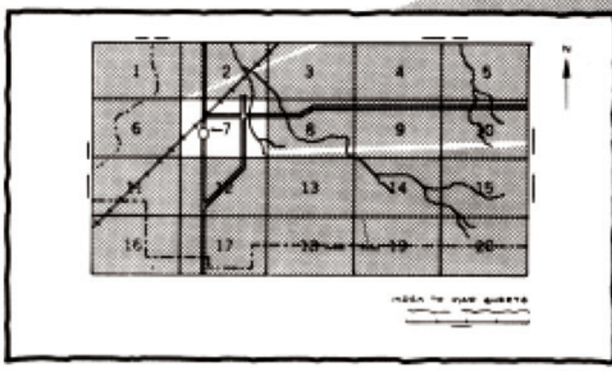
SOIL SURVEY OF

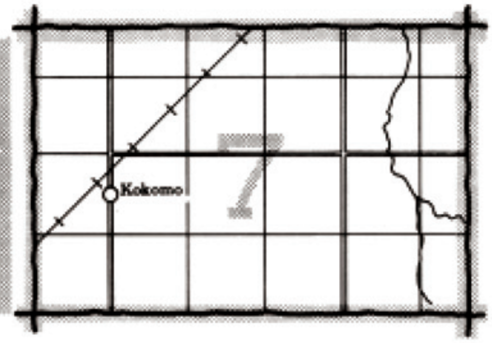
McClain County, Oklahoma

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

HOW TO USE

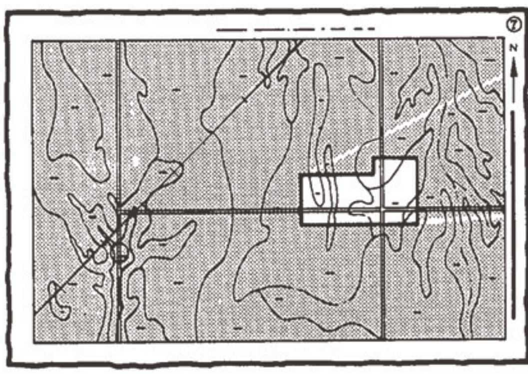
1. Locate your area of interest on the "Index to Map Sheets"

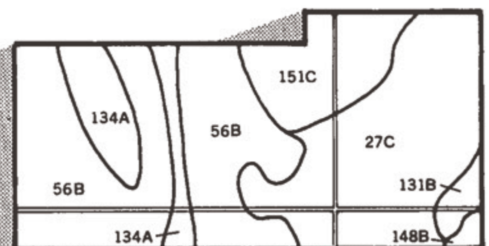




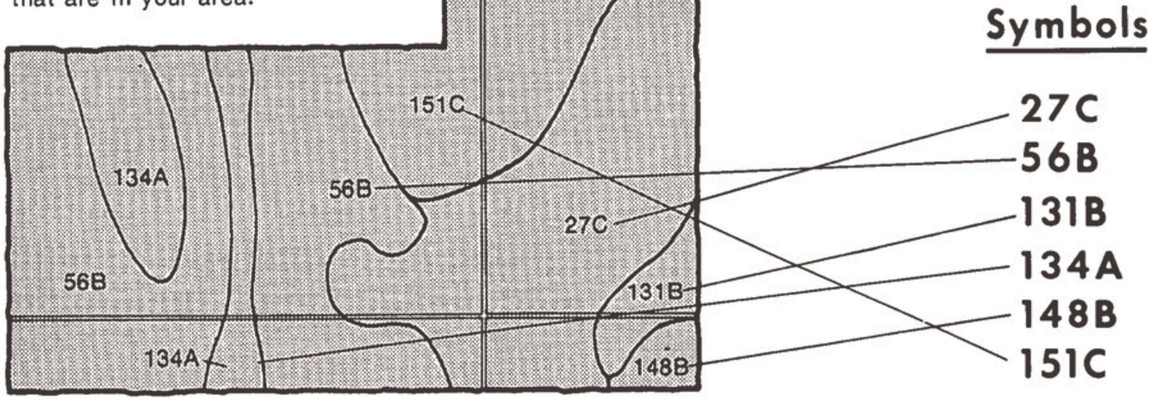
2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



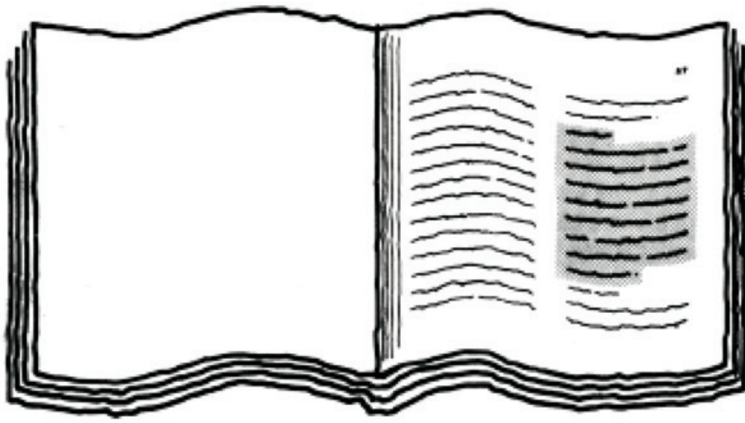


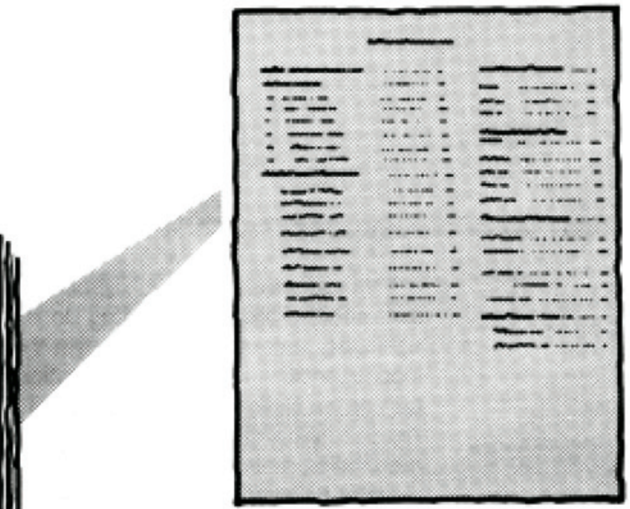
4. List the map unit symbols that are in your area.



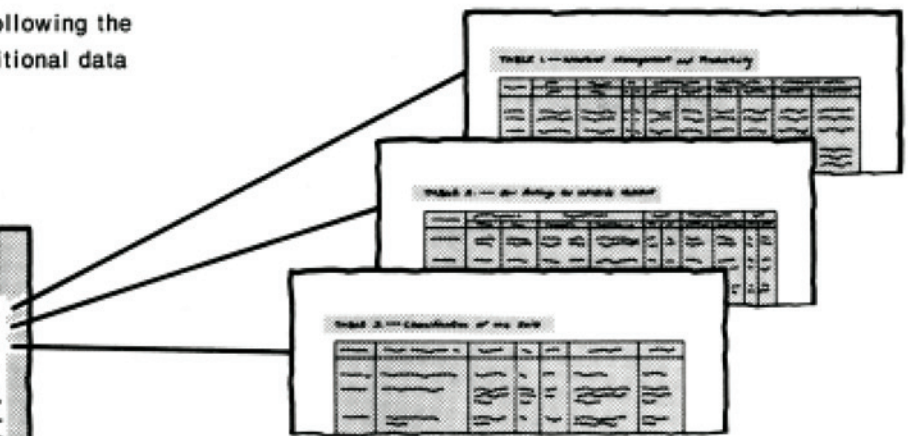
THIS SOIL SURVEY

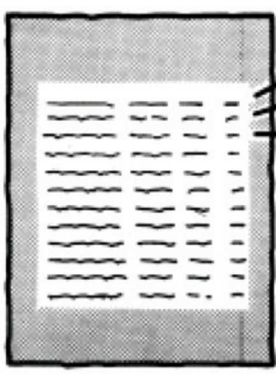
5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.





6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.





7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

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, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1961-76. Soil names and descriptions were approved in 1976. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1976. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station. It is part of the technical assistance furnished to the McClain County Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps can 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.

Contents

Issued April 1979

Index to Map Units

Summary of Tables

Summary of Tables—Continued

Foreword

The Soil Survey of McClain County, Oklahoma, contains much information useful in any land-planning program. Of prime importance are the predictions of soil behavior for selected land uses. Also highlighted are limitations or hazards to land uses that are inherent in the soil, improvements needed to overcome these limitations, and the impact that selected land uses will have on the environment.

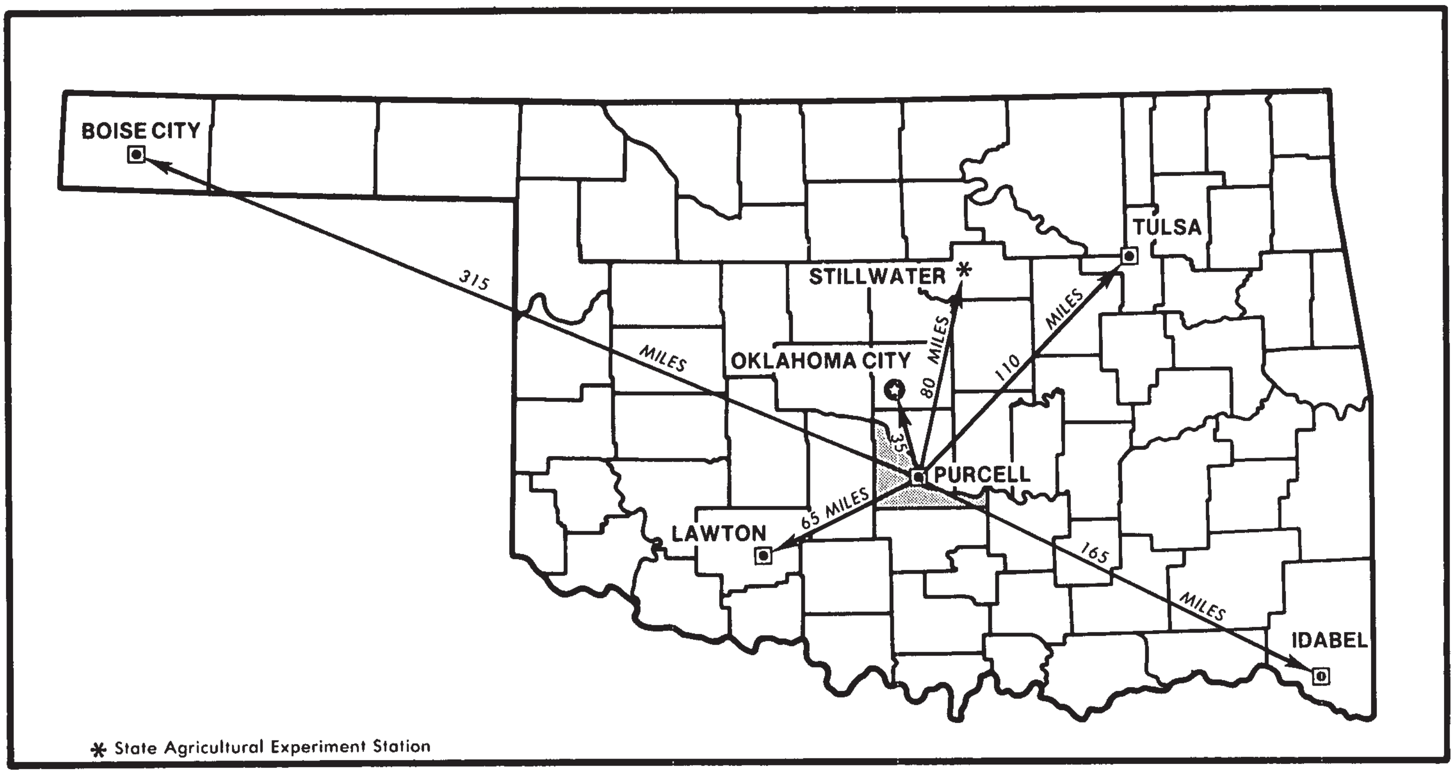
This soil survey has been prepared for many different users. Farmers, ranchers, foresters, and agronomists can use it to determine the potential of the soil and the management practices required for food and fiber production. Planners, community officials, engineers, developers; builders, and homebuyers can use it to plan land use, select sites for construction, develop soil resources, or identify any special practices that may be needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the soil survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur even within short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings or roads. Very clayey or wet soils are poorly suited to septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map; the location of each kind of soil is shown on detailed soil maps. Each kind of soil in the survey area is described, and much information is given about each soil for specific uses. Additional information or assistance in using this publication can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

This soil survey can be useful in the conservation, development, and productive use of soil, water, and other resources.

Roland R. Willis
State Conservationist
Soil Conservation Service



Location of McClain County in Oklahoma.

SOIL SURVEY OF McCLAIN COUNTY, OKLAHOMA

By Gordon E. Moebius and W. A. Sparwasser, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with Oklahoma Agricultural Experiment Station

McCLAIN COUNTY is in the south-central part of Oklahoma (see facing page). It has a total area of 366,720 acres, or 573 square miles. Purcell, the county seat, has a population of 4,076.

The county is in the central Rolling Red Prairies and Cross Timbers physiographic regions. Elevation is 1,102 feet in the north-central part at Purcell. The South Canadian River has cut a deep basin along the northern boundary. The western part of the county is a relatively high plateau dissected by numerous drainageways and streams. Several creeks have cut valleys that extend in a north-south direction through the center of the county. The eastern part of the county consists of intermingled areas of prairies and oak-savannahs on rolling uplands.

General nature of the county

This section gives general information concerning the county. It discusses natural resources; climate; farming; and physiography, drainage, and relief.

Natural resources

Soil is the most important natural resource in the county. Livestock that graze the grassland and crops produced on farms are marketable products that are derived from the soil.

In most of the county, the water supply is adequate for domestic use and watering livestock. Underground deposits of sand, gravel, and sandstone are important water-bearing sources for wells. Underground water has been found in sufficient volume for irrigation in the alluvial deposits adjacent to the South Canadian River.

The largest deposits of sand, gravel, and soil material used for construction are east of Newcastle in the northwestern part of the county. Other areas that have similar potential are not developed. Producing oil and gas wells are in the southwestern part of the county.

Climate

Prepared at the National Climatic Center, Ashville, North Carolina.

McClain County is hot in summer. It is cool in winter if an occasional surge of cold air causes a sharp drop in the otherwise mild temperatures. Rainfall is uniformly distributed throughout the year, reaching a slight peak in spring. Snowfall is infrequent. Total annual precipitation is normally adequate for growing cotton, feed grains, and small grains.

Table 1 gives data on temperature and precipitation for the survey area, as recorded at Purcell, Oklahoma, for the period 1951-74. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 40 degrees F, and the average daily minimum temperature is 28 degrees. The lowest temperature on record, which occurred at Purcell on January 11, 1962, is -4 degrees. In summer the average temperature is 81 degrees, and the average daily maximum temperature is 93 degrees. The highest recorded temperature, or 110 degrees, occurred on August 16, 1956.

Growing degree days, shown in table 1, are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

Of the total annual precipitation, 22 inches, or 65 percent, generally falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 5.73 inches at Purcell on June 3, 1971. Thunderstorms occur on about 51 days each year, and most are in summer.

Average seasonal snowfall is 6 inches. The greatest snow depth at any one time during the period of record was 8 inches. On the average, 3 days have at least 1 inch of snow on the ground, but the number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 55 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The percentage of possible sunshine is 75 in summer and 60 in winter. The prevailing wind is from the north-northwest. Average windspeed is highest, 15 miles per hour, in March.

Tornadoes and severe thunderstorms occur occasionally. These storms are local and of short duration. Damage is variable and spotty.

Farming

The first settlers in McClain County were mainly cattle ranchers, but when the land was opened to homesteaders, farming became important. Winter wheat, small grains, corn, and cotton were grown to help meet the need for food and fiber during the First World War.

Farmers were unfamiliar with the climate at this time. Only small amounts of crop residue were left on the soil, grassland was overgrazed, and erosion severely damaged many soils. Many fields were abandoned as a result. The depression and the Dust Bowl of the 1930's forced many farmers to leave their farms.

The enactment of Soil Conservation District legislation in 1937 interested many landowners in McClain County. The McClain County Conservation District, originally named the Canadian-Walnut Conservation District, was organized July 7, 1938.

Farmers and ranchers in the district began to protect the soil. Water erosion, soil blowing, overgrazing of grassland, shortage of livestock watering places, and invasion by brush and noxious weeds were concerns of management.

A succession of dry years in the 1950's again forced many farmers to sell their farms. Many acres of cropland were reseeded to grass or remained idle.

About 60,000 acres of the county are cropland, and about 60,000 acres have been established to pasture. Rangeland or abandoned cropland that is used for grazing makes up about 40 percent of the county.

The capability of the soils, the climate limitations, and the present economic conditions in McClain County indicate that the farming economy may continue to be based largely on the grazing of livestock and the production of small grains. Increasing urban demand for land in the northern part of the county could alter agricultural trends.

Physiography, drainage, and relief

McClain County is made up of about 14 percent flood plains and 86 percent uplands. About 15 percent of the uplands was originally oak-savannahs. The remaining part was grasslands. The native vegetation on the flood plains varied from grasslands to woodland. Most formerly wooded areas have been cleared and farmed.

The surface drainage of the county is divided into two separate drainage basins. The northern part of the county, about 57 percent, drains directly into the South Canadian River that forms the northern border of McClain County. The southern part of the county, about 43 percent, is drained by about twelve creeks that enter the Washita River to the south of McClain County. In this part, about 86 flood prevention structures have been installed.

Slopes in the county range from nearly level to moderately steep and have gradients of 0 to 20 percent. About 30 percent of the county has slopes of less than 3 percent; about 50 percent, slopes of 3 to 8 percent; and about 20 percent, slopes of 8 to 20 percent.

Along most of the northern border of the county are areas of smooth nearly level to gently sloping soils on high terraces and nearly level soils on flood plains. Most of these areas were originally native grasslands. They range from 1/4 mile to 5 miles wide and are parallel to the South Canadian River.

West of Purcell are mostly rolling sandstone ridges dissected by narrow drainageways. These mostly gently sloping to strongly sloping soils are on prairies, but the extreme western part is oak-savannah.

How this survey was made

Soil scientists made this survey to learn what kinds of soil are in the survey area, where they are, and how they can be used. The soil scientists went into the area knowing they likely would locate many soils they already knew something about and perhaps identify some they had never seen before. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; 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, which has been changed very little by leaching or by the action of plant roots.

The soil scientists recorded the characteristics of the profiles they studied, and they compared those profiles with others in counties nearby and in places more distant. Thus, through correlation, they classified and named the soils according to nationwide, uniform procedures.

After a guide for classifying and naming the soils was worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, roads, 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 soil map units. Some map units are made up of one kind of soil, others are made up of two or more kinds of soil, and a few have little or no soil material at all. Map units are discussed in the sections "General soil map for broad land use planning" and "Soil maps for detailed planning."

While a soil survey is in progress, samples of soils are taken as needed for laboratory measurements and for engineering tests. The soils are field tested, and interpretations of their behavior are modified as necessary during the course of the survey. New interpretations are added to meet local needs, mainly through field observations of different kinds of soil in different uses under different levels of management. Also, data are assembled from other sources, such as test results, records, field experience, and information available from state and local specialists. For example, data on crop yields under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it is readily available to different groups of users, among them farmers, managers of rangeland and woodland, engineers, planners, developers and builders, homebuyers, and those seeking recreation.

General soil map for broad land use planning

The general soil map at the back of this publication shows, in color, map units that have a distinct pattern of soils and of relief and drainage. Each map unit is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map provides a broad perspective of the soils and landscapes in the survey area. It provides a basis for comparing the potential of large areas for general kinds of land use. Areas that are, for the most part, suited to certain kinds of farming or to other land uses can be identified on the map. Likewise, areas of soils having properties that are distinctly unfavorable for certain land uses can be located.

Because of its small scale, the map does not show the kind of soil at a specific site. Thus, it is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The kinds of soil in any one map unit differ from place to place in slope, depth, stoniness, drainage, or other characteristics that affect their management.

Each map unit is rated for *cultivated farm crops* and *urban uses*. Cultivated farm crops are those grown extensively by farmers in the survey area. Urban uses include residential, commercial, and industrial developments.

Descriptions of map units

1. Gracemore-Gaddy-Gracemont

Deep, nearly level to undulating, somewhat poorly drained and somewhat excessively drained soils that have a loamy surface layer and are underlain by sandy or loamy material; formed in sandy or loamy sediment on flood plains

Areas of these nearly level to undulating soils are adjacent to the South Canadian River along the northern border of the county. These low lying areas are mostly recent alluvial deposits that have scattered low mounds worked by the wind.

This map unit occupies about 3 percent of the county. It is about 68 percent Gracemore soils, 18 percent Gaddy soils, 12 percent Gracemont soils, and 2 percent soils of minor extent.

Gracemore soils in most places are at lower elevation than Gaddy or Gracemont soils. Gaddy soils are at the highest elevation. Gracemore and Gracemont soils are somewhat poorly drained and have a seasonal high water table. Gaddy soils are somewhat excessively drained. Gracemont soils are loamy throughout. Gracemore and Gaddy soils have a loamy surface layer and are underlain by sandy stratified material.

Minor in this map unit are areas of Asher soils, Pits, and some water areas.

This map unit is used mainly for pasture, but some acreage is used for cultivated crops. Some areas are wooded and have an understory of native grasses. On Gracemont and Gracemore soils wetness is the main limitation for farming and most other uses. Occasional flooding is a hazard in the spring or the fall. Because Gaddy soils are intermingled with areas of Gracemore soils, the value of Gaddy soils for farming is reduced. Gaddy soils are low in fertility and droughty in the summer months.

This map unit has poor potential for cultivated crops. Wetness is difficult to overcome, and occasional flooding can severely damage drainage systems. Gaddy soils generally require smoothing or land leveling before tillage operations begin, and low available moisture reduces most crop growth.

The potential for residential and other urban uses is poor. The hazards of flooding and wetness are difficult to overcome. Seepage is a hazard on Gaddy soils.

2. Miller-Keokuk-Canadian

Deep, nearly level, moderately well drained and well drained soils that are loamy or clayey throughout; formed in loamy or clayey sediment on flood plains

Areas of these nearly level soils are mainly on the high flood plains of the South Canadian River along the northern border of the county.

This map unit occupies about 3 percent of the county. It is about 25 percent Miller soils, 24 percent Keokuk soils, 11 percent Canadian soils, and 40 percent soils of minor extent.

Miller soils are generally on the highest elevation and on the outer fringes of the flood plain. They are moderately well drained, and are clayey throughout. Canadian and Keokuk soils are about the same elevation as Miller soils, but are slightly closer to the river channel. They are well drained, and are loamy throughout.

Minor in this map unit are the somewhat poorly drained Lela soils, the moderately well drained Asher soils, and areas of the well drained Port and Pulaski soils.

This map unit is used mainly for cultivated crops, but some acreage is used for pasture. Principal crops are alfalfa, soybeans, grain or forage sorghum, and wheat. Some parts of the Miller soils need surface drainage in the spring to remove excess accumulation of surface water.

This map unit has good potential for cultivated farm crops. It has poor potential for residential and other urban uses because of the hazard of flooding. The Miller part of this map unit has high shrink-swell potential and seasonal surface wetness.

3. Grant-Minco-Pond Creek

Deep, nearly level to strongly sloping, well drained soils that are loamy throughout; formed in residuum, loess, alluvium, or a combination of these on uplands

Areas of these nearly level to strongly sloping soils are mainly along the northern border of the county, and in the southwestern part of the county near the southern border. The areas are on high terraces along the major streams.

This map unit occupies about 18 percent of the county. It is about 42 percent Grant soils, 24 percent Minco soils, 16 percent Pond Creek soils, and 18 percent minor soils.

Grant soils in most places are at a slightly higher elevation than Minco or Pond Creek soils. They are in breaks and drainageways and on side slopes at lower elevations. Slopes range from gently sloping to sloping. The nearly level Minco soils are on broad smooth terraces and the strongly sloping Minco soils are on hillsides. The nearly level to very gently sloping Pond Creek soils are in broad areas in slightly concave position.

Minor in this map unit are the well drained Teller and Bethany soils.

This map unit is used mainly for cropland, but large acreages of pasture are grown on the more sloping areas. Most of the acreage has good potential for farming, but the very gently sloping to strongly sloping soils are subject to water erosion if cultivated crops are grown. Returning crop residue to the soil and terracing help prevent excessive erosion. The potential for residential and other urban uses is good.

4. Nash-Lucien-Grant

Deep to shallow, gently sloping to moderately steep, well drained soils that are loamy throughout; formed in residuum from sandstone on uplands

Areas of these soils are scattered throughout the western part of the county. These soils are mainly on sandstone ridges that have narrow crests and long, sloping to moderately steep hillsides.

This map unit occupies about 25 percent of the county. It is about 62 percent Nash and Lucien soils. The Nash soils make up about 34 percent of the map unit, and Lucien soils make up about 28 percent. About 8 percent of the map unit is Grant soils, and the remaining 30 percent is minor soils.

Nash soils are moderately deep, and Lucien soils are shallow. The gently sloping Nash and Lucien soils are on ridge crests and the sloping to moderately steep soils are on hillsides. Grant soils are deep, sloping, and commonly on foot slopes.

Minor in this map unit are areas of the well drained Pulaski and Port soils along narrow drainageways.

This map unit is used for tame and native pasture. The strongly sloping and shallow areas are limited for farming.

This map unit has fair potential for tame pasture grasses. It has fair potential for residential or other urban uses. Slopes in excess of 8 percent, and bedrock at a depth of less than 40 inches limit the development of some facilities.

5. Stephenville

Moderately deep, very gently sloping to sloping, well drained soils that are loamy throughout; formed in residuum from sandstone on uplands

Areas of these soils are scattered throughout the county, the largest of which are in the western part. These moderately sloping to sloping soils are mainly smooth rounded ridge crests and hillsides.

This map unit occupies about 13 percent of the county. It is about 95 percent Stephenville soils and 5 percent soils of minor extent.

Stephenville soils are mainly very gently sloping to moderately sloping on ridge crests and the upper parts of hillsides. They are commonly moderately sloping or sloping on the lower parts. About 25 percent of the Stephenville soils are severely gullied.

Minor in this map unit are some areas of Grant soils and the Nash-Lucien complex on uplands, and Pulaski soils along narrow drainageways.

This map unit is used mainly for pasture, but some acreage is used for cultivated crops. Most of the acreage has been cleared. The hazard of erosion is the main limitation for farming. Natural fertility is low.

This map unit has good potential for cultivated crops if protection from erosion is adequate. It has good potential for tame pasture grasses if adequate management practices are followed.

The potential for urban use is fair. Depth to rock can be a limitation in developing some facilities.

6. Port-Pulaski-Keokuk

Deep, nearly level, well drained soils that are loamy throughout; formed in loamy sediment on flood plains

Areas of these nearly level soils are scattered throughout the county. These soils formed in alluvial sediment on low flood plains of local streams and along drainageways.

This map unit occupies about 11 percent of the county. It is about 48 percent Port soils, 21 percent Pulaski soils, 20 percent Keokuk soils, and 11 percent soils of minor extent.

Port soils in most places are in the flood plains in areas that drain large acreages of prairie. Pulaski and Keokuk soils are commonly in those areas that drain soils that have mixed forest and prairie vegetation. Port and Pulaski soils are occasionally flooded to frequently flooded, and Keokuk soil is occasionally flooded. Port and Keokuk soils have a silt loam surface layer, and Pulaski soil has a fine sandy loam surface layer.

Minor in this map unit are the well drained Asa soils, and areas of the somewhat poorly drained Gracemont soils.

This map unit is used mainly for cultivated crops, but large acreages are used for pasture. Occasional flooding is the main limitation for farming and for most other uses. Partial flood control measures have been installed in some of the streams.

This map unit has good potential for cultivated crops and for pasture. The potential for urban or residential use is poor. It is limited mainly by the hazard of flooding.

7. Grant-Renfrow-Grainola

Deep and moderately deep, very gently sloping to strongly sloping, well drained soils that have a loamy surface layer and a loamy or clayey subsoil; formed in residuum from sandstone, clay, or shale, on uplands

Areas of these soils are scattered throughout the central and eastern parts of the county. These smooth rolling soils are on plains and along breaks into drainageways. These soils formed in residuum from sandstone, clay beds, or soft shales.

This map unit makes up about 25 percent of the county. It is about 43 percent Grant soils, 17 percent Renfrow soils, 9 percent Grainola soils, and 31 percent soils of minor extent.

Grant soils are very gently sloping to strongly sloping soils that are loamy throughout, and formed in sandstone. Renfrow soils are deep, very gently sloping to gently sloping soils that have a loamy surface layer and a clay subsoil underlain by clay or soft shale. Grainola soils are moderately deep, gently sloping to strongly sloping soils that have a loamy surface layer and a clay subsoil underlain by soft shale.

Minor in this map unit are the well drained Clarita, Tamford, and Kirkland soils on uplands, and some areas of Port soils along narrow drainageways.

This map unit is used mainly for pasture, but large acreages are used for cultivated crops. The main limitation for farming is the hazard of erosion.

Most of this map unit has good potential for cultivated crops. Some strongly sloping and severely eroded soils, however, generally are not suited to cultivated crops. This unit has fair potential for urban or residential uses. Renfrow and Grainola soils have high shrink-swell potential.

8. Konawa

Deep, nearly level to sloping, well drained soils that have a sandy surface layer and a loamy subsoil; formed in sandy and loamy sediment on uplands

Areas of these soils are mostly in the eastern part of the county. These soils are on smooth terraces dissected by drainageways.

This map unit occupies about 2 percent of the county. It is about 95 percent Konawa soils and 5 percent soils of minor extent.

The nearly level to very gently sloping Konawa soils are on smooth broad terraces. The gently sloping to sloping Konawa soils are on hillsides above drainageways.

Minor in this map unit are areas of moderately deep, well drained Stephenville soils. The well drained Pulaski soils are along narrow drainageways.

This map unit is used mainly for pasture, but moderate acreages are used for cultivated crops. Most of the acreage has been cleared. Scattered areas are severely gullied and are not suited to farming. The hazard of erosion and low fertility are the main limitations to farming.

This map unit, if adequately fertilized and protected from erosion, has good potential for cultivated crops. It has good potential for urban residential uses.

Broad land use considerations

Each year a considerable amount of land is developed for urban uses in Purcell, Blanchard, Newcastle, and other cities in the county. About 16,000 acres is urban or built-up land. The general soil map is most helpful for planning the general outline of urban areas; it cannot be used for the selection of sites for specific urban structures. Generally the soils in the survey area that have good potential for cultivated crops also have good potential for urban development. The data about specific soils in this survey can be helpful in planning future land use patterns.

Areas where the soils are so unfavorable that urban development is prohibitive are not extensive in the survey area, but the Gracemore-Gaddy-Gracemont, Miller-Keokuk-Canadian, and Port-Pulaski-Keokuk map units are on flood plains. Flooding and wetness are severe limitations on these soils. Many parts of the Nash-Lucien-Grant map unit have strongly sloping soils that have bedrock only a few feet below the surface. Urban development is costly on these soils. The clayey soils of the Grant-

Renfrow-Grainola map unit have fair potential for urban development because of high shrink-swell potential.

In large areas of the county are soils that can be developed for urban uses at lower cost than can the soils named above. These include the Grant-Minco-Pond Creek, Stephenville, the Grant part of Grant-Renfrow-Grainola, and the Konawa map units. The Grant-Minco-Pond Creek map unit is excellent farmland. This potential should not be overlooked when broad land uses are considered. The Stephenville map unit is underlain by bedrock at a depth of less than 40 inches, but the rolling landscape, good soil drainage, and other soil qualities are favorable for residential and other nonfarm uses.

Map units 2 and 6 on the general soil map have good potential for farming but fair or poor potential for nonfarm uses. The dominant soils are the Miller, Keokuk, Canadian, Port, and Pulaski soils. Flooding is a limitation that is extremely difficult to overcome.

Vegetables, orchards, nurseries, and other specialty crops are suited to soils of the Grant-Minco-Pond Creek map unit and the Konawa map unit. These soils are well drained and warm up earlier in spring than the heavier, wetter soils.

Most of the soils of the county have poor potential for woodland. Trees either do not grow naturally or produce poor wood crops. Commercially valuable trees grow on soils of the Gracemore-Gaddy-Gracemont, the Miller-Keokuk-Canadian, and the Port-Pulaski-Keokuk map units.

The map units on the uplands have good potential as sites for parks and extensive recreation areas. Blackjack and post oak forests enhance the beauty of some of the units. Undrained areas of marshes and lakes of the Gracemore-Gaddy-Gracemont map unit are suitable for nature study. All of the map units provide habitat for many important species of wildlife.

Soil maps for detailed planning

The map units shown on the detailed soil maps at the back of this publication represent the kinds of soil in the survey area. They are described in this section. The descriptions together with the soil maps can be useful in determining the potential of a soil and in managing it for food and fiber production; in planning land use and developing soil resources; and in enhancing, protecting, and preserving the environment. More information for each map unit, or soil, is given in the section "Use and management of the soils."

Preceding the name of each map unit is the symbol that identifies the soil on the detailed soil maps. Each soil description includes general facts about the soil and a brief description of the soil profile. In each description, the principal hazards and limitations are indicated, and the management concerns and practices needed are discussed.

The map units on the detailed soil maps represent an area on the landscape made up mostly of the soil or soils for which the unit is named. Most of the delineations shown on the detailed soil map are phases of soil series.

Soils that have a profile that is almost alike make up a *soil series*. Except for allowable differences in texture of the surface layer or of the underlying substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement in the profile. A soil series commonly is named for a town or geographic feature near the place where a soil of that series was first observed and mapped. The Bethany and Minco series, for example, were named for towns.

Soils of one series can differ in texture of the surface layer or in the underlying substratum and in slope, erosion, stoniness, salinity, wetness, or other characteristics that affect their use. On the basis of such differences, a soil series is divided into phases. The name of a *soil phase* commonly indicates a feature that affects use or management. For example, Minco silt loam, 0 to 1 percent slopes, is one of several phases within the Minco series.

Some map units are made up of two or more dominant kinds of soil. Two such map units are in this county; soil complexes and undifferentiated groups.

A *soil complex* consists of areas of two or more soils that are so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area includes some of each of the two or more dominant soils, and the pattern and proportion are somewhat similar in all areas. Nash-Lucien complex is an example.

An *undifferentiated group* is made up of two or more soils that could be mapped individually but are mapped as one unit because there is little value in separating them. The pattern and proportion of the soils are not uniform. An area shown on the map has at least one of the dominant (named) soils or may have all of them. Pulaski and Port soils is an undifferentiated group in this survey area.

Most mapped areas include places that have little or no soil material and support little or no vegetation. Such places are called *miscellaneous areas*; they are delineated on the soil map and given descriptive names. Pits is an example. Some of these areas are too small to be delineated and are identified by a special symbol on the soil map.

The acreage and proportionate extent of each map unit are given in table 4, and additional information on properties, limitations, capabilities, and potentials for many soil uses is given for each kind of soil in other tables in this survey. (See "Summary of tables.") Many of the terms used in describing soils are defined in the Glossary.

Soil descriptions and potentials

1—Asa loam, overwash. This deep, well drained, nearly level soil is on flood plains. Slopes are smooth to very slightly concave. Individual areas vary from 10 acres to several hundred acres in size. Soils generally occupy elongated areas parallel to streams and are occasionally inundated for brief periods.

Typically, the surface layer is light reddish brown loam about 8 inches thick. It formed in recent sediment on the original surface layer. Below is reddish brown silty clay loam 14 inches thick. The weakly developed subsoil is reddish brown silty clay loam to a depth of 43 inches. The underlying material is reddish yellow stratified loamy or silty alluvium that extends to a depth of more than 60 inches.

Permeability is moderate. The available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. It is neutral or alkaline in the surface layer. This soil has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Asher, Port, Pulaski, and Keokuk soils. The included soils make up about 10 to 20 percent of this map unit.

This soil has good potential for row crops, sown crops, and tame pasture. Good tilth is maintained by returning crop residue to the soil, and timing tillage operations to proper soil moisture condition.

This soil has poor potential for most urban uses. The occasional hazard of flooding and low bearing strength are limitations. The flood hazard is difficult to overcome in most areas. Capability subclass IIw; Loamy Bottomland range site.

2—**Asher silty clay loam.** This deep, moderately well drained, nearly level soil is on flood plains of the South Canadian River. Slopes are smooth to slightly concave. Individual areas are 10 to 200 acres in size. This soil is rarely inundated for very brief periods.

Typically, the surface layer is brown silty clay loam about 11 inches thick. The subsoil is reddish brown silty clay loam to a depth of about 27 inches. The underlying material is light brown and pink loam and very fine sandy loam that extends to a depth of 60 inches or more.

Permeability is slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is moderately alkaline and calcareous throughout. It has fair tilth but has a narrow range of moisture conditions when tillage is optimum. The root zone is deep, and most plant roots penetrate the soil without difficulty.

Included with this soil in mapping are soils that have a seasonal high water table but otherwise are similar. Miller and Keokuk soils are included in some areas. These included soils make up 5 to 15 percent of the map unit.

This soil has good potential for row crops, small grains, and hay or pasture. Good tilth is maintained by proper timing of tillage, minimum tillage, and returning crop residue to the soil. The hazard of erosion is slight. Surface wetness is commonly a problem during rainy seasons.

This soil has poor potential for most urban uses. The rare hazard of flooding, surface wetness, low bearing strength, and slow percolation rate are limitations to urban development. Protecting this soil from flooding is very difficult. Capability subclass IIw, Loamy Bottomland range site.

3—**Bethany silt loam, 0 to 1 percent slopes.** This deep, well drained, nearly level soil is on uplands. Slopes are smooth. Individual areas are 10 to 500 acres in size.

Typically, the surface layer is brown silt loam about 15 inches thick. The upper part of the subsoil is brown silty clay loam to a depth of 24 inches, the next part is brown silty clay to a depth of 35 inches, and the lower part is mottled brown and reddish brown silty clay to a depth of 72 inches. The underlying material is red massive silty clay loam.

Permeability is slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. It has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and plant roots penetrate the soil easily.

Included with this soil in mapping are areas of Pond Creek, Pawhuska, and Kirkland soils. These included soils make up 10 percent of the map unit, but individual areas are smaller than 5 acres in size.

This soil has good potential for row crops, small grains, and hay or pasture. Tilth is maintained by returning crop residues to the soil, by performing tillage operations when the surface layer has moderate levels of moisture, and by using minimum tillage. If soil tilth is allowed to deteriorate, surface crusting is a hazard (fig. 1). Erosion is generally not a hazard, but terraces are sometimes needed to remove excess runoff safely.

This soil has fair potential for most urban uses. The high shrink-swell potential, slow percolation rate, and low strength are limitations that need to be overcome. Careful installation procedures can prevent these limitations from causing development problems. Capability class I; Loamy Prairie range site.

4—**Bethany silt loam, 1 to 3 percent slopes.** This deep, well drained, very gently sloping soil is on uplands. Slopes are smooth. Individual areas are 5 to 300 acres in size.

Typically, the surface layer is brown silt loam about 17 inches thick. The upper part of the subsoil is brown silty clay loam to a depth of 42 inches, mottled with strong brown, and yellowish brown; the lower part is pale brown, light brown, and reddish brown silty clay loam to a depth of 70 inches, mottled with strong brown, grayish brown, and yellowish red. Below is massive yellowish red silty clay loam.

Permeability is slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. It has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and plant roots penetrate the soil easily.

Included with this soil in mapping are about 15 percent Pond Creek soils on small, scattered convex areas and about 3 percent Pawhuska soils.

This soil has good potential for row crops, small grains, and hay or pasture. Tilth is maintained by returning crop residue to the soil, by performing tillage operations when the plow layer has moderate moisture levels, and by using minimum tillage methods. Erosion is a slight hazard, and terrace systems help to control excessive erosion in most cropping systems.

This soil has fair potential for most urban uses. The high shrink-swell potential, slow percolation rate, and low bearing strength are limitations that need to be overcome for some urban facilities. Careful design and installation of facilities can prevent these soil limitations from causing serious problems. Capability subclass IIe; Loamy Prairie range site.

5—Bethany-Pawhuska complex, 0 to 2 percent slopes. This complex consists of small areas of Bethany and Pawhuska soils so intermingled that they could not be separated at the scale selected for mapping. It occurs as broad irregularly shaped areas of 10 to 200 acres on uplands. Individual areas of each soil are 1/4 to 6 acres in size.

Bethany silt loam makes up 55 percent of the mapped area. Typically, the surface layer is grayish brown silt loam about 12 inches thick. The upper part of the subsoil is dark grayish brown silty clay loam to a depth of 18 inches, the next part is grayish brown and brown silty clay to a depth of 49 inches, and the lower part is brown clay loam to a depth of 64 inches. The underlying material is reddish yellow clay loam.

Permeability is slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer.

Pawhuska silt loam makes up about 30 percent of the mapped area. Typically, the surface layer is grayish brown silt loam about 8 inches thick. The upper part of the subsoil is gray silty clay to a depth of 27 inches. It is high in sodium content. The middle part is grayish brown and brown silty clay loam to a depth of about 51 inches. The lower part is mottled pale brown and yellowish red silty clay loam to a depth of 84 inches.

Permeability is very slow. Available water capacity is low. This soil is medium to low in natural fertility and organic-matter content. The surface layer is medium acid to neutral.

Included with this complex in mapping are soils similar to the Pawhuska soils but that have a light gray and brownish gray surface layer. These soils make up about 10 percent of the map unit. Some small areas of Pond Creek soils which make up about 5 percent of the unit are also included.

This complex has fair potential for farming and growing hay or pasture. The potential is limited because of the excessive amount of exchangeable sodium in the upper part of the subsoil of the Pawhuska soils. Soil tilth is improved by returning crop residue to the soil, using minimum tillage, and including grasses and legumes in the cropping system. Best yields are obtained by growing salt tolerant plants if hay and pasture crops are grown.

This complex has fair potential for most urban uses. The shrink-swell potential and low strength are limitations that can be overcome by good design and careful installation procedures. The clayey subsoil percolates slowly. Corrosivity of steel and concrete is high in the subsoil of the Pawhuska soils. Capability subclass IIIs; Bethany soil in Loamy Prairie range site, and Pawhuska soil in Shallow Claypan range site.

6—Canadian fine sandy loam. This deep, well drained, nearly level soil is on flood plains. Slopes are smooth and slightly convex. Individual areas are 10 to 100 acres in size. These soils generally occupy elongated areas parallel to major streams, and are rarely inundated for very brief periods.

Typically, the surface layer is brown fine sandy loam about 12 inches thick. The subsoil is light brown fine sandy loam to a depth of 39 inches. The underlying material is light brown very fine sandy loam to a depth of 80 inches.

Permeability is moderately rapid. Available water capacity is medium. This soil is medium to high in natural fertility and organic-matter content. It is calcareous and moderately alkaline throughout. The soil has good tilth and can be worked throughout a wide range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Keokuk and Miller soils and areas of similar soils that have more reddish colors. These included soils make up 20 to 25 percent of the map unit.

This soil has good potential for row crops, sown crops, and tame pastures. Good tilth is maintained by returning crop residue to the soil and by minimum tillage.

This soil has fair potential for most urban uses. The rare hazard of flooding and low bearing strength are limitations. The flood hazard is difficult to overcome in most areas. Capability class I; Loamy Bottomland range site.

7—Clarita clay, 1 to 3 percent slopes. This deep, moderately well drained, very gently sloping soil is on narrow to broad smooth ridgetops on uplands. Individual areas are generally more than 40 acres in size.

Typically, the surface layer is very dark gray clay about 14 inches thick. The upper part of the next layer is dark brown clay to a depth of 21 inches. The lower part is reddish brown clay to a depth of 48 inches. The underlying material is reddish brown massive clay.

Permeability is very slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is alkaline throughout. It has fair tilth. Optimum tillage is limited to a narrow range of moisture conditions. The root zone is deep, but root penetration by most plants is difficult.

Included with this soil in mapping are Renfrow and Tamford soils. They make up 5 to 15 percent of this map unit.

This soil has fair potential for row crops and high potential for small grains. The hazard of erosion is moderate if row crops are grown. The clay soil is difficult to till and is sticky when wet. Minimum tillage, sown crops, terrace systems, and growing grasses and legumes help to reduce loss by erosion.

This soil has fair potential for most urban uses. It has high shrink-swell potential and low bearing strength. These limitations can be overcome by good design and careful installation of facilities. The clayey subsoil percolates very slowly and severely limits the use of septic tank absorption fields on this soil. Capability subclass IIe; Black Clay Prairie range site.

8—Clarita clay, 3 to 8 percent slopes. This deep, moderately well drained, gently sloping and sloping soil is on narrow ridgetops and on side slopes of uplands. Slopes are smooth and convex. Individual areas are 10 to more than 100 acres in size.

Typically, the surface layer is dark gray clay about 10 inches thick. The next layer is reddish brown clay that extends to a depth of 45 inches. The underlying material is slightly altered massive reddish brown clay.

Permeability is very slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is generally alkaline throughout. It has fair tilth. Optimum tillage is limited to a narrow range of moisture conditions. The root zone is deep, but the soil is not easily penetrated by plant roots.

Included with this soil in mapping are soils that have more yellowish underlying layers, and soils that have a dark brown surface layer. Also included are a few areas of soils that have moderate erosion. The included soils make up 20 to 30 percent of this map unit.

This soil has fair potential for small grains, and low potential for row crops. Potential is limited by the hazard of erosion and by irregularly shaped areas. The soil has fair potential for hay and pasture. Tilth is maintained by returning crop residue to the soil and by timely tillage. The hazard of erosion is moderate if crops are grown. Minimum tillage, sown crops, using grasses and legumes in the cropping system, and terracing reduce runoff and help to control excessive erosion.

This soil has fair potential for most urban uses. It has a high shrink-swell potential and low bearing strength, but these limitations can be overcome by good design and careful installation procedures. The clayey subsoil, which percolates very slowly, is a severe limitation for septic tank absorption fields. Sloping areas of this soil tend to slide or slump if saturated with water. Capability subclass IVe; Black Clay Prairie range site.

9—Gaddy-Gracemore complex, undulating. This complex consists of areas of the Gaddy and Gracemore soils so intermingled that they could not be separated at the scale selected for mapping. It is mostly narrow elongated areas, 50 to 400 acres in size, on low undulating flood plains, and is occasionally inundated for very brief periods.

Gaddy soil makes up 60 percent of the mapped area. Typically, the soil is brown fine sandy loam about 15 inches thick over light brown, stratified, loamy fine sand to a depth of 6 feet.

Permeability is moderately rapid or rapid. Available water capacity is medium or low. This soil is low in natural fertility and organic-matter content. It is generally calcareous throughout the profile.

The Gracemore soil makes up 30 percent of the mapped area. Typically, the soil is reddish brown fine sandy loam about 8 inches thick over light reddish brown, stratified, loamy fine sand to a depth of 60 inches.

Permeability is moderately rapid above the water table. Available water capacity is low or medium when the water table is below 40 inches. This soil has a high water table most of the year. It is low in natural fertility and organic-matter content. It is usually calcareous throughout the profile.

Other soils mapped in this complex make up 10 percent of the unit. These soils have a high water table and 10 to 15 inches of a dark colored loamy surface layer underlain by loamy material. Also included are soils similar to Gaddy soils that have a slightly more loamy texture at a depth of 10 to 40 inches, or that have a reddish color.

This map unit has good potential for improved pasture and native range. Leveling and smoothing practices help to make the complex better suited to improved pasture. The high water table of the Gracemore soils, the occasional flooding, and the undulating topography severely limit the use of this complex for most cultivated crops. A management concern for tame pasture is establishing plants that can tolerate the high water table of the Gracemore soils and the droughtiness of the Gaddy soils. Maintaining and improving soil fertility, controlling weeds and brush, and using proper stocking rates maintain protective cover and help to reduce erosion if flooding occurs. Gaddy soils are subject to soil blowing if not protected by plant cover.

This map unit has very poor potential for most urban development. The water table, rapid percolation rate, and occasional flooding are limitations to most urban uses that are very difficult to overcome. Capability subclass IVs; Gaddy soil in Sandy Bottomland range site, and Gracemore soil in Subirrigated range site.

10—Gracemont fine sandy loam. This somewhat poorly drained, nearly level soil is on flood plains that have a high water table most of the year. Slopes are mostly concave and less than 1 percent. In places water ponds on the surface during wet seasons of the year. Occasionally the soil is inundated for very brief periods.

Typically, the surface layer is light reddish brown fine sandy loam 8 inches thick. The underlying material is stratified layers of light reddish brown fine sandy loam and brown loam.

Permeability is moderately rapid. Available water capacity is medium if the water table is below a depth of 40 inches. This soil is low in natural fertility and organic-matter content. It is mildly or moderately alkaline in the surface layer. The soil has fair tilth, but wetness is a problem in cool season months. The root zone is deep, but plant tolerance is limited by the high water table.

Included with this soil in mapping are 10 to 20 percent Gracemore soils and 5 to 10 percent Gaddy soils.

This soil has poor to fair potential for row crops and small grains. It has good potential for pasture. Tilth is improved by returning crop residue to the soil. If cultivated crops are grown, leveling or smoothing and surface drainage are generally needed. Subsurface soil drainage is generally difficult.

This soil has poor potential for most urban uses. Occasional flooding and the high water table are limitations. Capability subclass IIIw; Subirrigated range site.

11—Gracemore soils. This map unit consists of deep, somewhat poorly drained, nearly level to very gently sloping soils on low flood plains. Slopes are smooth to concave, and are occasionally dissected by narrow drainageways or abandoned stream channels. Individual areas range from 5 acres to several hundred acres in size. They occur generally as elongated areas parallel to streams and are frequently inundated for very brief periods.

Typically, the surface layer is brown clay loam about 9 inches thick. The underlying material is light brown fine sand to a depth of 43 inches. Below is pink fine sand.

The water table is in the upper 40 inches of soil most of the year. Permeability is moderately rapid above the water table. Available water capacity is low to moderate when the water table is below a depth of 40 inches. These soils have the highest water table from November through April. These soils are low in natural fertility and organic-matter content. They are usually calcareous throughout.

Included with these soils in mapping are soils similar to Gracemore soils that have more clay between depths of 10 to 40 inches and a few knolls of Gaddy soils. The included soils make up 10 to 20 percent of this map unit.

This map unit has poor potential for cultivated crops. Suitability is limited because of the flood hazard and high water table. The unit has good potential for pasture and hay. Pasture plants grown on these soils need to be tolerant of flooding and the high water table. Management for tame pasture needs to include weed and brush control, addition of fertilizers, and proper stocking rates.

This map unit has poor potential for most urban uses. The flood hazard, high water table, and rapid percolation rate are factors that severely limit use. Capability subclass Vw; Subirrigated range site.

12—Grainola clay loam, 3 to 5 percent slopes. This moderately deep, well drained, gently sloping soil is on hillsides on uplands. Slopes are smooth and convex. Individual areas are 8 to more than 100 acres in size.

Typically, the surface layer is reddish brown clay loam about 5 inches thick. The subsoil is reddish brown and red clay to a depth of about 22 inches. The underlying material is red weathered shale.

Permeability is slow. The available water capacity is low to medium. This soil is medium in natural fertility and organic-matter content. It is nonacid throughout. It has fair tilth and has a narrow range of moisture conditions when tillage is optimum. The root zone is moderately deep, but the soil is not readily penetrated by plant roots.

Included with this soil in mapping are areas of Grant silt loam and Renfrow silt loam. These included soils make up about 10 to 20 percent of the map unit, but separate areas are less than 5 acres in size.

This soil has poor potential for row crops, but it has fair potential for small grains. Potential is limited by the size and shape of the areas, the slope, and the low to medium available water capacity. The soil has fair potential for hay or pasture and native grasses. Soil tilth is maintained or improved by returning crop residue to the soil. The hazard of erosion is moderate if tilled crops are grown. Minimum tillage, the use of cover crops, and terraces slow the rate of runoff and help to reduce erosion.

This soil has fair to poor potential for most urban uses. The shrink-swell potential, low bearing strength, slow percolation rate, and soil depth are limitations to urban use, but these limitations can be overcome by careful installation procedures. Capability subclass IVe; Shallow Prairie range site.

13—Grant silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on broad smooth ridgetops or hillsides on the uplands. Slopes are smooth and convex. Individual areas are 10 to more than 300 acres in size.

Typically, the surface layer is brown silt loam about 12 inches thick. The subsoil is silty clay loam that is reddish brown in the upper part, yellowish red in the next part, and red in the lower part to a depth of 49 inches. The underlying material is soft silty sandstone.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is slightly acid or neutral in the surface layer. It has good tilth and has a moderate range of moisture conditions when tillage is optimum. Root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Teller loam, Nash loam, and Minco silt loam. These included soils make up about 20 percent of the map unit.

This soil has good potential for cultivated crops. It has good potential for pasture or native grasses. Soil tilth is maintained by returning crop residues to the soil and by growing grasses or legumes in the crop rotation. The hazard of erosion is slight if cultivated crops are grown. Minimum tillage, use of cover crops, and terrace systems help to reduce the risk of erosion.

This soil has good potential for most urban uses. Moderate shrink-swell potential, low bearing strength, and soft bedrock at a depth of 40 to 72 inches may limit some urban uses. These limitations can be overcome by careful design and installation procedures. Capability subclass IIe; Loamy Prairie range site.

14—Grant silt loam, 2 to 5 percent slopes, eroded. This deep, well drained, gently sloping soil is on eroded, convex, broad ridgetops and on side slopes of the uplands. Slopes are smooth but individual areas are irregular in shape and size, ranging from 10 to 75 acres in size. Erosion has removed part or all of the original surface layer in about 75 percent of the area. Rills, shallow gullies, and a few deep gullies are in about 25 to 40 percent of each area.

Typically, the surface layer is reddish brown silt loam about 10 inches thick. The upper part of the subsoil is reddish brown and red silty clay loam to a depth of 44 inches, and the lower part is red silt loam to a depth of 65 inches. The underlying material is red soft sandstone.

Permeability is moderate. Available water capacity is high. This soil is medium in natural fertility and organic-matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil. The middle and lower parts of the subsoil are slightly acid to moderately alkaline. This soil has fair tilth and can be worked under a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are similar soils in the northern part of the county that have a thicker solum. Also included are areas of Minco, Renfrow, and Pond Creek soils that are eroded. These soils make up about 25 percent of the map unit, but separate areas are generally less than 5 acres in size.

This soil has fair to poor potential for row crops and small grains. It has fair potential for hay and pasture. Tilth can be improved or maintained by using minimum tillage and by returning crop residue to the soil. Erosion is a continuing hazard if cultivated crops are grown. Terraces, use of crop residue, contour tillage, and minimum tillage reduce runoff and help to control erosion.

This soil has good potential for most urban uses. Sandstone at a depth of 40 to about 72 inches, moderate shrink-swell potential, and low bearing strength are limitations to the development of urban facilities. Capability subclass IIIe; Loamy Prairie range site.

15—Grant silt loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on convex ridgetops and side slopes on uplands. Slopes are smooth. Individual areas are irregular in shape and size and range from 10 to 50 acres in size.

Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil is reddish brown silty clay loam to a depth of 24 inches, the next part is yellowish red silty clay loam to a depth of 37 inches, and the lower part is red silty clay loam to a depth of 48 inches. The underlying material is red silty sandstone.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is slightly acid or neutral in the surface layer and slightly acid to moderately alkaline in the subsoil. It has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are soils that have sandstone bedrock at a depth of 20 to 40 inches. Also included are areas of Minco, Teller, and Renfrow soils. These included soils make up 15 to 20 percent of the map unit, but separate areas are less than 5 acres in size.

This soil has fair potential for row crops and small grains. It has good potential for hay and pasture. Good tilth is easily maintained by timely tillage and by returning crop residue to the soil. The hazard of erosion is moderate if cultivated crops are grown. Minimum tillage, contour tillage, use of crop residue, and terraces reduce runoff and help to control erosion.

This soil has good potential for most urban uses. Sandstone at a depth of 40 to 72 inches, moderate shrink-swell potential, and low bearing strength are limitations to the development of urban facilities. Capability subclass IIIe; Loamy Prairie range site.

16—Grant silt loam, 5 to 8 percent slopes, eroded. This deep, well drained, eroded, sloping soil is on convex hillsides and foot slopes on the upland prairies. Slopes are smooth. Individual areas vary from about 5 to 100 acres in size. Erosion has removed part or all of the original surface layer in about 75 percent of the area. Shallow gullies, rills, and a few deep gullies are in about 20 to 35 percent of each mapped area.

Typically, the surface layer is reddish brown silt loam about 10 inches thick. The upper part of the subsoil is reddish brown silty clay loam to a depth of 15 inches, the next part is reddish brown and red silty clay loam to a depth of 42 inches, and the lower part is red silt loam. At a depth of about 68 inches is red soft sandstone.

Permeability is moderate. Available water capacity is high. This soil is medium in natural fertility and organic-matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil. The lower part of the subsoil is slightly acid to moderately alkaline. The soil has fair tilth and can be worked under a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are soils similar to Grant soils that have a thicker solum. Also included are areas of Minco and Nash soils. These included soils make up about 20 to 25 percent of the map unit.

This soil has poor potential for row crops. It has fair potential for small grains and hay or pasture. Soil tilth is maintained or improved by returning crop residue to the soil and by timing tillage operations to optimum moisture conditions. The hazard of erosion is severe if crops are grown. Runoff from adjacent soils on higher elevations is frequently a problem. Contour tillage and seeding, minimum tillage, use of large amounts of crop residue, and terraces help to control erosion on this soil. The use of tame pasture or native grass helps to control additional soil erosion.

This soil has fair potential for most urban uses. Slope, depth to rock, moderate shrink-swell potential, and low bearing strength are limitations that commonly affect the development of urban facilities. Capability subclass IV; Loamy Prairie range site.

17—Grant-Port complex, 0 to 12 percent slopes. This complex consists of small areas of the Grant and Port soils so closely intermingled that they could not be separated at the scale selected for mapping. It consists of narrow elongated areas along prairie drainageways. Grant soils are on the sloping to moderately steep side slopes, and Port soils are on the nearly level to gently sloping valley floor. Port soils are frequently inundated for brief periods.

Grant soils make up about 45 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 11 inches thick. The upper part of the subsoil is reddish brown silty clay loam about 4 inches thick, the next part is reddish brown and red silty clay loam to a depth of about 40 inches, and the lower part is light red silt loam to a depth of about 48 inches. The underlying material is reddish sandstone bedrock.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content.

Port soils make up 25 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 20 inches thick. The subsoil is reddish brown silty clay loam to a depth of 40 inches. The underlying material is yellowish red silty clay loam to a depth of 60 inches.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. This soil is slightly acid to mildly alkaline in the surface layer. It is slightly acid to moderately alkaline in the subsoil.

Included with this complex in mapping are Nash, Pulaski, Renfrow, and Tamford soils. The Nash, Renfrow, and Tamford soils are on side slopes along the drainageways. The Pulaski soils are on the alluvial valley floor of the drainageways. These soils make up about 30 percent of the map unit.

This complex has poor potential for cultivated crops. It has fair potential for tame pasture crops and for native range. Strong slopes and flooded valley floors limit suitability for farming.

This complex has poor potential for urban use. Slopes in excess of 8 percent and partial flooding severely limit most urban development unless careful installation procedures are practiced. Flooding can be controlled on most of this complex by careful planning and by flood retarding structures. Capability subclass VIe; Grant soil in Loamy Prairie range site, and Port soil in Loamy Bottomland range site.

18—Grant soils, gullied. This map unit consists of deep, well drained, gently sloping to sloping soils on severely eroded ridgetops, hillsides, and foot slopes of upland prairies. Slopes are smooth but are dissected by shallow and deep gullies. They range from 3 to 8 percent. Individual areas range from 5 to about 80 acres in size.

Erosion has removed part or all of the original surface layer in most of the map unit. Shallow gullies 1/2 foot to 3 feet deep are in 20 to 30 percent of the area. Gullies 3 to 8 feet deep are in 20 to 30 percent of the map unit.

Typically, the surface layer is brown silt loam about 8 inches thick. The upper 4 inches of the subsoil is reddish brown silt loam, the middle part is reddish brown and yellowish red silty clay loam to a depth of 40 inches, and the lower part is red very fine sandy loam to a depth of 52 inches. The underlying material is red soft sandstone that has interbedded layers of soft shale.

Permeability is moderate. Available water capacity is high. Grant soils are medium in natural fertility and organic-matter content. They are slightly acid or neutral in the surface layer and upper part of the subsoil. The middle and lower parts are slightly acid to moderately alkaline. Grant soils have fair tilth and can be worked under a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with Grant soils in mapping are severely eroded areas of Nash, Minco, and Renfrow soils. These included soils make up 15 to 20 percent of the mapped area.

This map unit has poor potential for tilled crops. Deep gullies and susceptibility to erosion are limitations. The unit has fair potential for tame pasture or native grasses. Shaping and smoothing of gullies is generally needed before seedbeds can be prepared for tame pasture grasses.

This map unit has fair potential for most urban uses. Soil limitations that affect some urban facilities are slopes of up to 8 percent, bedrock at a depth of 40 to 72 inches, moderate shrink-swell potential, low strength, and gullies 3 to 8 feet deep. Capability subclass VIe; Eroded Prairie range site.

19—Keokuk loam. This deep, well drained, nearly level soil is on flood plains. Slopes are smooth to slightly convex. Individual areas range from 10 to more than 100 acres in size. Rarely, the soil is inundated for very brief periods.

Typically, the surface layer is brown loam about 18 inches thick. The subsoil is yellowish red loam to a depth of 34 inches. The underlying material is yellowish red loam to a depth of 72 inches.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is neutral to moderately alkaline in the surface layer. This soil has good tilth and can be worked throughout a wide range of moisture conditions.

Included with this soil in mapping are areas of Canadian fine sandy loam, areas similar to Keokuk soil that have more clayey underlying layers, and areas of Miller silty clay. These included soils make up about 20 percent of the mapped area.

This soil has good potential for row crops, small grains, and tame pasture. Tilth is easily maintained by returning crop residue to the soil.

This soil has poor to fair potential for most urban uses. Rare flooding and low strength are limitations. Flooding is difficult to overcome. Capability class I; Loamy Bottomland range site.

20—Keokuk silt loam. This deep, well drained, nearly level soil is on flood plains. Slopes are smooth to slightly convex. Individual areas range from 10 acres to several hundred acres in size. The soil is occasionally inundated for very brief periods.

Typically, the surface layer is reddish brown silt loam about 12 inches thick. The subsoil is reddish brown silt loam and loam to a depth of 38 inches. The underlying material is alternating layers of reddish brown and yellowish red loam to a depth of more than 60 inches.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is neutral or alkaline in the surface layer. This soil has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are 15 to 25 percent soils similar to the Keokuk soil that have 4 to 16 inches of recent loamy sediment on the surface. Also included are areas of Asa, Pulaski, and Port soils that make up about 10 to 15 percent of the mapped area.

This soil has high potential for row crops, small grains, and tame pasture. Tilth is maintained by returning crop residue to the soil and tilling the soil at proper moisture conditions.

This soil has poor potential for most urban uses. Occasional flooding and low strength are limitations. Flooding is difficult to overcome. Capability subclass IIw; Loamy Bottomland range site.

21—Kirkland silt loam, 0 to 2 percent slopes. This deep, well drained, nearly level to very gently sloping soil is on uplands. Slopes are broad and smooth to slightly concave. Individual areas are 5 to 250 acres in size.

Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil is dark brown silty clay to a depth of 20 inches, the next part is brown silty clay to a depth of 34 inches, and the lower part is yellowish red and red silty clay to a depth of 70 inches. The underlying material is red interbedded soft sandstone and shale.

Permeability is very slow. Available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. The surface layer is slightly acid or neutral. The soil has fair tilth and can be worked throughout a moderate range of moisture conditions. The root zone is severely limited by the dense clay subsoil. Plant roots have difficulty penetrating the subsoil layer.

Included with this soil in mapping are areas of Bethany, Renfrow, Pawhuska, and Grant soils. These included soils make up about 20 percent of the map unit. Individual areas of the included soils are generally less than 5 acres in size.

This soil has fair potential for cultivated crops, pasture, or hay. The growth potential is reduced for most plants by the restricted root zone. Because of the very slow permeability, much of the annual rainfall is lost as runoff. The rainfall does not enter into the soil and become available for plant use. Additions of large amounts of plant residue help to improve water holding capacity, improve infiltration, and maintain or improve soil tilth. The hazard of erosion is slight on slopes of 1 to 2 percent. Residue mulches, contour tillage, minimum tillage, and terraces reduce the risk of erosion. Native or tame pasture grasses provide excellent erosion protection and help improve water intake.

This soil has poor potential for most urban uses. Development of such sanitary facilities as septic tank filter fields and trench type sanitary landfills are severely affected by the slow percolation rate and clayey subsoil. Community developments such as dwellings, buildings, and streets or roads are severely affected by the high shrink-swell potential and low loadbearing strength of the subsoil. The limitations need to be overcome by careful engineering design and installation procedures to avoid damage to structures or facilities. Capability subclass IIIe; Claypan Prairie range site.

22—Konawa loamy fine sand, 0 to 3 percent slopes. This deep, well drained, nearly level to very gently sloping soil is on broad ridgetops of the uplands. Slopes are smooth and mostly convex. Individual areas are 10 to 300 acres in size.

Typically, the surface layer is pale brown loamy fine sand about 8 inches thick. The subsurface layer is very pale brown loamy fine sand about 9 inches thick. The subsoil is yellowish red sandy clay loam to a depth of 30 inches, the next part is reddish yellow sandy clay loam to a depth of 42 inches, and the lower part is reddish yellow fine sandy loam to a depth of 65 inches. The underlying material is reddish yellow loamy fine sand to a depth of 72 inches or more.

Permeability is moderate. Available water capacity is medium. This soil is low in natural fertility and organic-matter content. It is medium acid or slightly acid throughout, except where the surface layer has been limed. It has fair tilth and can be worked throughout a wide range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are soils in concave areas that have a more clayey subsoil mottled in brownish gray. Also included in areas of mounds or dunes are soils that have a thicker surface layer. These included soils make up 10 to 20 percent of this map unit.

This soil has fair potential for row crops, small grains, improved grasses, and orchards. The potential is limited because of susceptibility to severe erosion by water and soil blowing. Soil tilth is maintained and improved by returning crop residue to the soil. Erosion is a hazard if cultivated crops are grown. Minimum tillage and the use of cover crops, including grasses and legumes, in the cropping system reduce runoff and help to control erosion.

This soil has good potential for most urban uses. If the soil is used for sanitary facilities such as sewage lagoons, seepage is a hazard. The soil has low strength if used for streets and roads. Capability subclass IIIe; Deep Sand Savannah range site.

23—Konawa loamy fine sand, 3 to 8 percent slopes. This deep, well drained, gently sloping to sloping soil is on smooth hillsides and foot slopes on uplands. Slopes are mostly convex. Most individual areas are 10 to 125 acres in size.

Typically, the surface layer is brown loamy fine sand about 10 inches thick. The subsurface layer is light reddish brown loamy fine sand 16 inches thick. The upper part of the subsoil is red sandy clay loam to a depth of 31 inches, and the lower part is red fine sandy loam to a depth of 42 inches. The underlying material is red loamy fine sand.

Permeability is moderate. Available water capacity is medium. This soil is low in natural fertility and organic-matter content. It is medium acid or slightly acid in the surface layers unless limed. The subsoil is medium acid or slightly acid. The soil has fair tilth and can be worked throughout a wide range of moisture conditions. Roots easily penetrate the deep root zone.

Included with this soil in mapping are similar soils that have a surface layer and subsurface layer more than 20 inches thick. Also included are areas of soil similar to this soil that are mottled, and have a more clayey lower part of the subsoil and underlying material. These included soils make up 10 to 20 percent of the map unit.

This soil has fair potential for row crops, sown crops, and improved grasses. The potential is limited because of susceptibility to severe erosion by water and soil blowing. Crop residue mulches help maintain soil tilth and reduce the hazard of erosion. Minimum tillage, the use of grasses and legumes in the crop rotation, cover crops, contour tillage, and diversion terraces to protect from runoff water help reduce loss by erosion if this soil is used for growing crops that require annual tillage. Growing tame pasture grasses or native grasses best protects this soil from erosion.

This soil has good potential for most urban uses. Soil limitations that could affect urban development are slopes of 3 to 8 percent and low strength. Large sanitary facilities developed in this soil have a high probability of seepage into shallow underground water supplies unless installation procedures are designed to overcome this hazard. Capability subclass IVe; Deep Sand Savannah range site.

24—Konawa soils, gullied. This map unit consists of deep, well drained, very gently sloping to sloping soils on gullied hillsides and foot slopes of uplands. Slopes are mostly smooth and convex and range from 1 to 8 percent. Individual areas are 8 to 300 acres in size.

These formerly cultivated Konawa soils have eroded and the original surface layer has been thinned over most of each mapped area. Gullies 3 to 20 feet deep and commonly 6 to 50 feet wide have formed in 10 to 50 percent of each mapped area.

Typically, the surface layer is light brown loamy fine sand about 5 inches thick. The upper part of the subsoil is yellowish red sandy clay loam to a depth of 37 inches and the lower part is reddish yellow sandy clay loam to a depth of 48 inches. The underlying material is light red sandy loam.

Permeability is moderate. Available water capacity is medium. This soil is low in natural fertility and organic-matter content. It is medium or slightly acid in the surface layer unless limed. It has fair to poor tilth. Roots easily penetrate the deep root zone.

Included with Konawa soils in mapping are areas of gullied Stephenville and Minco soils. The included soils make up about 15 percent of the map unit.

These soils have poor potential for cultivated crops and for tame pasture. Susceptibility to severe erosion and numerous deep gullies are limitations. Gullies commonly must be shaped and established to permanent plant cover to prevent additional loss by erosion.

These soils have poor potential for most urban uses. Deep gullies, susceptibility to severe erosion, low bearing strength, and seepage potential are limitations that must be overcome before installing facilities. Capability subclass VIe; Eroded Sandy Savannah range site.

25—Lela clay. This deep, somewhat poorly drained, nearly level soil is on flood plains of major streams. It is flooded occasionally for very brief periods. Slopes are smooth and slightly concave. Individual areas are 100 to more than 500 acres in size.

Typically, the soil is clayey throughout. The surface layer is dark reddish gray and reddish brown clay 18 inches thick. The next layer is reddish brown mottled clay to a depth of 46 inches. The underlying material is reddish brown silty clay.

Permeability is very slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is neutral to moderately alkaline throughout. It has fair to poor tilth and can be worked through a very narrow range of moisture conditions. The root zone is deep, but the soil is not easily penetrated by plant roots.

Included with this soil in mapping are soils that are stratified and have less clay at a depth of 20 to 40 inches. Also included are soils that have a water table at a depth of 4 to 6 feet. These soils make up 10 to 15 percent of the map unit, but separate areas are less than 5 acres in size.

This soil has fair potential for cultivated crops. Average growth is reduced by flooding and slow runoff. The soil cracks severely during the dry season of the year which causes it to dry out and severely limits available moisture. Soil tilth is maintained or improved by returning crop residue to the soil, by minimum tillage procedures, and by avoiding tillage if the soil is wet or extremely dry. The hazard of erosion is slight. Surface drainage is occasionally needed to remove excess surface water safely. This soil has fair potential for tame pasture or hay.

This soil has poor potential for most urban development. Flooding, surface wetness, high shrink-swell potential, slow percolation rate, and low bearing strength are limitations to the development of most urban facilities. Capability subclass IIIw; Heavy Bottomland range site.

26—Miller silty clay. This deep, moderately well drained, nearly level soil formed in clayey sediment on flood plains. Slopes are smooth and slightly concave. Individual areas are 20 to more than 400 acres in size. The soil is occasionally inundated for brief periods.

Typically, the surface layer is reddish brown silty clay 24 inches thick. The next 18 inches is buried layers of dark reddish gray and reddish brown silty clay. The underlying material is massive reddish brown silty clay.

Permeability is very slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is moderately alkaline throughout. It has fair tilth and a limited range of moisture conditions for tillage operations. The root zone is deep, but the soil is not readily penetrated by plant roots.

Included with this soil in mapping are areas of Asher soils. Also included are soils similar to the Miller soils that have more sand at a depth of 30 to 40 inches. These included soils make up 10 to 30 percent of the map unit.

This soil has good potential for row crops, small grains, and hay or pasture. Soil tilth is maintained by returning crop residue to the soil and by avoiding tillage when the soil is wet or extremely dry (fig. 2). Erosion is not a hazard unless the soil is flooded or excessive overhead water accumulates. Diversion terraces may be needed to protect the soil from overhead water. In some places simple surface drains may be needed to remove surface water during wet years.

This soil has poor potential for most urban uses. Occasional flooding, high shrink-swell potential, and slow percolation rate are limitations if urban facilities are to be developed. Flooding is mainly on the major streams and is very difficult to overcome. Capability subclass IIIw; Heavy Bottomland range site.

27—**Minco very fine loam, 5 to 8 percent slopes.** This deep, well drained, sloping soil is on uplands. It is on smooth convex hillsides. Individual areas are 10 to 300 acres.

Typically, the surface layer is brown very fine sandy loam 10 inches thick. The upper part of the subsoil is reddish brown very fine sandy loam to a depth of 22 inches. The lower part is yellowish red very fine sandy loam to a depth of 72 inches.

Permeability is moderate. Available water capacity is high. This soil is moderate to high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. It has good tilth and a wide range of moisture conditions when tillage can be properly performed. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant, Teller, and Konawa soils. These included soils make up about 15 percent of the map unit.

This soil has fair potential for cultivated crops, hay, or pasture. Soil tilth is easily maintained by additions of crop residue and by timely tillage. The hazard of erosion is severe if cultivated crops are grown. The use of crop residue on the soil, cover crops, minimum tillage, terraces, contour tillage, the use of grasses or legumes in the crop rotation help control erosion. Growing pasture or native grasses helps control erosion.

This soil has good potential for most urban uses. Low bearing strength, slopes of 5 to 8 percent, and seepage potential are soil limitations that can affect the development of some facilities. Careful design and installation procedures easily overcome these limitations. Capability subclass IVe; Loamy Prairie range site.

28—**Minco very fine sandy loam, 8 to 20 percent slopes.** This deep, well drained, moderately steep soil is on uplands. It is on short convex hillsides. Individual areas are mostly 10 to 50 acres in size.

Typically, the surface layer is brown very fine sandy loam about 6 inches thick. The upper part of the subsoil is yellowish red or red silt loam to a depth of 33 inches, and the lower part is red loam to a depth of 60 inches (fig. 3).

Permeability is moderate. Available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant and Konawa soils. The soils make up about 10 percent of the mapped area.

This soil has poor potential for cultivated crops. It has moderate potential for pasture and hay. Moderately steep slopes and a very severe hazard of erosion are the greatest limitations. If tame pasture grasses are grown, adequate forage needs to be maintained on the soil to protect against erosion. Forage growth reaches moderate levels under intensive management.

This soil has fair to poor potential for most urban uses. Slopes of 8 to 20 percent, low bearing strength, and seepage potential are limitations that must be overcome for development of facilities. Slopes of more than 8 percent severely affect small commercial buildings and septic tank filter fields. Slopes of more than 15 percent severely affect most other facilities. Very careful design and installation procedures are commonly needed to overcome the limitations of this soil for most urban uses. Capability subclass VIe; Loamy Prairie range site.

29—**Minco silt loam, 0 to 1 percent slopes.** This deep, well drained, nearly level soil is on uplands. It is on broad, smooth, slightly convex slopes. Individual areas are 10 to 400 acres in size.

Typically, the surface layer is brown silt loam about 12 inches thick. The upper part of the subsoil is brown silt loam to a depth of 60 inches, and the lower part is light brown silt loam to a depth of 74 inches.

Permeability is moderate. Available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. Soil tilth is good. Tillage can be properly performed throughout a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant, Teller, and Pond Creek soils. These included soils make up about 15 percent of the map unit.

This soil has good potential for cultivated crops, hay, or pasture. Soil tilth is easily maintained by proper timing of tillage and by returning crop residue to the soil. The hazard of erosion is slight.

This soil has good potential for most urban uses. The soil has low bearing strength, and the percolation rate is generally too rapid for sewage lagoons. Proper engineering design and installation procedures are needed to overcome these limitations. Capability class I; Loamy Prairie range site.

30—Minco silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on uplands. Slopes are smooth and slightly convex. Individual areas are 10 to more than 200 acres in size.

Typically, the surface layer is brown silt loam 11 inches thick. The upper part of the subsoil is brown silt loam to a depth of 36 inches, and the lower part is yellowish red silt loam to a depth of 74 inches.

Permeability is moderate. Available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer unless limed. It has good tilth and a moderate range of moisture conditions when the soil can be properly tilled. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant, Teller, and Pond Creek soils. These included soils make up about 15 percent of the map unit.

This soil has good potential for cultivated crops, hay, or pasture. Soil tilth is maintained by returning crop residue to the soil and by tilling when soil moisture is optimum. The hazard of erosion is slight to moderate if cultivated crops are grown. Minimum tillage, the use of crop residue, and terraces help to control erosion.

This soil has good potential for most urban uses. The soil has low bearing strength which is easily overcome by proper design and installation procedures. The percolation rate is generally too rapid for such large facilities as sewage lagoons. Capability subclass IIe; Loamy Prairie range site.

31—Minco silt loam, 3 to 5 percent slopes. This deep, well drained, gently sloping soil is on uplands. Slopes are smooth and slightly convex. Individual areas are 5 to 200 acres in size.

Typically, the surface layer is brown silt loam 11 inches thick. The subsoil is yellowish red silt loam to a depth of 80 inches.

Permeability is moderate. Available water capacity is high. This soil is medium to high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer unless limed. It has good tilth and a moderate range of moisture conditions when tillage is optimum. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant, Teller, and Pond Creek soils. The included soils make up about 15 percent of the map unit.

This soil has good potential for cultivated crops, hay, or pasture. Soil tilth is easily maintained by proper timing of tillage and by returning crop residue to the soil. The hazard of erosion is moderate if cultivated crops are grown. Minimum tillage, contour tillage, cover crops, use of large amounts of residue, and terraces help to control erosion. Native grass or pasture helps prevent erosion.

This soil has good potential for most uses. It has low bearing strength, and the percolation rate is generally too high for sewage lagoons. Capability subclass IIIe; Loamy Prairie range site.

32—Nash-Lucien complex, 2 to 5 percent slopes. This complex consists of areas of Nash and Lucien soils that could not be separated at the scale selected for mapping. These very gently sloping to gently sloping soils are on narrow to broad ridge crests. Individual areas of each soil are 1/4 acre to 10 acres in size.

Nash loam makes up about 50 percent of each mapped area. Typically, the surface layer is reddish brown loam 14 inches thick. The subsoil is yellowish red loam to a depth of about 38 inches. The underlying material is weakly indurated sandstone.

Permeability is moderate, and available water capacity is medium to high. The soil is slightly acid to moderately alkaline throughout.

Lucien loam makes up about 30 percent of each mapped area. Typically, the surface layer is reddish brown loam 5 inches thick. The subsoil is yellowish red loam to a depth of 16 inches. The underlying material is weakly indurated sandstone (fig. 4).

Permeability is moderately rapid, and available water capacity is low. The Lucien loam is medium to high in natural fertility and organic-matter content. It is slightly acid or neutral throughout.

Included with this complex in mapping are some areas of Grant and Grainola soils, and sandstone rock outcrop. These included soils make up 20 percent of the map unit.

This complex has fair potential for cultivated crops and pasture or hay. Its potential is limited because of the areas of intermingled shallow soils and the risk of erosion. Soil tilth is good and is easily maintained by returning crop residue to the soil. If cultivated crops are grown, intensive conservation practices are needed to protect the soil from erosion, including minimum tillage, growing high residue crops, contour tillage, maintaining mulches on the soil surface, and terraces. Permanent plant cover helps protect this soil from erosion.

This complex has poor to fair potential for most urban uses. The soil limitations of this complex are soft sandstone at a depth of 10 to 40 inches and low bearing strength. The limited soil depth severely affects the development of sewage lagoons, septic tank filter fields, and other sanitary facilities. Community developments have medium limitations because of depth of rock and low bearing strength. These limitations can be overcome by careful design and installation procedures. Capability subclass IVe; Nash soil in Loamy Prairie range site, and Lucien soil in Shallow Prairie range site.

33—Nash-Lucien complex, 5 to 12 percent slopes. This complex consists of areas of intermingled Nash and Lucien soils that were impractical to separate at the scale selected for mapping. They are sloping to strongly sloping soils on broad, dissected ridge crests or hillsides. Individual areas are commonly 40 to 640 acres in size.

Nash loam makes up about 40 percent of each mapped area. Typically, the surface layer is reddish brown loam about 14 inches thick. The subsoil is yellowish red loam to a depth of 32 inches. The underlying material is red weakly indurated sandstone.

Permeability is moderate, and available water capacity is medium to high. Nash soil is high in natural fertility and organic-matter content. The soil is slightly acid to moderately alkaline.

Lucien loam makes up about 35 percent of each mapped area. Typically, the surface layer is reddish brown loam about 7 inches thick. The subsoil is yellowish red loam to a depth of about 14 inches. The underlying material is red weakly indurated sandstone.

Permeability is moderately rapid. Available water capacity is low. The Lucien soil is medium to high in natural fertility and organic-matter content. It is slightly acid or neutral.

Included with this complex in mapping are areas of Grant, Grainola, and Stephenville soils, and sandstone rock outcrop. Also included along some narrow drainageways are Port and Pulaski soils. The included soils make up 25 percent of this map unit.

This complex has poor potential for cultivated crops, and poor to fair potential for pasture. Potential is limited by steep slopes, the risk of erosion, and areas of intermingled shallow soils. Improved tame pasture grasses can be established and moderate growth obtained under high levels of management on most of each area. Permanent plant cover is needed to protect the soils from excessive erosion.

This complex has poor to fair potential for urban uses. Soil depth ranges from 10 to 40 inches to rippable bedrock, soil bearing strength is low, and slopes are 5 to 12 percent. These limitations severely affect development of such sanitary facilities as septic tank filter fields, sewage lagoons, and trench type landfill sites. Community developments are moderately to severely affected by limited soil depth, strong slopes, and susceptibility to erosion. Careful planning, design, and installation of structures are needed to overcome these limitations. Capability subclass VIe; Nash soil in Loamy Prairie range site, and Lucien soil in Shallow Prairie range site.

34—Pits. This map unit is made up of material that has been excavated for use elsewhere. Areas ranging in size from 2 to 40 acres or more have been excavated to depths of 4 to 30 feet or more. The excavated material is used as topsoil, graded material, sand and gravel, or a combination of these uses. Little or no vegetation is in recent excavations, and it is limited in the older areas. A few places contain water in the bottom of the pits. The water ranges from shallow to several feet in depth. A typical area of this unit is in the southwest quarter of section 12, T. 9 N., R. 4 W. (fig. 5). Capability subclass VIIe; no range site.

35—Pond Creek silt loam, 0 to 1 percent slopes. This deep, well drained, nearly level soil is on high stream terraces. Areas are broad and smooth. Individual areas are 10 to about 200 acres in size.

Typically, the surface layer is brown silt loam 15 inches thick. The upper part of the subsoil is brown silt loam to a depth of 23 inches,and the lower part is brown silty clay loam that extends to a depth of 72 inches.

Permeability is moderately slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. The soil has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and the soil is readily penetrated by plant roots.

Included with this soil in mapping are areas of Teller, Minco, and Bethany soils. Also included are soils similar to Pond Creek soils that have a thinner surface layer. The included soils make up about 15 percent of the map unit, but separate areas generally are less than 5 acres in size.

This soil has good potential for cultivated crops and pasture or hay. Tilth is easily maintained by proper timing of tillage and by returning crop residue to the soil. The hazard of erosion is slight. Occasionally runoff water needs to be diverted on long slopes.

This soil has good potential for most urban uses. Slow percolation rate, low bearing strength, and moderate shrink-swell potential are limitations that can be easily overcome. Capability class I; Loamy Prairie range site.

36—Pond Creek silt loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on high stream terraces. Slopes are long and smooth. Individual areas are 10 to about 300 acres in size.

Typically, the surface layer is dark brown silt loam 15 inches thick. The upper 10 inches of the subsoil is brown heavy silt loam, the next part is brown silty clay loam to a depth of 42 inches, and the lower part is yellowish red silty clay loam to a depth of 61 inches. The underlying material is yellowish red silt loam.

Permeability is moderately slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid or slightly acid in the surface layer unless it has been limed. It has good tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Teller, Minco, and Grant soils. Also included are soils similar to Pond Creek soils that have a thinner surface layer. The included soils make up 20 to 25 percent of the map unit. Separate areas generally are less than 5 acres in size.

This soil has good potential for row crops, small grains, and hay or pasture. Good tilth is easily maintained by returning crop residue to the soil and by tilling at proper moisture conditions. Erosion is a moderate hazard if cultivated crops are grown. Minimum tillage, use of crop residue, contour tillage, and terraces help to control erosion.

This soil has good potential for most urban uses. The slow percolation rate, low bearing strength, and moderate shrink-swell potential are limitations. Careful design and installation procedures can easily overcome these limitations. Capability subclass IIe; Loamy Prairie range site.

37—Port silt loam, overwash. This deep, well drained, nearly level soil is on smooth flood plains. Slopes are less than 1 percent. Individual areas generally are on narrow elongated areas parallel to the stream channels. They range from about 10 acres to several hundred acres in size. The soil is occasionally inundated for brief periods.

Typically, the upper part of the surface layer is reddish brown silt loam of recent alluvium about 14 inches thick. The lower part is reddish brown silt loam about 21 inches thick. The subsoil is yellowish red silty clay loam to a depth of about 60 inches. Below this is loamy to silty alluvium 2 to more than 10 feet thick.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is neutral to moderately alkaline in the upper part. The soil has generally good tilth. Tillage at proper moisture conditions and minimum tillage are needed to maintain soil structure and tilth. Returning crop residue to the soil helps maintain structure and tilth. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Asa, Keokuk, and Pulaski soils that make up 15 to 25 percent of this map unit. Each mapped area generally has some of the included soils.

This soil has good potential for row crops, small grains, and pasture or hay crops (fig. 6). Hazard of erosion is slight, but the soil is subject to occasional flooding.

This soil has poor potential for most urban uses. The hazard of flooding and low bearing strength are limitations. Flooding is difficult to overcome without major flood control measures. Capability subclass IIw; Loamy Bottomland range site.

38—Pulaski fine sandy loam. This deep, nearly level soil is on flood plains of local streams. It is flooded occasionally for very brief periods. Slopes are smooth and slightly convex. Individual areas frequently are long and narrow, and are parallel to the adjacent stream channel. Areas vary from about 20 to 600 acres in size.

Typically, the upper part of the surface layer is brown fine sandy loam 6 inches thick. The next 10 inches is reddish brown fine sandy loam, and below this is 22 inches of stratified layers of reddish yellow fine sandy loam and loam. The underlying material is reddish yellow stratified silt loam.

Permeability is moderately rapid. Available water capacity is medium. This soil is medium in natural fertility and organic-matter content. It is medium acid to neutral in the surface layer. It has good tilth, is easily worked, and has a deep root zone.

Included with this soil in mapping are areas of Port and Keokuk soils and areas similar to Pulaski soils that have a high water table part of the year. The included soils make up 15 to 20 percent of the map unit.

This soil has good potential for row crops and small grains. Good growth can be obtained, but potential is limited by the susceptibility to flooding. Good tilth is easily maintained by returning crop residue to the soil and by minimum tillage. This soil has good potential for pasture and hay. The hazard of erosion is slight except during periods of brief flooding.

This soil has poor potential for urban use. Occasional flooding is the chief limitation. The rapid percolation rate could also affect development. Capability subclass IIw; Loamy Bottomland range site.

39—Pulaski and Port soils. This map unit consists of nearly level to very gently sloping soils on flood plains along narrow drainageways. It consists of closely associated Pulaski and Port soils in an irregular pattern. Some individual areas of both soils are large enough to map separately; others are intermingled. Because of the similarity in present and predicted land use these soils were not separated in mapping. They are frequently flooded for brief periods. Slopes are 0 to 3 percent.

A typical area of this map unit is about 45 percent Pulaski soils, 25 percent Port soils, and about 5 percent each Asa, Gracemont, Gracemore, and Keokuk soils. About 10 percent of the mapped area is stream channels or abandoned stream channels.

Typically, Pulaski soils have a brown fine sandy loam surface layer about 10 inches thick over stratified reddish brown fine sandy loam to a depth of 40 inches. The next layer is stratified yellowish red loam to a depth of 64 inches.

Permeability is moderately rapid. Available water capacity is medium. Pulaski soils are slightly acid to mildly alkaline.

Typically, Port soils have a reddish brown loam surface layer about 11 inches thick over a reddish brown silt loam subsoil to a depth of about 32 inches. The underlying material is stratified layers of reddish brown to yellowish red very fine sandy loam and loam.

Permeability is moderate. Available water capacity is high. Port soils are slightly acid to moderately alkaline.

This soil is generally not suited to farming. Mapped areas are narrow, elongated, and are mostly dissected by narrow drainageways. Most areas are subject to frequent flooding. This unit has good potential for pasture or hay. Some areas have a scattering of hackberry, elm, and pecan trees growing along the stream channels.

This soil has poor potential for urban use. The hazard of frequent flooding is the principal limitation. Most areas require carefully designed flood control structures. Capability subclass Vw; Loamy Bottomland range site.

40—Renfrow silt loam, 2 to 5 percent slopes. This deep, well drained, very gently sloping and gently sloping soil is on uplands. Slopes are smooth to slightly convex. Individual areas are 8 to 200 acres in size.

Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil is reddish brown silty clay loam to a depth of 18 inches, and the lower part is red clay to a depth of 68 inches. The underlying material is massive red silty claybeds.

Permeability is very slow. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is slightly acid or neutral in the surface layer and upper part of the subsoil. It has fair tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, but the soil is not readily penetrated by plant roots.

Included with this soil in mapping are Grant, Grainola, Kirkland, and Tamford soils. The included soils make up about 20 percent of the mapped area.

This soil has good potential for cultivated crops and pasture or hay. Soil tilth is maintained or improved by additions of crop residue to the soil and by tilling when the soil has moderate levels of moisture. The hazard of erosion is moderate if cultivated crops are grown. Minimum tillage, contour tillage, returning crop residue to the soil, and terraces help protect the soil from erosion. Tame pasture grasses and native grasses for forage achieve moderate to good growth on this soil.

This soil has fair potential for most urban uses. The clayey subsoil has low strength, high shrink-swell potential, and slow percolation rate. Special design and installation procedures are needed to overcome these limitations. Capability subclass IIIe; Claypan Prairie range site.

41—Renfrow silt loam, 2 to 5 percent slopes, eroded. This deep, well drained, very gently sloping to gently sloping, eroded soil is on uplands. Slopes are moderate to long and are generally convex. Individual areas range from about 8 to 160 acres in size.

Typically, the surface layer has been thinned by erosion and is brown silt loam about 6 inches thick. The upper part of the subsoil is reddish brown clay loam to a depth of about 11 inches, and the lower part is reddish brown and red clay to a depth of 64 inches. The underlying material is red massive claybeds.

Erosion has removed part of the original surface layer on most of this soil. Shallow gullies and rills that are 1 to 3 feet deep are common. In some areas the surface layer and some of the upper part of the subsoil have been mixed by tillage.

Permeability is very slow. Available water capacity is high. This soil is medium in natural fertility and organic-matter content. It is slightly acid to mildly alkaline in the surface layer and upper part of the subsoil. The soil has fair to poor tilth and can be worked throughout a moderate range of moisture conditions. The root zone is deep, but the soil is not readily penetrated by plant roots.

Included with this soil in mapping are areas of eroded Grant, Grainola, Bethany, and Kirkland soils. These included soils make up about 20 percent of the mapped area.

This soil has fair potential for cultivated crops, pasture, or hay. Soil tilth is maintained or improved by addition of crop residue or by growing grasses and legumes in the rotation. Tillage is needed when moisture conditions are at moderate levels. Minimum tillage, residue mulches, contour tillage, and terraces help protect this soil from additional erosion. Maintaining a good cover of permanent grass helps prevent excessive erosion.

This soil has poor potential for most urban uses. The clayey subsoil that percolates slowly, high shrink-swell potential, and low bearing strength are limitations that affect urban development. Careful planning and special engineering design are needed to overcome these limitations. Capability subclass IVe; Claypan Prairie range site.

42—Renfrow soils, 2 to 5 percent slopes, severely eroded. These deep, well drained, very gently sloping to gently sloping, severely eroded soils are on uplands. Slopes are moderate to long and are generally convex. Individual areas are 5 to 50 acres in size.

Typically, the surface layer has been thinned by erosion and is brown silt loam 4 inches thick. The upper part of the subsoil is reddish brown silty clay loam to a depth of 11 inches. The lower part is yellowish red or red silty clay to a depth of 62 inches.

Erosion has removed nearly all of the original surface layer on most of these soils. The reddish subsoil is exposed in the shallow gullies and rills that commonly occur. Gullies 3 to 6 feet deep make up 15 to 25 percent of the mapped area.

Permeability is very slow. Available water capacity is high. These soils are low in natural fertility and organic-matter content. They are slightly acid to moderately alkaline in the surface layer and upper part of the subsoil. They have poor tilth. The root zone is deep, but the soils are not readily penetrated by plant roots.

Included with these soils in mapping are areas of severely eroded Grainola, Bethany, Kirkland, and Pawhuska soils. These soils make up about 20 percent of the mapped area.

These soils have poor potential for farming. Shallow and deep gullies, a thin surface layer, and additional risk of erosion are severe limitations. These soils can be protected from further erosion by shaping gullies, diverting excess overhead water, applying needed plant food amendments, and establishing a permanent plant cover. Exclusion of livestock from treated areas is generally needed until new plantings are established.

These soils have poor potential for most urban uses. Gullies, little or no topsoil, high shrink-swell potential, slow percolation rate, low bearing strength, and a clayey subsoil severely affect some urban uses. Very careful and costly design and installation procedures are generally needed for successful urban development. Capability subclass VIe; Eroded Clay range site.

43—Stephenville fine sandy loam, 2 to 5 percent slopes. This moderately deep, well drained, gently sloping soil is on uplands. It is on smooth, narrow to broad ridge crests or on hillsides. Individual areas are 5 to several hundred acres in size.

Typically, the surface layer is brown fine sandy loam 6 inches thick and the subsurface layer is reddish brown fine sandy loam 12 inches thick. The subsoil is red sandy clay loam to a depth of 36 inches. The underlying material is red soft sandstone.

Permeability is moderate. Available water capacity is medium. This soil is medium in natural fertility and organic-matter content. The surface layer is medium acid or slightly acid unless limed. The soil has good tilth and is easily worked throughout a wide range of moisture conditions. The root zone is moderately deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Nash and Lucien soils. Also included are soils that are similar to Stephenville soils that are more than 40 inches deep to rock. These included soils make up about 20 percent of the map unit.

This soil has good potential for cultivated crops, pasture, or hay. Good tilth is easily maintained by returning crop residue to the soil. The hazard of erosion is moderate if crops are grown. Crops that produce a high amount of residue provide effective erosion protection. Minimum tillage, residue mulches, contour tillage, and terraces provide additional protection against erosion. Permanent plant cover of tame pasture, native grasses, or trees help provide erosion protection. Fertilizer amendments are generally needed to produce good forage or crop growth.

This soil has fair to good potential for most urban uses. The principal limitations are rippable rock at 20 to 40 inches and low bearing strength. These limitations can be overcome by careful design and installation procedures. Capability subclass IIIe; Sandy Savannah range site.

44—Stephenville fine sandy loam, 2 to 5 percent slopes, eroded. This moderately deep, well drained, gently sloping eroded soil is on uplands. It is on long, narrow to broad ridgetops and short hillsides. Individual areas range from 10 to several hundred acres in size.

Typically, the surface layer has been thinned by erosion and is strong brown fine sandy loam 3 inches thick. The subsoil is yellowish red and red sandy clay loam to a depth of 32 inches. The underlying material is red soft sandstone.

Erosion has removed part of the original surface layer over most of each mapped area. Gullies 1 to 3 feet deep and 3 to 20 feet wide occupy 15 to 25 percent of each area.

Permeability is moderate. Available water capacity is medium. This soil is low in natural fertility and organic-matter content. It is medium acid or slightly acid in the surface layer unless it has been limed. It has fair tilth. The root zone is moderately deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of eroded loamy soils that are 4 to 20 inches deep over sandstone. Also included are eroded soils similar to the profile described that have a more clayey subsoil. These included soils make up 15 to 20 percent of the map unit.

This soil has fair potential for cultivated crops. Low fertility and risk of erosion are limitations. Intensive conservation measures are needed to protect this soil from additional erosion. Crops that return residue to the soil, contour tillage, terraces, residue mulches, minimum tillage, and growing grasses or legumes in the crop rotation reduce loss from erosion. Maintaining a permanent plant cover of native or tame pasture grasses most effectively prevents additional erosion.

This soil has fair potential for most urban uses. The principal limitations are bedrock at 20 to 40 inches, risk of erosion, and low bearing strength. Most of these limitations are easily overcome by careful planning and design before installation of facilities. Capability subclass IIIe; Sandy Savannah range site.

45—Stephenville fine sandy loam, gullied. This moderately deep, well drained, very gently sloping to sloping soil is on ridgetops and hillsides of gullied uplands. Slopes are mostly convex and are dissected by gullies. They range from 1 to 8 percent. Individual areas range from 5 to 400 acres in size.

Gullies that are 5 to 60 feet wide and 3 to 10 feet deep make up about 25 percent of the area. They range from about 15 percent to 45 percent. Erosion has exposed the subsoil in about 25 percent of the area between the gullies.

Typically, the surface layer is brown fine sandy loam about 4 inches thick. The upper part of the subsoil is yellowish red sandy clay loam to a depth of 21 inches, and the lower part is red sandy clay loam to a depth of 36 inches. The underlying material is red soft sandstone.

Permeability is moderate. Available water capacity is medium. This soil is low in natural fertility and organic-matter content. It is medium acid or slightly acid in the surface layer unless it has been limed. It has fair tilth and can be worked throughout a wide range of moisture conditions. The root zone is moderately deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping is about 10 percent gullied soils similar to the Stephenville soils that are 40 to 65 inches thick. Also included are areas of gullied Nash soils that make up about 5 percent of the area. Separate areas of Nash soils are less than 5 acres in size.

This soil has poor potential for row crops, small grains, or other tilled crops. Gullies make the use of most farm equipment unfeasible, and susceptibility to erosion is high. This soil has poor potential for hay or pasture. Fair growth can be obtained by shaping and smoothing gullies and by applying fertilizer amendments according to plant needs. Growing perennial pasture plants and maintaining plant growth and residue on the surface throughout the year help control erosion.

This soil has fair potential for most urban development. Moderate depth to rock, low strength, slopes of 2 to 6 percent, numerous gullies 3 to 10 feet deep, and susceptibility to erosion are the principal limitations. Most of these limitations can be overcome by very careful planning and design before installation of facilities. Capability subclass VIe; Eroded Sandy Savannah range site.

46—Tamford-Grainola complex, 5 to 12 percent slopes. This complex consists of small areas of Tamford and Grainola soils that could not be separated at the scale selected for mapping. It occurs as narrow bands above drainageways and as broad convex areas of ridgetops and side slopes. Individual areas range from 1/4 acre to about 6 acres in size.

Tamford clay loam makes up about 50 percent of each mapped area. Typically, the surface layer is reddish brown clay loam about 6 inches thick. The next layer is reddish brown and red clay to a depth of 48 inches. The underlying material is red weathered shale (fig. 7).

Permeability is very slow. Available water capacity is high. This soil is medium in natural fertility and organic-matter content. It is moderately alkaline or mildly alkaline in the surface layer and moderately alkaline in the remainder of the profile.

Grainola clay loam makes up 35 percent of each mapped area. Typically, the surface layer is dark reddish gray clay loam about 4 inches thick. The upper part of the subsoil is reddish brown clay to a depth of about 20 inches, and the lower part is red shaly clay to a depth of 26 inches. The underlying material is red weathered shale.

Permeability is slow. Available water capacity is medium. This soil is medium in natural fertility and organic-matter content. It is moderately alkaline throughout.

Included with this complex in mapping are small areas of Lucien and Renfrow soils. Also included along small narrow alluvial drainageways are areas that consist of loamy sediment. South of Purcell are a few areas of steep clayey escarpments. The included soils make up 15 percent of the soil complex.

This complex has low potential for farming. It has fair potential for tame pasture or native grass.

This complex has poor potential for urban use. High shrink-swell potential, slope, low bearing strength, and slow percolation rate are the main limitations. Capability subclass VIe; Tamford soil in Red Clay Prairie range site, and Grainola soil in Shallow Prairie range site.

47—Teller loam, 1 to 3 percent slopes. This deep, well drained, very gently sloping soil is on high terraces. Slopes are smooth and convex. Individual areas are 5 to 400 acres in size.

Typically, the surface layer is brown loam about 12 inches thick. The upper part of the subsoil is yellowish brown loam to a depth of 19 inches, the next part is light brown and light reddish brown loam to a depth of 50 inches, and the lower part is reddish yellow fine sandy loam to a depth of more than 60 inches.

Permeability is moderate. Available water capacity is high. This soil is high in natural fertility and organic-matter content. It is medium acid or slightly acid in the surface layer unless limed. The subsoil layers are medium acid to neutral. The soil has good tilth and can be worked throughout a wide range of moisture conditions. The root zone is deep, and the soil is easily penetrated by plant roots.

Included with this soil in mapping are areas of Grant and Pond Creek soils. Also included are soils similar to the Teller soil that are more clayey in the lower part of the subsoil. These included soils make up 10 to 20 percent of the map unit, but separate areas are less than 5 acres in size.

This soil has good potential for row crops, small grains, and hay or pasture. Good tilth is easily maintained by returning crop residue to the soil. Erosion is a moderate hazard if cultivated crops are grown. Minimum tillage, contour tillage, the use of cover crops, and terraces slow runoff and help to control erosion.

This soil has good potential for most urban uses. Seepage into underground water supplies can be a hazard for some facilities. Capability subclass IIe; Loamy Prairie range site.

Use and management of the soils

The soil survey is a detailed inventory and evaluation of the most basic resource of the survey area—the soil. It is useful in adjusting land use, including urbanization, to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in uses of the land.

While a soil survey is in progress, soil scientists, conservationists, engineers, and others keep extensive notes about the nature of the soils and about unique aspects of behavior of the soils. These notes include data on erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic tank disposal systems, and other factors affecting the productivity, potential, and limitations of the soils under various uses and management. In this way, field experience and measured data on soil properties and performance are used as a basis for predicting soil behavior.

Information in this section is useful in planning use and management of soils for crops and pasture, rangeland, and woodland; as sites for buildings, highways and other transportation systems, sanitary facilities, and parks and other recreation facilities; and for wildlife habitat. From the data presented, the potential of each soil for specified land uses can be determined, soil limitations to these land uses can be identified, and costly failures in houses and other structures, caused by unfavorable soil properties, can be avoided. A site where soil properties are favorable can be selected, or practices that will overcome the soil limitations can be planned.

Planners and others using the soil survey can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area and on the environment. Productivity and the environment are closely related to the nature of the soil. Plans should maintain or create a land-use pattern in harmony with the natural soil.

Contractors can find information that is useful in locating sources of sand and gravel, roadfill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists also can find useful information in this soil survey. The safe disposal of wastes, for example, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, and trees and shrubs are influenced by the nature of the soil.

Crops and pasture

TED LEHMAN, conservation agronomist, Soil Conservation Service, helped prepare this section.

The major management concerns in the use of the soils for crops and pasture are described in this section. In addition, the crops or pasture plants best suited to the soil, including some not commonly grown in the survey area, are discussed; the system of land capability classification used by the Soil Conservation Service is explained; and the predicted yields of the main crops and hay and pasture plants are presented for each soil.

This section provides information about the overall agricultural potential of the survey area and about the management practices that are needed. The information is useful to equipment dealers, land improvement contractors, fertilizer companies, processing companies, planners, conservationists, and others. For each kind of soil, information about management is presented in the section "Soil maps for detailed planning." Planners of management systems for individual fields or farms, should also consider the detailed information given in the description of each soil.

More than 160,000 acres in the survey area was used for crops and pasture in 1967, according to the Conservation Needs Inventory (*3*). Of this total, 60,000 acres was used for permanent pasture; 28,000 acres, for row crops, mainly cotton and grain sorghum; 33,000 acres, for close-growing crops, mainly wheat and oats; and 16,000 acres, for rotation hay and pasture. The rest was idle cropland.

The soils in McClain County have good potential for increased production of food. About 82,000 acres of potentially good cropland is currently used as range, and about 33,000 acres is pasture. In addition to the reserve productive capacity represented by this land, food production could also be increased considerably by extending the latest crop production technology to all cropland in the survey area. This soil survey can help facilitate the application of such technology.

Acreage in crops and pasture has gradually been decreasing as more and more land is used for urban development. In 1967 there were about 15,000 acres of urban and built-up land in the survey area, and this figure has been growing at the rate of about 160 acres per year. The use of this soil survey to help make land use decisions that will influence the future role of farming in the county is discussed in the section "General soil map for broad land use planning."

Soil erosion is the major concern on about two-thirds of the cropland and pasture in McClain County. If slope is more than 2 percent, erosion is a hazard. Grant, Konawa, Minco, Renfrow, and Stephenville soils, for example, have slopes of 2 percent or more.

Loss of the surface layer through erosion is damaging for two reasons. First, productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the plow layer. Loss of the surface layer is especially damaging on soils that have a clayey subsoil, such as Kirkland, Renfrow, and Grainola soils, and on soils that have a layer in or below the subsoil that limits the depth of the root zone. Such layers include bedrock, as in Nash, Lucien, Grant, Stephenville, and Grainola soils. Erosion also reduces productivity on soils that tend to be droughty, such as Konawa loamy fine sand and Gaddy soils. Second, soil erosion on farmland results in sedimentation of streams. Control of erosion minimizes the pollution of streams by sediment and improves the quality of water for municipal use, for recreation, and for fish and wildlife.

In many sloping fields, tilling or preparing a good seedbed is difficult on clayey or hardpan spots because the original friable surface soil has been eroded away. Such spots are common in areas of moderately eroded Renfrow soils.

Erosion control practices provide protective surface cover, reduce runoff, and increase infiltration. A cropping system that keeps plant cover on the soil for extended periods can hold soil erosion losses to amounts that will not reduce the productive capacity of the soils. On livestock farms, which require pasture and hay, the legume and grass forage crops in the cropping system reduce erosion on sloping land, provide nitrogen, and improve tilth for the following crop.

Slopes are so short and irregular that contour tillage or terracing is not practical in most areas of the undulating Gaddy-Gracemore complex. On these soils, a cropping system that provides substantial plant cover is required to control erosion unless minimum tillage is practiced. Minimizing tillage and leaving crop residue on the surface help increase infiltration and reduce the hazards of runoff and erosion. These practices can be adapted to most soils in the survey area, but they are more difficult to use sucessfully on the eroded soils and on the soils that have a clayey surface layer, such as Renfrow and Clarita soils. No-tillage for corn is effective in reducing erosion on sloping land and can be adapted to some soils in the survey area. It is more difficult to practice successfully, however, on the soils that have a clayey surface layer.

Terraces or diversions reduce the length of slope and reduce runoff and erosion. They are most practical on deep, well drained soils that have nearly level slopes. Most soils in the county are suitable for terraces. Some soils are less suitable for terraces and diversions because of irregular slopes, excessive wetness in the terrace channels, a clayey subsoil which would be exposed in terrace channels, or bedrock at a depth of less than 40 inches.

Contouring and contour stripcropping are erosion control practices in the survey area. They are best adapted to soils that have smooth, uniform slopes, including most areas of the sloping Bethany, Clarita, Grainola, Grant, Minco, Pond Creek, Renfrow, Stephenville, and Teller soils.

Soil blowing is a hazard on the sandy Konawa and Gaddy soils. Soil blowing can damage these soils in a few hours if winds are strong and the soils are dry and bare of vegetation or surface mulch. Maintaining vegetative cover, surface mulch, or rough surfaces through proper tillage minimizes soil blowing on these soils. Windbreaks of suited trees and shrubs are effective in reducing soil blowing.

Information for the design of erosion control practices for each kind of soil is contained in the Technical Guide, available in local offices of the Soil Conservation Service.

Soil drainage is the major management need on some of the acreage used for crops and pasture in the survey area.

Unless artifically drained, the somewhat poorly drained soils are so wet that crops are damaged during most years. In this category are the Gracemont, Gracemore, and Lela soils.

Asher, Clarita, Miller, and Pawhuska soils have good natural drainage most of the year, but they tend to dry out slowly after rains. Small areas of wetter soils along drainageways and in swales are commonly included in areas of these moderately well drained soils. Artificial drainage is needed in some of these wetter areas.

The design of both surface and subsurface drainage systems depends on the kind of soil. A combination of surface drainage and tile drainage is needed in some areas of the somewhat poorly drained soils used for intensive row cropping. Drains have to be more closely spaced in soils that have slow permeability than in more permeable soils. Tile drainage is very slow in Lela soils. Finding adequate outlets for tile drainage systems is difficult in many areas of Gracemont and Gracemore soils.

Information on drainage design for each kind of soil is contained in the Technical Guide, available in local offices of the Soil Conservation Service.

Soil fertility is naturally moderate to high in most soils on uplands in the survey area. Most soils are slightly acid. The soils on flood plains, such as Asher, Asa, Canadian, Gaddy, Gracemont, Gracemore, Keokuk, Lela, Miller, and Port soils, range from neutral to moderately alkaline and are naturally higher in plant nutrients than most upland soil. Pulaski soils are slightly acid or medium acid.

Some soils on uplands are naturally medium acid. If they have never been limed, applications of ground limestone are required to raise the pH level sufficiently for good growth of alfalfa and other crops that grow only on nearly neutral soils. Available phosphorus and potash levels are naturally low in most of these soils. On all soils additions of lime and fertilizer should be based on the results of soil tests, on the need of the crop, and on the expected level of yields. The County Extension Service can help in determining the kinds and amounts of fertilizer and lime to apply.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils with good tilth are granular and porous.

Most of the soils used for crops in the survey area have a surface layer of silt loam that is dark in color and high or moderate in content of organic matter. Generally the structure of such soils is weak, and intense rainfall causes the formation of a crust on the surface. The crust is hard when dry and nearly impervious to water. Once the crust forms, it reduces infiltration and increases runoff. Regular additions of crop residue, manure, and other organic material can help improve soil structure and reduce crust formation.

Fall plowing is generally not a good practice on the county's soils that have a surface layer of silt loam because of the crust that forms during winter and spring. Many of the soils are nearly as dense and hard at planting time after fall plowing as they were before they were plowed. Also, most of the cropland consists of sloping soils that are subject to damaging erosion if they are plowed in the fall.

The dark colored Miller, Lela, and Clarita soils are clayey, and tilth is a concern because the soils often stay wet until late in spring. If they are wet when plowed, they tend to be very cloddy when dry and good seedbeds are difficult to prepare. Fall plowing on such wet soils generally results in good tilth in the spring.

Field crops suited to the soils and climate of the survey area include many that are not now commonly grown. Cotton, grain sorghum, peanuts, and soybeans are the row crops. Corn, sunflowers, navy beans, potatoes, and similar crops can be grown if economic conditions are favorable.

Wheat, alfalfa, and oats are the common close-growing crops. Rye, barley, and forage sorghums could be grown, and grass seed could be produced from weeping lovegrass, switchgrass, or other suited grasses.

Special crops grown commercially in the survey area are vegetables, small fruits, tree fruits, and nursery plants. A small acreage throughout the county is used for melons, strawberries, squash, okra, sweet corn, tomatoes, peppers, and other vegetables and small fruits. In addition, large areas can be adapted to other special crops such as blackberries, grapes, and many vegetables. Apples and peaches are the most important tree fruits grown in the county. Pecans are an important nut crop.

Deep soils that have good natural drainage and that warm up early in spring are especially well suited to many vegetables and small fruits. In the survey area these are the Grant, Minco, Konawa, Pond Creek, and Teller soils on slopes of less than 6 percent.

Most of the deep, well drained soils in the survey area are suited to orchards and nursery plants. Soils in low positions where frost is frequent and air drainage is poor, however, generally are poorly suited to early vegetables, small fruits, and orchards.

Latest information and suggestions for growing special crops can be obtained from local offices of the County Extension Service and the Soil Conservation Service.

Pasture management

The acreage of soils used for pasture and hay production in McClain County is increasing rapidly. Many idle fields that were fomerly cultivated and native range in poor condition are being converted to tame pasture. Most of the soils in the county are suited.

The principal tame pasture grasses are improved bermudagrass, weeping lovegrass, and King Ranch bluestem.

Bermudagrass pastures are occasionally overseeded with rye, winter wheat, ryegrass, or fescue to provide grazing late in fall and early in spring. Cool season legumes, such as hairy vetch, are overseeded in some bermudagrass pastures.

Weeping lovegrass is an important grass in the county. It is better suited to sandy or loamy soils that are well drained, such as Konawa or Stephenville soils, than to other soils. It supplies abundant summer forage, but must be carefully managed to maintain livestock palatability.

King Ranch bluestem is a common pasture grass. It is better suited to the more clayey soils, such as Grainola, Clarita, and Tamford soils, than to other soils. It is difficult to establish but is drought resistant.

Sudangrass and hybrid forage sorghums are grown for hay and pasture in some parts of the county. These grasses are commonly planted on such flood plain soils as Pulaski and Port for supplemental summer grazing.

Fescue is better suited to the flood plain soils that have large amounts of available moisture than to other soils. Fescue grass furnishes some fall and winter grazing, but the best forage production is early in spring. It is difficult to maintain a vigorous stand of fescue on most soils in the county.

Winter small grains combinations such as rye and ryegrass, and vetch and rye are grown on some cultivated soils to provide winter and spring forage. These crops are harvested for grain or hay, or are grazed.

A pasture program needs to be planned to provide the desired amount of forage for each month of the year. In figure 8 the months in which various kinds of forage plants grow, and the percent of growth for each kind of plant are indicated. For example, bermudagrass makes 24 percent of its yearly growth for forage during the month of June.

Soils vary in their ability to produce forage for grazing. The Bethany soil produces more forage than the Renfrow soil, mainly because it furnishes more available moisture to the plant. The Soil Conservation Service or the County Extension Service can assist in planning a pasture program.

Yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors. Absence of an estimated yield indicates that the crop is not suited to or not commonly grown on the soil.

The estimated yields were based mainly on the experience and records of farmers, conservationists, and extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The yields were estimated assuming that the latest soil and crop management practices were used. Hay and pasture yields were estimated for the most productive varieties of grasses and legumes suited to the climate and the soil. A few farmers may be obtaining average yields higher than those shown in table 5.

The management needed to achieve the indicated yields of the various crops depends on the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including time of tillage and seedbed preparation and tilling when soil moisture is favorable; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residues, barnyard manure, and green-manure crops; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

The estimated yields reflect the productive capacity of the soils for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not included because the acreage of these crops is small. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide information about the management concerns and productivity of the soils for these crops.

Capability classes and subclasses

Capability classes and subclasses show, in a general way, the suitability of soils for most kinds of field crops. The soils are classed according to their limitations 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 rice, cranberries, horticultural crops, or other crops that require special management. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forest trees, or for engineering purposes.

In the capability system, all kinds of soil are grouped at two levels: capability class and subclass. Only the levels class and subclass were used in this soil survey. These levels are defined in the following paragraphs. A survey area may not have soils of all classes.

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

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, or that 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.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and landforms have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

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

The capability subclass is identified in the description of each soil mapping unit in the section "Soil maps for detailed planning."

Rangeland

ERNEST C. SNOOK, range conservationist, Soil Conservation Service, helped prepare this section.

About 42 percent of McClain County is range. About half of the farm income is derived from livestock, principally cattle. Cow-calf-steer operations are dominant in the northern part of the county, and cow-calf-steer-yearling operations are prevalent in the western and southern part.

On many ranches the forage produced on rangeland is supplemented by crop stubble and small grain. In winter the native forage is often supplemented with protein concentrate. Creep feeding of calves and yearlings to increase market weight is practiced on some ranches.

The native vegetation in some parts of the survey area has been greatly depleted by continued excessive use. Some of the acreage that was once open grassland is now covered with brush and weeds. The amount of forage produced may be less than half of that originally produced. Productivity of the range can be increased by using management practices that are effective for specific kinds of soil and range sites.

Where climate and topography are about the same, differences in the kind and amount of vegetation that rangeland can produce are related closely to the kind of soil. Effective management is based on the relationships among soils, vegetation, and water.

Table 6 shows, for each kind of soil, the name of the range site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the expected percentage of each species in the composition of the potential natural plant community. Soils not listed cannot support a natural plant community of predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. The following are explanations of column headings in table 6.

A *range site* is a distinctive kind of rangeland that differs from other kinds of rangeland in its ability to produce a characteristic natural plant community. Soils that produce a similar kind, amount, and proportion of range plants are grouped into range sites. For those areas where the relationship between soils and vegetation has been established, range sites can be interpreted directly from the soil map. Properties that determine the capacity of the soil to supply moisture and plant nutrients have the greatest influence on the productivity of range plants. Soil reaction and salt content are also important.

Total production refers to the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting the potential natural plant community. It is expressed in pounds per acre of air-dry vegetation for favorable, normal, and unfavorable years. In a favorable year the amount and distribution of precipitation and the temperatures are such that growing conditions are substantially better than average; in a normal year these conditions are about average for the area; in an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Dry weight refers to the total air-dry vegetation produced per acre each year by the potential natural plant community. Vegetation that is highly palatable to livestock and vegetation that is unpalatable are included. Some of the vegetation can also be grazed extensively by wildlife.

Characteristic vegetation is grasses, grasslike plants, forbs, and shrubs that make up most of the potential natural plant community on each soil listed by common name. Under *Composition*, the expected proportion of each species is presented as the percentage, in air-dry weight, of the total annual production of herbaceous and woody plants. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season. Generally all of the vegetation produced is not used.

Range management requires, in addition to knowledge of the kinds of soil and the potential natural plant community, an evaluation of the present condition of the range vegetation in relation to its potential. Range condition is determined by comparing the present plant community with the potential natural plant community on a particular range site. The more closely the existing community resembles the potential community, the better the range condition. The objective in range management is to control grazing so that the plants growing on a site are about the same in kind and amount as the potential natural plant community for that site. Such management generally results in the maximum production of vegetation, conservation of water, and control of erosion. Sometimes, however, a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Most of the soils in the northern part of the county are deep and loamy. These soils originally supported tall grasses. Potential productivity is high because of the deep rooting depth. The soils in much of the southwestern part of the county are shallow and moderately deep. Large areas are covered by oak brush. Potential productivity of these soils is much less than that of the deeper soils.

Management of grazing animals to maintain the kinds and amounts of plants that make up the potential plant community or allow them to become reestablished is the major management concern. Managing brush and minimizing soil erosion are also important management concerns. Potential is good for increasing range productivity if range management is based on soil survey information and rangeland inventories.

Windbreaks and environmental plantings

NORMAN E. SMOLA, woodland conservationist, Soil Conservation Service, helped prepare this section.

Windbreaks are established to protect livestock, buildings, and yards from wind and snow. Windbreaks also help protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broad-leaved and coniferous species provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field, the interval depending on erodibility of the soil. They protect cropland and crops from wind, hold snow on the fields, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. A healthy planting stock of suitable species planted properly on a well prepared site and maintained in good condition can insure a high degree of plant survival.

Table 7 shows the height that locally grown trees and shrubs are expected to reach on various kinds of soil in 20 years. The estimates in table 7 based on measurements and observation of established plantings that have been given adequate care, can be used as a guide in planning windbreaks and screens. Additional information about planning windbreaks and screens and the planting and care of trees can be obtained from local offices of the Soil Conservation Service or the County Extension Service or from nurserymen.

Engineering

WILLIAM E. HARDESTY, civil engineer, Soil Conservation Service, helped prepare this section.

This section provides information about the use of soils for building sites, sanitary facilities, construction material, and water management. Among those who can benefit from this information are engineers, landowners, community planners, town and city managers, land developers, builders, contractors, and farmers and ranchers.

The ratings in the engineering tables are based on test data and estimated data in the "Soil properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service using known relationships between the soil properties and the behavior of soils in various engineering uses.

Among the soil properties and site conditions identified by a soil survey and used in determining the ratings in this section were grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock that is within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of absorbed cations were also considered.

On the basis of information assembled about soil properties, ranges of values can be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of expected soil behavior in engineering uses. As appropriate, these values can be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works. The ranges of values can be used to (1) select potential residential, commercial, industrial, and recreational uses; (2) make preliminary estimates pertinent to construction in a particular area; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities; (5) plan detailed onsite investigations of soils and geology; (6) find sources of gravel, sand, clay, and topsoil; (7) plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; (8) relate performance of structures already built to the properties of the kinds of soil on which they are built so that performance of similar structures on the same or a similar soil in other locations can be predicted; and (9) predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. First, the data are generally not presented for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations, testing, and analysis by personnel having expertise in the specific use contemplated.

The information is presented mainly in tables. Table 8 shows, for each kind of soil, the degree and kind of limitations for building site development, and table 9, for sanitary facilities. Table 10 shows the suitability of each kind of soil as a source of construction materials. Table 11 shows the degree and kind of limitation for water management.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations and to construct interpretive maps for specific uses of land.

Some of the terms used in this soil survey have a special meaning in soil science. Many of these terms are defined in the Glossary.

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 8. A *slight* limitation indicates that soil properties generally are favorable for the specified use; any limitation is minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are made for pipelines, sewerlines, communications and power transmission lines, basements, open ditches, and cemeteries. Such digging or trenching is influenced by soil wetness caused by a seasonal high water table; the texture and consistence of soils; the tendency of soils to cave in or slough; and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the soil series descriptions, the consistence of each soil horizon is given, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and *small commercial buildings* referred to in table 8 are built on undisturbed soil and have foundation loads of a dwelling no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence of the structure from settling or shear failure of the foundation does not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and large stones in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious hazard.

Local roads and streets referred to in table 8 have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than 6 feet deep.

The load supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in design and construction of roads and streets. The classifications of the soil and the soil texture, density, shrink-swell potential, and potential frost action are indicators of the traffic supporting capacity used in making the ratings. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones affect stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, those soil properties that affect ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 9 shows the degree and kind of limitations of each soil for such uses and for use of the soil as daily cover for landfills. It is important to observe local ordinances and regulations.

If the degree of soil limitation is expressed as *slight*, soils are generally favorable for the specified use and limitations are minor and easily overcome; if *moderate*, soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe*, soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance is required. Soil suitability is rated by the terms *good, fair*, or *poor*, which, respectively, mean about the same as the terms *slight, moderate*, and *severe*.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and those that affect the construction of the system.

Properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and shallowness to bedrock interfere with installation. Excessive slope can cause lateral seepage and surfacing of the effluent. Also, soil erosion and soil slippage are hazards if absorption fields are installed on sloping soils.

In some soils, loose sand and gravel or fractured bedrock is less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and ground water in the area may be contaminated.

On many of the soils that have moderate or severe limitations for use as septic tank absorption fields, a system to lower the seasonal water table can be installed or the size of the absorption field can be increased so that performance is satisfactory.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons have a nearly level floor and cut slopes or embankments of compacted soil material. Aerobic lagoons generally are designed to hold sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Soils that are very high in content of organic matter and those that have cobbles, stones, or boulders are not suitable. Unless the soil has very slow permeability, contamination of ground water is a hazard where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce the lagoon's capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the suitability of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soil material affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste by placing refuse in successive layers either in excavated trenches or on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil material. Landfill areas are subject to heavy vehicular traffic. Risk of polluting ground water and trafficability affect the suitability of a soil for this use. The best soils have a loamy or silty texture, have moderate to slow permeability, are deep to a seasonal water table, and are not subject to flooding. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability, which might allow noxious liquids to contaminate ground water. Soil wetness can be a limitation, because operating heavy equipment on a wet soil is difficult. Seepage into the refuse increases the risk of pollution of ground water.

Ease of excavation affects the suitability of a soil for the trench type of landfill. A suitable soil is deep to bedrock and free of large stones and boulders. If the seasonal water table is high, water will seep into trenches.

Unless otherwise stated, the limitations in table 9 apply only to the soil material within a depth of about 6 feet. If the trench is deeper, a limitation of slight or moderate may not be valid. Site investigation is needed before a site is selected.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill in wet and dry periods. Soils that are loamy or silty and free of stones or boulders are better than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

The soils selected for final cover of landfills should be suitable for growing plants. Of all the horizons, the A horizon in most soils has the best workability, more organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

Where it is necessary to bring in soil material for daily or final cover, thickness of suitable soil material available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas. These factors include slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of roadfill, sand, gravel, and topsoil is indicated in table 10 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth observed, generally about 6 feet.

Roadfill is soil material used in embankments for roads. Soils are evaluated as a source of roadfill for low embankments, which generally are less than 6 feet high and less exacting in design than high embankments. The ratings reflect the ease of excavating and working the material and the expected performance of the material where it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about some of the soil properties that influence such performance is given in the descriptions of the soil series.

The ratings apply to the soil material between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within their profile. The estimated engineering properties in table 14 provide specific information about the nature of each horizon. This information can help determine the suitability of each horizon for roadfill.

Soils rated *good* are coarse grained. They have low shrink-swell potential, low potential frost action, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as moderate shrink-swell potential, moderately steep slopes, wetness, or many stones. If the thickness of suitable material is less than 3 feet, the entire soil is rated *poor*.

Sand and *gravel* are used in great quantities in many kinds of construction. The ratings in table 10 provide guidance as to where to look for probable sources and are based on the probability that soils in a given area contain sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, and stratification are given in the soil series descriptions and in table 14.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to support plantlife. Also considered is the damage that can result at the area from which the topsoil is taken.

The ease of excavation is influenced by the thickness of suitable material, wetness, slope, and amount of stones. The ability of the soil to support plantlife is determined by texture, structure, and the amount of soluble salts or toxic substances. Organic matter in the A1 or Ap horizon greatly increases the absorption and retention of moisture and nutrients. Therefore, the soil material from these horizons should be carefully preserved for later use.

Soils rated *good* have at least 16 inches of friable loamy material at their surface. They are free of stones and cobbles, are low in content of gravel, and have gentle slopes. They are low in soluble salts that can limit or prevent plant growth. They are naturally fertile or respond well to fertilizer. They are not so wet that excavation is difficult during most of the year.

Soils rated *fair* are loose sandy soils or firm loamy or clayey soils in which the suitable material is only 8 to 16 inches thick or soils that have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils and very firm clayey soils; soils with suitable layers less than 8 inches thick; soils having large amounts of gravel, stones, or soluble salt; steep soils; and poorly drained soils.

Although a rating of *good* is not based entirely on high content of organic matter, a surface horizon is generally preferred for topsoil because of its organic-matter content. This horizon is designated as A1 or Ap in the soil series descriptions. The absorption and retention of moisture and nutrients for plant growth are greatly increased by organic matter.

Water management

Many soil properties and site features that affect water management practices have been identified in this soil survey. In table 11 the degree of soil limitation and soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water control structures.

Soil and site limitations are expressed as slight, moderate, and severe. *Slight* means that the soil properties and site features are generally favorable for the specified use and that any limitation is minor and easily overcome. *Moderate* means that some soil properties or site features are unfavorable for the specified use but can be overcome or modified by special planning and design. *Severe* means that the soil properties and site features are so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have a low seepage potential, which is determined by permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and has favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Large stones and organic matter in a soil downgrade the suitability of a soil for use in embankments, dikes, and levees.

Aquifer-fed excavated ponds are bodies of water made by excavating a pit or dugout into a ground-water aquifer. Excluded are ponds that are fed by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Ratings in table 11 are for ponds that are properly designed, located, and constructed. Soil properties and site features that affect aquifer-fed ponds are depth to a permanent water table, permeability of the aquifer, quality of the water, and ease of excavation.

Drainage of soil is affected by such soil properties as permeability; texture; depth to bedrock, hardpan, or other layers that affect the rate of water movement; depth to the water table; slope; stability of ditchbanks; susceptibility to flooding; salinity and alkalinity; and availability of outlets for drainage.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to intercept runoff. They allow water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock, hardpan, or other unfavorable material; large stones; permeability; ease of establishing vegetation; and resistance to water erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff to outlets at a nonerosive velocity. Features that affect the use of soils for waterways are slope, permeability, erodibility, wetness, and suitability for permanent vegetation.

Recreation

The soils of the survey area are rated in table 12 according to limitations that affect their suitability for recreation uses. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area and its scenic quality, the ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degree, for recreation use by the duration and intensity of flooding and the season when flooding occurs. Onsite assessment of height, duration, intensity, and frequency of flooding is essential in planning recreation facilities.

The degree of the limitation of the soils is expressed as slight, moderate, or severe. *Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 12 can be supplemented by information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 9, and interpretations for dwellings without basements and for local roads and streets, given in table 8.

Camp areas require such site preparation as shaping and leveling for tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils for this use have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing camping sites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for use as picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones or boulders, is firm after rains, and is not dusty when dry. If shaping is required to obtain a uniform grade, the depth of the soil over bedrock or hardpan should be enough to allow necessary grading.

Paths and trails for walking, horseback riding, bicycling, and other uses should require little or no cutting and filling. The best soils for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the annual period of use. They should have moderate slopes and have few or no stones or boulders on the surface.

Wildlife habitat

Jerome F. Sykora, biologist, Soil Conservation Service, helped prepare this section.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the construction of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, is inadequate, or is inaccessible, wildlife either are scarce or do not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by helping the natural establishment of desirable plants.

In table 13, the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in planning for parks, wildlife refuges, nature study areas, and other developments for wildlife; selecting areas that are suitable for wildlife; selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat; and determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, lespedeza, lovegrass, switchgrass, bromegrass, orchardgrass, clover, alfalfa, and crownvetch.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds, that provide food and cover for wildlife. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiangrass, goldenrod, beggarweed, pokeweed, partridgepea, wheatgrass, fescue, and grama.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of native plants are oak, pecan, cherry, mulberry, apple, hawthorn, dogwood, persimmon, sassafras, sumac, hickory, hackberry, black walnut, blackberry, grape, blackhaw, viburnum, black locust, and briers. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated *good* are Russian-olive, autumn-olive, wild plum, and crabapple.

Coniferous plants are cone-bearing trees, shrubs, or ground cover plants that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Soil properties that have a major effect on the growth of coniferous plants are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, yew, cedar, and juniper.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture. Examples of shrubs are coralberry, currant, leadplant, and elderberry.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, saltgrass, and cordgrass and rushes, sedges, and reeds.

Shallow water areas are bodies of water that have an average depth of less than 5 feet and that are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control structures in marshes or streams. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, meadowlark, field sparrow, killdeer, cottontail rabbit, fox, and coyote.

Woodland habitat consists of areas of hardwoods or conifers, or a mixture of both, and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas includes wild turkey, thrushes, vireos, woodpeckers, squirrels, gray fox, raccoon, and deer.

Wetland habitat consists of open, marshy or swampy, shallow water areas where water-tolerant plants grow. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, rail, kingfishers, muskrat, mink, and beaver.

Rangeland habitat consists of areas of wild herbaceous plants and shrubs. Wildlife attracted to rangeland includes white-tailed deer, prairie dog, bobwhite quail, jackrabbit, meadowlark, and lark bunting.

Soil properties

Extensive data about soil properties are summarized on the following pages. The two main sources of these data are the many thousands of soil borings made during the course of the survey and the laboratory analyses of selected soil samples from typical profiles.

In making soil borings during field mapping, soil scientists can identify several important soil properties. They note the seasonal soil moisture condition or the presence of free water and its depth. For each horizon in the profile, they note the thickness and color of the soil material; the texture, or amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or the natural pattern of cracks and pores in the undisturbed soil; and the consistence of the soil material in place under the existing soil moisture conditions. They record the depth of plant roots, determine the pH or reaction of the soil, and identify any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to determine all major properties of key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many soil series not tested are available from nearby survey areas.

The available field and laboratory data are summarized in tables. The tables give the estimated range of engineering properties, the engineering classifications, and the physical and chemical properties of each major horizon of each soil in the survey area. They also present data about pertinent soil and water features, engineering test data, and data obtained from physical and chemical laboratory analyses of soils.

Engineering properties

Table 14 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. Table 14 gives information for each of these contrasting horizons in a typical profile. *Depth* to the upper and lower boundaries of each horizon is indicated. More information about the range in depth and about other properties in each horizon is given for each soil series in the section "Soil series and morphology."

Texture is described in table 14 in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified Soil Classification System (Unified) (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*).

The *Unified* system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes—eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes have a dual classification symbol, for example, CL-ML.

The *AASHTO* system classifies soils according to those properties that affect their use in highway construction and maintenance. In this system a mineral soil is classified 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. Soils in group A-1 are coarse grained and low in content of fines. At the other extreme, in group A-7, are fine-grained soils. Highly organic soils are classified in group A-8 on the basis of visual inspection. The estimated classification, without group index numbers, is given in table 14. Also in table 14 the percentage, by weight, of rock fragments more than 3 inches in diameter is estimated for each major horizon. These estimates are determined mainly by observing volume percentage in the field and then converting that, by formula, to weight percentage.

Percentage of the soil material less than 3 inches in diameter that passes each of four sieves (U.S. standard) is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas and on field estimates from many borings made during the survey.

Liquid limit and *plasticity index* indicate the effect of water on the strength and consistence of soil. These indexes are used in both the Unified and AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior. Range in liquid limit and plasticity index are estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

In some surveys, the estimates are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount across classification boundaries (1 or 2 percent), the classification in the marginal zone is omitted.

Physical and chemical properties

Table 15 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the typical pedon of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships among the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for vertical water movement when the soil is saturated. Not considered in the estimates is lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in planning and designing drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

Available water capacity is rated on the basis of soil characteristics that influence the ability of the soil to hold water and make it available to plants. Important characteristics are content of organic matter, soil texture, and soil structure. Shallow-rooted plants are not likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown.

Soil reaction is expressed as a range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops, ornamental plants, or other plants to be grown; in evaluating soil amendments for fertility and stabilization; and in evaluating the corrosivity of soils.

Salinity is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of the nonirrigated soils. The salinity of individual irrigated fields is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of individual fields can differ greatly from the value given in table 15. Salinity affects the suitability of a soil for crop production, its stability when used as a construction material, and its potential to corrode metal and concrete.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others the swelling was estimated on the basis of the kind and amount of clay in the soil and on measurements of similar soils. The size of the load and the magnitude of the change in soil moisture content also influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A high shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Uncoated steel intersecting soil boundaries or soil horizons is more susceptible to corrosion than an installation that is entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the erodibility of a soil and its tolerance to erosion in relation to specific kinds of land use and treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values range from 0.10 to 0.64. To estimate annual soil loss per acre, the K value of a soil is modified by factors representing plant cover, grade and length of slope, management practices, and climate. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. The rate is expressed in tons of soil loss per acre per year.

Wind erodibility groups are made up of soils that have similar properties that affect their resistance to soil blowing if cultivated. The groups are used to predict the susceptibility of soil to blowing and the amount of soil lost as a result of blowing.

Soil and water features

Table 16 contains information helpful in planning land uses and engineering projects that are likely to be affected by soil and water features.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is the temporary covering of soil with water from overflowing streams, with runoff from adjacent slopes, and by tides. Water standing for short periods after rains or after snowmelts is not considered flooding, nor is water in swamps and marshes. Flooding is rated in general terms that describe the frequency and duration of flooding and the time of year when flooding is most likely. The ratings are based on evidence in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to flooding. The ratings are also based on local information about floodwater levels in the area and the extent of flooding; and on information that relates the position of each soil on the landscape to historic floods.

The generalized description of flood hazards is of value in land-use planning and provides a valid basis for land-use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table is the highest level of a saturated zone more than 6 inches thick for a continuous period of more than 2 weeks during most years. The depth to a seasonal high water table applies to undrained soils. Estimates are based mainly on the relationship between grayish colors or mottles in the soil and the depth to free water observed in many borings made during the course of the soil survey. Indicated in table 16 are the depth to the seasonal high water table; the kind of water table, that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. Only saturated zones above a depth of 5 or 6 feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not construction of basements is feasible and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown for all soils that are underlain by bedrock at a depth of 5 to 6 feet or less. For many soils, the limited depth to bedrock is a part of the definition of the soil series. The depths shown are based on measurements made in many soil borings and on other observations during the mapping of the soils. The kind of bedrock and its hardness as related to ease of excavation is also shown. Rippable bedrock can be excavated with a single-tooth ripping attachment on a 200-horsepower tractor, but hard bedrock generally requires blasting.

Soil series and morphology

In this section, each soil series recognized in the survey area is described in detail. The descriptions are arranged in alphabetic order by series name.

Characteristics of the soil and the material in which it formed are discussed for each series. The soil is then compared to similar soils and to nearby soils of other series. Then a pedon, a small three-dimensional area of soil that is typical of the soil series in the survey area, is described. The detailed descriptions of each soil horizon follow standards in the Soil Survey Manual (*4*). Unless otherwise noted, colors described are for dry soil.

Following the pedon description is the range of important characteristics of the soil series in this survey area. Phases, or map units, of each soil series are described in the section "Soil maps for detailed planning."

Asa series

The Asa series consists of well drained soils that formed in stratified loamy or silty alluvium on flood plains. These soils are smooth or slightly concave. Permeability is moderate. Slopes are less than 1 percent.

Asa soils are geographically associated with the Pulaski, Port, and Keokuk soils. Pulaski and Keokuk soils have less than 18 percent clay in the control section. Port soils have a thicker mollic epipedon.

Typical pedon of Asa loam, in a field 1,000 feet west and 350 feet south of the northeast corner of sec. 27, T. 6 N., R. 4 W.:

Ap—0 to 8 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; weak fine granular structure; hard, very friable; neutral; clear smooth boundary.

A1b—8 to 24 inches; reddish brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; weak medium subangular blocky structure; very hard, firm; mildly alkaline; clear smooth boundary.

B2b—24 to 43 inches; reddish brown (5YR 5/4) silty clay loam, dark reddish brown (5YR 3/4) moist, weak coarse subangular blocky structure; very hard, firm; few films of calcium carbonate; calcareous; moderately alkaline; clear smooth boundary.

Cb—43 to 60 inches; reddish yellow (5YR 6/6) loam, yellowish red (5YR 4/6) moist; hard, very friable; few thin strata of fine sandy loam; few films of calcium carbonate; calcareous; moderately alkaline.

Solum thickness ranges from 30 to 50 inches. The reaction of the A horizon and upper B2b horizon is neutral to moderately alkaline.

The Ap or upper part of the A1b horizon is commonly overwashed with 4 to 17 inches of loam or silty clay loam. It has a hue of 7.5YR or 5YR, value of 5 or 6, and chroma of 2 through 4.

The lower part of the A1b horizon has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3. It is silt loam or silty clay loam. It is 10 to 20 inches thick.

The B2b horizon has a hue of 7.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. It is silty clay loam or silt loam.

The Cb horizon has colors like the B2b horizon and may include stratification with lighter and darker colors. It is loam, silty clay loam, or silt loam.

Asher series

The Asher series consists of deep, moderately well drained soils that formed in thick loamy sediment on flood plains. These nearly level soils are on narrow bands of high flood plains along the South Canadian River. Permeability is slow. Slopes are less than 1 percent.

Asher soils are geographically associated with the Keokuk and Miller soils. Keokuk soils are at a slightly higher elevation and have a coarse-silty control section. Miller soils are on a slightly concave position on the flood plain and have a fine control section.

Typical pedon of Asher silty clay loam, in a field 100 feet west and 250 feet north of the southeast corner of the NW1/4 sec. 7, T. 5 N., R. 2 E.:

Ap—0 to 11 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; very hard, firm; calcareous; moderately alkaline; clear smooth boundary.

B2—11 to 27 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; very hard, very firm; few films of calcium carbonate; calcareous; moderately alkaline; clear smooth boundary.

IIC1—27 to 36 inches; light brown (7.5YR 6/4) loam; brown (7.5YR 4/4) moist; massive; hard, friable; calcareous, moderately alkaline; clear smooth boundary.

IIC2—36 to 65 inches; pink (7.5YR 7/4) very fine sandy loam, brown (7.5YR 5/4) moist; massive; hard, very friable; calcareous; moderately alkaline.

Solum thickness ranges from 20 to 30 inches. All horizons are moderately alkaline and calcareous.

The A horizon is 7 to 12 inches thick. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2.

The B2 horizon is 10 to 20 inches thick. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 to 4. It is silty clay loam.

The IIC horizons have a hue of 7.5YR or 5YR, value of 5 to 7, and chroma of 3 or 4. They are loam, very fine sandy loam, and silt loam with clay content from 8 to 18 percent. Thin strata of fine sandy loam or silty clay loam are in some pedons.

Bethany series

The Bethany series consists of deep, well drained soils that formed in thick Permian deposits on uplands. These nearly level to very gently sloping soils are on broad prairies. Permeability is slow. Slopes are 0 to 3 percent.

Bethany soils are geographically associated with the Pawhuska and Pond Creek soils. The Pawhuska soils are intermingled with Bethany soils on slightly concave areas. The Pawhuska soils lack a mollic epipedon and have a natric horizon. Pond Creek soils are at a slightly higher elevation and have a fine-silty control section.

Typical pedon of Bethany silt loam, in an area of Bethany silt loam, 0 to 1 percent slopes, in a field 2,575 feet west and 50 feet south of the northeast corner of sec. 26, T. 9 N., R. 4 W.:

Ap—0 to 7 inches; brown (10YR 4/3) silt loam, dark brown (10YR 3/3) moist; weak fine granular structure; hard, friable; slightly acid; abrupt smooth boundary.

A1—7 to 15 inches; brown (7.5YR 4/2) heavy silt loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; hard, friable; slightly acid; gradual smooth boundary.

B1—15 to 24 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; very hard, firm; slightly acid; gradual smooth boundary.

B21t—24 to 35 inches; brown (10YR 5/3) silty clay, dark brown (10YR 4/3) moist; moderate medium blocky structure; extremely hard, very firm; clay films on faces of peds; few fine black concretions; neutral; gradual smooth boundary.

B22t—35 to 60 inches; brown (10YR 5/3) silty clay, dark brown (10YR 4/3) moist; common medium distinct mottles of strong brown (7.5YR 5/6) and yellowish brown (10YR 5/8); weak coarse blocky structure; very hard, very firm; clay films on faces of peds; few fine black concretions; neutral; diffuse smooth boundary.

B3—60 to 72 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; few medium distinct mottles of light brown (7.5YR 6/4); weak coarse blocky structure; very hard, very firm; few fine black concretions; common fine concretions of calcium carbonate; moderately alkaline; diffuse smooth boundary.

C—72 to 80 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; massive; very hard, very firm; few concretions of calcium carbonate; few black concretions; moderately alkaline.

Solum thickness ranges from 60 inches to more than 80 inches. Reaction is medium acid to neutral in the A horizon and the B1 horizon. The Bt and B3 horizons are neutral to moderately alkaline. The soils crack when dry, but cracks rarely extend upward through the A horizon.

The A horizon is 10 to 18 inches thick. It has a hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3.

The B1 horizon is 3 to 10 inches thick. It has colors like the A horizon. It is silty clay loam or clay loam.

The B2t horizon is 25 to 50 inches thick and has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5, and chroma of 2 to 4. It is silty clay loam or silty clay with clay content of 35 to 45 percent. Mottling ranges from none to common and includes brownish or reddish colors. Below a depth of 50 inches grayish mottles occur in places.

The B3 horizon is 15 to 30 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 5 or 6, and chroma of 3 to 6. It is silty clay, clay loam, or silty clay loam. Mottles range from none to common, and are reddish, brownish, and in places are grayish.

The C horizon has a hue of 7.5YR, 5YR, or 2.5YR, value of 5 to 7, and chroma of 4 to 8. It is clay loam, silty clay loam, or clay. Mottles are few to common, and are reddish, brownish, and in places are grayish.

These soils are taxadjuncts to the Bethany series. They have high chroma mottles higher in the profile than is allowed in the series and lack the coarse mottles or high chroma colors at a depth of less than 60 inches which is typical for the series. Their behavior is essentially the same as that of the Bethany series.

Canadian series

The Canadian series consists of well drained soils that formed in loamy sediment on flood plains. These soils are smooth or slightly convex. Permeability is moderately rapid. Slopes are less than 1 percent.

Canadian soils are geographically associated with the Gaddy, Gracemont, Gracemore, and Keokuk soils. Gaddy, Gracemont, and Gracemore soils lack a mollic epipedon. Keokuk soils have a coarse-silty control section.

Typical pedon of Canadian fine sandy loam, in a field 1,100 feet east and 50 feet north of the southwest corner of sec. 3, T. 8 N., R. 3 W.:

Ap—0 to 8 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; slightly hard, very friable; calcareous, moderately alkaline; abrupt smooth boundary.

A1—8 to 12 inches; brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; calcareous, moderately alkaline; diffuse smooth boundary.

B2—12 to 39 inches; light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; slightly hard, very friable; calcareous, moderately alkaline; diffuse smooth boundary.

C—39 to 80 inches; light brown (7.5YR 6/4) very fine sandy loam, dark brown (7.5YR 4/4) moist; massive; hard, very friable; calcareous, moderately alkaline.

Solum thickness ranges from 20 to 40 inches. Reaction is moderately alkaline throughout.

The Ap horizon is 4 to 8 inches thick. It has a hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 4.

The A1 horizon is 3 to 10 inches thick. It has a hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3.

The B2 horizon is 13 to 30 inches thick. It has a hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 4 or 6. It is fine sandy loam or loam.

The C horizon has colors like those of the B2 horizon, and occasionally has some stratification of lighter or darker colors. It is fine sandy loam, very fine sandy loam, or loam.

The Canadian soils in this county are taxadjuncts to the Canadian series because the plow layer part of the A horizon does not have mollic colors, and it is slightly more alkaline in reaction than is allowed for the series. These soils are similar in morphology, use, behavior, and management.

Clarita series

The Clarita series consists of deep, moderately well drained soils that formed in clayey sediment on uplands. These very gently sloping soils are on prairies or are sloping and have gilgai relief. They are very slowly permeable. Slopes are 1 to 8 percent.

Clarita soils are geographically associated with the Grainola, Tamford, and Renfrow soils. Grainola and Tamford soils are on sloping adjacent side slopes and have a thinner and browner surface layer. Renfrow soils are on nearby ridges and have a less clayey surface layer and lack pronounced vertic properties.

Typical pedon of Clarita clay, in an area of Clarita clay, 1 to 3 percent slopes, in a pasture, 1,500 feet west and 200 feet south of the northeast corner of sec. 26, T. 5 N., R. 3 E.:

A1—0 to 14 inches; very dark gray (10YR 3/1) clay; black (10YR 2/1) moist; moderate fine blocky structure; extremely hard, very firm; moderately alkaline; clear wavy boundary.

AC1—14 to 21 inches; dark brown (7.5YR 4/2) clay; dark brown (7.5YR 3/2) moist; weak coarse blocky structure; extremely hard, extremely firm; distinct intersecting slickensides; very dark gray soil material in some vertical cracks; few soft calcium carbonate masses; calcareous, moderately alkaline; gradual wavy boundary.

AC2—21 to 48 inches; reddish brown (5YR 5/3) clay; reddish brown (5YR 4/3) moist; weak coarse blocky structure; extremely hard, extremely firm; distinct intersecting slickensides; very dark gray soil material in some vertical cracks; few soft masses of calcium carbonate; calcareous, moderately alkaline.

C—48 to 65 inches; reddish brown (5YR 5/3) clay; reddish brown (5YR 4/3) moist; massive; extremely hard, extremely firm; few black concretions; few soft masses of calcium carbonate; calcareous, moderately alkaline.

Solum thickness ranges from 40 to more than 60 inches. Depth to shale bedrock is more than 60 inches. Reaction is mildly alkaline or moderately alkaline in the surface layer and moderately alkaline in the AC and C horizons.

The A horizon is more than 12 inches thick in more than 50 percent of each pedon, but ranges from 12 to 38 inches in thickness. It has a hue of 10YR, a dry value of 3 or 4, and chroma of 1. It is calcareous or noncalcareous.

The AC horizon has a hue of 2.5YR, 5YR, or 7.5YR, value of 4 or 5, and chroma of 2 to 4. It is clay or clay loam with more than 35 percent clay. Old cracks are filled or lined with very dark gray soil material.

The C horizon has a hue of 10R, 2.5YR, or 5YR, value of 4 to 6, and chroma of 3 to 6. It is massive clay or is clay with interbedded soft shale.

Gaddy series

The Gaddy series consists of somewhat excessively drained, undulating soils that formed in sandy alluvial sediment on flood plains. Permeability is moderately rapid or rapid. Slopes are mostly 0 to 2 percent.

Gaddy soils are geographically associated with the Gracemore, Gracemont, Keokuk, and Canadian soils. Gracemore and Gracemont soils are intermingled and are on adjacent concave areas that have a high water table. Keokuk and Canadian soils are at a higher elevation and have a coarse-silty and coarse-loamy control section. Gracemont soils have a coarse-loamy control section.

Typical pedon of Gaddy fine sandy loam, in an area of Gaddy-Gracemore complex, undulating, in a pasture 1,700 feet north and 1,600 feet west of the southeast corner of sec. 3, T. 8 N., R. 3 W.:

A1—0 to 15 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak fine granular structure; slightly hard, very friable; calcareous, moderately alkaline; gradual smooth boundary.

C—15 to 72 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; massive; soft, very friable; few thin strata of fine sand; calcareous; moderately alkaline.

Solum thickness varies from 7 to 20 inches. Depth to bedrock is more than 60 inches. Depth to the water table is more than 72 inches. Reaction is mildly alkaline or moderately alkaline in the surface layer and moderately alkaline in the underlying layers.

The A horizon has a hue of 10YR or 7.5YR, value of 5 or 6, and chroma of 3 or 4. It is fine sandy loam or loamy fine sand.

The C horizon has a hue of 7.5YR, value of 4 to 7, and chroma of 3 to 6. It is massive loamy fine sand or fine sand with thin stratification of fine sandy loam or loam.

Gracemont series

The Gracemont series consists of somewhat poorly drained soils with a high water table that formed in stratified sandy or loamy alluvium on flood plains. These soils are smooth or slightly concave. Permeability is moderately rapid. Slopes are generally less than 2 percent.

Gracemont soils are geographically associated with the Canadian, Gracemore, Gaddy, and Keokuk soils. Gaddy and Gracemore soils have a sandy control section. Canadian and Gaddy soils lack a high water table most of the year. Keokuk soils have a coarse-silty control section.

A typical pedon of Gracemont fine sandy loam, in a field 1,800 feet east and 900 feet north of the southwest corner of sec. 14, T. 7 N., R. 2 W.:

A1—0 to 8 inches; light reddish brown (5YR 6/3) fine sandy loam, reddish brown (5YR 4/3) moist; weak medium subangular blocky structure; slightly hard, very friable; calcareous, moderately alkaline; clear smooth boundary.

C1—8 to 25 inches; light reddish brown (5YR 6/3) fine sandy loam, reddish brown (5YR 5/3) moist; massive; slightly hard, very friable; common strata of very fine sandy loam; calcareous, moderately alkaline; clear smooth boundary.

C2—25 to 60 inches; brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) moist; massive; hard, very friable; many thin strata of fine sandy loam and loamy very fine sand; calcareous, moderately alkaline.

This soil is moderately alkaline and calcareous throughout the control section in most pedons. Depth to the water table ranges from about 6 inches to 40 inches from November through May of most years.

The A horizon ranges from 4 to 14 inches thick.

The A1 or Ap horizon has a hue of 7.5YR or 5YR, value of 4 through 6, and chroma of 2 through 4. In places where the A1 or Ap horizon is less than 10 inches thick, value is 4 or 5, and chroma is 2 or 3.

The C horizon has a hue of 7.5YR or 5YR, value of 5 to 7, and chroma of 3 to 6. It is loam or fine sandy loam and has strata of loamy very fine sand. Degree of stratification varies widely in texture and color.

Gracemore series

The Gracemore series consists of somewhat poorly drained soils that formed in sandy alluvium on flood plains. These soils are subject to flooding and have a high water table most of the year. They are smooth or concave. Permeability is moderately rapid. Slopes are dominantly less than 2 percent.

Gracemore soils are geographically associated with the Gaddy, Gracemont, Keokuk, and Canadian soils. Gracemont soils have a coarse-loamy control section. The other associated soils are at a higher elevation on the flood plains and lack a high water table most of the year.

Typical pedon of Gracemore clay loam, in an area of Gracemore soils, in a pasture 500 feet north and 1,300 feet west of the southeast corner of sec. 4, T. 8 N., R. 3 W.:

A1—0 to 9 inches; brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) moist; weak fine granular structure; hard, friable; calcareous; moderately alkaline; clear smooth boundary.

C1—9 to 43 inches; light brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 5/4) moist; massive; soft, loose; calcareous; moderately alkaline; gradual smooth boundary.

C2—43 to 60 inches; pink (7.5YR 7/4) fine sand, light brown (7.5YR 6/4) moist; massive, single grained; loose; few thin strata of loamy fine sand; calcareous; moderately alkaline.

Solum thickness varies from 6 to 15 inches. Depth to bedrock is more than 60 inches. Depth to the water table ranges from 0 to 40 inches most of the year. Reaction is mildly alkaline or moderately alkaline in the surface layer, and moderately alkaline in the underlying layers.

The A horizon has a hue of 7.5YR to 5YR, value of 5 to 7, and chroma of 3 to 4. When chroma is 3, value is 6 or more. Texture varies widely within short distances and includes clay loam, fine sandy loam, or silt loam.

The C horizon has a hue of 7.5YR to 5YR, value of 5 to 7, and chroma of 3 to 4. It is loamy fine sand or fine sand and has few to common thin strata of fine sandy loam or loamy fine sand.

Grainola series

The Grainola series consists of moderately deep, well drained soils that formed in material weathered from shale on rolling uplands. These gently sloping to strongly sloping soils are on irregularly shaped prairies. Permeability is slow. Slopes are dominantly less than 5 percent but range to 12 percent along drainageways.

Grainola soils are geographically associated with the Grant, Renfrow, and Tamford soils. Grant soils are on higher lying convex ridges and adjacent hillsides and have a fine-silty control section. Renfrow soils are on higher lying broad convex ridges and have a mollic epipedon and a thicker solum. Tamford soils are intermingled with Grainola soils on hillsides. They have a thicker solum and pronounced vertic properties.

Typical pedon of Grainola clay loam, in an area of Grainola clay loam, 3 to 5 percent slopes, 1,320 feet west and 400 feet north of the southeast corner of sec. 35, T. 6 N., R. 3 W.:

Ap—0 to 5 inches; reddish brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) moist; moderate fine granular structure; very hard, friable; moderately alkaline; clear wavy boundary.

B1—5 to 13 inches; reddish brown (5YR 4/4) light clay, dark reddish brown (5YR 3/4) moist; weak medium blocky structure; very hard, very firm; few fragments of red shale; calcareous; moderately alkaline; gradual wavy boundary.

B2t—13 to 22 inches; red (2.5YR 5/6) clay, red (2.5YR 4/6) moist; moderate medium blocky structure; extremely hard, very firm; thin clay films on faces of peds; 5 percent by volume shale fragments; few slickensides; few soft masses of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

Cr—22 to 40 inches; red (2.5YR 5/6) weathered shale, red (2.5YR 4/6) moist; extremely hard, extremely firm; calcareous; moderately alkaline.

Solum thickness ranges from 20 to 40 inches. Reaction is moderately alkaline in the A horizon. The B horizons are moderately alkaline and calcareous. The soil cracks severely if dry, commonly extending upward through the A horizon.

The A horizon is 3 to 8 inches thick. It has a hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. It ranges from calcareous to noncalcareous.

The B1 horizon is 3 to 8 inches thick. It has a hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It is clay loam or clay. Fragments of sandstone or shale less than 3 inches in diameter range from 0 to 5 percent by volume.

The B2t horizon is 8 to 16 inches thick. It has a hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. It is clay or silty clay. Fragments of shale or sandstone less than 3 inches in diameter range from 0 to 15 percent by volume.

Some pedons have a 3 to 8 inch thick B3 horizon that is similar in color and texture to the B2t horizon. This horizon contains fragments of shale or sandstone less than 3 inches in diameter that range from 2 to 25 percent by volume.

The Cr horizon has a hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. It is weathered shale or shale with interbedded seams of soft sandstone and massive clay. This material may be streaked or splotched with gray and brown.

Grant series

The Grant series consists of deep, well drained soils that formed in material weathered from weakly consolidated sandstone on uplands. These very gently sloping soils are on moderately broad ridge crests or are gently sloping to strongly sloping hillside prairies. Permeability is moderate. Slopes are dominantly 1 to 8 percent, but range to 12 percent along drainageways.

Grant soils are geographically associated with the Teller, Port, Renfrow, Lucien, Nash, and Pond Creek soils. The Lucien soils and Nash soils have a thinner solum. Renfrow soils have a fine control section. Teller soils have a fine-loamy control section. Port soils are alluvial soils on flood plains. The nearly level Pond Creek soils are on broad smooth areas and have a thicker mollic epipedon. They developed in thick deposits of loamy earth.

Typical pedon of Grant silt loam, in an area of Grant silt loam, 1 to 3 percent slopes, 100 feet east and 150 feet north of the southwest corner of sec. 13, T. 5 N., R. 3 W.:

A1—0 to 12 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium granular structure; slightly hard, friable; slightly acid; gradual smooth boundary.

B1—12 to 19 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; very hard, firm; slightly acid; gradual smooth boundary.

B21t—19 to 25 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; very hard, firm; clay films on faces of peds; few fine black concretions; slightly acid; gradual smooth boundary.

B22t—25 to 37 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; moderate medium subangular blocky structure; very hard, firm; clay films on faces of peds; few fine black concretions; slightly acid; diffuse smooth boundary.

B3—37 to 52 inches; red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; weak coarse subangular blocky structure; hard, firm; few fine black concretions; slightly acid; clear wavy boundary.

Cr—52 to 72 inches; red (2.5YR 5/6) soft sandstone; interbedded layers of clay and soft shale; moderately alkaline.

Solum thickness ranges from 40 to 60 inches. Depth to bedrock ranges from 40 to more than 72 inches. Reaction of the A horizon and upper B horizon is slightly acid or neutral. The lower B horizons are slightly acid to moderately alkaline.

The A horizon is 10 to 15 inches thick, except in severely eroded areas. It has a hue of 5YR, 7.5YR, or 10YR, value of 4 or 5, and chroma of 2 or 3.

The B1 horizon is 0 to 13 inches thick. It has a hue of 2.5YR, 5YR, or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It is dominantly silty clay loam, but is silt loam in places.

The B2t horizon is 13 to 32 inches thick. It has a hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 4 to 8. It is silty clay loam or silt loam.

The B3 horizon is 10 to 26 inches thick. It has colors like the B2t horizon. It is silty clay loam, silt loam, or very fine sandy loam.

The Cr horizon is soft sandstone. Interbedded seams of soft shale are common. It is red, reddish brown, or yellowish red.

The Grant soils, gullied, map unit has an A horizon slightly thinner than is allowed for the series and is considered a taxadjunct. The morphology, use, and behavior are the same.

Keokuk series

The Keokuk series consists of deep, well drained soils that formed in stratified loamy or silty alluvium on flood plains. These soils are smooth or slightly convex. Permeability is moderate. Slopes are less than 1 percent.

Keokuk soils are geographically associated with the Asher, Canadian, Pulaski, Miller, and Port soils. Asher soils have a fine-silty control section. Pulaski soils lack a mollic epipedon. Port soils have a thicker mollic epipedon and a fine-silty control section. Canadian soils have a coarse-loamy control section. Miller soils are more clayey and are in concave positions.

Typical pedon of Keokuk silt loam, in a field 300 feet east and 2,000 feet south of the northwest corner of the NE1/4 of sec. 30, T. 7 N., R. 2 W.:

A1—0 to 12 inches; reddish brown (5YR 5/3) silt loam, dark reddish brown (5YR 3/3) moist; weak fine granular structure; hard, friable; neutral; clear smooth boundary.

B21—12 to 25 inches; reddish brown (5YR 5/4) silt loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; hard, friable; mildly alkaline; clear smooth boundary.

B22—25 to 38 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; hard, very friable; few soft masses of calcium carbonate; moderately alkaline; clear smooth boundary.

C—38 to 60 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; massive; hard, very friable; stratified with reddish yellow (5YR 6/6); calcareous, moderately alkaline.

The A1 or Ap horizon has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3. It is 10 to 20 inches thick. Reaction is neutral to moderately alkaline.

The B2 horizon has a hue of 7.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6. It is silt loam, loam, or very fine sandy loam. Reaction is neutral to moderately alkaline. Some B2 horizons are calcareous.

The C horizon has a hue of 7.5YR or 5YR, value of 5 to 6, and chroma of 4 to 8. It is loam, silt loam, or very fine sandy loam. It is mostly calcareous.

In places a buried A horizon is between depths of 40 to 60 inches.

Kirkland series

The Kirkland series consists of deep, well drained soils that formed in material weathered from shale on uplands. These nearly level to very gently sloping soils are on broad prairies. Permeability is very slow. Slopes are 0 to 2 percent.

Kirkland soils are geographically associated with the Renfrow, Tamford, and Grainola soils. Renfrow and Grainola soils lack an abrupt textural change between the A and B horizons. Grainola soils have a solum 20 to 40 inches thick. Tamford soils are clayey throughout.

Typical pedon of Kirkland silt loam, in a field 1,100 feet south and 400 feet east of the northwest corner of the NE1/4 of sec. 36, T. 6 N., R. 3 W.:

A1—0 to 11 inches; brown (10YR 4/3) silt loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, friable; slightly acid; abrupt smooth boundary.

B21t—11 to 20 inches; dark brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium blocky structure; extremely hard, very firm; clay films on faces of peds; neutral; gradual smooth boundary.

B22t—20 to 34 inches; brown (7.5YR 5/4) silty clay, dark brown (7.5YR 3/2) moist; weak coarse blocky structure; extremely hard, very firm; clay films on faces of peds; few distinct slickensides; few calcium carbonate concretions; mildly alkaline; gradual smooth boundary.

B23tca—34 to 45 inches; yellowish red (5YR 5/6) silty clay, yellowish red (5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; clay films on faces of peds; few concretions and soft lumps of calcium carbonate; calcareous, moderately alkaline; gradual wavy boundary.

B3—45 to 70 inches; red (2.5YR 5/6) silty clay, red (2.5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; few slickensides; calcareous, moderately alkaline; clear wavy boundary.

Cr—70 to 80 inches; red (2.5YR 5/6) interbedded shale and silty sandstone; moderately alkaline.

The solum thickness is more than 60 inches. The reaction of the A1 horizon is slightly acid or neutral. The B21t horizon is neutral or mildly alkaline. The B22t, B23t, B3, and C horizons are moderately alkaline.

The A horizon is 9 to 12 inches thick. It has a hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3.

The B21t horizon is 8 to 12 inches thick. It has a hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. It is silty clay or clay.

The B22t horizon is 8 to 16 inches thick. It has colors like the B21t horizon, but includes a hue of 5YR, value of 5, and chroma of 4. It is silty clay or clay.

The B23tca horizon is 8 to 16 inches thick. It has a hue of 7.5YR, 5YR, or 2.5YR, value of 5 or 6, and chroma of 4 or 6. It is clay or silty clay.

The B3 horizon is 8 to 15 inches thick. It has color and texture like the B23tca horizon.

The C horizon is weathered shale, or clay or interbedded shale and soft sandstone.

Konawa series

The Konawa series consists of deep, well drained soils that formed in thick, sandy or loamy sediment on high mantles. These soils are on broad, nearly level to sloping savannahs. Permeability is moderate. Slopes are 0 to 8 percent.

Konawa soils are geographically associated with the Stephenville soils. Stephenville soils are on lower lying convex ridges that have sandstone bedrock at a depth of 20 to 40 inches.

Typical pedon of Konawa loamy fine sand, 0 to 3 percent slopes, in an abandoned cultivated field, 500 feet north and 60 feet west of the southeast corner of sec. 28, T. 5 N., R. 3 E.:

Ap—0 to 8 inches; pale brown (10YR 6/3) loamy fine sand, brown (10YR 4/3) moist; weak fine granular structure; slightly hard, very friable; neutral; clear smooth boundary.

A2—8 to 17 inches; very pale brown (10YR 6/4) loamy fine sand; yellowish brown (10YR 5/4) moist; weak fine granular structure; soft, very friable; slightly acid; clear smooth boundary.

B21t—17 to 30 inches; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) moist; moderate medium prismatic structure; very hard, firm; clay films on faces of peds; medium acid; gradual smooth boundary.

B22t—30 to 42 inches; reddish yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 5/6) moist; moderate medium prismatic structure; very hard, firm; clay films on faces of peds; medium acid; diffuse smooth boundary.

B3—42 to 65 inches; reddish yellow (7.5YR 7/6) fine sandy loam, strong brown (7.5YR 6/6) moist; few medium distinct pale brown mottles; weak coarse prismatic structure; hard, very friable; medium acid; diffuse smooth boundary.

C—65 to 76 inches; reddish yellow (7.5YR 7/6) loamy fine sand, strong brown (7.5YR 6/6) moist; common medium distinct pale brown mottles; massive; slightly hard, very friable; medium acid.

Solum thickness ranges from 48 to more than 72 inches. Reaction is medium acid or slightly acid in the A horizon if the soil has not been limed. The B or C horizons are medium acid or slightly acid.

The A horizon is about 6 inches thick in eroded areas, but ranges up to 20 inches thick in noneroded areas. It has a hue of 10YR or 7.5YR, value of 5 to 7, and chroma of 2 to 4. Most pedons have an A2 horizon of higher value than the A1 or Ap horizon where the A horizon is thickest.

The B2t horizon is 15 to 35 inches thick. It has a hue of 5YR or 7.5YR, value of 5 or 6, and chroma of 4 to 6.

The B3 horizon is 10 to 30 inches thick. It has hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 4 to 6. Texture is sandy clay loam, fine sandy loam, or loamy fine sand. Mottling ranges from none to faint brown or pale brown.

The C horizon has a hue of 5YR or 7.5YR, value of 5 to 7, and chroma of 4 to 6. It is fine sandy loam or loamy fine sand. Mottling ranges from few to common brown or pale brown.

The Konawa soils in the Konawa loamy fine sand, 0 to 3 percent slopes, map unit are taxadjuncts to the Konawa series because the B3 horizon and the C horizon have mottles and a hue of 7.5YR, which are outside the range of the series. They are similar in morphology, use, behavior, and management.

Lela series

The Lela series consists of deep, somewhat poorly drained soils that formed in thick clayey sediment on flood plains. These soils are on broad, nearly level to slightly concave alluvium. Permeability is very slow. Slopes are less than 1 percent.

Lela soils are geographically associated with the Asa and Keokuk soils. Asa soils are well drained and have a fine-silty control section. Keokuk soils are well drained and have a coarse-silty control section. Both soils lack the vertic properties of Lela soils.

Typical pedon of Lela clay, 1,200 feet north and 300 feet west of the southeast corner of sec. 36, T. 5 N., R. 4 W.:

Ap—0 to 5 inches; dark reddish gray (5YR 4/2) clay, dark reddish brown (5YR 3/2) moist; strong fine blocky structure; very hard, firm; moderately alkaline; clear smooth boundary.

A11—5 to 11 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; weak medium blocky structure; extremely hard, very firm; few distinct slickensides; calcareous; moderately alkaline; gradual wavy boundary.

A12—11 to 18 inches; dark reddish gray (5YR 4/2) clay, dark reddish brown (5YR 3/2) moist; weak coarse blocky structure; extremely hard, extremely firm; few distinct intersecting slickensides; few old cracks with reddish brown (5YR 4/3) coatings; few concretions of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

AC—18 to 46 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; few medium distinct mottles of dark gray (5YR 4/1); weak coarse blocky structure; extremely hard, extremely firm; few distinct intersecting slickensides; common coatings in old cracks and bodies of dark reddish gray (5YR 4/2); few soft masses and concretions of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

C—46 to 84 inches; reddish brown (5YR 5/4) silty clay, reddish brown (5YR 4/4) moist; massive; extremely hard, extremely firm; few soft masses and concretions of calcium carbonate; calcareous; moderately alkaline.

Solum thickness is 20 to 65 inches. In undisturbed areas, the soil has gilgai relief. Reaction is neutral to moderately alkaline throughout the solum. The soil cracks severely if dry. Intersecting slickensides are at depths between 10 and 40 inches.

The A horizon ranges from 12 to 40 inches in thickness, generally between intervals of 8 to 12 feet. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3.

The AC horizon ranges from 20 to 40 inches in thickness. It has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 to 6, and chroma of 3 or 4. Mottles range from none to common. Texture is clay or silty clay.

The C horizon has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 to 6, and chroma of 3 to 6. Mottles range from none to common. Texture is clay, silty clay, or silty clay loam.

The Lela soils in this county are taxadjuncts to the Lela series because they are slightly more alkaline in the A horizon and have mottles in the AC horizon which are not in the Lela series. They are similar in morphology, use, behavior, and management.

Lucien series

The Lucien series consists of shallow, well drained soils that formed in material weathered from sandstone on uplands. These gently sloping to strongly sloping soils are intermingled on ridge crests and hillsides on prairies. Permeability is moderately rapid. Slopes are 2 to 12 percent.

Lucien soils are geographically associated with the Nash and Grant soils. Nash and Grant soils are more than 20 inches deep to bedrock.

Typical pedon of Lucien loam, in an area of Nash-Lucien complex, 5 to 12 percent slopes, 650 feet east and 200 feet south of the northwest corner of the NE1/4 of sec. 34, T. 5 N., R. 3 W.:

A1—0 to 7 inches; reddish brown (5YR 4/3) loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; hard, friable; slightly acid; gradual smooth boundary.

B2—7 to 14 inches; yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; weak medium granular structure; hard, friable; neutral; gradual smooth boundary.

Cr—14 to 30 inches; red (2.5YR 5/8) soft sandstone; moderately alkaline.

The solum thickness and depth to bedrock ranges from 10 to 20 inches. The reaction of the A and B horizon is medium acid to neutral.

The A horizon is 5 to 10 inches thick. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3. Rock fragments less than 6 inches in diameter range from 0 to 5 percent.

The B2 horizon is 0 to 10 inches thick. It has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 or 5, and chroma of 3 through 6. It is loam, silt loam, or fine sandy loam.

The Cr horizon is soft rippable sandstone. In places the horizon has thin interbedded layers of silty shale. The sandstone has a hue of 5YR or 2.5YR, value of 4 or 5, and chroma of 4 or 6. It is neutral to moderately alkaline.

Miller series

The Miller series consists of deep, moderately well drained soils that formed in clayey sediment on flood plains. These nearly level soils are on smooth alluvium. They are subject to occasional flooding. Permeability is very slow. Slopes are less than 1 percent.

Miller soils are geographically associated with the Asher, Keokuk, and Port soils. These associated soils have less than 35 percent clay in the control section and lack vertic properties.

Typical pedon of Miller silty clay, 2,500 feet north and 200 feet east of the southwest corner of sec. 13, T. 8 N., R. 3 W.:

A11—0 to 12 inches; reddish brown (5YR 4/3) silty clay, dark reddish brown (5YR 3/3) moist; weak medium blocky structure; very hard; very firm; calcareous; moderately alkaline; gradual smooth boundary.

A12—12 to 24 inches; reddish brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) moist; weak medium blocky structure; extremely hard, very firm; few slickensides; few old cracks and reddish brown (5YR 4/3) coatings on faces of peds; calcareous; clear wavy boundary.

Ab—24 to 32 inches; dark reddish gray (5YR 4/2) silty clay, dark reddish brown (5YR 3/2) moist; weak coarse blocky structure; extremely hard, very firm; few slickensides; few old cracks and faces of peds lined with reddish brown (5YR 4/4); few masses of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

B2b—32 to 42 inches; reddish brown (5YR 4/3) silty clay, dark reddish brown (5YR 3/3) moist; weak coarse blocky structure; extremely hard, very firm; few slickensides; few masses of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

Cb—42 to 65 inches; reddish brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) moist; massive; extremely hard, very firm; few masses of calcium carbonate; calcareous; moderately alkaline.

Solum thickness ranges from 35 to 60 inches. Some pedons lack buried horizons. The soils are calcareous throughout. They crack if dry. Cracks more than 1 centimeter wide extend from the surface to a depth of 30 inches or more in most years.

The A horizon is 10 to 30 inches thick. It has a hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 2 or 3. It has chroma of 4 at a depth of more than 10 inches in most pedons.

The Ab horizon, if present, has a hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 2 or 3. It is silty clay or heavy silty clay loam with a clay content of 35 to 45 percent.

The B2b horizon has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 or 5, and chroma of 3 or 4. It is clay, silty clay, or silty clay loam with 35 to 45 percent clay content.

The Cb horizon has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 to 6, and chroma of 4 to 6. Texture ranges from silty clay to clay loam, and may be stratified with loam to fine sandy loam. In some pedons the Cb horizon has few to common reddish or brownish mottles below a depth of 40 inches.

Minco series

The Minco series consists of deep, well drained soils that formed in material weathered from eolian sediment on uplands. These nearly level to moderately steep soils are on broad smooth prairies. Permeability is moderate. Slopes are 0 to 20 percent.

Minco soils are geographically associated with the Pond Creek and Teller soils. Pond Creek soils have a fine-silty control section. Teller soils have a fine-loamy control section.

Typical pedon of Minco silt loam, in an area of Minco silt loam, 0 to 1 percent slopes, in a field 900 feet north and 500 feet east of the southwest corner of sec. 35, T. 10 N., R. 4 W.:

A1—0 to 12 inches; brown (10YR 4/3) silt loam, dark brown (10YR 3/3) moist; weak medium granular structure; slightly hard, friable; neutral; gradual smooth boundary.

B21—12 to 24 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 3/4) moist; weak medium prismatic structure; hard, friable; mildly alkaline; gradual smooth boundary.

B22—24 to 49 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 3/4) moist; moderate medium prismatic structure; hard, friable; common fine tubular pores; mildly alkaline; diffuse smooth boundary.

B23—49 to 60 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/4) moist; moderate coarse prismatic structure; hard, friable; many fine tubular pores; mildly alkaline; diffuse smooth boundary.

B3—60 to 74 inches; light brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) moist; weak coarse prismatic structure; hard, friable; many fine tubular pores; few concretions and soft lumps of calcium carbonate; calcareous, moderately alkaline.

Solum thickness is more than 40 inches. Depth to bedrock is more than 72 inches. Reaction is medium acid to neutral in the A horizon, and slightly acid to moderately alkaline in the B horizons.

The A1 horizon is 10 to 15 inches thick. It has a hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. It is silt loam or very fine sandy loam.

The B2 horizon has a hue of 2.5YR, 5YR, or 7.5YR, value of 4 or 5, and chroma of 3 to 6. It is silt loam or very fine sandy loam.

The B3 horizon has a hue of 2.5YR, 5YR, or 7.5YR, value of 5 or 6, and chroma of 4 or 6. It is silt loam, very fine sandy loam, or loam.

The soils in the Minco very fine sandy loam, 8 to 20 percent slopes, map unit are taxadjuncts to the Minco series because they lack a mollic epipedon and have secondary carbonates slightly higher in the profile than is allowed in the Minco series. They are similar in morphology, use, behavior, and management.

Nash series

The Nash series consists of moderately deep, well drained soils that formed in material weathered from sandstone on uplands. These gently sloping to moderately steep soils are intermingled on ridge crests and hillsides. Permeability is moderate. Slopes are 2 to 20 percent.

Nash soils are geographically associated with the Grant and Lucien soils. Grant soils have a fine-silty control section and have more than 40 inches of solum thickness. Lucien soils have a loamy control section and are less than 20 inches deep to bedrock.

Typical pedon of Nash loam in an area of Nash-Lucien complex, 5 to 12 percent slopes, in a pasture 800 feet west and 500 feet south of the northeast corner of sec. 34, T. 5 N., R. 3 W.:

A1—0 to 14 inches; reddish brown (5YR 4/3) loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; slightly hard, friable; slightly acid; gradual smooth boundary.

B2—14 to 23 inches; yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; hard, friable; neutral; diffuse smooth boundary.

B3—23 to 32 inches; red (2.5YR 5/8) loam, red (2.5YR 4/8) moist; weak medium subangular blocky structure; hard, friable; mildly alkaline; gradual smooth boundary.

Cr—32 to 40 inches; red (2.5YR 5/8) soft sandstone; moderately alkaline.

Solum thickness and depth to bedrock range from 20 to 40 inches. The soil is slightly acid to moderately alkaline throughout.

The A horizon is 7 to 16 inches thick. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3. It is dominantly loam, but has areas of silt loam.

The B2 horizon is 8 to 20 inches thick. It has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 or 5, and chroma of 3 to 6. It is loam or silt loam.

The B3 horizon is 0 to 12 inches thick. It has a hue of 5YR or 2.5YR, value of 5 or 6, and chroma of 6 or 8. It is loam, silt loam, or very fine sandy loam. It is 0 to 10 percent sandstone fragments.

The C horizon is weakly cemented reddish sandstone. It is calcareous or noncalcareous.

Pawhuska series

The Pawhuska series consists of deep, moderately well drained soils that formed in material weathered from shale on uplands. These nearly level to very gently sloping soils are on prairies. Permeability is very slow. Slopes are 0 to 2 percent.

Pawhuska soils are geographically associated with the Bethany and Pond Creek soils. The Pawhuska soils are intermingled with Bethany soils. The Bethany soils have a thick dark mollic epipedon. Pond Creek soils occur at a slightly higher elevation. They have a thick dark mollic epipedon and a fine-silty control section.

Typical pedon of Pawhuska silt loam, in an area of Bethany-Pawhuska complex, 0 to 2 percent slopes, 1,320 feet north and 150 feet west of the southeast corner of sec. 1, T. 7 N., R. 3 W.:

Ap—0 to 8 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; very hard, friable; slightly acid; abrupt smooth boundary.

B21t—8 to 27 inches; gray (10YR 5/1) silty clay, dark gray (10YR 4/1) moist; weak coarse columnar structure; extremely hard, extremely firm; column faces with coatings of grayish brown (10YR 5/2); clay films on face of peds; mildly alkaline; gradual smooth boundary.

B22t—27 to 42 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; moderate medium blocky structure; extremely hard, very firm; few brownish gray (10YR 6/2) coatings on faces of peds; clay films on faces of peds; few slickensides; few black concretions; moderately alkaline; diffuse wavy boundary.

B23t—42 to 51 inches; brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; weak medium blocky structure; extremely hard, very firm; clay films on faces of peds; few calcareous concretions; calcareous; moderately alkaline; diffuse wavy boundary.

B24t—51 to 70 inches; pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; common medium distinct mottles of yellowish brown (10YR 5/6); weak coarse blocky structure; clay films patchy on faces of peds; calcareous; moderately alkaline; diffuse smooth boundary.

B3—70 to 84 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; calcareous; moderately alkaline.

Solum thickness and depth to bedrock is more than 50 inches. Reaction of the A horizon is slightly acid or neutral. The Bt horizons are mildly alkaline or moderately alkaline. The soil cracks if dry but only occasionally to the surface.

The A horizon is 4 to 10 inches thick. It has a hue of 10YR, value of 4 or 5, and chroma 1 or 2. In some places the A horizon is massive and very hard if dry.

The B21 horizon is 6 to 24 inches thick. It has a hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 1 or 2. The exchangeable sodium is about 15 to 20 percent. Texture is silty clay or silty clay loam with clay content of 35 to 45 percent.

The lower B2t horizons total 25 to 50 inches in thickness. They have a hue of 10YR, 7.5YR, or 5YR, value 5 or 6, and chroma of 2 to 4. Texture is similar to that of the B21t horizon. Exchangeable sodium ranges from 5 to 15 percent.

The B3 horizon has a hue of 2.5YR or 5YR, value of 5 or 6, and chroma of 4 to 6. Texture is silty clay loam or silty clay. Brownish or reddish mottles range from none to common in the B3 and lower B2t horizons.

The Pawhuska soils in this county are considered taxadjuncts to the series. They have a pale brown (10YR 6/3) lower B2t horizon and a yellowish red (5YR 5/6) B3 horizon which is not in the range for the Pawhuska series. They are similar in morphology, use, behavior, and management.

Pond Creek series

The Pond Creek series consists of deep, well drained soils that formed in loess or thick deposits of loamy earth on uplands. These nearly level to very gently sloping soils are on broad smooth prairies. Permeability is moderately slow. Slopes are 0 to 3 percent.

Pond Creek soils are geographically associated with the Bethany, Minco, and Teller soils. Bethany soils have a fine control section. Minco soils have a coarse-silty control section. Both Minco and Teller soils have a thinner mollic epipedon. Teller soils have a fine-loamy control section.

Typical pedon of Pond Creek silt loam, in an area of Pond Creek silt loam, 0 to 1 percent slopes, in a field 450 feet east and 300 feet south of the northwest corner of the SE1/4 of sec. 25, T. 8 N., R. 3 W.:

Ap—0 to 7 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium and fine granular structure; slightly hard, friable; medium acid; abrupt smooth boundary.

A1—7 to 15 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; slightly hard, friable; slightly acid; diffuse smooth boundary.

B1—15 to 23 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; hard, friable; many fine tubular pores; slightly acid; gradual smooth boundary.

B21t—23 to 46 inches; brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; weak medium and coarse subangular blocky structure; very hard, very firm; clay films on faces of peds; few black concretions; common tubular pores; slightly acid; diffuse smooth boundary.

B22t—46 to 58 inches; brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; common distinct fine mottles of strong brown; moderate medium subangular blocky structure; very hard, very firm; clay films on faces of peds; few black concretions; common root channels and tubular pores; neutral; diffuse smooth boundary.

B3—58 to 72 inches; brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; common distinct fine and medium mottles of strong brown; weak medium subangular blocky structure; very hard, very firm; few fine calcium carbonate and black concretions; few tubular pores; moderately alkaline.

Solum thickness is more than 40 inches. Depth to rock is more than 72 inches. Reaction of the Ap or A1 horizon is medium acid to neutral. The B1 and B2t horizons are slightly acid or neutral. The B3 horizon is neutral to moderately alkaline.

The A horizon is 12 to 22 inches thick. It has a hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3.

The B1 horizon is 6 to 10 inches thick. It has colors like the A horizon. It is silt loam or silty clay loam.

The B2t horizon is 16 to 40 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5, and chroma of 3 or 4.

The B3 horizon is 10 to 20 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 5 or 6, and chroma of 3 to 6. It is silty clay loam or clay loam.

Some pedons have a C horizon. It is reddish silt loam or silty clay loam that is mildly alkaline or moderately alkaline.

Port series

The Port series consists of deep, well drained soils that formed in alluvium on flood plains. These nearly level soils are on smooth, narrow to broad areas. Permeability is moderate. Slopes are less than 1 percent along streams and large drainageways.

Port soils are associated with the Keokuk, Asa, Pulaski, Miller, and Grant soils. Keokuk and Asa soils have less than 20 inches of mollic epipedon, and Keokuk soils have less than 18 percent clay in the control section. Pulaski soils lack a mollic epipedon. Miller soils have a fine control section. Grant soils are on adjacent uplands.

Typical pedon of Port silt loam, in a field 1,400 feet north and 300 feet east of the southwest corner of sec. 11, T. 7 N., R. 3 W.:

A11—0 to 14 inches; reddish brown (5YR 5/4) silt loam, dark reddish brown (5YR 3/4) moist; weak fine granular structure; hard, friable; neutral; clear smooth boundary.

A12b—14 to 35 inches; reddish brown (5YR 5/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate fine granular structure; very hard, friable; mildly alkaline; clear smooth boundary.

B2b—35 to 60 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; very hard, firm; calcareous at 48 inches; moderately alkaline.

The A11 horizon is silt loam, silty clay loam, or occasionally loam. It has a hue of 7.5 or 5YR, value of 4 or 5, and chroma of 4 to 6. This layer is a recent deposit and ranges from 6 to 18 inches in thickness. Some pedons lack this overwash horizon.

The A12b horizon is silt loam or silty clay loam. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 or 3. It is neutral or mildly alkaline and ranges from 18 to 36 inches in thickness.

The B2b horizon is silty clay loam or silt loam with a hue of 7.5YR or 5YR, value of 4 to 6, and chroma of 2 to 6. It is mildly alkaline or moderately alkaline.

Underlying layers are silty or loamy calcareous sediment to a depth of more than 6 feet.

Pulaski series

The Pulaski series consists of deep, well drained soils that formed in loamy sediment on flood plains. These nearly level to very gently sloping soils are in narrow, elongated, alluvial valleys. Slope is dominantly less than 1 percent but ranges to 3 percent along drainageways.

Pulaski soils are geographically associated with the Asa, Keokuk, and Port soils. Asa and Port soils have mollic epipedons and fine-silty control section. Keokuk soils have a mollic epipedon and a coarse-silty control section. Pulaski soils are nearest the stream channel. Keokuk soils are adjacent to Pulaski soils. Port and Asa soils are on the outer edges of the plain.

Typical pedon of Pulaski fine sandy loam, in a field 2,500 feet west and 175 feet south of the northeast corner of sec. 22, T. 7 N., R. 3 W.:

Ap—0 to 6 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; hard, very friable; medium acid, clear smooth boundary.

A1—6 to 16 inches; reddish brown (5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak fine granular structure; hard, very friable; medium acid; gradual smooth boundary.

C1—16 to 22 inches; yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; massive; very hard, very friable; neutral; clear smooth boundary.

C2—22 to 38 inches; reddish yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 4/6) moist; massive; hard, very friable; neutral; abrupt smooth boundary.

C3—38 to 80 inches; reddish yellow (5YR 6/6) silt loam; yellowish red (5YR 4/6) moist; massive; very hard, friable; few strata of fine sandy loam; calcareous; moderately alkaline.

Thickness of the A horizon ranges from about 10 to 20 inches. Reaction of the A horizon is medium acid or slightly acid. Below the A horizon reaction ranges from slightly acid to moderately alkaline. Depth to calcareous material ranges from 30 to 60 inches.

The A horizon has a hue of 7.5YR or 5YR, value of 4 to 6, and chroma of 3 or 4. If chroma is 3, the dry value is 6. Texture is dominantly fine sandy loam.

The C horizon has a hue of 7.5YR, 5YR, or 2.5YR, value of 4 to 7, and chroma of 4 to 8. It is dominantly fine sandy loam above 40 inches. Strata include loam, silt loam, or loamy fine sand. Texture is fine sandy loam to silt loam below about 40 inches.

Clay content of the 10 to 40 inch control section is 8 to 18 percent with more than 15 percent particles of fine sand.

The Pulaski soils in the Pulaski fine sandy loam map unit are taxadjuncts to the Pulaski series because they are slightly more alkaline in the lower part of the pedon than is typical for the series.

Renfrow series

The Renfrow series consists of deep, well drained soils that formed in material weathered from clay and shale on uplands. These very gently sloping to gently sloping soils are on broad prairies. Permeability is very slow. Slopes are 2 to 5 percent.

Renfrow soils are geographically associated with the Kirkland, Grainola, Grant, and Tamford soils. Kirkland soils have an abrupt textural change between the A and B horizons. Grainola soils lack a mollic epipedon. Grant soils have a fine-silty control section. Tamford soils are clayey throughout and have more pronounced vertic properties.

Typical pedon of Renfrow silt loam, in an area of Renfrow silt loam, 2 to 5 percent slopes, in a field 1,000 feet east and 600 feet south of the northwest corner of sec. 6, T. 7 N., R. 2 W.:

A1—0 to 11 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; hard, friable; slightly acid; gradual smooth boundary.

B1—11 to 18 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; moderate fine blocky structure; hard, friable; slightly acid; gradual smooth boundary.

B21t—18 to 24 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; moderate medium blocky structure; very hard, very firm; clay films on faces of peds; few calcium carbonate concretions; neutral; gradual smooth boundary.

B22t—24 to 37 inches; red (2.5YR 5/6) clay, red (2.5YR 4/6) moist; weak medium blocky structure; very hard, very firm; clay films on faces of peds; few calcium carbonate concretions; few slickensides; calcareous; moderately alkaline; gradual smooth boundary.

B3—37 to 68 inches; red (2.5YR 5/6) clay, red (2.5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; few calcium carbonate concretions; calcareous; moderately alkaline; gradual wavy boundary.

C—68 to 84 inches; red (2.5YR 5/8) silty clay, red (2.5YR 4/8) moist; massive; extremely hard, very firm; few calcium carbonate concretions; few sandstone and shale fragments; calcareous, moderately alkaline.

Solum thickness is more than 60 inches. The A horizon and B1 horizon are slightly acid to mildly alkaline. The B2t and B3 horizons are neutral to moderately alkaline. The soil cracks if dry, but cracks rarely extend upward through the A horizon.

The A horizon is 4 to 12 inches thick. It is mostly more than 8 inches thick, unless thinned by erosion. It has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5, and chroma of 2 or 3. It is mostly silt loam, unless the A1 and B1 horizon have been mixed by tillage.

The B1 horizon is 3 to 10 inches thick. It has a hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 2 to 4. It is silty clay loam or clay loam.

The B2t horizon is 18 to 30 inches thick. It has a hue of 5YR or 2.5YR, value of 4 or 5, and chroma of 3 to 6. It is silty clay or clay.

The B3 horizon is 15 to 32 inches thick. It has a hue of 5YR or 2.5YR, value of 5 or 6, and chroma of 4 to 8. It is silty clay or clay.

The C horizon is massive reddish clay or silty clay, and occasionally soft shale.

Stephenville series

The Stephenville series consists of moderately deep, well drained soils that formed in material weathered from sandstone on uplands. These soils are on ridge crests and hillsides. Permeability is moderate. Slopes are 2 to 6 percent.

Stephenville soils are geographically associated with the Konawa soils. Konawa soils have a solum more than 40 inches thick.

Typical pedon of Stephenville fine sandy loam, in an area of Stephenville fine sandy loam, 2 to 5 percent slopes, in a pasture 200 feet south and 100 feet west of the northeast corner of sec. 18, T. 6 N., R. 4 W.:

A1—0 to 6 inches; brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; slightly hard, very friable; slightly acid; clear smooth boundary.

A2—6 to 12 inches; reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak fine granular structure; slightly hard, very friable; slightly acid; clear smooth boundary.

B2t—12 to 36 inches; red (2.5YR 5/8) sandy clay loam, red (2.5YR 4/8) moist; weak subangular blocky structure; hard, friable; patchy clay films on faces of peds; strongly acid; clear wavy boundary.

Cr—36 to 40 inches; red (2.5YR 5/8) soft sandstone, red (2.5YR 4/8) moist; medium acid.

Solum thickness and depth to bedrock is 20 to 40 inches. Reaction of the A horizons is strongly acid to slightly acid unless limed. The B2t horizon is strongly acid or medium acid.

The A1 horizon is 3 to 7 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 4 to 6, and chroma of 2 to 4.

The A2 horizon is 0 to 10 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 5 to 7, and chroma of 2 to 4. In areas thinned by erosion, the A2 and A1 horizons have been mixed by tillage.

The B2t horizon is 10 to 32 inches thick. It has a hue of 5YR or 2.5YR, value of 4 to 6, and chroma of 4 to 8. It is sandy clay loam or fine sandy loam. Some pedons have a B3 horizon similar in color, texture, and reaction to that of the B2t horizon.

The Cr horizon is reddish soft sandstone. It is weakly consolidated and is occasionally laminated with layers of soft sandy shale.

Tamford series

The Tamford series consists of deep, well drained soils that formed in massive clay or weakly consolidated shale on uplands. These sloping to moderately sloping soils are on irregularly shaped prairies. Permeability is very slow. Slopes are dominantly less than 8 percent but range to 12 percent on some hillsides.

Tamford soils are geographically associated with the Renfrow and Grainola soils. Grainola soils are intermingled on side slopes and have a thinner solum. The gently sloping Renfrow soils are on higher lying smooth areas. They have less pronounced vertic properties.

Typical pedon of Tamford clay loam, in an area of Tamford-Grainola complex, 5 to 12 percent slopes, in a pasture 920 feet north and 300 feet west of the southeast corner of sec. 17, T. 5 N., R. 1 W.:

A1—0 to 6 inches; reddish brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) moist; moderate fine blocky structure; extremely hard, very firm; moderately alkaline; clear wavy boundary.

AC1—6 to 20 inches; reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; moderate medium blocky structure; extremely hard, very firm; vertical cracks filled with reddish brown (5YR 4/3) clay loam; distinct slickensides; calcareous; moderately alkaline; gradual wavy boundary.

AC2—20 to 32 inches; reddish brown (2.5YR 5/4) clay, reddish brown (2.5YR 4/4) moist; weak coarse blocky structure; extremely hard, extremely firm; few intersecting slickensides; few old cracks filled with reddish brown (5YR 4/3) clay loam; calcareous, moderately alkaline; gradual wavy boundary.

AC3—32 to 48 inches; red (2.5YR 5/6) shaly clay, red (2.5YR 4/6) moist; extremely hard, extremely firm; few bodies and old cracks lined with surface horizon colors; few intersecting slickensides; 15 percent by volume shale fragments; calcareous, moderately alkaline; gradual wavy boundary.

Cr—48 to 65 inches; light red (2.5YR 6/6) shale, red (2.5YR 5/6) moist; massive; extremely hard, extremely firm; few soft masses of calcium carbonate; calcareous, moderately alkaline.

Solum thickness is 40 to 60 inches to shale or massive clay. Intersecting slickensides are within 40 inches of the surface, and the soil cracks to the surface if dry. Reaction of the A horizon is mildly alkaline or moderately alkaline, and the AC horizons are moderately alkaline.

The A horizon is less than 12 inches thick in more than 50 percent of each pedon but ranges to 16 inches in thickness. It has a hue of 7.5YR and 5YR, value of 4 or 5 dry, 2 or 3 moist, and chroma of 2 or 3. It is more than 35 percent clay.

The AC horizon has a hue of 2.5YR, 5YR, and 7.5YR, value of 4 or 5, and chroma of 4 to 6. It is clay or silty clay with 40 to 50 percent clay. Some pedons have a few limestone or chert pebbles.

The C horizon has a hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 4 to 6.

Teller series

The Teller series consists of deep, well drained soils that formed in thick loamy sediment on high stream terraces. These very gently sloping soils are on broad smooth prairies. Slopes are 1 to 3 percent.

Teller soils are geographically associated with the Grant, Minco, and Pond Creek soils. Grant soils have a fine-silty control section and formed over sandstone. Minco soils have a coarse-silty control section. Pond Creek soils have a thicker mollic epipedon and a fine-silty control section.

Typical pedon of Teller loam in an area of Teller loam, 1 to 3 percent slopes, 200 feet west and 150 feet north of the southeast corner of sec. 31, T. 5 N., R. 2 W.:

Ap—0 to 12 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak fine granular structure; hard, very friable; slightly acid; gradual smooth boundary.

B1—12 to 19 inches; yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 3/4) moist; weak coarse prismatic structure; hard, friable; slightly acid; gradual smooth boundary.

B21t—19 to 36 inches; light brown (7.5YR 6/4) loam, brown (7.5YR 4/4) moist; weak coarse prismatic structure; very hard, firm; thin clay films on faces of peds; slightly acid; gradual smooth boundary.

B22t—36 to 50 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; weak coarse prismatic structure; very hard, firm; thin clay films on faces of peds; slightly acid; diffuse smooth boundary.

B3—50 to 80 inches; reddish yellow (5YR 7/6) fine sandy loam, yellowish red (5YR 5/6) moist; weak coarse prismatic structure; hard, very friable; slightly acid.

Solum thickness ranges from 60 to more than 72 inches. Reaction is medium acid or slightly acid in the A and B1 horizons, and medium acid to neutral in the Bt and B3 horizons.

The A horizon is 10 to 20 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5, and chroma of 2 or 3.

The B1 horizon is 3 to 10 inches thick. It has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5, and chroma of 3 or 4.

The B2t horizons range from 25 to 40 inches in thickness. They have a hue of 7.5YR or 5YR, value of 5 or 6, and chroma of 4 to 6.

The B3 horizon is 20 to 35 inches thick. It has a hue of 7.5YR, 5YR, or 2.5YR, value of 5 to 7, and chroma of 4 to 8. It is fine sandy loam or loam.

In some places a C horizon with color and texture similar to those of the B3 horizon is at depths between 60 and 80 inches.

The Teller soils in this county are taxadjuncts to the Teller series because the upper B2t horizon has hue of 7.5YR and the B2t horizon has a loam texture, which is outside the range of the Teller series. They are similar in morphology, use, behavior and management.

Classification of the soils

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to "Soil taxonomy" (*5*).

The system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the classification is based on the different soil properties that can be observed in the field or those that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis. In table 17, the soils of the survey area are classified according to the system. Categories of the system are discussed in the following paragraphs.

ORDER. Ten soil orders are recognized as classes in the system. The properties used to differentiate among orders are those that reflect the kind and degree of dominant soil-forming processes that have taken place. Each order is identified by a word ending in *sol.* An example is Entisol.

SUBORDER. Each order is divided into suborders based primarily on properties that influence soil genesis and are important to plant growth or that are selected to reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Fluvent (*Flu*, meaning fluvial, plus *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of expression of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and a prefix that suggests something about the properties of the soil. An example is Ustifluvents (*Usti*, meaning ustic horizons, plus *fluvent*, the suborder of Entisols that have a Ustic moisture regime).

SUBGROUP. Each great group may be divided into three subgroups: the central (typic) concept of the great groups, which is not necessarily the most extensive subgroup; the intergrades, or transitional forms to other orders, suborders, or great groups; and the extragrades, which have some properties that are representative of the great groups but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that is thought to typify the great group. An example is Typic Ustifluvents.

FAMILY. Families are established within a subgroup on the basis of similar physical and chemical properties that affect management. Among the properties considered in horizons of major biological activity below plow depth are particle-size distribution, mineral content, temperature regime, thickness of the soil penetrable by roots, consistence, moisture equivalent, soil slope, and permanent cracks. A family name consists of the name of a subgroup and a series of adjectives. The adjectives are the class names for the soil properties used as family differentiae. An example is coarse-loamy, mixed, nonacid, thermic, Typic Ustifluvents.

SERIES. The series consists of soils that formed in a particular kind of material and have horizons that, except for texture of the surface soil or of the underlying substratum, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineral and chemical composition.

Factors of soil formation

The first part of this section discusses the factors of soil formation and relates them to the soils in the survey area. The second part explains the processes of soil formation.

The properties of the soil are the integrated effects of five major factors of soil formation—parent material, climate, plant and animal life, relief, and time. Few generalizations can be made regarding the effects of any one factor because the effects of each is modified by the other four.

Formation of the soils

Parent material. Parent material is the unconsolidated material from which soil is formed. It is one of the most influential factors of soil formation. It sets the limits of the chemical and mineralogical composition of the soil and influences the rate of soil development.

Several kinds of parent material are in McClain County. They all produce different soils. Soils formed in material weathered from shale, such as Grainola soils, have a clayey subsoil. Soils formed in material weathered from sandstone, such as Stephenville soils, have a loamy subsoil. Clarita soils, formed in and weathered from limy material, have an adequate supply of bases. Examples of soils formed in clayey, loamy, or sandy sediment are Lela, Port, and Gaddy soils.

Climate. The moist, subhumid continental climate of McClain County is characterized by rains of high intensity. Sufficient moisture and warm temperature have promoted the formation of distinct horizons in many of the soils, but differences in soil cannot be attributed to climate, because the climate is uniform throughout the county. Heavy rains have caused rapid runoff that has eroded many of the soils. This erosion is an indirect effect of climate.

Plants and animals. Plants, burrowing annimals, insects, and soil micro-organisms have a direct influence on the formation of soil. Such native vegetation as trees, grasses, or a combination of both, has a bearing on the amount of organic matter, amount and kind of plant nutrients, and the type of soil structure and consistence. The Grant and Renfrow soils formed under native grasses. The fibrous roots of these native grasses promote a good granular structure that is high in organic-matter content. This type of vegetation reduces loss of soil nutrients by the recycling and by the feeding ability of the deep grass roots. Consequently, the soils that formed under grass in McClain County tend to have more bases and to contain more organic matter than the soils that formed under trees. The Stephenville and Konawa soils formed under trees and are lower in plant nutrients and organic matter than those soils formed under grass.

During the past century, man has altered this soil-forming process by removing the native vegetation in much of the county. Lack of adequate conservation measures has resulted in much soil loss through sheet and gully erosion. Where some of the surface layer has been removed and gullies have formed, eroded or gullied phases of soils are mapped. An example is Konawa soils, gullied.

Relief. Relief affects soil formation through its influence on moisture, drainage, erosion, temperature, and plant cover. The relief of McClain County is determined largely by the resistance of underlying parent material to weathering and geological erosion.

The effects of relief on soil formation are illustrated in the Grant and Lucien soils, both of which formed in material weathered from sandstone under a cover of grasses. The Grant soils generally are in areas of less sloping relief. They have less surface runoff and more water percolates through these soils to influence the loss, gain, or transfer of soil constituents. The Lucien soils typically have a more sloping relief and a less clearly defined profile than do the Grant soils. On these soils, rainwater runs off instead of moving through the soil to help in the formation of a deeper solum.

Time. Time as a factor cannot be measured strictly in years. The length of time needed for the development of genetic horizons depends on the intensity of the interaction of the soil-forming factors in promoting the losses, gains, transfers, or transformation of soil constituents that are necessary for forming soil horizons. Soils that lack a definite horizon are young or immature. Soils that have approached equilibrium with their environment and tend to have a well defined horizon are mature.

The soils of McClain County range from young to old. Renfrow and Kirkland soils on uplands are examples of mature soils. The Teller and Konawa soils are younger but have clearly defined horizons. The Lucien soils are young soils. They have had sufficient time to develop clearly defined horizons, but because they are sloping, geological erosion has removed soil material almost as fast as it has formed. Gaddy and Gracemore soils on flood plains have been developing for such a short time that they show little horizon development.

Processes of soil formation

Active processes that have influenced the formation of horizons in the soils of McClain County are (1) accumulation of organic matter, (2) leaching of calcium carbonates and bases, and (3) translocation of silicate clay minerals. In most soils, more than one of these processes have been active in the development of horizons.

The addition of organic matter to the surface layer by native grasses has contributed to the granular structure. The granular structure is high in organic matter in such soils as Bethany and is called a mollic epipedon in the soil classification system (*4*). The Konawa soils formed under trees and contain less organic matter than Bethany soils. Their surface layer is called an ochric epipedon in the classification system.

Leaching of carbonates and bases is active in the formation of soils. The accumulation of calcium carbonates and bases in the lower part of the B horizon of the Bethany soils indicates the depth to which water has percolated. The Konawa soils have been leached to the extent that they lack accumulation of calcium carbonates. The B horizon of these soils has had more leaching of bases and this is reflected by their base saturation.

Soils on flood plains, such as Gracemore and Gracemont soils, are recharged with bases when flooding occurs. The more acid Pulaski soils have not been leached, but their sediment comes from neutral to acid soils. The Clarita soils formed over weathered shale beds and clayey sediment and are high in carbonates. Calcium carbonates in Clarita soils are related to the nature of the parent materials.

The translocation of silicate clay minerals is very important in establishing the properties and classification of soils. Argillic horizons are diagnostic for classification. Clay films on ped surfaces, bridges of sand grains, and increases in total clay are evidences of argillic horizons. The argillic horizon is in many soils, as in the Grant, Kirkland, and Renfrow soils. The varying degrees of translocated silicate clay minerals and the kind of parent material have resulted in wide variation in the texture and other properties of the argillic horizons of soils. The Konawa and Stephenville soils have a subsurface layer that is more intensely leached of silicate clay minerals than the surface layer of other soils in the county.

The grasses on the soils bring bases to the surface, and this retards leaching and the formation of an A2 horizon. Geological erosion on such soils as the Lucien soil hinders horizon development through soil loss. The sediment on Gracemore and Pulaski soils on flood plains was deposited recently and there has not been enough time for the formation of horizons.

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(4) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 pp., illus. Supplements replacing pp. 173-188 issued May 1962.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Alkali (sodic) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim. An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single mapping unit.

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 40-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 2
Low	2 to 4
Moderate	4 to 6
High	More than 6

Base saturation. The degree to which material having base exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the exchange capacity.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

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.

Caliche. A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas. Caliche occurs as soft, thin layers in the soil or as hard, thick beds just beneath the solum, or it is exposed at the surface by erosion.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Chiseling. Tillage with an implement having one or more soil-penetrating points that loosen the subsoil and bring clods to the surface. A form of emergency tillage to control soil blowing.

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.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. Mineral or rock particles up to 3 inches (2 millimeters to 7.5 centimeters) in diameter.

Coarse textured (light textured) soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures is difficult.

Complex, soil. A mapping unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

Compressible. Excessive decrease in volume of soft soil under load.

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 pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; 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.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is 40 or 80 inches (1 or 2 meters).

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave. Unstable walls of cuts made by earthmoving equipment. The soil sloughs easily.

Cyclic. Relates to soil horizons that recur in cycles. In cyclic pedons the soil horizons are intermittent and recur within linear intervals of 2 to 7 meters (roughly 7 to 25 feet).

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. A delay in grazing until range plants have reached a specified stage of growth. Grazing is deferred in order to increase the vigor of forage and to allow desirable plants to produce seed. Contrasts with continuous grazing and rotation grazing.

Depth to rock. Bedrock at a depth that adversely affects the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

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."

Drainage, surface. Runoff, or surface flow of water, from an area.

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.

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Excess alkali. Excess exchangeable sodium. The resulting poor physical properties restrict the growth of plants.

Excess fines. Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Excess lime. Excess carbonates. Excessive carbonates, or lime, restrict the growth of some plants.

Excess salts. Excess water soluble salts. Excessive salts restrict the growth of most plants.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake. The rapid movement of water into the soil.

Favorable. Favorable soil features for the specified use.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fine textured (heavy textured) soil. Sandy clay, silty clay, and clay.

Flooding. The temporary covering of soil with water from overflowing streams, runoff from adjacent slopes, and tides. Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *occasional* that it occurs on an average of once or less in 2 years; and *frequent* that it occurs on an average of more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; *November-May*, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forage. Plant material used as feed by domestic animals. Forage can be grazed or cut for hay.

Forb. Any herbaceous plant not a grass or a sedge.

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.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material from 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Green manure (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Gypsum. Hydrous calcium sulphate.

Habitat. The natural abode of a plant or animal; refers to the kind of environment in which a plant or animal normally lives, as opposed to the range or geographical distribution.

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.

Hummocky. Refers to a landscape of hillocks, separated by low sags, having sharply rounded tops and steep sides. Hummocky relief resembles rolling or undulating relief, but the tops of ridges are narrower and the sides are shorter and less even.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants are those that follow disturbance of the surface.

Large stones. Rock fragments 10 inches (25 centimeters) or more across. Large stones adversely affect the specified use.

Leaching. The removal of soluble material from soil or other material by percolating water.

Light textured soil. Sand and loamy sand.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. Inadequate strength for supporting loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is greater than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous areas. Areas that have little or no natural soil, are too nearly inaccessible for orderly examination, or cannot otherwise be feasibly classified.

Moderately coarse textured (moderately light textured) soil. Sandy loam and fine sandy loam.

Moderately fine textured (moderately heavy textured) soil. Clay loam, sandy clay loam, and silty clay loam.

Mollic epipedon. A surface horizon of mineral soil that is dark colored and relatively thick, contains at least 0.58 percent organic carbon, is not massive and hard or very hard when dry, has a base saturation of more than 50 percent when measured at pH7, has less than 250 ppm of P205 soluble in 1 percent citric acid and is dominantly saturated with bivalent cations.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

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).

Munsell notation. A designation of color by degrees of the three single variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3.

Nutrient, plant. Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Plant nutrients are nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil; and carbon, hydrogen, and oxygen obtained largely from the air and water.

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.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

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).

Phase, soil. A subdivision of a soil series or other unit in the soil classification system based on differences in the soil that affect its management. A soil series, for example, may be divided into phases on the bases of differences in slope, stoniness, thickness, or some other characterisitc that affects management. These differencees are too small to justify separate series.

pH value. (See Reaction, soil). A numerical designation of acidity and alkalinity in soil.

Piping. Moving water of subsurface tunnels or pipelike cavities in the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from a semisolid to a plastic state.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Poor outlets. Surface or subsurface drainage outlets difficult or expensive to install.

Productivity (soil). The capability of a soil for producing a specified plant or sequence of plants under a specified system of management. Productivity is measured in terms of output, or harvest, in relation to input.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Range (or rangeland). Land that, for the most part, produces native plants suitable for grazing by livestock; includes land supporting some forest trees.

Range condition. The health or productivity of forage plants on a given range, in terms of the potential productivity under normal climate and the best practical management. Condition classes generally recognized are—*excellent*, *good*, *fair*, and *poor*. The classification is based on the percentage of original, or assumed climax vegetation on a site, as compared to what has been observed to grow on it when well managed.

Range site. An area of range where climate, soil, and relief are sufficiently uniform to produce a distinct kind and amount of native vegetation.

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
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock. Soil scientists regard as soil only the part of the regolith that is modified by organisms and other soil-building forces. Most engineers describe the whole regolith, even to a great depth, as "soil."

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulates over disintegrating rock.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth. Shallow root zone. The soil is shallow over a layer that greatly restricts roots. See Root zone.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline-alkali soil. A soil that contains a harmful concentration of salts and exchangeable sodium; contains harmful salts and is strongly alkaline; or contains harmful salts and exchangeable sodium and is very strongly alkaline. The salts, exchangeable sodium, and alkaline reaction are in the soil in such location that growth of most crop plants is less than normal.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 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.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Saprolite (geology). Soft, earthy, clay-rich, thoroughly decomposed rock formed in place by chemical weathering of igneous and metamorphic rock. In soil survey, the term saprolite is applied to any unconsolidated residual material underlying the soil and grading to hard bedrock below.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils, formed from a particular type of parent material, having horizons that, except for the texture of the A or surface horizon, are similar in all profile characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

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.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slick spot. Locally, a small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Sloughed till. Water-saturated till that has flowed slowly downhill from its original place of deposit by glacial ice. It may rest on other till, on glacial outwash, or on a glaciolacustrine deposit.

Slow intake. The slow movement of water into the soil.

Slow refill. The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones. Rock fragments 3 to 10 inches (7.5 to 25 centimeters) in diameter. Small stones adversely affect the specified use.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

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.

Stone line. A concentration of coarse fragments in soils that generally marks an old weathering surface. In a cross section, the line may be one fragment or more thick. The line generally overlies material that weathered in place and marks the top of a paleosol. It is ordinarily overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

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).

Stubble mulch. Stubble or other crop residue left on the soil, or partly worked into the soil, to provide protection from soil blowing and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitaion is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use or management.

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."

Thin layer. Otherwise suitable soil material too thin for the specified use.

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.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Unstable fill. Risk of caving or sloughing in banks of fill material.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Vertic. Term refers to soils with clayey horizons that contain expanding clay minerals. The soils shrink and form deep cracks when dry and swell and expand upon wetting.

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.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Illustrations

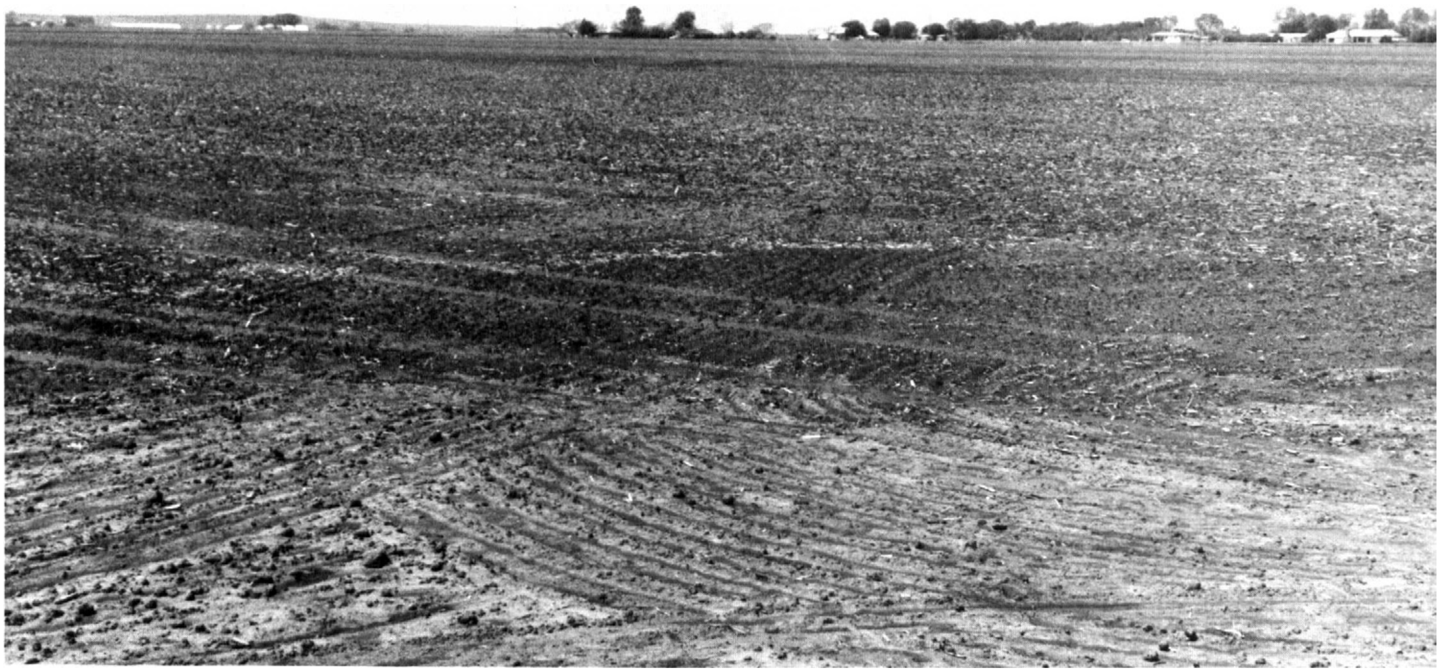

Figure 1.—Surface crusting on Bethany silt loam, 0 to 1 percent slopes.

Figure 2.—High levels of crop residue being returned to the soil on an area of Miller silty clay.

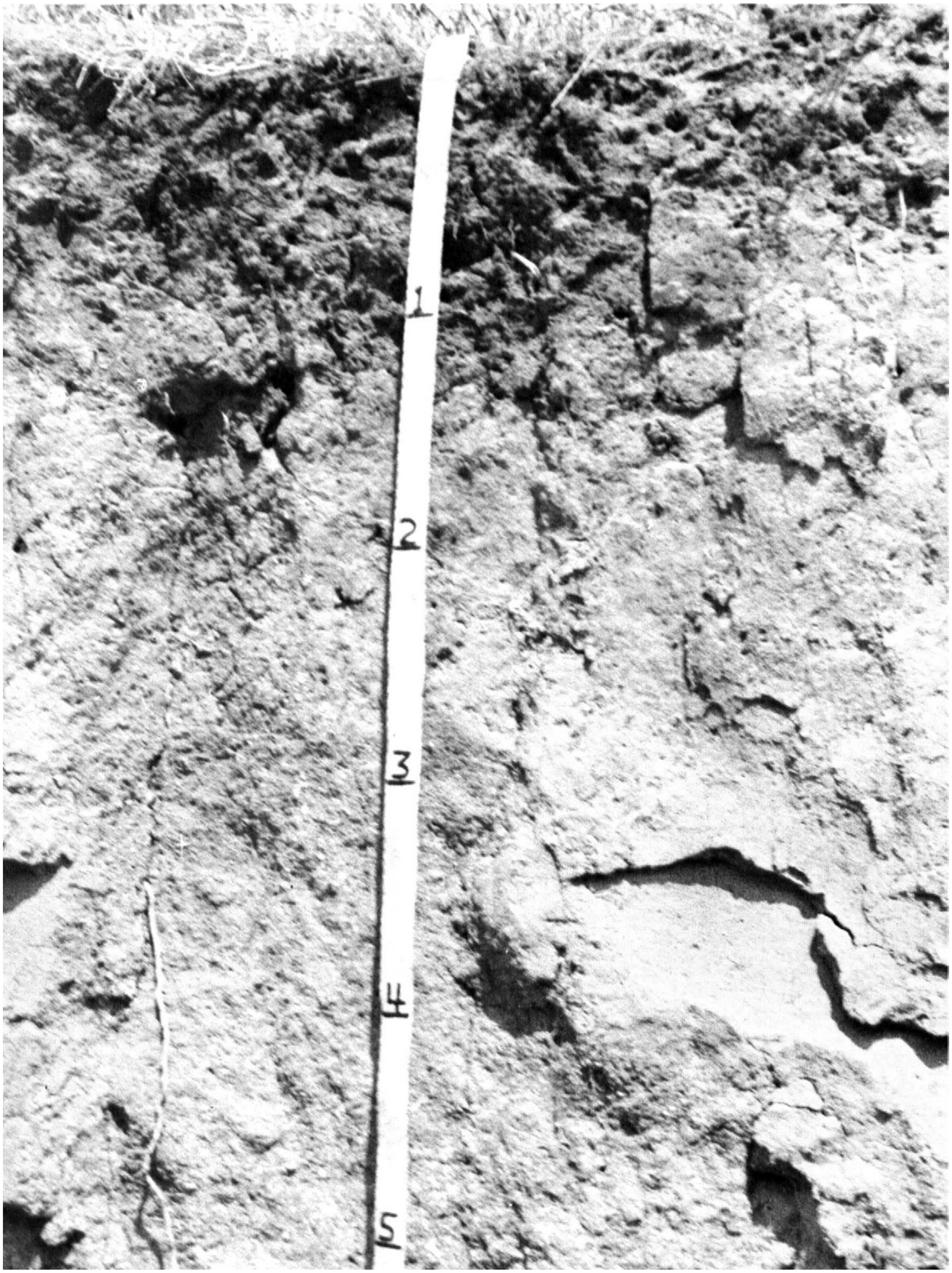

Figure 3.—Minco very fine sandy loam, 8 to 20 percent slopes. Roots easily penetrate deep into the soil.

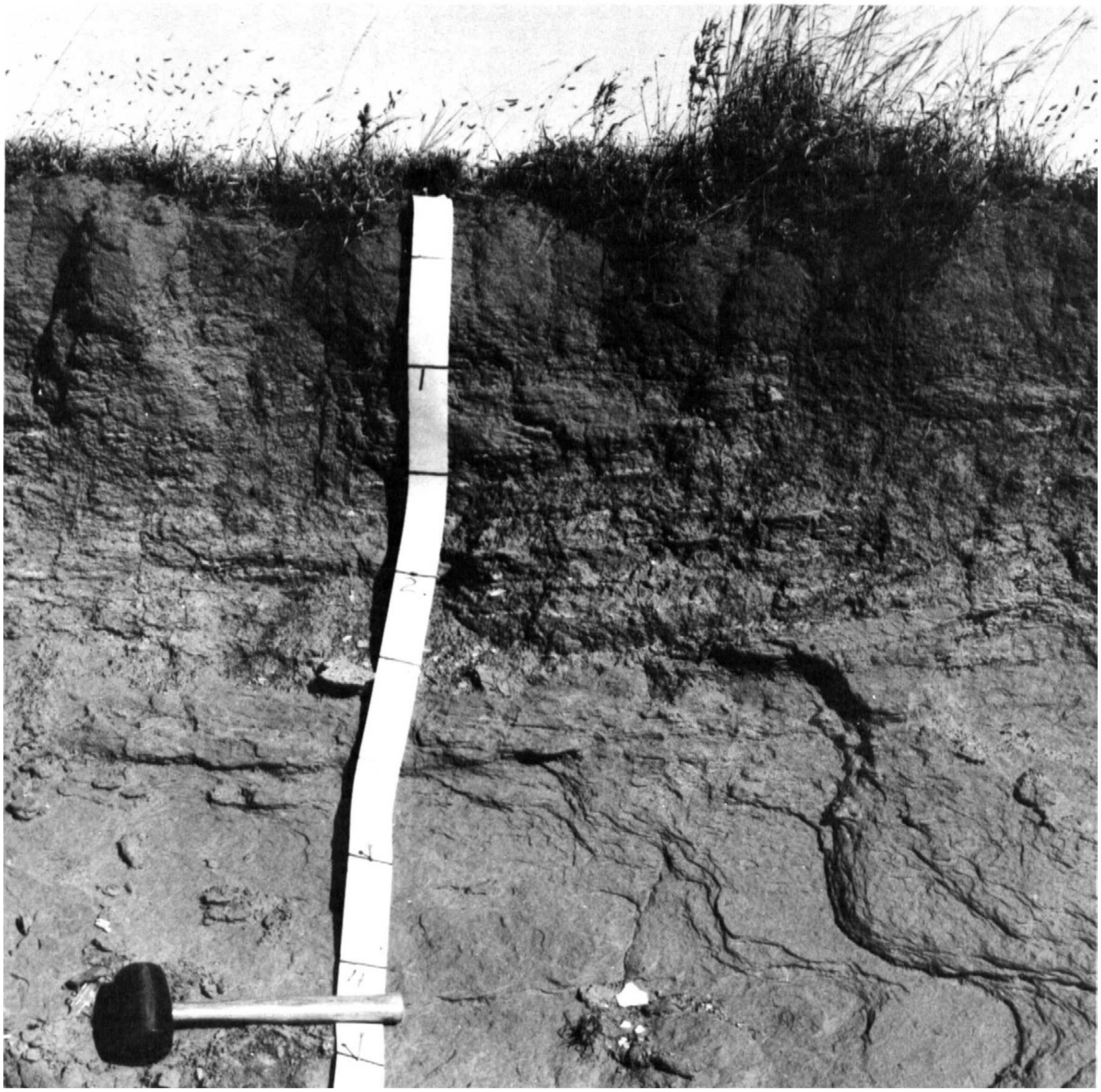

Figure 4.—Shallow Lucien soil in an area of Nash-Lucien complex, 2 to 5 percent slopes.

Figure 5.—Typical area of Pits. Soil material has been removed for construction purposes.

Figure 6.—Improved bermudagrass on Port silt loam, overwash.

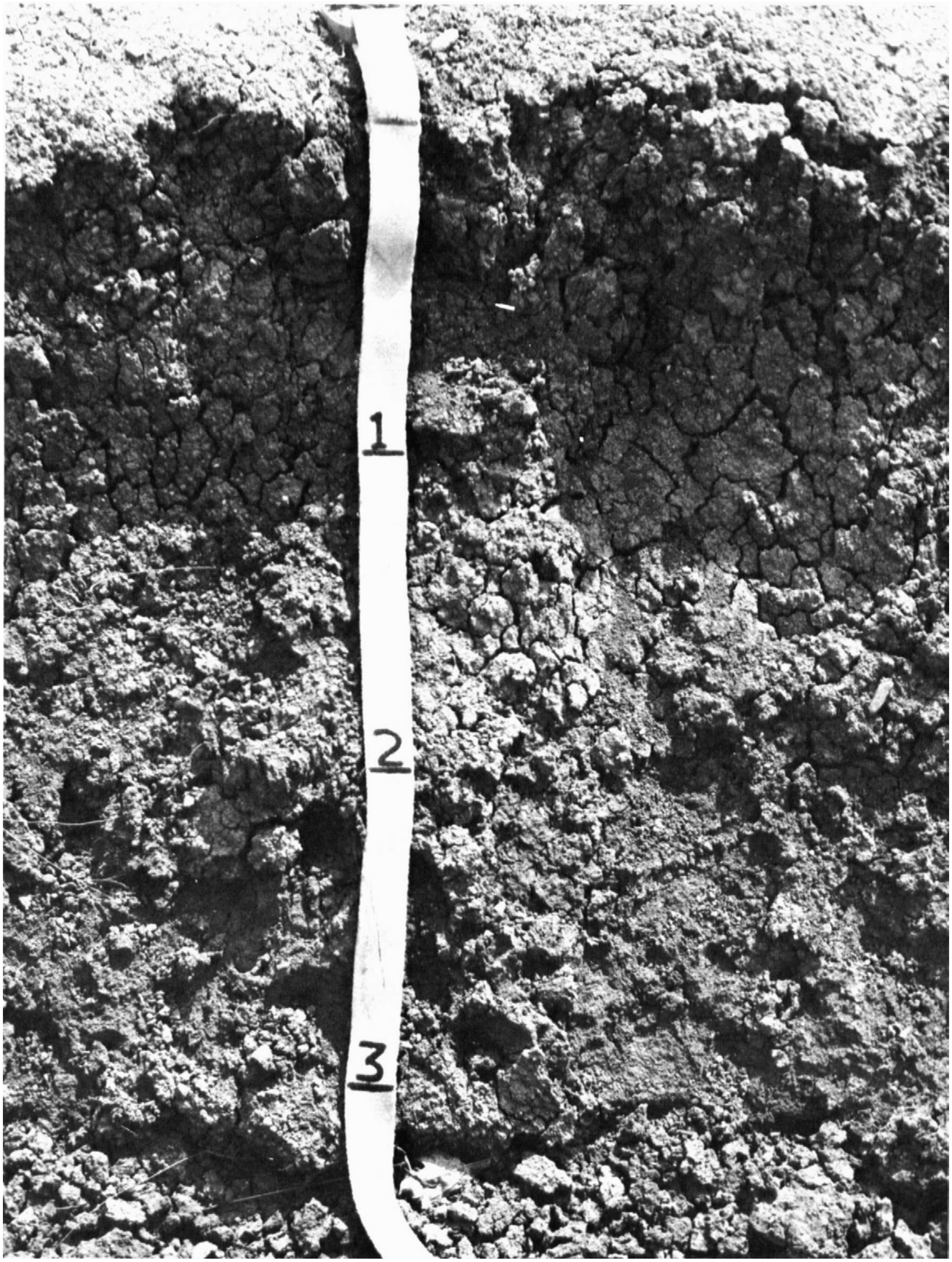

Figure 7.—Tamford clay loam in the Tamford-Grainola complex, 5 to 12 percent slopes. The soil cracks severely when dry.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Bermudagrass (Improved)				5	18	24	17	12	15	9		
Weeping Lovegrass			3	12	17	20	11	8	13	13	3	
Tall Fescue	3	3	15	26	22	5			2	8	12	4
King Ranch and Caucasian Bluestem					7	25	23	20	15	10		
Forage Sorghum						40	30	20	10			
Rye and Vetch Graze out	3	3	16	22	25	15				5	6	5
Native Grass (deferred)	5	4	3			15	25	25	13			10

Figure 8.—Forage calendar. Production shown in percentages.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION DATA

Month	Temperature[1]						Precipitation[1]				
	Average daily maximum	Average daily minimum	Average	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days[2]	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	49.7	25.2	37.5	74	0	10	1.02	.23	1.63	2	1.8
February---	55.4	29.4	42.4	81	7	21	1.27	.55	1.86	3	1.6
March------	63.2	36.6	50.0	89	13	175	2.28	1.01	3.30	4	1.1
April------	74.2	48.7	61.5	93	25	354	3.41	1.79	4.73	5	.0
May--------	81.2	57.6	69.4	95	38	601	5.73	3.09	7.88	7	.0
June-------	89.5	66.0	77.7	101	50	831	3.52	1.32	5.30	5	.0
July-------	95.0	69.8	82.4	106	54	1,004	2.83	.93	4.33	4	.0
August-----	94.6	68.3	81.5	106	54	977	2.59	.93	3.91	4	.0
September--	86.8	60.7	73.8	102	41	714	4.40	1.09	7.01	5	.0
October----	76.2	49.5	62.9	94	29	400	3.56	1.08	5.55	4	.0
November---	62.4	36.4	49.4	82	16	108	2.12	.52	3.40	3	.3
December---	52.7	28.7	40.7	75	3	16	1.51	.62	2.22	3	1.5
Year-----	73.4	48.1	60.8	108	-1	5,211	34.24	26.49	41.49	49	6.3

[1]Recorded in the period 1951-74 at Purcell, Okla.

[2]A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

Probability	Temperature[1]		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	March 31	April 16	April 20
2 years in 10 later than--	March 26	April 11	April 15
5 years in 10 later than--	March 15	March 31	April 6
First freezing temperature in fall:			
1 year in 10 earlier than--	October 26	October 23	October 15
2 years in 10 earlier than--	November 2	October 29	October 21
5 years in 10 earlier than--	November 15	November 9	October 31

[1]Recorded in the period 1951-74 at Purcell, Oklahoma.

TABLE 3.--GROWING SEASON LENGTH

Probability	Daily minimum temperature during growing season[1]		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	218	197	183
8 years in 10	227	205	191
5 years in 10	244	222	206
2 years in 10	261	238	222
1 year in 10	269	247	230

[1]Recorded in the period 1951-74 at Purcell, Oklahoma.

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
1	Asa loam, overwash	4,600	1.3
2	Asher silty clay loam	1,015	0.3
3	Bethany silt loam, 0 to 1 percent slopes	3,823	1.0
4	Bethany silt loam, 1 to 3 percent slopes	3,339	0.9
5	Bethany-Pawhuska complex, 0 to 2 percent slopes	1,485	0.4
6	Canadian fine sandy loam	1,296	0.4
7	Clarita clay, 1 to 3 percent slopes	177	*
8	Clarita clay, 3 to 8 percent slopes	3,960	1.1
9	Gaddy-Gracemore complex, undulating	3,489	1.0
10	Gracemont fine sandy loam	1,520	0.4
11	Gracemore soils	6,566	1.8
12	Grainola clay loam, 3 to 5 percent slopes	4,103	1.1
13	Grant silt loam, 1 to 3 percent slopes	3,135	0.9
14	Grant silt loam, 2 to 5 percent slopes, eroded	39,231	10.7
15	Grant silt loam, 3 to 5 percent slopes	6,781	1.8
16	Grant silt loam, 5 to 8 percent slopes, eroded	13,653	3.7
17	Grant-Port complex, 0 to 12 percent slopes	14,024	3.8
18	Grant soils, gullied	5,945	1.6
19	Keokuk loam	3,047	0.8
20	Keokuk silt loam	8,578	2.3
21	Kirkland silt loam, 0 to 2 percent slopes	7,359	2.0
22	Konawa loamy fine sand, 0 to 3 percent slopes	1,825	0.5
23	Konawa loamy fine sand, 3 to 8 percent slopes	4,561	1.2
24	Konawa soils, gullied	943	0.3
25	Lela clay	2,027	0.6
26	Miller silty clay	2,772	0.8
27	Minco very fine sandy loam, 5 to 8 percent slopes	3,078	0.8
28	Minco very fine sandy loam, 8 to 20 percent slopes	2,073	0.6
29	Minco silt loam, 0 to 1 percent slopes	2,125	0.6
30	Minco silt loam, 1 to 3 percent slopes	6,213	1.7
31	Minco silt loam, 3 to 5 percent slopes	2,889	0.8
32	Nash-Lucien complex, 2 to 5 percent slopes	12,420	3.4
33	Nash-Lucien complex, 5 to 12 percent slopes	66,246	18.0
34	Pits	554	0.2
35	Pond Creek silt loam, 0 to 1 percent slopes	4,709	1.3
36	Pond Creek silt loam, 1 to 3 percent slopes	6,406	1.7
37	Port silt loam, overwash	18,043	4.9
38	Pulaski fine sandy loam	6,579	1.8
39	Pulaski and Port soils	4,036	1.1
40	Renfrow silt loam, 2 to 5 percent slopes	3,679	1.0
41	Renfrow silt loam, 2 to 5 percent slopes, eroded	11,392	3.1
42	Renfrow soils, 2 to 5 percent slopes, severely eroded	1,396	0.4
43	Stephenville fine sandy loam, 2 to 5 percent slopes	10,887	3.0
44	Stephenville fine sandy loam, 2 to 5 percent slopes, eroded	25,811	7.0
45	Stephenville fine sandy loam, gullied	12,145	3.3
46	Tamford-Grainola complex, 5 to 12 percent slopes	13,249	3.6
47	Teller loam, 1 to 3 percent slopes	3,344	0.9
	Water	192	0.1
	Total	366,720	100.0

* Less than 0.1 percent.

TABLE 5.--YIELDS PER ACRE OF CROPS

[Yields are those that can be expected under a high level of management. The estimates were made in 1976. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Alfalfa hay	Cotton lint	Grain sorghum	Peanuts	Wheat	Soybeans
	Ton	Lb	Bu	Lb	Bu	Bu
1 Asa	5.0	500	65	---	40	30
2 Asher	4.5	500	60	---	40	30
3 Bethany	3.5	400	55	---	35	25
4 Bethany	3.0	350	50	---	30	20
5 Bethany	---	250	32	---	20	---
6 Canadian	4.0	400	50	1,650	35	25
7 Clarita	---	300	40	---	25	---
8 Clarita	---	225	30	---	20	---
9 Gaddy	3.0	---	32	1,200	20	---
10 Gracemont	3.5	300	40	---	25	25
11 Gracemore	---	---	---	---	---	---
12 Grainola	---	225	25	---	16	---
13 Grant	2.8	350	45	---	30	20
14 Grant	---	275	30	---	20	---
15 Grant	2.0	300	40	---	25	---
16 Grant	---	---	---	---	15	---
17 Grant	---	---	---	---	---	---
18 Grant	---	---	---	---	---	---
19 Keokuk	4.5	500	60	1,650	40	25
20 Keokuk	5.0	500	65	---	40	30
21 Kirkland	---	300	35	---	25	20

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS--Continued

Soil name and map symbol	Alfalfa hay	Cotton lint	Grain sorghum	Peanuts	Wheat	Soybeans
	Ton	Lb	Bu	Lb	Bu	Bu
22-------------------------- Konawa	---	285	40	1,300	20	---
23-------------------------- Konawa	---	---	30	---	15	---
24-------------------------- Konawa	---	---	---	---	---	---
25-------------------------- Lela	3.5	400	45	---	30	22
26-------------------------- Miller	4.3	450	60	---	35	30
27-------------------------- Minco	---	---	---	1,100	25	---
28-------------------------- Minco	---	---	---	---	---	---
29-------------------------- Minco	3.5	450	55	1,800	35	28
30-------------------------- Minco	3.0	400	50	1,700	30	25
31-------------------------- Minco	2.5	325	40	1,500	30	20
32-------------------------- Nash	---	---	30	---	19	---
33-------------------------- Nash	---	---	---	---	---	---
34* Pits						
35-------------------------- Pond Creek	3.5	450	60	---	35	30
36-------------------------- Pond Creek	3.0	400	55	---	30	28
37-------------------------- Port	5.0	500	65	---	40	30
38-------------------------- Pulaski	4.0	400	60	1,500	30	25
39-------------------------- Pulaski	---	---	---	---	---	---
40-------------------------- Renfrow	---	240	30	---	25	---
41-------------------------- Renfrow	---	---	---	---	15	---
42-------------------------- Renfrow	---	---	---	---	---	---
43-------------------------- Stephenville	---	275	30	1,100	20	---
44-------------------------- Stephenville	---	---	25	950	15	---

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS--Continued

Soil name and map symbol	Alfalfa hay	Cotton lint	Grain sorghum	Peanuts	Wheat	Soybeans
	Ton	Lb	Bu	Lb	Bu	Bu
45------------------------- Stephenville	---	---	---	---	---	---
46------------------------- Tamford	---	---	---	---	---	---
47------------------------- Teller	3.0	400	50	1,500	30	25

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES

[Only the soils that support rangeland vegetation are listed]

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
1 Asa	Loamy Bottomland	Favorable	8,000	Virginia wildrye	15
		Normal	6,500	Indiangrass	10
		Unfavorable	5,000	Little bluestem	10
				Beaked panicum	10
				Switchgrass	10
				Sedge	10
				Big bluestem	5
				Rustyseed paspalum	5
2 Asher	Loamy Bottomland	Favorable	8,000	Big bluestem	25
		Normal	5,600	Switchgrass	15
		Unfavorable	4,000	Indiangrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Sunflower	5
				Eastern cottonwood	5
				Sedge	5
3, 4 Bethany	Loamy Prairie	Favorable	5,000	Little bluestem	25
		Normal	3,500	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Dotted gayfeather	5
5*:					
Bethany	Loamy Prairie	Favorable	5,000	Little bluestem	25
		Normal	3,500	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Dotted gayfeather	5
Pawhuska	Shallow Claypan	Favorable	3,000	Little bluestem	25
		Normal	2,100	Indiangrass	10
		Unfavorable	1,500	Sideoats grama	10
				Big bluestem	10
				Scribner panicum	5
				Silver bluestem	5
				Switchgrass	5
				Dotted gayfeather	5
				Tall dropseed	5
6 Canadian	Loamy Bottomland	Favorable	8,000	Big bluestem	25
		Normal	5,600	Indiangrass	15
		Unfavorable	4,000	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Heath aster	5
				Sedge	5

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
7, 8: Clarita	Black Clay Prairie	Favorable	4,800	Little bluestem	25
		Normal	3,300	Big bluestem	15
		Unfavorable	2,300	Indiangrass	15
				Switchgrass	10
				Eastern gamagrass	5
				Sideoats grama	5
				Tall dropseed	5
9*:					
Gaddy	Sandy Bottomland	Favorable	3,800	Switchgrass	30
		Normal	2,700	Sand bluestem	15
		Unfavorable	2,000	Indiangrass	15
				Little bluestem	5
				Texas bluegrass	5
				Beaked panicum	5
				Purpletop	5
				Goldenrod	5
				Heath aster	5
				Maximilian sunflower	5
Gracemore	Subirrigated	Favorable	8,000	Switchgrass	25
		Normal	6,500	Big bluestem	20
		Unfavorable	4,500	Indiangrass	10
				Eastern gamagrass	10
				Beaked panicum	10
				Canada wildrye	5
				Scribner panicum	5
				Purpletop	5
				Maximilian sunflower	5
10: Gracemont	Subirrigated	Favorable	8,000	Switchgrass	25
		Normal	6,500	Big bluestem	20
		Unfavorable	4,500	Indiangrass	10
				Eastern gamagrass	10
				Canada wildrye	5
				Maximilian sunflower	5
11*: Gracemore	Subirrigated	Favorable	8,000	Switchgrass	25
		Normal	6,500	Big bluestem	20
		Unfavorable	4,500	Indiangrass	10
				Eastern gamagrass	10
				Beaked panicum	10
				Canada wildrye	5
				Scribner panicum	5
				Purpletop	5
				Maximilian sunflower	5
12: Grainola	Shallow Prairie	Favorable	3,000	Little bluestem	30
		Normal	2,100	Big bluestem	15
		Unfavorable	1,500	Indiangrass	10
				Switchgrass	10
				Tall dropseed	5
				Scribner panicum	5
				Sideoats grama	5
				Prairie-clover	5
13, 14, 15, 16: Grant	Loamy Prairie	Favorable	5,500	Little bluestem	25
		Normal	3,300	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Sideoats grama	5
				Canada wildrye	5

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
17*:					
Grant	Loamy Prairie	Favorable	5,500	Little bluestem	25
		Normal	3,300	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Sideoats grama	5
				Canada wildrye	5
Port	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Heath aster	5
				Sedge	5
18* Grant	Eroded Prairie	Favorable	2,500	Little bluestem	35
		Normal	2,000	Big bluestem	10
		Unfavorable	1,700	Sideoats grama	10
				Tall dropseed	10
19, 20 Keokuk	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Florida paspalum	5
				Canada wildrye	5
				Maximilian sunflower	5
				Eastern cottonwood	5
21 Kirkland	Claypan Prairie	Favorable	3,500	Little bluestem	25
		Normal	2,400	Big bluestem	20
		Unfavorable	1,400	Switchgrass	15
				Indiangrass	10
				Sideoats grama	5
				Blue grama	5
				Buffalograss	5
				Goldenrod	5
				Indiancurrant coralberry	5
22, 23 Konawa	Deep Sand Savannah	Favorable	3,800	Little bluestem	25
		Normal	2,700	Big bluestem	20
		Unfavorable	1,800	Indiangrass	5
				Switchgrass	5
				Purpletop	5
				Scribner panicum	5
				Arrowfeather threeawn	5
				Sideoats grama	5
				Lespedeza	5
24* Konawa	Eroded Sandy Savannah	Favorable	2,500	Little bluestem	30
		Normal	1,600	Indiangrass	10
		Unfavorable	1,250	Splitbeard bluestem	10
				Big bluestem	5
				Switchgrass	5
				Purpletop	5
				Purple lovegrass	5
				Carolina jointtail	5

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
25 Lela	Heavy Bottomland	Favorable	5,500	Big bluestem	25
		Normal	3,700	Switchgrass	15
		Unfavorable	2,500	Indiangrass	15
				Prairie cordgrass	10
				Western wheatgrass	5
				Tall dropseed	5
				Sunflower	5
				Goldenrod	5
				Sedge	5
26 Miller	Heavy Bottomland	Favorable	5,500	Big bluestem	25
		Normal	3,700	Switchgrass	15
		Unfavorable	2,500	Indiangrass	15
				Prairie cordgrass	10
				Western wheatgrass	5
				Tall dropseed	5
				Sunflower	5
				Goldenrod	5
				Sedge	5
27, 28, 29, 30, 31 Minco	Loamy Prairie	Favorable	5,500	Little bluestem	25
		Normal	3,700	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Lespedeza	5
				Dotted gayfeather	5
32*, 33*:					
Nash	Loamy Prairie	Favorable	4,800	Little bluestem	25
		Normal	3,200	Big bluestem	20
		Unfavorable	2,200	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Lespedeza	5
				Dotted gayfeather	5
Lucien	Shallow Prairie	Favorable	3,000	Little bluestem	30
		Normal	2,100	Big bluestem	15
		Unfavorable	1,500	Indiangrass	10
				Switchgrass	10
				Tall dropseed	10
				Scribner panicum	5
				Sideoats grama	5
				Prairie-clover	5
				Dotted gayfeather	5
35, 36 Pond Creek	Loamy Prairie	Favorable	5,000	Little bluestem	25
		Normal	3,300	Big bluestem	20
		Unfavorable	2,200	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Prairie-clover	5
				Dotted gayfeather	5

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Compo- sition
			Lb/acre		Pct
37 Port	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Heath aster	5
				Sedge	5
38 Pulaski	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Sedge	5
				Heath aster	5
39*:					
Pulaski	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Sedge	5
				Heath aster	5
Port	Loamy Bottomland	Favorable	8,500	Big bluestem	25
		Normal	6,100	Indiangrass	15
		Unfavorable	4,500	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Tall dropseed	5
				Beaked panicum	5
				Compassplant	5
				Heath aster	5
				Sedge	5
40, 41 Renfrow	Claypan Prairie	Favorable	3,500	Little bluestem	25
		Normal	2,500	Big bluestem	20
		Unfavorable	1,400	Switchgrass	15
				Indiangrass	10
				Sideoats grama	5
				Blue grama	5
				Buffalograss	5
				Leadplant	5
				Goldenrod	5
				Indiancurrant coralberry	5
42* Renfrow	Eroded Clay	Favorable	2,000	Sideoats grama	30
		Normal	1,400	Blue grama	15
		Unfavorable	1,000	Buffalograss	15
				Little bluestem	10

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production		Characteristic vegetation	Composition
		Kind of year	Dry weight		
			Lb/acre		Pct
43, 44 Stephenville	Sandy Savannah	Favorable	4,500	Little bluestem	25
		Normal	3,300	Big bluestem	20
		Unfavorable	2,500	Indiangrass	5
				Switchgrass	5
				Sand lovegrass	5
				Scribner panicum	5
				Sunflower	5
45 Stephenville	Eroded Sandy Savannah	Favorable	2,200	Little bluestem	30
		Normal	1,500	Indiangrass	10
		Unfavorable	1,100	Big bluestem	5
				Switchgrass	5
				Purpletop	5
				Tickclover	5
46*:					
Tamford	Red Clay Prairie	Favorable	3,000	Little bluestem	25
		Normal	2,200	Sideoats grama	15
		Unfavorable	1,500	Big bluestem	10
				Indiangrass	5
				Switchgrass	5
				Blue grama	5
				Buffalograss	5
				Longspike tridens	5
Grainola	Shallow Prairie	Favorable	2,700	Little bluestem	30
		Normal	1,800	Big bluestem	15
		Unfavorable	1,300	Indiangrass	10
				Switchgrass	10
				Tall dropseed	5
				Scribner panicum	5
				Sideoats grama	5
				Prairie-clover	5
47 Teller	Loamy Prairie	Favorable	5,000	Little bluestem	25
		Normal	3,500	Big bluestem	20
		Unfavorable	2,500	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Dotted gayfeather	5

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[Absence of an entry indicates that trees do not grow to the given height on that soil]

Soil name and map symbol	Expected heights of specified trees at 20 years of age								
	American plum	Autumn-olive	Eastern cotton-wood	Eastern redcedar	Loblolly pine	Osage-orange	Scotch pine	Shortleaf pine	American sycamore
	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft
1 Asa	--	18	65	35	40	30	40	45	50
2 Asher	--	18	65	35	40	30	40	45	50
3, 4 Bethany	--	--	--	20	--	22	--	25	--
5*:									
Bethany	--	--	--	20	--	20	--	25	--
Pawhuska	--	--	--	15	--	15	--	--	--
6 Canadian	16	18	65	30	40	20	35	35	40
7, 8 Clarita	--	--	--	15	--	15	--	25	--
9*:									
Gaddy	12	14	60	30	--	18	30	30	45
Gracemore	--	--	80	25	35	22	--	--	50
10 Gracemont	--	--	80	35	40	30	--	--	50
11* Gracemore	--	--	80	25	30	22	--	--	50
12 Grainola	--	--	--	15	--	15	--	--	--
13, 14, 15, 16 Grant	10	16	50	20	25	18	30	25	--
17*:									
Grant	10	16	50	20	20	18	25	20	--
Port	--	18	65	35	40	30	40	40	--
18* Grant	8	12	50	15	20	15	25	20	--
19, 20 Keokuk	--	18	65	35	40	30	35	40	--
21 Kirkland	--	--	--	15	--	15	--	25	--
22, 23, 24* Konawa	8	14	50	20	25	18	30	30	--
25 Lela	--	--	50	20	--	25	--	25	40
26 Miller	--	--	55	20	--	25	--	30	45
27, 28, 29, 30, 31 Minco	10	18	50	30	32	20	30	25	30
32*, 33*:									
Nash	8	12	--	20	25	18	25	20	--

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Expected heights of specified trees at 20 years of age								
	American plum	Autumn-olive	Eastern cotton-wood	Eastern redcedar	Loblolly pine	Osage-orange	Scotch pine	Shortleaf pine	American sycamore
	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft	Ft
32*, 33*:									
Lucien	--	--	--	15	--	15	--	--	--
34*. Pits									
35, 36 Pond Creek	10	18	50	25	30	25	30	30	--
37 Port	--	18	65	35	40	30	40	40	--
38 Pulaski	16	18	60	30	35	25	40	35	45
39*:									
Pulaski	16	18	70	30	35	25	40	35	45
Port	--	18	70	35	40	30	40	40	50
40, 41, 42* Renfrow	--	--	--	18	--	15	--	--	--
43 Stephenville	10	12	--	20	25	20	25	25	--
44, 45 Stephenville	8	10	--	18	20	15	20	20	--
46*:									
Tamford	--	--	--	15	--	15	20	--	--
Grainola	--	--	--	15	--	15	--	--	--
47 Teller	10	18	50	25	25	20	30	30	30

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
1 Asa	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: low strength.
2 Asher	Moderate: wetness, floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength.
3, 4 Bethany	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
5*: Bethany	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
Pawhuska	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: low strength, shrink-swell.
6 Canadian	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, low strength.
7, 8 Clarita	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: low strength, shrink-swell.	Severe: low strength, shrink-swell.
9*: Gaddy	Severe: floods, cutbanks cave.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods.
Gracemore	Severe: wetness, floods, cutbanks cave.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Moderate: floods.
10 Gracemont	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: floods.
11* Gracemore	Severe: wetness, floods, cutbanks cave.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: floods.
12 Grainola	Severe: too clayey.	Severe: low strength, shrink-swell.	Severe: low strength, shrink-swell.	Severe: low strength, slope, shrink-swell.	Severe: low strength, shrink-swell.
13, 14, 15, 16 Grant	Slight	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: low strength.
17*: Grant	Moderate: slope.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: slope.	Moderate: low strength.
Port	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.

See footnote at end of table.

TABLE 8.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
18*: Grant	Slight	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: low strength.
19: Keokuk	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, low strength.
20: Keokuk	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, low strength.
21: Kirkland	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
22: Konawa	Slight	Slight	Slight	Slight	Moderate: low strength.
23, 24*: Konawa	Slight	Slight	Slight	Moderate: slope.	Moderate: low strength.
25: Lela	Severe: floods, wetness, too clayey.	Severe: low strength, floods, shrink-swell.	Severe: low strength, floods, shrink-swell.	Severe: low strength, floods, shrink-swell.	Severe: low strength, shrink-swell.
26: Miller	Severe: floods, too clayey.	Severe: floods, shrink-swell, low strength.	Severe: floods, shrink-swell, low strength.	Severe: floods, shrink-swell, low strength.	Severe: low strength, shrink-swell.
27: Minco	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Moderate: low strength.
28: Minco	Moderate: slope.	Moderate: low strength, slope.	Moderate: low strength, slope.	Severe: slope.	Moderate: low strength, slope.
29, 30: Minco	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.
31: Minco	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Moderate: low strength.
32*:					
Nash	Moderate: depth to rock.	Moderate: low strength.	Moderate: depth to rock.	Moderate: low strength.	Moderate: low strength.
Lucien	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.
33*:					
Nash	Moderate: depth to rock, slope.	Moderate: slope, low strength.	Moderate: depth to rock, slope.	Severe: slope.	Moderate: low strength, slope.
Lucien	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Severe: slope.	Moderate: depth to rock.
34*. Pits					
35, 36: Pond Creek	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: low strength.

See footnote at end of table.

TABLE 8.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
37----------------- Port	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: low strength, shrink-swell, floods.
38----------------- Pulaski	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, low strength.
39*:					
Pulaski-----------	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Port--------------	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
40, 41, 42*-------- Renfrow	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
43----------------- Stephenville	Moderate: depth to rock.	Slight------------	Moderate: depth to rock.	Moderate: slope.	Moderate: low strength.
44, 45------------- Stephenville	Moderate: depth to rock.	Slight------------	Moderate: depth to rock.	Moderate: slope.	Moderate: low strength.
46*:					
Tamford-----------	Severe: too clayey.	Severe: low strength, shrink-swell.	Severe: low strength, shrink-swell.	Severe: low strength, slope, shrink-swell.	Severe: low strength, shrink-swell.
Grainola----------	Severe: too clayey.	Severe: low strength, shrink-swell.	Severe: low strength, shrink-swell.	Severe: low strength, slope, shrink-swell.	Severe: low strength, shrink-swell.
47----------------- Teller	Slight------------	Slight------------	Slight------------	Slight-------------	Moderate: low strength.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," and "fair." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1 Asa	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
2 Asher	Moderate: floods.	Moderate: seepage.	Moderate: floods.	Moderate: floods.	Fair: too clayey.
3, 4 Bethany	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey.
5*:					
Bethany	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey.
Pawhuska	Severe: percs slowly.	Slight	Severe: too clayey:	Slight	Poor: too clayey.
6 Canadian	Moderate: floods.	Severe: seepage, floods.	Severe: seepage.	Severe: seepage.	Good.
7, 8 Clarita	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey.
9*:					
Gaddy	Severe: floods.	Severe: seepage, floods.	Severe: seepage, too sandy, floods.	Severe: floods, seepage.	Fair: too sandy.
Gracemore	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: floods, seepage, wetness.	Severe: wetness, floods, seepage.	Poor: too sandy.
10 Gracemont	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: floods, seepage.	Severe: wetness, floods, seepage.	Good.
11* Gracemore	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: floods, seepage, wetness.	Severe: wetness, floods, seepage.	Poor: too sandy.
12 Grainola	Severe: percs slowly, depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Slight	Poor: too clayey.
13, 14, 15, 16 Grant	Moderate: depth to rock.	Moderate: seepage, depth to rock.	Moderate: depth to rock, too clayey.	Slight	Fair: thin layer.
17*:					
Grant	Moderate: depth to rock.	Severe: slope.	Moderate: depth to rock, too clayey.	Moderate: slope.	Fair: thin layer.
Port	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
18* Grant	Moderate: depth to rock.	Moderate: seepage, depth to rock.	Moderate: depth to rock, too clayey.	Slight	Fair: thin layer.

See footnote at end of table.

TABLE 9.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
19 Keokuk	Moderate: floods.	Moderate: seepage.	Moderate: floods, seepage.	Moderate: floods.	Good.
20 Keokuk	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
21 Kirkland	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: thin layer, too clayey.
22, 23, 24* Konawa	Slight	Severe: seepage.	Severe: seepage.	Slight	Fair: thin layer.
25 Lela	Severe: percs slowly, floods.	Slight	Severe: floods, too clayey.	Severe: floods.	Poor: too clayey.
26 Miller	Severe: percs slowly, floods.	Severe: floods.	Severe: floods, too clayey.	Severe: floods.	Poor: too clayey, hard to pack.
27 Minco	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
28 Minco	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.	Fair: slope.
29 Minco	Slight	Moderate: seepage.	Slight	Slight	Good.
30, 31 Minco	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
32*: Nash	Severe: depth to rock.	Severe: depth to rock, slope.	Moderate: depth to rock.	Slight	Fair: thin layer.
Lucien	Severe: depth to rock.	Severe: seepage, depth to rock.	Severe: seepage, depth to rock.	Severe: seepage.	Poor: thin layer.
33*: Nash	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Moderate: depth to rock.	Moderate: slope.	Fair: thin layer, slope.
Lucien	Severe: depth to rock.	Severe: seepage depth to rock.	Severe: seepage, depth to rock.	Severe: seepage.	Poor: thin layer.
34*. Pits					
35 Pond Creek	Severe: percs slowly.	Slight	Moderate: too clayey.	Slight	Fair: too clayey.
36 Pond Creek	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
37 Port	Severe: floods.	Moderate: seepage.	Severe: floods.	Severe: floods.	Good.

See footnote at end of table.

TABLE 9.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
38 Pulaski	Severe: floods.	Severe: seepage, floods.	Severe: floods, seepage.	Severe: floods, seepage.	Good.
39*:					
Pulaski	Severe: floods.	Severe: seepage, floods.	Severe: floods, seepage.	Severe: floods, seepage.	Good.
Port	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
40, 41, 42* Renfrow	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: thin layer.
43, 44, 45 Stephenville	Severe: depth to rock.	Severe: depth to rock, slope.	Moderate: depth to rock.	Slight	Fair: thin layer.
46*:					
Tamford	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: hard to pack, too clayey.
Grainola	Severe: percs slowly, depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Moderate: slope.	Poor: too clayey.
47 Teller	Slight	Severe: seepage.	Severe: seepage.	Slight	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1 Asa	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
2 Asher	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
3, 4 Bethany	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
5*:				
Bethany	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Pawhuska	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: thin layer, excess salt.
6 Canadian	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
7, 8 Clarita	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
9*:				
Gaddy	Good	Poor: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Gracemore	Fair: low strength, wetness.	Poor: excess fines.	Unsuited excess fines.	Poor: too sandy.
10 Gracemont	Fair: wetness, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
11* Gracemore	Fair: low strength, wetness.	Poor: excess fines.	Unsuited: excess fines.	Poor: too sandy.
12 Grainola	Poor: low strength, shrink-swell, thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
13, 14, 15, 16 Grant	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
17*:				
Grant	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Port	Fair: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
18* Grant	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
19, 20 Keokuk	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.

See footnote at end of table.

TABLE 10.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
21------ Kirkland	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
22, 23, 24*------ Konawa	Fair: low strength.	Poor: excess fines.	Unsuited: excess fines.	Poor: too sandy.
25------ Lela	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
26------ Miller	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
27------ Minco	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
28------ Minco	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: slope.
29, 30, 31------ Minco	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
32*:				
Nash------	Fair: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Lucien------	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
33*:				
Nash------	Fair: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: slope.
Lucien------	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
34*. Pits				
35, 36------ Pond Creek	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
37------ Port	Fair: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
38------ Pulaski	Fair: low strength.	Poor: excess fines.	Unsuited: excess fines.	Good.
39*:				
Pulaski------	Fair: low strength.	Poor: excess fines.	Unsuited: excess fines.	Good.
Port------	Fair: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
40, 41, 42*------ Renfrow	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
43, 44, 45------ Stephenville	Fair: thin layer, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.

See footnote at end of table.

TABLE 10.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
46*:				
Tamford	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey, slope.
Grainola	Poor: low strength, shrink-swell, thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
47 Teller	Good	Unsuited: excess fines.	Unsuited: excess fines.	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
1 Asa	Moderate: seepage.	Moderate: piping, erodes easily.	Severe: deep to water.	Not needed	Not needed	Erodes easily.
2 Asher	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: deep to water.	Floods	Favorable	Favorable.
3, 4 Bethany	Slight	Moderate: unstable fill, compressible.	Severe: no water.	Not needed	Percs slowly	Percs slowly.
5*:						
Bethany	Slight	Moderate: unstable fill, compressible.	Severe: no water.	Not needed	Percs slowly	Percs slowly.
Pawhuska	Slight	Severe: unstable fill.	Severe: no water.	Excess salt, percs slowly.	Percs slowly, excess salt.	Percs slowly, excess salt.
6 Canadian	Severe: seepage.	Moderate: unstable fill.	Severe: deep to water.	Not needed	Erodes easily	Erodes easily.
7, 8 Clarita	Slight	Severe: unstable fill, compressible, low strength.	Severe: no water.	Not needed	Percs slowly, erodes easily.	Percs slowly, erodes easily.
9*:						
Gaddy	Severe: seepage.	Moderate: unstable fill, piping.	Severe: deep to water.	Not needed	Erodes easily	Erodes easily.
Gracemore	Severe: seepage.	Moderate: unstable fill, low strength, piping.	Moderate: deep to water.	Wetness, floods, cutbanks cave.	Not needed	Wetness, seepage.
10 Gracemont	Severe: seepage.	Moderate: unstable fill, piping.	Moderate: deep to water.	Floods	Not needed	Wetness, seepage.
11* Gracemore	Severe: seepage.	Moderate: unstable fill, low strength, piping.	Moderate: deep to water.	Wetness, floods, cutbanks cave.	Not needed	Wetness, seepage.
12 Grainola	Slight	Severe: compressible, shrink-swell.	Severe: no water.	Percs slowly, slope.	Percs slowly, slope.	Percs slowly, slope.
13, 14, 15, 16 Grant	Moderate: seepage.	Moderate: unstable fill, piping, compressible.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
17*:						
Grant	Moderate: seepage.	Moderate: unstable fill, piping, compressible.	Severe: no water.	Not needed	Slope	Slope.
Port	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: deep to water.	Not needed	Not needed	Not needed.

See footnote at end of table.

TABLE 11.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
18* Grant	Moderate: seepage.	Moderate: unstable fill, piping, compressible.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
19, 20 Keokuk	Moderate: seepage.	Moderate: piping, compressible, low strength.	Severe: no water.	Not needed	Favorable	Favorable.
21 Kirkland	Slight	Severe: compressible, piping.	Severe: no water.	Not needed	Percs slowly, piping.	Percs slowly.
22, 23, 24* Konawa	Severe: seepage.	Moderate: low strength, unstable fill, piping.	Severe: deep to water.	Not needed	Erodes easily	Erodes easily.
25 Lela	Slight	Moderate: unstable fill, compressible.	Severe: deep to water.	Percs slowly, wetness, floods.	Not needed	Percs slowly, wetness.
26 Miller	Slight	Moderate: unstable fill, compressible.	Severe: deep to water.	Floods, percs slowly.	Not needed	Percs slowly.
27 Minco	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
28 Minco	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: no water.	Not needed	Slope, erodes easily.	Slope, erodes easily.
29 Minco	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: no water.	Not needed	Favorable	Favorable.
30, 31 Minco	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
32*: Nash	Severe: depth to rock.	Moderate: unstable fill, piping, thin layer.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
Lucien	Severe: depth to rock, seepage.	Severe: thin layer.	Severe: no water.	Not needed	Depth to rock	Rooting depth, seepage.
33*: Nash	Severe: depth to rock.	Moderate: unstable fill, piping, thin layer.	Severe: no water.	Not needed	Slope	Slope.
Lucien	Severe: depth to rock, seepage.	Severe: thin layer.	Severe: no water.	Not needed	Not needed	Not needed.
34*. Pits						

See footnote at end of table.

TABLE 11.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
35, 36 Pond Creek	Moderate: seepage.	Moderate: unstable fill, piping.	Severe: no water.	Not needed	Favorable	Favorable.
37 Port	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: deep to water.	Not needed	Not needed	Not needed.
38 Pulaski	Severe: seepage.	Moderate: unstable fill, seepage, piping.	Severe: deep to water.	Not needed	Not needed	Not needed.
39*:						
Pulaski	Severe: seepage.	Moderate: unstable fill, seepage, piping.	Severe: deep to water.	Not needed	Not needed	Not needed.
Port	Moderate: seepage.	Moderate: unstable fill, compressible, piping.	Severe: deep to water.	Not needed	Not needed	Not needed.
40, 41, 42* Renfrow	Slight	Moderate: unstable fill, compressible.	Severe: no water.	Not needed	Erodes easily, percs slowly.	Erodes easily, percs slowly.
43, 44, 45 Stephenville	Severe: depth to rock.	Moderate: thin layer.	Severe: no water.	Not needed	Erodes easily	Erodes easily.
46*:						
Tamford	Slight	Severe: compressible, piping, shrink-swell.	Severe: no water.	Percs slowly	Percs slowly	Percs slowly.
Grainola	Slight	Severe: compressible, shrink-swell.	Severe: no water.	Percs slowly, slope.	Percs slowly, slope.	Percs slowly, slope.
47 Teller	Severe: seepage.	Moderate: unstable fill, piping.	Severe: no water.	Not needed	Erodes easily, piping.	Erodes easily.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
1 Asa	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
2 Asher	Severe: floods.	Moderate: floods, too clayey.	Moderate: floods, percs slowly, too clayey.	Moderate: too clayey.
3, 4 Bethany	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
5*:				
Bethany	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Pawhuska	Severe: percs slowly.	Slight	Severe: percs slowly.	Slight.
6 Canadian	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
7, 8 Clarita	Severe: percs slowly.	Severe: too clayey.	Severe: percs slowly.	Severe: too clayey.
9*:				
Gaddy	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
Gracemore	Severe: floods.	Moderate: floods, wetness.	Moderate: wetness, floods.	Moderate: wetness, floods.
10 Gracemont	Severe: floods, wetness.	Moderate: wetness, floods.	Moderate: wetness, floods.	Moderate: floods, wetness.
11* Gracemore	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: wetness, floods.
12 Grainola	Moderate: percs slowly, slope, too clayey.	Moderate: slope, too clayey.	Moderate: too clayey.	Moderate: too clayey.
13, 14, 15 Grant	Slight	Slight	Moderate: slope.	Slight.
16 Grant	Slight	Slight	Severe: slope.	Slight.
17*:				
Grant	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight.
Port	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods.
18* Grant	Slight	Slight	Moderate: slope.	Slight.
19, 20 Keokuk	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.

See footnote at end of table.

TABLE 12.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
21: Kirkland	Severe: percs slowly.	Slight	Severe: percs slowly.	Slight.
22, 23, 24*: Konawa	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
25: Lela	Severe: floods, percs slowly, too clayey.	Severe: too clayey.	Severe: percs slowly, too clayey.	Severe: too clayey.
26: Miller	Severe: floods, percs slowly, too clayey.	Severe: too clayey.	Severe: percs slowly.	Severe: too clayey.
27: Minco	Slight	Slight	Severe: slope.	Slight.
28: Minco	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight.
29: Minco	Slight	Slight	Slight	Slight.
30, 31: Minco	Slight	Slight	Moderate: slope.	Slight.
32*:				
Nash	Slight	Slight	Moderate: slope.	Slight.
Lucien	Slight	Slight	Severe: depth to rock.	Slight.
33*:				
Nash	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight.
Lucien	Moderate: slope.	Moderate: slope.	Severe: depth to rock.	Slight.
34*. Pits				
35: Pond Creek	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
36: Pond Creek	Moderate: percs slowly.	Slight	Moderate: percs slowly, slope.	Slight.
37: Port	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
38: Pulaski	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
39*:				
Pulaski	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods.
Port	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods.
40, 41, 42*: Renfrow	Severe: percs slowly.	Slight	Severe: slope, percs slowly.	Slight.

See footnote at end of table.

TABLE 12.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
43, 44, 45 Stephenville	Slight	Slight	Moderate: slope.	Slight.
46*:				
Tamford	Severe: percs slowly.	Moderate: slope, too clayey.	Severe: percs slowly, slope.	Moderate: too clayey.
Grainola	Moderate: percs slowly, slope, too clayey.	Moderate: slope, too clayey.	Severe: slope.	Moderate: too clayey.
47 Teller	Slight	Slight	Moderate: slope.	Slight.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
1-------------------Asa	Good	Good	Fair	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
2-------------------Asher	Good	Good	Fair	Good	Good	Fair	Poor	Poor	Good	---	Poor	Fair.
3, 4----------------Bethany	Good	Good	Fair	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
5*:												
Bethany------------	Good	Good	Fair	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
Pawhuska-----------	Poor	Poor	Very poor	---	---	Poor	Very poor	Poor	Poor	---	Very poor.	Very poor.
6-------------------Canadian	Good	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.
7-------------------Clarita	Fair	Fair	Poor	---	---	Poor	Poor	Poor	Fair	---	Poor	Poor.
8-------------------Clarita	Fair	Fair	Poor	---	---	Poor	Poor	Very poor.	Fair	---	Very poor.	Poor.
9*:												
Gaddy--------------	Fair	Fair	Fair	Fair	---	Fair	Very poor.	Very poor.	Fair	---	Very poor.	Fair.
Gracemore----------	Fair	Fair	Good	Good	Good	---	Fair	Poor	Fair	Good	Poor	---
10------------------Gracemont	Fair	Good	Good	Good	Good	---	Fair	Poor	Good	Good	Poor	---
11*-----------------Gracemore	Poor	Fair	Fair	Good	Good	---	Fair	Poor	Fair	Fair	Poor	---
12------------------Grainola	Fair	Good	Fair	---	Fair	Fair	Very poor.	Very poor.	Fair	---	Very poor.	Fair.
13, 14, 15----------Grant	Good	Good	Good	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
16------------------Grant	Fair	Good	Good	---	---	Fair	Very poor.	Very poor.	Good	---	Very poor.	Fair.
17*:												
Grant--------------	Fair	Good	Good	---	---	Fair	Very poor.	Very poor.	Good	---	Very poor.	Fair.
Port---------------	Poor	Fair	Fair	---	---	Good	Poor	Very poor.	Fair	---	Very poor.	Fair.
18*-----------------Grant	Fair	Good	Good	---	---	Fair	Very poor.	Very poor.	Good	---	Very poor.	Fair.
19, 20--------------Keokuk	Good	Good	Good	Good	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.
21------------------Kirkland	Good	Good	Good	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.

See footnote at end of table.

TABLE 13.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
22, 23, 24*: Konawa	Fair	Fair	Good	---	---	Good	Poor	Very poor.	Fair	---	Very poor.	Good.
25: Lela	Fair	Fair	Fair	Good	Good	---	Poor	Fair	Fair	Good	Poor	---
26: Miller	Fair	Fair	Poor	---	---	Poor	Poor	Poor	Fair	---	Poor	Poor.
27: Minco	Fair	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.
28: Minco	Fair	Good	Good	---	---	Fair	Very poor.	Very poor.	Good	---	Very poor.	Fair.
29, 30, 31: Minco	Good	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.
32*:												
Nash	Fair	Good	Good	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
Lucien	Poor	Fair	Fair	---	---	Fair	Poor	Very poor.	Fair	---	Very poor.	Fair.
33*:												
Nash	Fair	Good	Good	---	---	Fair	Very poor.	Very poor.	Good	---	Very poor.	Fair.
Lucien	Poor	Fair	Fair	---	---	Fair	Poor	Very poor.	Fair	---	Very poor.	Fair.
34*. Pits												
35, 36: Pond Creek	Good	Good	Good	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
37: Port	Good	Good	Fair	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Fair.
38: Pulaski	Good	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.
39*:												
Pulaski	Poor	Fair	Fair	---	---	Good	Poor	Very poor.	Fair	---	Very poor.	Fair.
Port	Poor	Fair	Fair	---	---	Good	Poor	Very poor.	Fair	---	Very poor.	Fair.
40, 41, 42*: Renfrow	Good	Good	Good	---	---	Fair	Poor	Very poor.	Good	---	Very poor.	Fair.
43, 44, 45: Stephenville	Good	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.
46*:												
Tamford	Fair	Good	Fair	---	---	Poor	Very poor.	Very poor.	Fair	---	Very poor.	Poor.
Grainola	Poor	Fair	Fair	---	Fair	Fair	Very poor.	Very poor.	Fair	---	Very poor.	Fair.
47: Teller	Good	Good	Good	---	---	Good	Poor	Very poor.	Good	---	Very poor.	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
1-------------------- Asa	0-8	Loam-------------	CL, CL-ML	A-6, A-4	0	98-100	98-100	95-100	70-95	25-40	6-21
	8-43	Silty clay loam, silt loam.	CL, CL-ML	A-6, A-4	0	98-100	98-100	90-100	70-95	25-40	6-20
	43-60	Very fine sandy loam, silty clay loam.	CL, CL-ML	A-4, A-6	0	98-100	98-100	85-95	60-95	20-35	6-20
2-------------------- Asher	0-27	Silty clay loam	CL	A-7, A-6	0	100	100	95-100	90-98	37-50	15-25
	27-65	Silt loam, loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	85-100	51-97	<30	NP-10
3-------------------- Bethany	0-15	Silt loam--------	CL, ML	A-4, A-6	0	100	100	96-100	80-98	21-40	1-15
	15-24	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-50	15-26
	24-80	Silty clay, clay, silty clay loam.	CL, CH	A-7, A-6	0	100	95-100	96-100	90-99	37-60	15-33
4-------------------- Bethany	0-17	Silt loam--------	CL, ML	A-4, A-6	0	100	100	96-100	80-98	21-40	1-15
	17-24	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-50	15-26
	24-84	Silty clay, clay, silty clay loam.	CL, CH	A-7, A-6	0	100	95-100	96-100	90-99	37-60	15-33
5*:											
Bethany------------	0-12	Silt loam--------	CL, ML	A-4, A-6	0	100	100	96-100	80-98	21-40	1-15
	12-18	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-50	15-26
	18-74	Silty clay, clay, silty clay loam.	CL, CH	A-7, A-6	0	100	95-100	96-100	90-99	37-60	15-33
Pawhuska-----------	0-8	Silt loam--------	ML, CL-ML	A-4	0	100	100	96-100	80-97	22-30	2-7
	8-84	Silty clay loam, silty clay.	CL, CH	A-7	0	90-100	90-100	85-100	85-99	41-70	20-40
6-------------------- Canadian	0-39	Fine sandy loam	SM, ML, SC, CL	A-4	0	100	98-100	94-100	36-85	<31	NP-10
	39-80	Fine sandy loam, loam, sandy loam.	SM, ML, SC, CL	A-4, A-2	0	100	98-100	90-100	15-85	<31	NP-10
7-------------------- Clarita	0-48	Clay-------------	CL, CH, MH	A-7	0	95-100	95-100	90-100	80-95	45-70	25-45
	48-65	Clay-------------	CL, CH, MH	A-7	0	80-100	80-100	75-100	70-95	40-70	20-45
8-------------------- Clarita	0-45	Clay-------------	CL, CH, MH	A-7	0	95-100	95-100	90-100	80-95	45-70	25-45
	45-65	Clay-------------	CL, CH, MH	A-7	0	80-100	80-100	75-100	70-95	40-70	20-45
9*:											
Gaddy--------------	0-15	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	98-100	94-100	36-80	<30	NP-10
	15-72	Loamy fine sand, fine sand.	SM	A-2	0	100	98-100	90-100	15-35	---	NP
Gracemore----------	0-8	Fine sandy loam	SM, ML, CL	A-4, A-6	0	100	98-100	94-100	36-97	<40	NP-18
	8-72	Fine sand, loamy fine sand.	SM, SP-SM	A-2, A-3	0	100	98-100	82-100	5-35	---	NP

See footnote at end of table.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
10----------------- Gracemont	0-8	Fine sandy loam	ML, CL, SM, SC	A-4, A-6	0	100	98-100	94-100	36-90	<40	NP-18
	8-60	Fine sandy loam, loam.	ML, CL, SM, SC	A-4	0	100	98-100	94-100	36-85	<31	NP-10
11*----------------- Gracemore	0-9	Clay loam--------	SM, ML, CL	A-4, A-6	0	100	100	96	75-90	<40	10-18
	9-60	Fine sand, loamy fine sand.	SM, SP-SM	A-2, A-3	0	100	98-100	82-100	5-35	---	NP
12----------------- Grainola	0-5	Clay loam--------	CL, SC, GC	A-6, A-7	0-55	40-95	40-95	40-95	36-90	37-50	15-25
	5-22	Silty clay, silty clay loam, clay.	CL, CH	A-7	0	75-100	75-100	75-98	73-98	41-70	20-40
	22-40	Weathered bedrock.	---	---	---	---	---	---	---	---	---
13----------------- Grant	0-12	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	12-49	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	49-70	Weathered bedrock.	---	---	---	---	---	---	---	---	---
14----------------- Grant	0-10	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	10-65	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	65-75	Weathered bedrock.	---	---	---	---	---	---	---	---	---
15----------------- Grant	0-11	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	11-48	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	48-60	Weathered bedrock.	---	---	---	---	---	---	---	---	---
16----------------- Grant	0-10	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	10-68	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	68-72	Weathered bedrock.	---	---	---	---	---	---	---	---	---
17*: Grant--------------	0-11	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	11-48	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	48-55	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Port---------------	0-20	Silt loam--------	ML, CL	A-4, A-6, A-7	0	100	100	96-100	80-98	27-43	8-20
	20-65	Silty clay loam, clay loam, loam.	ML, CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20

See footnote at end of table.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
18*----------------- Grant	0-8	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	20-30	1-10
	8-52	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-43	8-20
	52-68	Weathered bedrock.	---	---	---	---	---	---	---	---	---
19----------------- Keokuk	0-72	Loam-------------	ML, CL, CL-ML	A-4	0	100	100	94-100	51-97	<30	NP-10
20----------------- Keokuk	0-60	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	94-100	51-97	<30	NP-10
21----------------- Kirkland	0-11	Silt loam--------	CL, ML	A-4, A-6	0	100	100	96-100	80-98	30-40	8-18
	11-70	Silty clay, clay	CL, CH, MH	A-7	0	100	100	96-100	90-99	41-65	18-38
	70-84	Weathered bedrock.	---	---	---	---	---	---	---	---	---
22----------------- Konawa	0-17	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
	17-42	Sandy clay loam, fine sandy loam.	SC, CL	A-4, A-6	0	98-100	98-100	85-100	40-60	26-40	8-18
	42-65	Fine sandy loam, sandy clay loam.	SM-SC, CL CL-ML, SC	A-4, A-6	0	98-100	98-100	85-100	40-60	21-34	4-14
	65-70	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
23----------------- Konawa	0-16	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
	16-42	Sandy clay loam, fine sandy loam.	SC, CL	A-4, A-6	0	98-100	98-100	85-100	40-60	26-40	8-18
	42-72	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
24*----------------- Konawa	0-5	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
	5-48	Sandy clay loam, fine sandy loam.	SC, CL	A-4, A-6	0	98-100	98-100	85-100	40-60	26-40	8-18
	48-65	Loamy fine sand	SM	A-2	0	98-100	98-100	85-100	15-35	---	NP
25----------------- Lela	0-18	Clay-------------	CL, MH, CH	A-7	0	100	100	96-100	90-99	41-70	20-38
	18-84	Silty clay, clay	CL, MH, CH	A-7	0	100	100	96-100	90-99	41-70	20-38
26----------------- Miller	0-24	Silty clay-------	CL, CH	A-6, A-7	0	100	98-100	96-100	80-99	35-60	15-35
	24-65	Clay, silty clay, silty clay loam.	CL, CH	A-7	0	100	98-100	96-100	90-99	41-65	20-40
27----------------- Minco	0-85	Very fine sandy loam.	ML, CL	A-4	0	100	100	94-100	51-97	<31	NP-10
28----------------- Minco	0-60	Very fine sandy loam.	ML, CL	A-4	0	100	100	94-100	51-97	<31	NP-10
29, 30------------- Minco	0-74	Silt loam--------	ML, CL	A-4	0	100	100	94-100	51-97	<31	NP-10
31----------------- Minco	0-80	Silt loam--------	ML, CL	A-4	0	100	100	94-100	51-97	<31	NP-10
32*: Nash---------------	0-38	Loam-------------	ML, CL, SM, SC	A-4	0	100	95-100	85-100	40-90	<30	NP-10
	38-44	Weathered bedrock.	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
32*: Lucien-------------	0-16	Loam-------------	SM, SC, ML, CL	A-2, A-4	0-20	95-100	90-100	85-100	30-97	<31	NP-10
	16-30	Weathered bedrock.	---	---	---	---	---	---	---	---	---
33*: Nash---------------	0-32	Loam-------------	ML, CL, SM, SC	A-4	0	100	95-100	85-100	40-90	<30	NP-10
	32-40	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Lucien-------------	0-14	Loam-------------	SM, SC, ML, CL	A-2, A-4	0-20	95-100	90-100	85-100	30-97	<31	NP-10
	14-30	Weathered bedrock.	---	---	---	---	---	---	---	---	---
34*. Pits											
35------------------ Pond Creek	0-15	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	15-72	Silty clay loam	CL, ML	A-6, A-7	0	100	100	96-100	65-98	30-43	8-20
36------------------ Pond Creek	0-15	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	15-80	Silty clay loam	CL, ML	A-6, A-7	0	100	100	96-100	65-98	30-43	8-20
37------------------ Port	0-35	Silt loam--------	ML, CL	A-4, A-6, A-7	0	100	100	96-100	80-98	27-43	8-20
	35-60	Silty clay loam, clay loam, loam.	ML, CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
38------------------ Pulaski	0-16	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	95-100	90-100	36-85	<30	NP-10
	16-80	Fine sandy loam, loam.	SM, SC, ML, CL	A-4	0	100	95-100	90-100	36-85	<30	NP-10
39*: Pulaski------------	0-10	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	95-100	90-100	36-85	<30	NP-10
	10-40	Fine sandy loam, loam.	SM, SC, ML, CL	A-4	0	100	95-100	90-100	36-85	<30	NP-10
	40-64	Fine sandy loam, loam, loamy fine sand.	SM, SC, ML, CL	A-4, A-2	0	100	95-100	90-100	15-85	<30	NP-10
Port---------------	0-11	Loam-------------	ML, CL, SM, SC	A-4, A-6	0	100	98-100	94-100	36-85	22-37	2-14
	11-62	Silty clay loam, clay loam, loam.	ML, CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
40------------------ Renfrow	0-11	Silt loam--------	ML, CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	11-18	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	37-49	15-26
	18-84	Clay, silty clay, silty clay loam.	ML, CL, CH, MH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38
41------------------ Renfrow	0-6	Silt loam--------	ML, CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	6-11	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	37-49	15-26
	11-80	Clay, silty clay, silty clay loam.	ML, CL, CH, MH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38

See footnote at end of table.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
42* Renfrow	0-4	Silt loam	ML, CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	4-62	Clay, silty clay, silty clay loam.	ML, CL, CH, MH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38
43 Stephenville	0-12	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	98-100	94-100	36-60	<30	NP-10
	12-36	Fine sandy loam, sandy clay loam.	SC, CL	A-4, A-6	0	100	98-100	90-100	36-65	25-37	7-16
	36-40	Weathered bedrock.	---	---	---	---	---	---	---	---	---
44 Stephenville	0-3	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	98-100	94-100	36-60	<30	NP-10
	3-32	Fine sandy loam, sandy clay loam.	SC, CL	A-4, A-6	0	100	98-100	90-100	36-65	25-37	7-16
	32-45	Weathered bedrock.	---	---	---	---	---	---	---	---	---
45 Stephenville	0-4	Fine sandy loam	SM, SC, ML, CL	A-4	0	100	98-100	94-100	36-60	<30	NP-10
	4-36	Fine sandy loam, sandy clay loam.	SC, CL	A-4, A-6	0	100	98-100	90-100	36-65	25-37	7-16
	36-60	Weathered bedrock.	---	---	---	---	---	---	---	---	---
46*: Tamford	0-6	Clay loam	CL	A-6, A-7	0	100	100	96-100	80-98	37-50	15-26
	6-48	Clay	CL, CH	A-7	0	100	100	96-100	90-95	45-70	25-45
	48-65	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Grainola	0-4	Clay loam	CL, SC, GC	A-6, A-7	0-55	40-95	40-95	40-95	36-90	37-50	15-25
	4-20	Silty clay, silty clay loam, clay.	CL, CH	A-7	0	75-100	75-100	75-98	73-98	41-70	20-40
	20-26	Silty clay, silty clay loam, clay.	CL, CH, SC, GC	A-2, A-7	0	20-90	20-90	20-85	18-85	41-70	20-40
	26-45	Weathered bedrock.	---	---	---	---	---	---	---	---	---
47 Teller	0-19	Loam	SM, SC, ML, CL	A-4	0	100	100	94-100	36-85	<30	NP-10
	19-80	Fine sandy loam, very fine sandy loam, loam.	SM, SC, ML, CL	A-4, A-6	0	100	100	94-100	45-85	20-34	3-13

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than. Entries under "Erosion factors--T" apply to the entire profile. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
	In	In/hr	In/in	pH	Mmhos/cm						
1 Asa	0-8	0.6-2.0	0.17-0.22	6.6-8.4	<2	Low	High	Low	0.28	5	---
	8-43	0.6-2.0	0.17-0.22	7.9-8.4	<2	Low	High	Low	0.43		
	43-60	0.6-2.0	0.15-0.22	7.9-8.4	<2	Low	High	Low	0.43		
2 Asher	0-27	0.06-0.2	0.18-0.22	6.1-8.4	<2	Moderate	High	Low	0.37	5	---
	27-65	0.6-2.0	0.13-0.24	7.4-8.4	<2	Low	Low	Low	0.43		
3 Bethany	0-15	0.06-2.0	0.18-0.22	5.6-7.3	<2	Low	Low	Low	0.43	5	---
	15-24	0.20-0.60	0.16-0.20	6.1-7.3	<2	Moderate	Moderate	Low	0.37		
	24-80	0.06-0.20	0.14-0.18	6.6-8.4	<2	High	High	Low	0.37		
4 Bethany	0-17	0.06-2.0	0.18-0.22	5.6-7.3	<2	Low	Low	Low	0.43	5	---
	17-24	0.20-0.60	0.16-0.20	6.1-7.3	<2	Moderate	Moderate	Low	0.37		
	24-84	0.06-0.20	0.14-0.18	6.6-8.4	<2	High	High	Low	0.37		
5*:											
Bethany	0-12	0.06-2.0	0.18-0.22	5.6-7.3	<2	Low	Low	Low	0.43	5	---
	12-18	0.20-0.60	0.16-0.20	6.1-7.3	<2	Moderate	Moderate	Low	0.37		
	18-74	0.06-0.20	0.14-0.18	6.6-8.4	<2	High	High	Low	0.37		
Pawhuska	0-8	0.6-2.0	0.12-0.18	5.6-6.5	<2	Low	High	High	0.49	1	---
	8-84	<0.06	0.10-0.16	6.1-8.4	2-8	High	High	High	0.43		
6 Canadian	0-39	2.0-6.0	0.11-0.20	5.6-8.4	<2	Low	Low	Low	0.20	5	3
	39-80	2.0-20	0.07-0.20	6.1-8.4	<2	Low	Low	Low	0.20		
7 Clarita	0-48	<0.06	0.12-0.20	6.6-8.4	<2	High	High	Low	0.43	4	---
	48-65	<0.06	0.12-0.18	7.9-8.4	<2	High	High	Low	0.37		
8 Clarita	0-45	<0.06	0.12-0.20	6.6-8.4	<2	High	High	Low	0.43	4	---
	45-65	<0.06	0.12-0.18	7.9-8.4	<2	High	High	Low	0.37		
9*:											
Gaddy	0-15	2.0-6.0	0.11-0.15	7.4-8.4	<2	Low	Low	Low	0.32	5	3
	15-72	6.0-20	0.06-0.10	7.9-8.4	<2	Low	Low	Low	0.17		
Gracemore	0-8	0.2-6.0	0.11-0.24	7.4-8.4	<2	Low	Low	Low	0.32	5	---
	8-72	2.0-6.0	0.05-0.11	7.9-8.4	<2	Low	Low	Low	0.17		
10 Gracemont	0-8	0.6-6.0	0.11-0.20	6.6-8.4	0-2	Low	Moderate	Low	0.28	5	---
	8-60	2.0-6.0	0.11-0.20	7.9-8.4	0-2	Low	Moderate	Low	0.32		
11* Gracemore	0-9	0.2-6.0	0.11-0.24	7.4-8.4	<2	Low	Low	Low	0.32	5	---
	9-60	2.0-6.0	0.05-0.11	7.9-8.4	<2	Low	Low	Low	0.17		
12 Grainola	0-5	0.2-0.6	0.10-0.20	7.4-8.4	<2	Moderate	High	Low	0.37	3	7
	5-22	0.06-0.2	0.12-0.20	7.4-8.4	<2	High	High	Low	---		
	22-40	---	---	---	---				---		
13 Grant	0-12	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	12-49	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	49-70	---	---	---	---				---		
14 Grant	0-10	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	10-65	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	65-75	---	---	---	---				---		
15 Grant	0-11	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	11-48	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	48-60	---	---	---	---				---		
16 Grant	0-10	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	10-68	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	68-72	---	---	---	---				---		

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
	In	In/hr	In/in	pH	Mmhos/cm						
17*:											
Grant	0-11	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	11-48	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	48-55	---	---	---	---	---	---	---	---		
Port	0-20	0.6-2.0	0.15-0.24	5.6-7.8	<2	Moderate	Moderate	Low	0.37	5	---
	20-65	0.6-2.0	0.15-0.24	6.1-8.4	<2	Moderate	Moderate	Low	0.37		
18*, Grant	0-8	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low	Low	Low	0.37	5	---
	8-52	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37		
	52-68	---	---	---	---	---	---	---	---		
19, Keokuk	0-72	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37	5	---
20, Keokuk	0-60	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low	Low	Low	0.37	5	---
21, Kirkland	0-11	0.6-2.0	0.15-0.24	5.6-7.3	<2	Low	Low	Low	0.49	5	6
	11-70	<0.06	0.12-0.18	6.6-8.4	<2	High	High	Low	0.37		
	70-84	---	---	---	---	---	---	---	---		
22, Konawa	0-17	6.0-20.0	0.06-0.10	5.6-6.5	<2	Low	Low	Moderate	0.20	5	2
	17-42	0.6-2.0	0.12-0.16	5.1-6.0	<2	Low	Moderate	Moderate	0.32		
	42-65	2.0-6.0	0.11-0.15	5.1-7.3	<2	Low	Low	Moderate	0.24		
	65-70	6.0-20.0	0.07-0.11	5.1-7.3	<2	Low	Low	Moderate	0.24		
23, Konawa	0-16	6.0-20.0	0.06-0.10	5.6-6.5	<2	Low	Low	Moderate	0.20	5	2
	16-42	0.6-2.0	0.12-0.16	5.1-6.0	<2	Low	Moderate	Moderate	0.32		
	42-72	6.0-20.0	0.07-0.11	5.1-7.3	<2	Low	Low	Moderate	0.24		
24*, Konawa	0-5	6.0-20.0	0.06-0.10	5.6-6.5	<2	Low	Low	Moderate	0.20	5	2
	5-48	0.6-2.0	0.12-0.16	5.1-6.0	<2	Low	Moderate	Moderate	0.32		
	48-65	6.0-20.0	0.07-0.11	5.1-7.3	<2	Low	Low	Moderate	0.24		
25, Lela	0-18	<0.06	0.12-0.22	6.1-8.4	<2	High	High	Low	0.43	4	---
	18-84	<0.06	0.12-0.18	7.4-8.4	<2	High	High	Low	0.37		
26, Miller	0-24	0.06-0.2	0.16-0.2	7.4-8.4	<2	High	High	Low	0.43	5	---
	24-65	<0.06	0.15-0.19	7.4-8.4	<2	High	High	Low	0.43		
27, Minco	0-85	.6-2.0	0.13-0.24	5.6-7.3	<2	Low	Low	Low	0.37	5	---
28, Minco	0-60	.6-2.0	0.13-0.24	5.6-7.3	<2	Low	Low	Low	0.37	5	---
29, 30, Minco	0-74	.6-2.0	0.13-0.24	5.6-7.3	<2	Low	Low	Low	0.37	5	---
31, Minco	0-80	.6-2.0	0.13-0.24	5.6-7.3	<2	Low	Low	Low	0.37	5	---
32*:											
Nash	0-38	0.6-2.0	0.13-0.24	6.1-8.4	<2	Low	Low	Low	0.37	3	---
	38-44	---	---	---	---	---	---	---	---		
Lucien	0-16	2.0-6.0	0.10-0.24	5.6-7.3	<2	Low	Low	Low	0.32	2	---
	16-30	---	---	---	---	---	---	---	---		
33*:											
Nash	0-32	0.6-2.0	0.13-0.24	6.1-8.4	<2	Low	Low	Low	0.37	3	---
	32-40	---	---	---	---	---	---	---	---		
Lucien	0-14	2.0-6.0	0.10-0.24	5.6-7.3	<2	Low	Low	Low	0.32	2	---
	14-30	---	---	---	---	---	---	---	---		

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
	In	In/hr	In/in	pH	Mmhos/cm						
34*. Pits											
35 Pond Creek	0-15	0.6-2.0	0.15-0.20	5.6-7.3	<2	Low	Low	Low	0.37	5	---
	15-72	0.2-0.6	0.15-0.22	6.1-8.4	<2	Moderate	Moderate	Low	0.37		
36 Pond Creek	0-15	0.6-2.0	0.15-0.20	5.6-7.3	<2	Low	Low	Low	0.37	5	---
	15-80	0.2-0.6	0.15-0.22	6.1-8.4	<2	Moderate	Moderate	Low	0.37		
37 Port	0-35	0.6-2.0	0.15-0.24	5.6-7.8	<2	Moderate	Moderate	Low	0.37	5	---
	35-60	0.6-2.0	0.15-0.24	6.1-8.4	<2	Moderate	Moderate	Low	0.37		
38 Pulaski	0-16	2.0-6.0	0.12-0.16	5.6-7.3	<2	Low	Low	Moderate	0.32	5	---
	16-80	2.0-6.0	0.12-0.16	5.6-8.4	<2	Low	Low	Moderate	0.32		
39*:											
Pulaski	0-10	2.0-6.0	0.12-0.16	5.6-7.3	<2	Low	Low	Moderate	0.32	5	---
	10-40	2.0-6.0	0.12-0.16	5.6-7.3	<2	Low	Low	Moderate	0.32		
	40-64	2.0-6.0	0.07-0.16	5.6-8.4	<2	Low	Low	Low	0.32		
Port	0-11	0.6-2.0	0.11-0.20	5.6-7.8	<2	Low	Low	Low	0.37	5	---
	11-62	0.6-2.0	0.15-0.24	6.1-8.4	<2	Moderate	Moderate	Low	0.37		
40 Renfrow	0-11	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low	Low	Low	0.49	4	---
	11-18	0.2-0.6	0.15-0.22	6.1-7.8	<2	Moderate	Moderate	Low	0.43		
	18-84	<0.06	0.12-0.22	6.1-8.4	<2	High	High	Low	0.43		
41 Renfrow	0-6	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low	Low	Low	0.49	4	---
	6-11	0.2-0.6	0.15-0.22	6.1-7.8	<2	Moderate	Moderate	Low	0.43		
	11-80	<0.06	0.12-0.22	6.1-8.4	<2	High	High	Low	0.43		
42* Renfrow	0-4	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low	Low	Low	0.49	4	---
	4-62	<0.06	0.12-0.22	6.1-8.4	<2	High	High	Low	0.43		
43 Stephenville	0-12	2.0-6.0	0.11-0.15	5.1-7.3	<2	Low	Low	Moderate	0.24	3	---
	12-36	0.6-2.0	0.11-0.17	5.1-6.5	<2	Low	Moderate	Moderate	0.32		
	36-40	---	---	---	---	---	---	---	---		
44 Stephenville	0-3	2.0-6.0	0.11-0.15	5.1-7.3	<2	Low	Low	Moderate	0.24	3	---
	3-32	0.6-2.0	0.11-0.17	5.1-6.5	<2	Low	Moderate	Moderate	0.32		
	32-45	---	---	---	---	---	---	---	---		
45 Stephenville	0-4	2.0-6.0	0.11-0.15	5.1-7.3	<2	Low	Low	Moderate	0.24	3	---
	4-36	0.6-2.0	0.11-0.17	5.1-6.5	<2	Low	Moderate	Moderate	0.32		
	36-60	---	---	---	---	---	---	---	---		
46*:											
Tamford	0-6	0.06-0.6	0.12-0.20	6.1-8.4	<2	High	High	Low	0.43	4	6
	6-48	<0.06	0.12-0.18	7.4-8.4	<2	High	High	Low	0.37		
	48-65	---	---	---	---	---	---	---	---		
Grainola	0-4	0.2-0.6	0.10-0.20	7.4-8.4	<2	Moderate	High	Low	0.37	3	7
	4-20	0.06-0.2	0.12-0.20	7.4-8.4	<2	High	High	Low	---		
	20-26	0.06-0.2	0.05-0.18	7.4-8.4	<2	High	High	Low	---		
	26-45	---	---	---	---	---	---	---	---		
47 Teller	0-19	2.0-6.0	0.12-0.16	5.6-6.5	<2	Low	Low	Moderate	0.37	5	---
	19-80	2.0-6.0	0.13-0.17	5.6-7.3	<2	Low	Low	Moderate	0.32		

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--SOIL AND WATER FEATURES

[The definitions of "flooding" and "water table" in the Glossary explain such terms as "rare," "brief," and "apparent." The symbol > means greater than]

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness
					Ft			In	
1------------------ Asa	B	Common-------	Brief------	Mar-Aug	>6.0	---	---	>60	---
2------------------ Asher	C	Rare---------	Very brief	Mar-Aug	>6.0	---	---	>60	---
3, 4--------------- Bethany	C	None---------	---	---	>6.0	---	---	>60	---
5*:									
Bethany-----------	C	None---------	---	---	>6.0	---	---	>60	---
Pawhuska----------	D	None---------	---	---	>6.0	---	---	>60	---
6------------------ Canadian	B	Rare---------	Very brief	---	>6.0	---	---	>60	---
7, 8--------------- Clarita	D	None---------	---	---	>6.0	---	---	>60	---
9*:									
Gaddy-------------	A	Common-------	Very brief	Mar-Aug	>6.0	---	---	>60	---
Gracemore---------	C	Common-------	Very brief	Apr-Aug	0.5-3.0	Apparent	Nov-May	>60	---
10----------------- Gracemont	B	Common-------	Very brief to brief.	Mar-Aug	0.5-3.0	Apparent	Nov-May	>60	---
11*---------------- Gracemore	C	Common-------	Very brief	Apr-Aug	0.5-3.0	Apparent	Nov-May	>60	---
12----------------- Grainola	D	None---------	---	---	>6.0	---	---	20-40	Rippable
13, 14, 15, 16---- Grant	B	None---------	---	---	>6.0	---	---	>40	Rippable
17*:									
Grant-------------	B	None---------	---	---	>6.0	---	---	>40	Rippable
Port--------------	B	Common-------	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---
18*---------------- Grant	B	None---------	---	---	>6.0	---	---	>40	Rippable
19, 20------------- Keokuk	B	Rare to common.	Very brief	Mar-Aug	>6.0	---	---	>60	---
21----------------- Kirkland	D	None---------	---	---	>6.0	---	---	>60	---
22, 23, 24*-------- Konawa	B	None---------	---	---	>6.0	---	---	>60	---
25----------------- Lela	D	Common-------	Very brief	Apr-Oct	>6.0	---	---	>60	---
26----------------- Miller	D	Common-------	Brief------	Mar-May	>6.0	---	---	>60	---
27, 28, 29, 30, 31----------------- Minco	B	None---------	---	---	>6.0	---	---	>60	---

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness
					Ft			In	
32*, 33*:									
Nash	B	None	---	---	>6.0	---	---	20-40	Rippable
Lucien	C	None	---	---	>6.0	---	---	10-20	Rippable
34*. Pits									
35, 36 Pond Creek	B	None	---	---	>6.0	---	---	>60	---
37 Port	B	Common	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---
38 Pulaski	B	Common	Very brief	Mar-Aug	>6.0	---	---	>60	---
39*:									
Pulaski	B	Common	Very brief	Mar-Aug	>6.0	---	---	>60	---
Port	B	Common	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---
40, 41, 42* Renfrow	D	None	---	---	>6.0	---	---	>60	---
43, 44, 45 Stephenville	B	None	---	---	>6.0	---	---	20-40	Rippable
46*:									
Tamford	D	None	---	---	>6.0	---	---	>60	---
Grainola	D	None	---	---	>6.0	---	---	20-40	Rippable
47 Teller	B	None	---	---	>6.0	---	---	>60	---

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

[An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series]

Soil name	Family or higher taxonomic class
Asa	Fine-silty, mixed, thermic Fluventic Haplustolls
Asher	Fine-silty, mixed, thermic Fluventic Haplustolls
*Bethany	Fine, mixed, thermic Pachic Paleustolls
*Canadian	Coarse-loamy, mixed, thermic Udic Haplustolls
Clarita	Fine, montmorillonitic, thermic Udic Pellusterts
Gaddy	Sandy, mixed, thermic Typic Ustifluvents
Gracemont	Coarse-loamy, mixed (calcareous), thermic Aquic Udifluvents
Gracemore	Sandy, mixed, thermic Aquic Udifluvents
Grainola	Fine, mixed, thermic Vertic Haplustalfs
*Grant	Fine-silty, mixed, thermic Udic Argiustolls
Keokuk	Coarse-silty, mixed, thermic Fluventic Haplustolls
Kirkland	Fine, mixed, thermic Udertic Paleustolls
*Konawa	Fine-loamy, mixed, thermic Ultic Haplustalfs
*Lela	Fine, mixed, thermic Typic Chromuderts
Lucien	Loamy, mixed, thermic, shallow Typic Haplustolls
Miller	Fine, mixed, thermic Vertic Haplustolls
*Minco	Coarse-silty, mixed, thermic Udic Haplustolls
Nash	Coarse-silty, mixed, thermic Udic Haplustolls
*Pawhuska	Fine, mixed, thermic Mollic Natrustalfs
Pond Creek	Fine-silty, mixed, thermic Pachic Argiustolls
Port	Fine-silty, mixed, thermic Cumulic Haplustolls
*Pulaski	Coarse-loamy, mixed, nonacid, thermic Typic Ustifluvents
Renfrow	Fine, mixed, thermic Udertic Paleustolls
Stephenville	Fine-loamy, siliceous, thermic Ultic Haplustalfs
Tamford	Fine, montmorillonitic, thermic Udic Chromusterts
*Teller	Fine-loamy, mixed, thermic Udic Argiustolls

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