silty clay loam, 0 to 2 percent slopes	17	IIw-1	47	2	50
174	Bolan loam, 0 to 2 percent slopes	15	IIs-1	48	1	50
174B	Bolan loam, 2 to 5 percent slopes	15	IIe-3	47	1	50
174C2	Bolan loam, 5 to 9 percent slopes, moderately eroded	15	IIIe-2	48	1	50
174D2	Bolan loam, 9 to 14 percent slopes, moderately eroded	16	IVe-1	49	1	50
189	Omadi silt loam, occasionally flooded, 0 to 2 percent slopes	34	IIw-1	47	3	50
203	Cylinder silty clay loam, deep, 0 to 2 percent slopes	19	I-2	46	1	50
259	Biscay clay loam, deep, 0 to 2 percent slopes	15	IIw-3	47	2	50
310	Galva silty clay loam, 0 to 2 percent slopes	27	I-3	46	1	50
310B	Galva silty clay loam, 2 to 5 percent slopes	27	IIe-3	47	1	50
310B2	Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	27	IIe-3	47	1	50
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	27	IIIe-3	48	1	50
311	Galva silty clay loam, stratified substratum, 0 to 2 percent slopes	27	I-3	46	1	50
311B	Galva silty clay loam, stratified substratum, 2 to 5 percent slopes	27	IIe-3	47	1	50
315	Alluvial land	13	Vw-1	49	4	52
401C	Crofton silt loam, 5 to 9 percent slopes	18	IIIe-3	48	3	50
401D	Crofton silt loam, 9 to 14 percent slopes	18	IIIe-4	49	3	50

Map symbol	Mapping unit	Page	Capability unit		Environmental planting group	
			Symbol	Page		Page
401D3	Crofton silt loam, 9 to 14 percent slopes, severely eroded	18	IIIe-4	49	3	50
401E3	Crofton silt loam, 14 to 20 percent slopes, severely eroded	18	IVe-1	49	3	50
410	Moody silty clay loam, 0 to 2 percent slopes	31	I-3	46	1	50
410B	Moody silty clay loam, 2 to 5 percent slopes	31	IIe-3	47	1	50
410B2	Moody silty clay loam, 2 to 5 percent slopes, moderately eroded	31	IIe-3	47	1	50
410C2	Moody silty clay loam, 5 to 9 percent slopes, moderately eroded	31	IIIe-3	48	1	50
410D2	Moody silty clay loam, 9 to 14 percent slopes, moderately eroded	32	IIIe-4	49	1	50
T410	Moody silty clay loam, benches, 0 to 2 percent slopes	32	I-2	46	1	50
T410B	Moody silty clay loam, benches, 2 to 5 percent slopes	32	IIe-3	47	1	50
411B	Egan silty clay loam, 2 to 5 percent slopes	23	IIe-3	47	1	50
411B2	Egan silty clay loam, 2 to 5 percent slopes, moderately eroded	23	IIe-3	47	1	50
411C2	Egan silty clay loam, 5 to 9 percent slopes, moderately eroded	23	IIIe-3	48	1	50
411D2	Egan silty clay loam, 9 to 14 percent slopes, moderately eroded	23	IIIe-4	49	1	50
430	Ackmore silty clay loam, 1 to 3 percent slopes	11	IIw-2	47	3	50
458	Millington loam, somewhat poorly drained, 0 to 2 percent slopes	30	IIw-1	47	3	50
486	Davis loam, 0 to 2 percent slopes	20	IIw-1	47	1	50
501	Gravel pit	27	VIIs-1	50	4	52
505	Sperry silt loam, 0 to 1 percent slopes	38	IIIw-1	49	2	50
541C	Estherville-Salida complex, 5 to 9 percent slopes	25	IIIe-2	48	4	52
541D	Estherville-Salida complex, 9 to 14 percent slopes	25	IVe-2	49	4	52
577B	Everly clay loam, 2 to 5 percent slopes	26	IIe-3	47	1	50
608	Dempster silt loam, moderately deep, 0 to 2 percent slopes	21	IIs-1	48	1	50
608B	Dempster silt loam, moderately deep, 2 to 5 percent slopes	21	IIs-2	48	1	50
608C2	Dempster silt loam, moderately deep, 5 to 9 percent slopes, moderately eroded	21	IIIe-2	48	1	50
658	Mayer loam, 0 to 2 percent slopes	30	IIw-3	47	3	50
710	Wentworth silty clay loam, 0 to 2 percent slopes	43	I-2	46	1	50
710B	Wentworth silty clay loam, 2 to 5 percent slopes	44	IIe-3	47	1	50
710C2	Wentworth silty clay loam, 5 to 9 percent slopes, moderately eroded	44	IIIe-3	48	1	50
733	Calco silty clay loam, 0 to 2 percent slopes	16	IIw-1	47	2	50
785	Spillco loam, 0 to 2 percent slopes	40	IIw-1	47	1	50
791	Primghar silty clay loam, calcareous variant, 0 to 2 percent slopes	36	I-3	46	3	50
808	Dempster silt loam, deep, 0 to 2 percent slopes	20	I-2	46	1	50
808B	Dempster silt loam, deep, 2 to 5 percent slopes	20	IIe-2	47	1	50
878	Ocheyedan loam, 0 to 2 percent slopes	33	I-3	46	1	50
878B	Ocheyedan loam, 2 to 5 percent slopes	33	IIe-3	47	1	50
878B2	Ocheyedan loam, 2 to 5 percent slopes, moderately eroded	33	IIe-3	47	1	50
878C2	Ocheyedan loam, 5 to 9 percent slopes, moderately eroded	34	IIIe-3	48	1	50
878D2	Ocheyedan loam, 9 to 14 percent slopes, moderately eroded	34	IIIe-4	49	1	50
890B	Moody silty clay loam, loamy substratum, 2 to 5 percent slopes	32	IIe-3	47	1	50
890B2	Moody silty clay loam, loamy substratum, 2 to 5 percent slopes, moderately eroded	32	IIe-3	47	1	50
890C2	Moody silty clay loam, loamy substratum, 5 to 9 percent slopes, moderately eroded	32	IIIe-3	48	1	50

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Page	Capability unit		Environmental planting group	
			Symbol	Page		Page
899	Davis silt loam, 0 to 2 percent slopes----------	20	I-1	46	1	50
910	Trent silty clay loam, 0 to 2 percent slopes----------	42	I-3	46	1	50
910B	Trent silty clay loam, 2 to 5 percent slopes----------	43	IIe-1	47	1	50

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