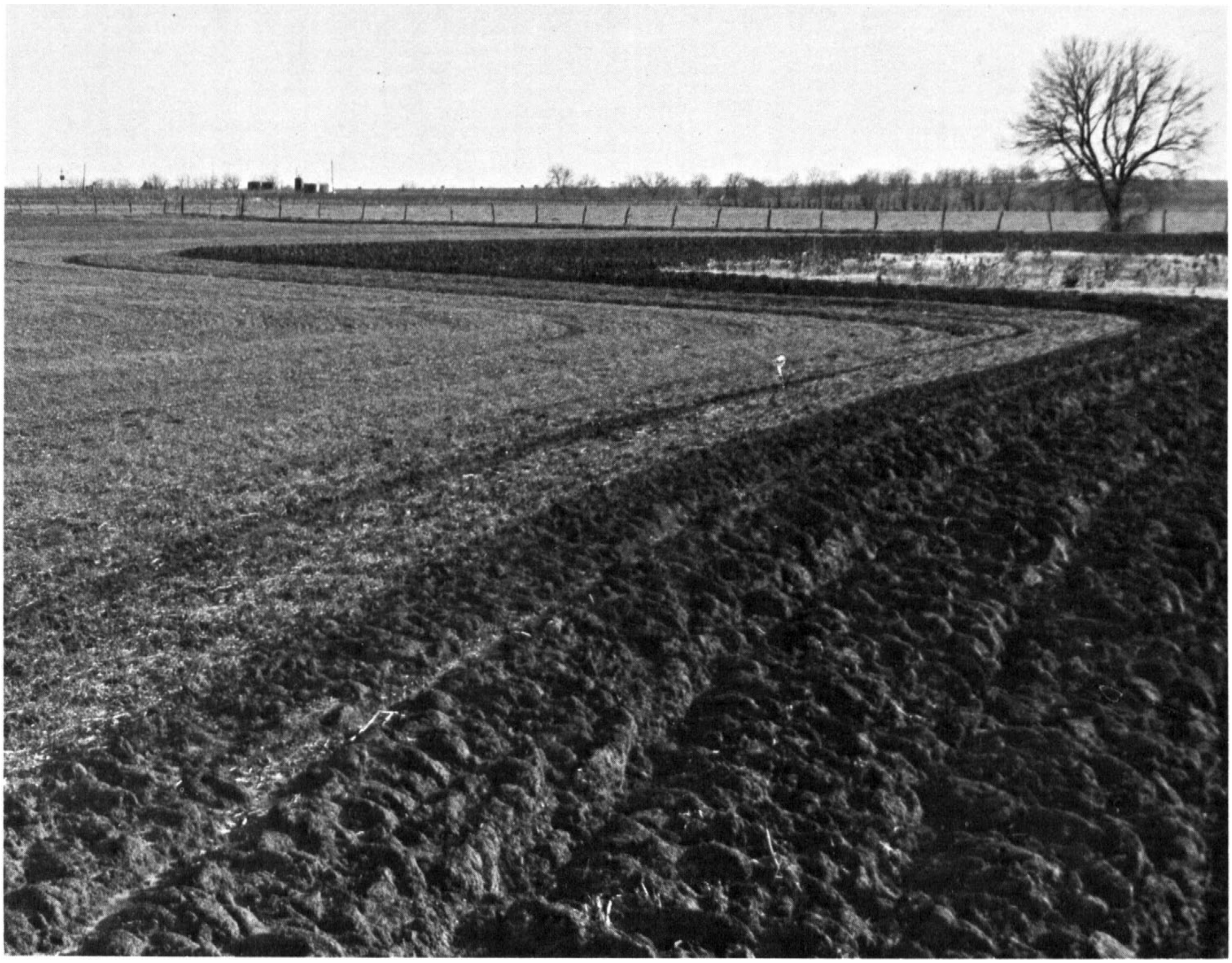
SOIL SURVEY OF

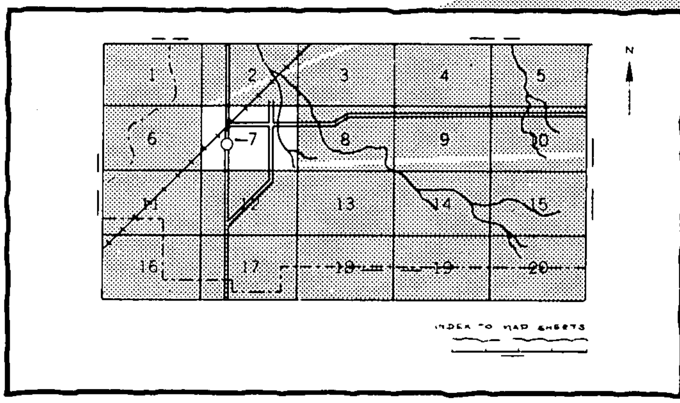
Allen County, Kansas

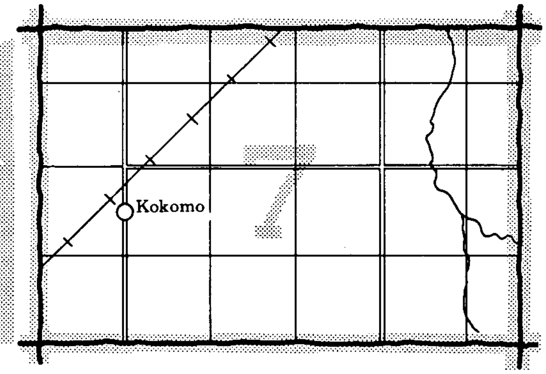


United States Department of Agriculture
Soil Conservation Service
in cooperation with
Kansas Agricultural Experiment Station

HOW TO USE

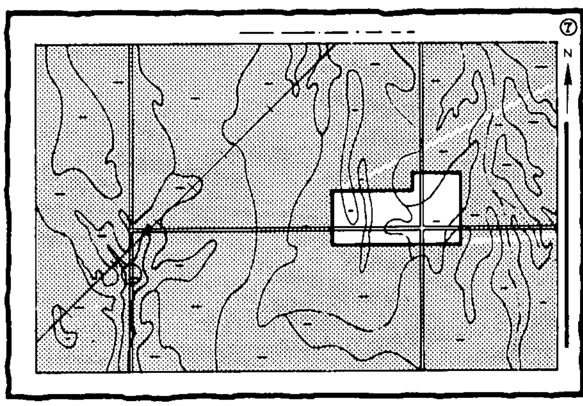
1. Locate your area of interest on the "Index to Map Sheets" (the last page of this publication).

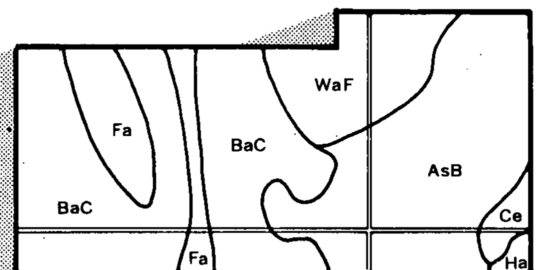




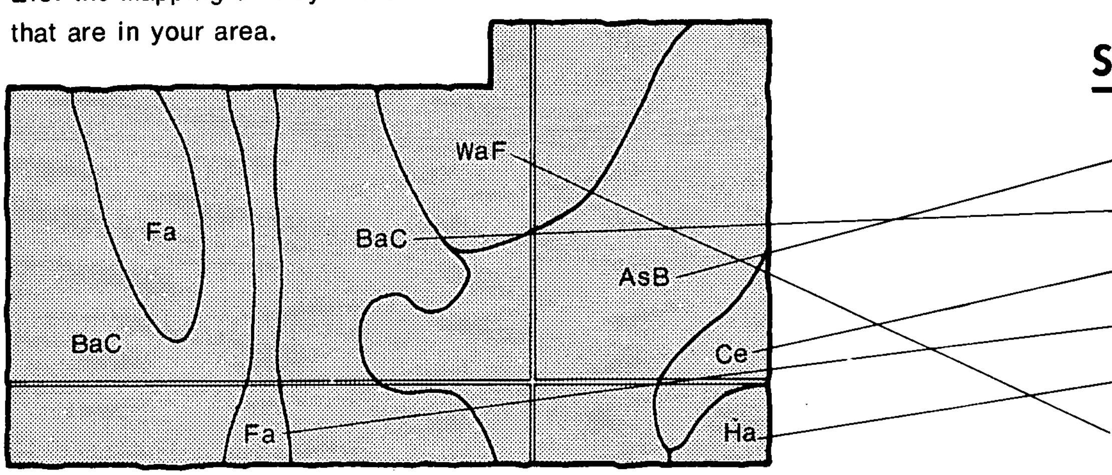
2. Note the number of the map sheet and turn to that sheet.

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





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



Symbols

AsB
BaC
Ce
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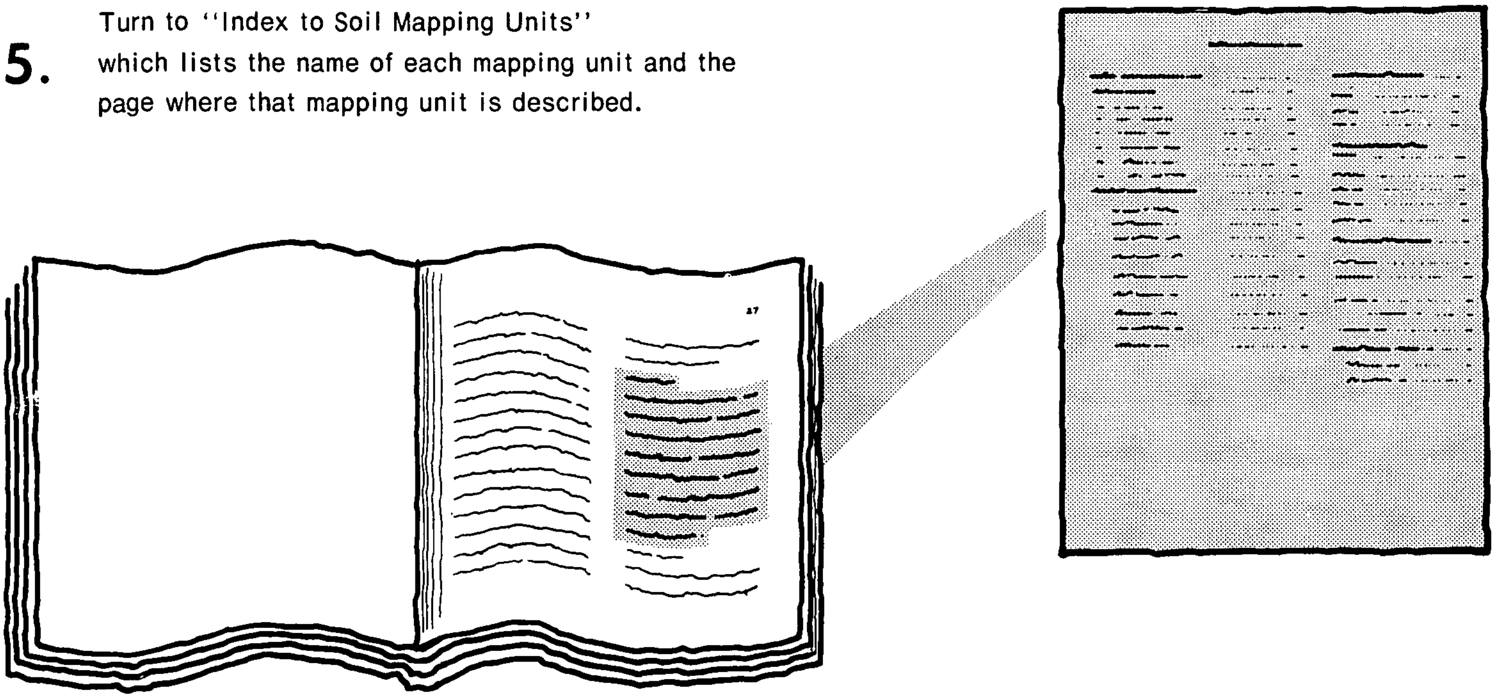
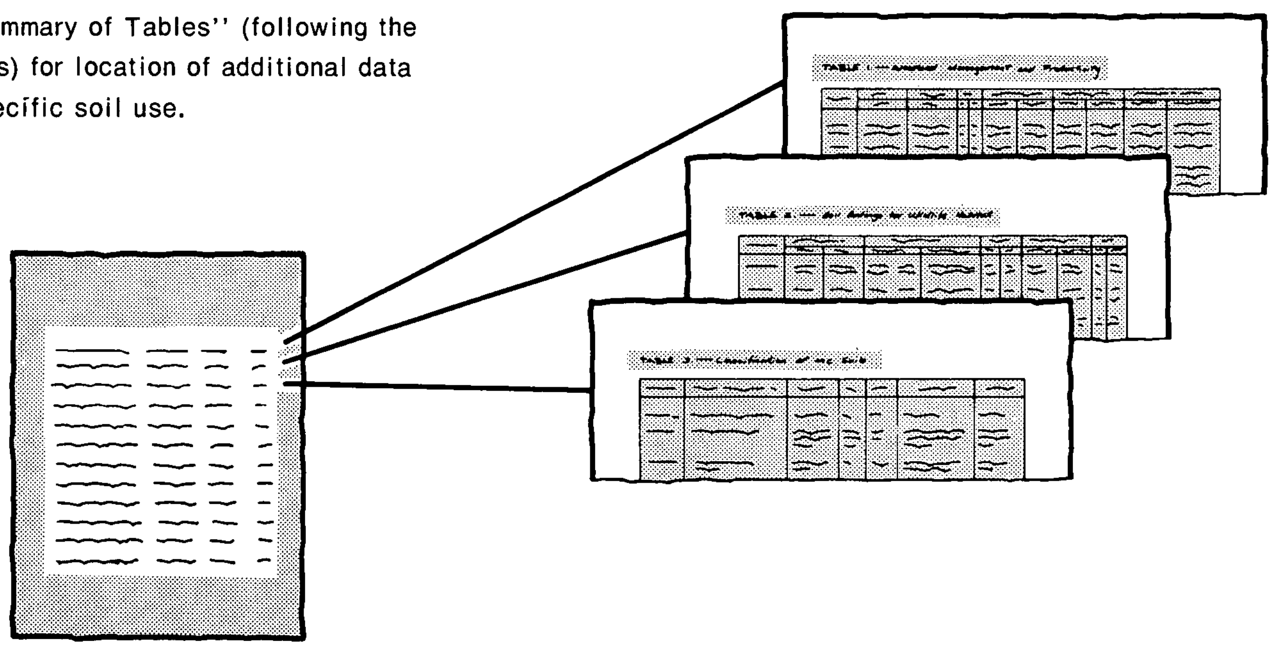
THIS SOIL SURVEY

5. Turn to "Index to Soil Mapping Units" which lists the name of each mapping unit and the page where that mapping 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 1970-74. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1975. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Allen County Conservation District.

Cover: Terrace on Catoosa silt loam, 0 to 2 percent slopes.

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Issued November 1978

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Summary of Tables

Foreword

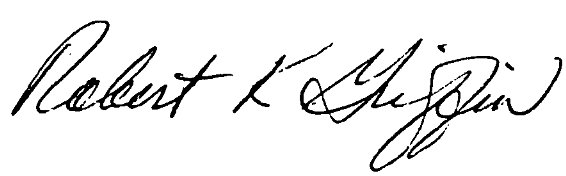
The Soil Survey of Allen County, Kansas, contains much information useful in any land-planning program. Of prime importance are the predictions of soil behavior for selected land uses. Also highlighted are limitations or hazards to land uses that are inherent in the soil, improvements needed to overcome 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.

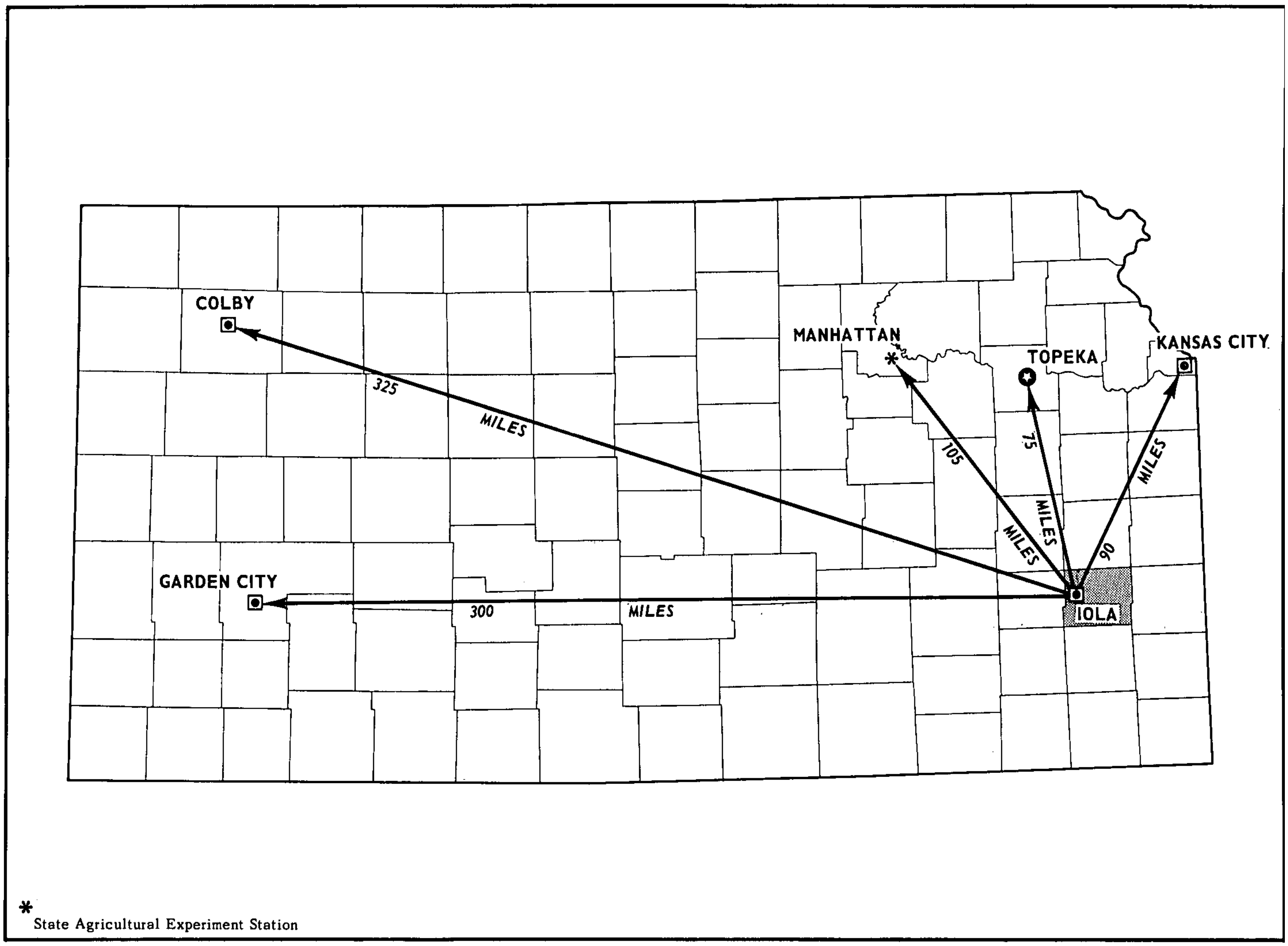
Many people assume that soils are all more or less alike. They are unaware that great differences in soil properties can occur even within short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings 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.

We believe that this soil survey can help bring us a better environment and a better life. Its widespread use can greatly assist us in the conservation, development, and productive use of our soil, water, and other resources.



Robert K. Griffin
State Conservationist
Soil Conservation Service



Location of Allen County in Kansas.

SOIL SURVEY OF ALLEN COUNTY, KANSAS

By Edward L. Fleming, Jim R. Fortner, and Deane W. Swanson,
Soil Conservation Service

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

ALLEN COUNTY is in the southeastern part of Kansas (see facing page). It has a total area of 505 square miles, or about 323,136 acres. Iola, which is in the west-central part of the county, is the county seat. The population of the county is 15,343 (*5*).

The boundaries of Allen County were designated by the Territorial Legislature of 1855, and the organization was completed in 1856. The county was named in honor of William Allen, ex-Governor of Ohio. The town of Iola was organized on January 1, 1859.

Farming and related services are the most important enterprises in Allen County. According to the 1969 Census of Agriculture, the average farm is about 276 acres. About 55 percent of the acreage is cropland, 35 percent pasture and range, 5 percent woodland, and 5 percent other areas, such as urban areas and water areas. Grain sorghum, soybeans, wheat, and alfalfa are the main crops. Beef cattle is the chief kind of livestock. There are several dairy herds and a few hog farms.

General nature of the county

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

Physiography, drainage, and relief

Allen County lies within the Osage Plains section of the Central Lowland physiographic province and the Cherokee Prairies land resource area. The land surface is dominantly nearly level to gently rolling and has few outstanding differences in relief (fig. 1). The surface is dissected by a number of stream valleys.

The Neosho River flows from north to south through the western part of the county in a shallow valley. The river and its tributaries drain all of the county but the eastern one-quarter, which is drained by the Little Osage and Marmaton Rivers and their tributaries. The Little Osage and Marmaton Rivers flow in a generally easterly direction into Bourbon County. In Allen County the Neosho River has an average gradient of about 1.5 feet per mile.

Elevation in most areas ranges from about 950 to 1,100 feet above sea level. It is about 950 feet at Iola, 1,110 feet at Moran in the eastern part of the county, 960 feet at Humboldt in the southwestern part, 1,010 feet at Geneva in the northwestern part, and 1,058 feet at Savonburg in the southeastern part.

Water supply

The water supply in most of Allen County varies. A dependable supply of ground water is not available in many parts of the county. In most of the county, adequate drilled wells on uplands are difficult to obtain. Most successful wells are drilled in the shallow alluvial deposits along small drainageways. Yields from wells range from 1 gallon to 5 gallons per minute.

The water supply is generally adequate in the valley of the Neosho River and the lower reaches of the larger stream valleys. Wells that yield 10 to 100 gallons per minute can be developed successfully in these areas. Smaller streams and ground water discharged by seeps and springs are sources of water, but the streams and the seeps and springs can dry up during prolonged periods of low rainfall.

The principal source of water for livestock is surface water impounded by dams on intermittent streams. In 1974, there were about 2,822 farm ponds that had an approximate storage capacity of 25,000 acre-feet of water.

Rural water districts supply water to farmers in most areas of the county.

Natural resources

Soil is the most important natural resource in the county. Crops produced on farms and livestock that graze the grassland are marketable products affected by the soil.

Other mineral resources are oil and gas, limestone, sand and gravel, and shale. The limestone is quarried for cement, road material, riprap, subgrade, and embankment material. The sand and gravel deposits are restricted to the valleys of the major streams and to areas of Olpe soils, 3 to 15 percent slopes. The shale is used in the manufacture of brick.

Climate

By L. DEAN BARK, climatologist, Kansas Agricultural Experiment Station, Manhattan, Kans.

The climate of Allen County is typical continental, as would be expected of a location in the interior of a large land mass in the middle latitudes. Such a climate is characterized by large diurnal and annual variations in temperature. Allen County is far enough east to be out of the rain shadow of the Rocky Mountains and in the path of the moisture-laden air currents from the Gulf of Mexico. Precipitation is heaviest late in spring and early in summer. Most of it falls late in the evening, or as nighttime thunderstorms. Although prolonged dry periods occur during the growing season, they are not so frequent as in western Kansas. A surplus of precipitation often produces muddy fields that delay planting and harvesting.

Table 1 provides data on temperature and precipitation for Allen County, as recorded at Iola for the period 1941 to 1970 (*4*). Table 2 shows the probable dates of the first freeze in fall and the last freeze in spring (*3*). Table 3 provides data on the length of the growing season.

In winter, the average temperature is 56.6 degrees F and the average daily minimum is 45.5 degrees. The lowest temperature on record, which occurred at Iola on January 30, 1949, is 20 degrees below zero. In summer, the average temperature is 77.4 degrees and the average daily maximum is 88.3 degrees. The highest temperature, which was recorded on July 18, 1954, is 115 degrees.

The annual precipitation is 36.45 inches. Of this total, 26.41 inches, or 72 percent, usually falls during the period April through September, which includes the growing season for most crops. During 2 years in 10, the April-September rainfall is less than 19.16 inches. The heaviest 1-day rainfall during the period of record was 6.78 inches at Iola on September 12, 1926.

The average annual snowfall is 12.1 inches. The winters with the greatest total snowfall were 1911-12 and 1955-56, when 35.7 inches of snow was recorded. In an average year, 15 days have at least 1 inch of snow on the ground, but the number of days varies greatly from year to year. Snow cover seldom remains on the ground for more than a day or two. In January and February of 1956, however, there was snow on the ground continuously for over 3 weeks.

The average relative humidity at midafternoon in spring is less than 65 percent. During the rest of the year, it is about 55 percent. Humidity is higher at night in all seasons and averages about 80 percent at dawn. The average percentage of possible sunshine is 75 in summer and 55 in winter. The prevailing wind direction is usually southerly, but is northerly during February. The average annual windspeed is 12 miles per hour. The windspeed is highest in March and April.

Tornadoes and severe thunderstorms occur occasionally in Allen County. These storms are usually local in extent and of short duration so that the risk of damage is small. Hail occurs infrequently during the warmer part of the year. It is local in extent. Crop damage by hail is less in this part of the State than in western Kansas.

Farming

Farming has developed in Allen County through the raising of livestock, mainly beef cattle, and the growing of cash crops. The main crops are soybeans, grain sorghum, and wheat. Forage sorghum and alfalfa are also grown. In 1973, about 61,000 acres of soybeans, 20,000 acres of grain sorghum, 18,000 acres of wheat, and 12,000 acres of corn were harvested. These acreages fluctuate from year to year according to market prices. In 1973, about 12,000 acres of alfalfa, 17,000 acres of native hay, and 20,000 acres of tall fescue were harvested (*6*).

Beef cattle outnumber other kinds of livestock. There are several dairy herds and a few small hog farms. The number of sheep and chickens fluctuates from year to year.

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. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Soil series commonly are named for towns or other geographic features near the place where they were first observed and mapped. Dennis and Woodson, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in characteristics.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Bates loam, 1 to 4 percent slopes, is one of several phases within the Bates series.

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 mapping units. Some mapping 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. Mapping units are discussed in the section "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 their interpretations 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 useful 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, the soil units for broad land-use planning described in this survey. Each soil unit is a unique natural landscape that has a distinct pattern of soils and of relief and drainage features. A unit typically consists of one or more soils of major extent and some soils of minor extent. It is named for the major soils. The kinds of soil in one unit can occur in other soil units, but in a different pattern.

The 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 generally suitable for certain kinds of farming or 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 soils in any one soil unit ordinarily differ from place to place in slope, depth, stoniness, drainage, or other characteristics that affect their management.

1. Kenoma-Woodson-Dennis

Deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained soils that have a dominantly silty clay subsoil; on uplands

This unit is on broad ridgetops and long side slopes that are dissected by shallow drainageways. The landscape is nearly level to gently sloping. This unit consists of the claypan areas of the county.

This unit occupies about 37 percent of the county. It is about 38 percent Kenoma soils, 24 percent Woodson soils, 10 percent Dennis soils, and 28 percent minor soils (fig. 2).

Kenoma soils are on ridgetops. They are nearly level to gently sloping and are moderately well drained. The surface layer typically is very dark gray silt loam about 8 inches thick. It rests abruptly on a silty clay subsoil. The upper part of the subsoil is very dark grayish brown, and the lower part to a depth of more than 60 inches is mixed strong brown and gray.

Woodson soils are in broad, nearly level areas. They are somewhat poorly drained. The surface layer typically is very dark gray silt loam about 8 inches thick. It rests abruptly on a very firm silty clay subsoil. The upper part of the subsoil is very dark gray, and the lower part to a depth of more than 60 inches is gray.

Dennis soils are on low knolls and gentle side slopes. They are nearly level to gently sloping and are moderately well drained. The surface layer typically is very dark brown silt loam about 10 inches thick. The subsoil is more than 50 inches thick. It is dark brown silty clay loam and silty clay in the upper part and brown and light brownish gray silty clay in the lower part.

Of minor extent in this unit are Catoosa, Verdigris, and Zaar soils. The silty Verdigris soils occupy the nearly level flood plains of narrow drainageways. The clayey Zaar soils are on gentle foot slopes and in swales and concave drainageways. The nearly level silty Catoosa soils are on ridgetops throughout the unit.

Most of this unit is cultivated. Some areas are used for hay and range. All locally suited crops are grown. The largest acreage is planted to wheat, grain sorghum, and soybeans.

The main concerns of management are improving drainage, controlling water erosion, and maintaining tilth and fertility. In some years seasonal wetness or droughtiness may affect crop production.

2. Catoosa-Kenoma-Zaar

Moderately deep and deep, nearly level to moderately sloping, well drained to somewhat poorly drained soils that have a silty clay loam and silty clay subsoil; on uplands

This unit is along drainageways and on ridgetops. The landscape is dominantly nearly level to moderately sloping, but is steeper along the few large drainageways dissecting the unit. The steeper slopes generally are short.

This unit occupies about 35 percent of the county. It is about 37 percent Catoosa soils, 20 percent Kenoma soils, 15 percent Zaar soils, and 28 percent minor soils (fig. 3).

Catoosa soils are on ridgetops and side slopes. They are moderately deep, nearly level to moderately sloping, and well drained. The surface layer typically is dark reddish brown silt loam about 11 inches thick. The subsoil is dark reddish brown silty clay loam. Hard limestone is at a depth of about 27 inches.

Kenoma soils are on ridgetops. They are deep, gently sloping, and moderately well drained. The surface layer typically is very dark gray silt loam about 8 inches thick. It rests abruptly on a silty clay subsoil. The upper part of the subsoil is very dark grayish brown, and the lower part to a depth of more than 60 inches is mixed strong brown and gray.

Zaar soils are along drainageways and on low slopes below Catoosa soils. They are deep, gently sloping to moderately sloping, and somewhat poorly drained. The surface layer typically is black silty clay about 18 inches thick. The subsoil is silty clay. The upper part is black and very dark grayish brown, and the lower part is dark brown. The underlying material is olive brown and dark yellowish brown silty clay.

Of minor extent in this unit are Dennis, Eram, Mason, Nowata, Olpe, and Verdigris soils. The gently sloping to moderately sloping Dennis soils are on side slopes throughout the unit. The gently sloping to moderately sloping Eram soils are on low hills and side slopes. The nearly level silty Verdigris soils occupy the flood plains of narrow drainageways. The nearly level Mason soils are on terraces along streams. The moderately sloping Nowata soils are on the valley sides along the Marmaton River and Big Creek. The moderately sloping to strongly sloping Olpe soils are on low hills and side slopes in the northwestern part of the county.

About half of this unit is cultivated. The more sloping or stony soils are used for range. Deciduous trees grow along most of the larger drainageways and streams. All locally suited crops are grown. The largest acreage is planted to wheat, grain sorghum, soybeans, and corn.

The main concerns of management are controlling water erosion, improving drainage, and maintaining tilth and fertility. Good range management is needed if this unit is used for range. Invasion of brush, trees, and weeds is a problem.

3. Bates-Dennis-Kenoma

Moderately deep and deep, gently sloping to moderately sloping, moderately well drained and well drained soils that have a dominantly silty clay and clay loam subsoil; on uplands

This unit is on low hills and ridgetops and along drainageways. The landscape is gently sloping to moderately sloping.

This unit occupies about 21 percent of the county. It is about 20 percent Bates soils, 17 percent Dennis soils, 15 percent Kenoma soils, and 48 percent minor soils (fig. 4).

Bates soils are gently sloping on ridgetops and moderately sloping on side slopes. They are moderately deep and well drained. The surface layer typically is very dark brown loam about 10 inches thick. The subsoil is about 22 inches thick. The upper part is very dark grayish brown loam, and the lower part is dark brown clay loam. Soft sandstone and shale are at a depth of 32 inches.

Dennis soils are gently sloping on ridgetops and gently sloping to moderately sloping on side slopes. They are deep and moderately well drained. The surface layer typically is very dark brown silt loam about 10 inches thick. The subsoil is more than 50 inches thick. The upper part is dark brown silty clay loam and silty clay, and the lower part is brown and light brownish gray silty clay.

Kenoma soils are on ridgetops. They are deep, gently sloping, and moderately well drained. The surface layer typically is very dark gray silt loam about 8 inches thick. It rests abruptly on a silty clay subsoil. The subsoil extends to a depth of more than 60 inches. The upper part is very dark grayish brown, and the lower part is mixed strong brown and gray.

Of minor extent in this unit are Catoosa, Collinsville, Nowata, Verdigris, and Zaar soils. The nearly level and moderately sloping silty Catoosa and Nowata soils are on ridgetops and side slopes throughout the unit. The loamy Collinsville soils are on low hills and side slopes. They are moderately sloping to strongly sloping. The nearly level silty Verdigris soils occupy the flood plains of narrow drainageways. The gently sloping clayey Zaar soils are on foot slopes and in swales and concave drainageways.

Most of this unit is cultivated. Some areas are used for hay and range. All locally suited crops are grown. The largest acreage is planted to wheat, grain sorghum, and soybeans.

The main concerns of management are controlling water erosion, improving drainage, and maintaining tilth and fertility. In some years seasonal wetness or droughtiness affects crop production.

4. Verdigris-Osage-Mason

Deep, nearly level, well drained, moderately well drained, and poorly drained soils that have a silt loam to silty clay subsoil; on flood plains and low stream terraces

This unit is on stream terraces and flood plains along the Neosho River and the larger streams in the county. Except for abandoned stream channels and low narrow benches adjacent to the active stream, the landscape is nearly level.

This unit occupies about 7 percent of the county. It is about 48 percent Verdigris soils, 35 percent Osage soils, 13 percent Mason soils, and 4 percent minor soils (fig. 5).

Verdigris soils are nearly level and moderately well drained. The surface layer typically is very dark grayish brown silt loam about 23 inches thick. Below this to a depth of more than 60 inches is very dark grayish brown and very dark brown silt loam.

Osage soils are nearly level to slightly concave and are poorly drained. The surface layer typically is very dark gray silty clay loam or black silty clay about 26 inches thick. Below this to a depth of more than 60 inches is very dark gray silty clay.

Mason soils are nearly level and well drained. The surface layer typically is very dark brown silt loam about 17 inches thick. The subsoil is very dark grayish brown silty clay loam about 28 inches thick. The underlying material to a depth of more than 60 inches is dark grayish brown silty clay loam.

Of minor extent in this unit are Leanna soils, which are in a few scattered nearly level areas throughout the unit. Dennis, Kenoma, and Woodson soils occupy adjoining uplands. They are deep silty soils in nearly level and gently sloping areas.

Nearly all of this unit is cultivated. A few small areas are in woodland and native grass. All locally suited crops are grown. The largest acreage is planted to corn, soybeans, grain sorghum, and wheat.

The main concerns of management are controlling flooding and maintaining good tilth and fertility. Surface drainage is a problem on Osage soils.

Soil maps for detailed planning

The kinds of soil (mapping units) shown on the detailed soil maps at the back of this publication 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 soil is given in the section "Use and management of the soils."

Preceding the name of each mapping unit is the symbol that identifies the unit on the detailed soil map. Each mapping unit 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.

A mapping unit represents an area on the landscape and consists mostly of the soil or soils for which the unit is named. Most mapping units have one dominant soil, but some have two or more dominant soils. A mapping unit commonly includes small, scattered areas of other soils. The properties of some included soils can differ substantially from those of the dominant soil or soils and thus greatly influence the use of the dominant soil. How the included soils may affect the use and management of the mapping unit is discussed.

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. Quarry 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 mapping 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

Ba—Bates loam, 1 to 4 percent slopes. This gently sloping, well drained soil is on ridgetops and side slopes. It occurs as long, irregularly shaped areas. Areas range from 20 to 200 acres in size.

Typically, the surface layer is very dark brown loam about 10 inches thick (fig. 6). The subsoil is about 22 inches thick. The upper part is very dark grayish brown, friable heavy loam, and the lower part is dark brown, firm and friable clay loam. Interbedded sandstone and shale is at a depth of 32 inches. In some places the subsoil contains many sandstone fragments. In some the surface layer is silt loam or fine sandy loam.

Included with this soil in mapping are small intermingled areas of Collinsville, Eram, and Dennis soils. The Collinsville soil is underlain by sandstone bedrock within a depth of 20 inches. It occupies the higher convex areas. The Eram and Dennis soils have a silty surface layer and a clayey subsoil. They commonly are on foot slopes. Also included are a few eroded spots where the surface layer is clay loam and a few areas that are cut by shallow gullies. Included areas range from 2 to 4 acres in size and make up about 10 to 15 percent of the mapping unit.

Permeability and available water capacity are moderate. Runoff is medium. The surface layer is friable, and tilth is good. The shrink-swell potential is low to moderate. The depth of the root zone, which is less than 40 inches, averages about 32 inches. In most unlimed areas, the surface layer and subsoil are strongly acid.

This soil has good potential for crops, native grass, and tame pasture. About half the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is only fair.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

If this soil is used for native range, good range management, including control of undesirable plants that compete with native grasses, is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is moderately limited for building site development because of the moderate shrink-swell potential. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of the depth to sandstone. Increasing the size of the absorption field can improve the functioning of septic tank systems. This soil is severely limited for sewage lagoons because of the depth to rock. Small lagoons can be constructed by the use of embankments. Capability unit IIe-1; Loamy Upland range site.

Bb—Bates loam, 4 to 7 percent slopes. This moderately sloping, well drained soil is on narrow ridgetops and side slopes. It occupies long, irregularly shaped areas and isolated low hills. Areas range from 20 to 150 acres in size.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsoil is about 22 inches thick. The upper part is very dark grayish brown, friable loam, and the lower part is dark brown, firm and friable clay loam. Interbedded soft sandstone and sandy shale are at a depth of 32 inches. In some places the subsoil contains many sandstone fragments. In some the surface layer is silt loam.

Included with this soil in mapping are small intermingled areas of Collinsville, Eram, and Dennis soils. The Collinsville soil is underlain by sandstone bedrock within a depth of 20 inches. It occurs on the steeper parts of the landscape. The Eram and Dennis soils have a silty surface layer and a silty clay subsoil. They are commonly on foot slopes. Also included are a few eroded spots where the surface layer is clay loam and a few small areas that are cut by shallow gullies. Included areas range from 1 acre to 3 acres in size and make up about 10 to 15 percent of this mapping unit.

Permeability and available water capacity are moderate. Runoff is rapid. The surface layer is friable, and tilth is good. The shrink-swell potential is low to moderate. The depth of the root zone, which is less than 40 inches, averages about 32 inches. In most unlimed areas, the surface layer and subsoil are strongly acid.

This soil has good potential for crops, native grass, and tame pasture. About half the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is only fair.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. If the soil is cultivated under poor management, water erosion and soil blowing can be problems. The hazard of erosion is moderate. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grass and tame pasture are also suited. If this soil is used for native range, good range management, including control of undesirable plants that compete with native grasses, is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is moderately limited for building site development because of the moderate shrink-swell potential. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because it is shallow over sandstone and moderately sloping. Locating septic tank absorption fields on less sloping soils and increasing the size of the field can improve the functioning of septic tank systems. This soil is severely limited for sewage lagoons because it is shallow over rock and moderately sloping. If the soil is used for sewage lagoons, onsite investigation is needed. Small lagoons can be constructed by the use of embankments. Capability unit IIIe-1; Loamy Upland range site.

Bc—Bates loam, 2 to 7 percent slopes, eroded. This gently sloping to moderately sloping, well drained soil is mostly on side slopes. It occurs as irregularly shaped areas on the upper parts of hillsides. Areas range from 10 to 100 acres in size.

This soil has lost most of the original surface layer through erosion. Typically, the surface layer is very dark grayish brown loam about 5 inches thick. It is uneven and in a few areas contains sandstone fragments. The subsoil is dark brown clay loam about 18 inches thick. Soft sandstone and sandy shale are at a depth of 24 inches. In some places the surface layer is clay loam, and in some the soil is thicker and deeper over sandstone than is typical.

Included with this soil in mapping are small intermingled areas of Collinsville, Eram, and Dennis soils. The Collinsville and Eram soils are generally eroded. The Collinsville soil is underlain by sandstone bedrock within a depth of 20 inches and has a surface layer that contains many sandstone fragments. It occurs on the steeper parts of the landscape. The Dennis and Eram soils are on foot slopes. The Eram soil has a surface layer of heavy silty clay loam and a subsoil of silty clay. The Dennis soil has a surface layer of heavy silt loam or silty clay loam and a subsoil of silty clay. It is more than 60 inches deep over bedrock. Also included are many shallow gullies and a few deep gullies. Included areas range from 1 acre to 3 acres in size and make up about 15 percent of this mapping unit.

Permeability and available water capacity are moderate. Runoff is rapid. The surface layer is friable, and tilth is poor. The shrink-swell potential is low to moderate. The depth of the root zone, which is less than 40 inches, averages about 24 inches. In unlimed areas, the surface layer and subsoil are commonly strongly acid.

This soil has fair potential for crops and good potential for native grass and tame pasture. About half the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is only fair.

Many areas of this soil are reverting to annual grasses and brush. The soil is suited to most crops grown in the county. It is better suited to wheat, soybeans, and grain sorghum than to other crops. Corn is not well suited. If the soil is cultivated under poor management, further erosion is the major concern. Increasing the content of organic matter and improving tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grass and tame pasture are suited. Range seeding is needed to restore productivity on abandoned cropland. If this soil is used for native range, good range management, including control of undesirable plants that compete with native grasses, is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is moderately limited for building site development because of the moderate shrink-swell potential. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because it is shallow over sandstone and moderately sloping. Locating septic tank absorption fields on less sloping soils and increasing the size of the absorption field can improve the functioning of septic tank systems. This soil is severely limited for sewage lagoons because it is shallow over rock and moderately sloping. If the soil is used for sewage lagoons, onsite investigation is needed. Small lagoons can be constructed by the use of embankments. Capability unit IVe-1; Loamy Upland range site.

Ca—Catoosa silt loam, 0 to 2 percent slopes. This nearly level, well drained soil is on ridgetops. It occurs mostly as large, irregularly shaped areas and as some small isolated areas. Areas range from about 20 to 500 acres in size.

Typically, the surface layer is dark reddish brown, friable silt loam about 11 inches thick. The subsoil is dark reddish brown, friable and firm silty clay loam about 16 inches thick. Hard limestone is at a depth of 27 inches. In places depth to hard limestone is more than 40 inches.

Included with this soil in mapping are small intermingled areas of Kenoma and Zaar soils. These soils are grayer than the Catoosa soil and are more than 40 inches deep over limestone. The Kenoma soils occupy the higher convex areas. The Zaar soils occupy shallow depressions and drainageways. These included areas range from 3 to 5 acres in size and make up about 10 percent of this mapping unit. Also included are areas of rock outcrop that are less than half an acre in size and areas where depth to limestone is less than 20 inches.

Permeability and available water capacity are moderate. Runoff is medium. The surface layer is friable, and tilth is good. The subsoil has a moderate shrink-swell potential. The depth of the root zone, which is less than 40 inches, averages about 27 inches. In most unlimed areas, the surface layer and subsoil are medium acid or strongly acid.

This soil has good potential for crops. It is subject to seasonal droughtiness during periods of low rainfall. It has good potential for native grass and tame pasture. Most of the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is only fair.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grass and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is moderately limited for building site development because of the moderate shrink-swell potential. Also, depth to limestone can be a limiting factor. Onsite investigation is needed to determine depth to hard limestone. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of the depth to hard limestone. Increasing the size of the absorption field can improve the functioning of septic tank systems. This soil is severely limited for sewage lagoons because of the depth to rock. Small lagoons can be constructed by the use of embankments. Capability unit IIe-2; Loamy Upland range site.

Cb—Catoosa-Rock outcrop complex, 1 to 8 percent slopes. This mapping unit consists of gently sloping to moderately sloping, well drained soils and Rock outcrop. It is along drainageways and on low knolls. Areas of this unit are 45 to 60 percent Catoosa silt loam and 15 to 30 percent Rock outcrop. They range from about 25 to 600 acres in size. The Catoosa soil and Rock outcrop are so intermingled that mapping them separately was not feasible.

Hard limestone rocks are exposed or are covered by a layer of silt loam less than 6 inches thick. Typically, the Catoosa soil has a surface layer of dark reddish brown silt loam about 11 inches thick. The subsoil is dark reddish brown, friable and firm silty clay loam about 16 inches thick. Hard limestone is at a depth of 27 inches (fig. 7). In places depth to hard limestone is slightly more than 40 inches.

Included with this unit in mapping are small intermingled areas of Eram soil. This Eram soil has a silty clay loam surface layer and is underlain by soft shale. It occupies side slopes where shale occurs between ledges of limestone outcrops. Also included are areas of bottom land less than 200 feet wide and small areas of moderately steep soils. Included areas range from 3 to 5 acres in size and make up about 10 to 15 percent of the mapping unit.

The Catoosa soil is moderately permeable. Available water capacity is moderate. Runoff is medium. The subsoil has a moderate shrink-swell potential. The depth of the root zone, which is less than 40 inches, averages about 27 inches.

This mapping unit has poor potential for crops, fair potential for tame pasture, and good potential for range. It has good potential for recreation and wildlife and poor potential for engineering uses.

This mapping unit is generally not suitable for cultivation and has limited suitability for hay and tame pasture. Maintaining pasture and harvesting hay are difficult because the rock outcrop hinders farm machinery.

If this mapping unit is used for native range, control of undesirable plants that compete with native grasses is needed. Also essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Continued heavy grazing reduces the plant composition to annual grasses, weeds, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential natural plant community because tillage is not feasible on this mapping unit.

This mapping unit is limited for building site development because of the hard limestone outcrops and the limestone near the surface. Also, in areas of deeper soil, the shrink-swell potential is moderate. Onsite investigation is needed to determine depth over limestone. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel.

This mapping unit is severely limited for septic tank absorption fields because of the depth to hard limestone. Increasing the size of the absorption field can improve the functioning of the septic tank system. This mapping unit is severely limited for sewage lagoons because of the depth to rock and the areas of Rock outcrop. Small lagoons can be constructed within areas of deeper soil by the use of embankments. Capability unit VIs-1; Catoosa soil in Loamy Upland range site.

Cc—Collinsville-Bates complex, 2 to 15 percent slopes. This mapping unit consists of gently sloping to strongly sloping, well drained soils on side slopes and low hills. It occupies long, irregularly shaped areas and isolated hills. Areas of this unit are 40 to 50 percent Collinsville fine sandy loam and 35 to 45 percent Bates loam. They range from 20 to 200 acres in size. These soils are so intermingled that mapping them separately was not feasible. The Collinsville soil generally occupies the more sloping parts of the landscape.

Typically, the Collinsville soil has a surface layer of very dark grayish brown fine sandy loam about 7 inches thick. The underlying material is about 8 inches thick. It is dark brown, friable fine sandy loam that contains a few small sandstone fragments. Sandstone bedrock is at a depth of 15 inches. In places the surface layer contains many sandstone rocks.

Typically, the Bates soil has a surface layer of very dark brown loam about 8 inches thick. The subsoil is about 22 inches thick. The upper part is very dark grayish brown, friable loam, and the lower part is dark brown, firm and friable clay loam. Soft sandstone and sandy shale are at a depth of 32 inches. In places the subsoil contains many sandstone fragments.

Included with these soils in mapping are small intermingled areas of Catoosa, Dennis, and Eram soils. The Catoosa soils occupy the lower foot slopes. They contain less sand than the Collinsville and Bates soils and are moderately deep over limestone. The Dennis soils are on side slopes. They are deep over bedrock and contain less sand throughout the profile than the Collinsville and Bates soils. The Eram soils are also on foot slopes. They are finer textured and less well drained than Bates soils. Included areas range from 2 to 4 acres in size and make up 5 to 15 percent of the mapping unit.

Permeability is moderately rapid in the Collinsville soil and moderate in the Bates soil. Runoff is rapid on both soils. In the Collinsville soil, the depth of the root zone, which is less than 20 inches, averages about 14 inches. In the Bates soil, the depth of the root zone, which is less than 40 inches, averages about 32 inches.

This mapping unit has poor potential for crops. It has good potential for native range and tame pasture. Nearly all of the acreage is range. The potential for recreation and wildlife is good, but the potential for engineering uses is only fair.

This mapping unit is generally not suitable for cultivation. Its best potential use is native range, hay, or tame pasture. The hazard of erosion is very severe if the plant cover is removed.

If this mapping unit is used for native range, control of undesirable plants that compete with native grasses is needed. Also essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Range seeding is needed to restore productivity on abandoned cropland. Continued heavy grazing reduces the plant composition to annual grasses, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential plant community. If this mapping unit is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

The Collinsville soil is severely limited for building site development because it is shallow over rock and strongly sloping. The Bates soil is moderately limited for building site development because of the moderate shrink-swell potential and the depth to rock. Onsite investigation is needed because buildings can be constructed on the less sloping sites. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel.

This mapping unit is severely limited for septic tank absorption fields because of the depth to sandstone and the slope. If the soils are used for sewage absorption fields, there is a danger of surface seepage below the site. This unit is severely limited for sewage lagoons because of depth to rock, rapid percolation, and the slope. Onsite investigation is needed. Sewage disposal systems can be built in the less sloping areas of deeper soil. Capability unit VIe-1; Collinsville soil in Shallow Savannah range site, Bates soil in Loamy Upland range site.

Da—Dennis silt loam, 1 to 3 percent slopes. This gently sloping, moderately well drained soil is along drainageways, on foot slopes of hillsides, and on low knolls. It occupies broad, irregularly shaped areas and isolated knolls. Areas range from 40 to 500 acres in size.

Typically, the surface layer is very dark brown silt loam about 10 inches thick. The subsoil to a depth of more than 60 inches is dark brown, friable silty clay loam over dark brown and brown, firm silty clay and mottled brown and yellowish brown, firm silty clay. In places the surface layer rests abruptly on a firm silty clay subsoil. In a few eroded spots, it is silty clay loam.

Included with this soil in mapping near Mildred, Moran, and Leanna are small intermingled areas of Bates soil. This Bates soil has a loam surface layer and a clay loam subsoil and is underlain by sandstone at a depth of about 32 inches. Also included near Geneva and Petrolia are small areas of Olpe soil. This Olpe soil has a gravelly silt loam surface layer and a gravelly silty clay subsoil. These included soils occur on the higher parts of the landscape. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is slow, and available water capacity is high. Runoff is medium. The surface layer is friable, and tilth is good. The subsoil is highly plastic and has a moderate to high shrink-swell potential. This soil has a seasonal high water table that is perched 20 to 36 inches below the surface, generally from December through April. In most unlimed areas, the surface layer and subsoil are strongly acid.

This soil has good potential for crops, native range, and tame pasture. Most of the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is poor.

Locally grown crops are suited. Soybeans, grain sorghum, corn, and wheat are the most common crops. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Maintaining tilth and the content of organic matter are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grasses and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand and gravel. A large spread footing is essential. For homes built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For homes with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IIe-3; Loamy Upland range site.

Db—Dennis silt loam, 3 to 7 percent slopes. This moderately sloping, moderately well drained soil is on side slopes along drainageways and on foot slopes of hillsides. It occurs as long, irregularly shaped areas. Areas range from 20 to 150 acres in size.

Typically, the surface layer is very dark brown silt loam about 9 inches thick. The subsoil to a depth of more than 60 inches is dark brown, friable silty clay loam over dark brown and brown, firm silty clay and mottled brown and yellowish brown, firm silty clay. In places the silt loam surface layer rests abruptly on a firm silty clay subsoil. In a few eroded spots, the surface layer is silty clay loam.

Included with this soil in mapping are small intermingled areas of Zaar soils. These Zaar soils generally occupy concave areas or slight depressions. They have a black silty clay surface layer and are somewhat poorly drained. Also included near Mildred, Moran, and Leanna are small intermingled areas of Bates soil, which has a loam surface layer and a clay loam subsoil and is underlain by sandstone at a depth of about 32 inches, and near Geneva and Petrolia small areas of Olpe soil, which has a gravelly silt loam surface layer and a gravelly silty clay subsoil. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is slow, and available water capacity is high. Runoff is medium. The surface layer is friable, and tilth is good. The subsoil is highly plastic and has a moderate to high shrink-swell potential. The seasonal high water table is perched 20 to 36 inches below the surface, generally from December through April. In most unlimed areas, the surface layer and subsoil are strongly acid.

This soil has good potential for crops, native range, and tame pasture. Most of the acreage is cultivated. The potential for recreation and wildlife is good, but the potential for engineering uses is poor.

Locally grown crops are suited. Grain sorghum, soybeans, and wheat are the most common crops. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Maintaining tilth and the content of organic matter are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grass and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Also essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of the slow percolation rate and seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IIIe-2; Loamy Upland range site.

Dc—Dennis-Kenoma silt loams, 0 to 2 percent slopes. This mapping unit consists of nearly level, moderately well drained soils on ridgetops. Areas of this unit are 45 to 55 percent Dennis silt loam, 25 to 35 percent Kenoma silt loam, and about 10 percent slick spots. They are irregularly shaped and range from 20 to 100 acres in size. The Dennis and Kenoma soils are so intermingled that mapping them separately was not feasible. The slick spots are less than half an acre in size.

Typically, the Dennis soil has a surface layer of very dark brown silt loam about 10 inches thick. The subsoil to a depth of more than 60 inches is dark brown, friable silty clay loam over dark brown and brown, firm silty clay and mottled brown and yellowish brown, firm silty clay.

The Kenoma soil typically has a surface layer of very dark gray silt loam about 8 inches thick. The surface layer rests abruptly on a very firm silty clay subsoil. The subsoil is more than 52 inches thick. The upper part is very dark grayish brown, and the lower part is mixed brown and gray.

The slick spots have a surface layer of very dark grayish brown heavy silt loam about 6 inches thick. The surface layer lies abruptly on a firm silty clay subsoil that contains a large amount of sodium. The vegetation on these spots is generally thin and suppressed.

Included with this unit in mapping are small intermingled areas of Catoosa soils. These Catoosa soils have a surface layer of dark reddish brown silt loam and are underlain by hard limestone at a depth of about 27 inches. These included areas are 2 or 3 acres in size and make up about 5 to 15 percent of the mapping unit.

Permeability is slow in the Dennis soil and very slow in the Kenoma soil. Available water capacity in both soils is high, and runoff is slow. The subsoil of both soils has a high shrink-swell potential and is highly plastic. As a result of the slick spots, tilth is poor in these soils. In most unlimed areas, the surface layer and subsoil are strongly acid.

This mapping unit has fair potential for crops and good potential for native range and tame pasture. The potential for recreation is poor, and the potential for wildlife is good. The potential for engineering uses is poor. Most of the acreage is used for crops.

Locally grown crops are suited. Grain sorghum, soybeans, and wheat are the most common crops. Because the silty clay subsoil fails to release water readily for plants, these soils are droughty during extended periods of low rainfall. Corn and other crops are sometimes damaged during these dry periods. If these soils are cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and improving tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion and improve tilth in cultivated areas.

Native grass and tame pasture are also suited. If these soils are used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soils are used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This mapping unit is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This mapping unit is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This mapping unit is suited to sewage lagoons. Capability unit IIIe-4; Dennis soil in Loamy Upland range site, Kenoma soil in Clay Upland range site.

Ea—Eram silty clay loam, 1 to 4 percent slopes. This gently sloping, moderately well drained soil is on narrow ridgetops. It occurs as long, irregularly shaped areas. Areas range from 20 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 9 inches thick. The subsoil is about 24 inches thick. The upper part is very dark grayish brown, firm silty clay, and the lower part is olive brown, firm silty clay. Soft, unweathered shale is at a depth of about 34 inches. In places depth to unweathered shale is less than 20 inches. This shallow soil is generally on the more sloping parts of the landscape. In a few eroded spots, the surface layer is heavy silty clay loam and is lighter in color than is typical.

Included with this soil in mapping are small intermingled areas of Bates soil. This Bates soil occupies the higher parts of the landscape. It has a loam surface layer and is underlain by sandstone at a depth of 20 to 40 inches. Included areas are 1 acre to 2 acres in size and make up about 10 percent of the mapping unit.

Permeability is slow, and available water capacity is low. Runoff is medium. The surface layer is friable, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. This soil has a seasonal high water table. The depth of the root zone, which is less than 40 inches, averages about 30 inches. In most unlimed areas, the surface layer is slightly acid.

This soil has fair potential for crops. It has good potential for native range and tame pasture. The potential for recreation is fair, the potential for wildlife is good, and the potential for engineering uses is poor. About half of the acreage is used for crops.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

Native grass and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is generally unsuited to septic tank absorption fields because of a slow percolation rate, the depth to bedrock, and the seasonal wetness. It is limited for sewage lagoons because of depth to bedrock. The shale bedrock is rippable under certain moisture conditions. Small lagoons can be constructed by the use of embankments. Capability unit IIIe-5; Clay Upland range site.

Eb—Eram silty clay loam, 4 to 7 percent slopes. This moderately sloping, moderately well drained soil is along drainageways and on ridgetops. It occupies long, irregularly shaped areas and isolated low hills. Areas range from 20 to 150 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The subsoil is firm silty clay about 22 inches thick. The upper part is very dark grayish brown, and the lower part is olive brown. Soft, unweathered shale is at a depth of 30 inches. In places depth to unweathered shale is less than 20 inches. In a few eroded spots, the surface layer is heavy silty clay loam and is lighter in color than is typical.

Included with this soil in mapping are small intermingled areas of Bates soils. These Bates soils occupy the higher parts of the landscape. They have a loam surface layer and are underlain by sandstone and shale at a depth of 32 inches. Included areas are 1 acre to 2 acres in size and make up about 10 percent of the mapping unit.

Permeability is slow, and available water capacity is low. Runoff is rapid. The surface layer is friable, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. This soil has a seasonal high water table. The depth of the root zone, which is less than 40 inches, averages about 30 inches. In most unlimed areas, the surface layer is slightly acid.

This soil has fair potential for crops. It has good potential for native range and tame pasture. The potential for recreation is fair, the potential for wildlife is good, and the potential for engineering uses is good. Most areas are used for native range or tame pasture.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. Corn is not well suited. If this soil is cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas. Conservation practices are difficult to apply and maintain, however, because the soil is moderately sloping and moderately deep.

Native grass and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is generally unsuited to septic tanks and filter fields because of a slow percolation rate, the depth to bedrock, the seasonal wetness, and the slope. If the soil is used for sewage absorption fields, there is a danger of surface seepage below the site. The soil is limited for sewage lagoons because of the depth to bedrock and the slope. The shale bedrock is rippable under certain moisture conditions. Small lagoons can be constructed, in the less sloping areas, by the use of embankments. Capability unit IVe-3; Clay Upland range site.

Ec—Eram silty clay loam, 2 to 7 percent slopes, eroded. This gently sloping or moderately sloping, moderately well drained soil is on narrow ridgetops and side slopes. It occurs as irregularly shaped areas on the upper parts of hillsides (fig. 8). Areas range from 10 to 100 acres in size.

This soil has lost most of the original surface layer through erosion. Typically, the surface layer is very dark grayish brown and olive brown heavy silty clay loam about 6 inches thick. It is not uniform and in a few areas contains unweathered shale fragments. The subsoil is olive brown silty clay about 16 inches thick. Soft, unweathered shale is at a depth of about 24 inches. In places depth to unweathered shale is less than 20 inches.

Included with this soil in mapping are small intermingled areas of Bates soils and unweathered shale outcrops. The Bates soils occupy the higher parts of the landscape. They have a loam surface layer and a clay loam subsoil and are underlain by sandstone and shale at a depth of 32 inches. Shale outcrops occur on some of the steeper breaks and side slopes. Included areas are 1 acre to 2 acres in size and make up about 10 percent of the mapping unit.

Permeability is slow, and available water capacity is low. Runoff is rapid. The surface layer is firm, and tilth is poor. The subsoil is highly plastic and has a high shrink-swell potential. This soil has a seasonal high water table. The depth of the root zone, which is less than 40 inches, averages about 24 inches. In most unlimed areas, the surface layer is slightly acid.

This soil has poor potential for crops. It has good potential for native range and tame pasture. The potential for recreation is fair, the potential for wildlife is good, and the potential for engineering uses is poor. About half of the acreage is used for crops.

Many areas of this soil are reverting to annual grasses and brush. If very carefully managed, the soil is suited to most crops grown in the county. It is better suited to wheat, grain sorghum, and soybeans than to other crops. Corn is not well suited. If the soil is cultivated under poor management, further erosion is the major concern. Increasing the content of organic matter and improving tilth are also concerns. Keeping the soil in good tilth is difficult in cultivated areas. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion and improve tilth in these areas, but conservation practices are difficult to apply and maintain.

Native grass and tame pasture are also suited. Range seeding is needed to restore productivity on abandoned cropland. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease, and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is generally unsuited to septic tanks and filter fields because of a slow percolation rate, the depth to bedrock, the seasonal wetness, and the slope. If the soil is used for sewage absorption fields, there is a danger of surface seepage below the site. The soil is limited for sewage lagoons because of the depth to bedrock and the slope. The shale bedrock is rippable under certain moisture conditions. Small lagoons can be constructed, in the less sloping areas, by the use of embankments. Capability unit IVe-1; Clay Upland range site.

Ka—Kenoma silt loam, 1 to 3 percent slopes. This gently sloping, moderately well drained soil is in broad upland areas and on ridgetops. It occurs as large, irregularly shaped areas. Areas range from about 40 to 800 acres in size.

Typically, the surface layer is very dark gray silt loam about 8 inches thick. It rests abruptly on a firm silty clay subsoil. The subsoil is more than 52 inches thick. The upper part is very dark grayish brown, and the lower part is mixed brown, dark grayish brown, strong brown, and gray. In places, there is no abrupt textural change between the surface layer and the subsoil and the upper part of the subsoil is silty clay loam. In a few eroded spots, the surface layer is heavy silty clay loam and is lighter in color than is typical.

Included with this soil in mapping are small intermingled areas of Catoosa and Zaar soils. The Catoosa soils are in the same positions on the landscape as Kenoma soils. They have a surface layer of dark reddish brown silt loam and a subsoil of dark reddish brown silty clay loam and are underlain by hard limestone at a depth of 27 inches. The Zaar soils are generally in concave areas at the upper ends of drainageways. They have a black silty clay surface layer and a silty clay subsoil. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is very slow, and available water capacity is high. Runoff is medium. The surface layer is friable, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. In most places this soil has a temporary perched water table above the clay subsoil during wet periods. In most unlimed areas, the surface layer and subsoil are medium acid.

This soil has good potential for crops, native range, and tame pasture. The potential for recreation is poor, the potential for wildlife is good, and the potential for engineering uses is poor. Most areas are used for crops.

Locally grown crops are suited. Soybeans, grain sorghum, and wheat are the most common crops. Because the silty clay subsoil fails to release water readily for plants, this soil is droughty during extended periods of low rainfall. Corn and other crops are sometimes damaged during these dry periods. If the soil is cultivated under poor management, water erosion and soil blowing can be problems. Maintaining tilth and the content of organic matter are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming help control erosion in cultivated areas.

Native grass and tame pasture are also suited. If the soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture (fig. 9), fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the high shrink-swell potential and seasonal wetness. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IIIe-4; Clay Upland range site.

La—Leanna silt loam. This nearly level, somewhat poorly drained soil is on flood plains, low stream terraces, and terrace fans. It occurs as irregularly shaped areas ranging from 20 to 120 acres in size. Low areas are subject to occasional flooding.

Typically, the surface layer is black silt loam about 7 inches thick. The subsurface layer is dark gray silt loam about 6 inches thick. The subsoil is about 39 inches thick. The upper part is very dark gray, firm silty clay, and the lower part is dark gray, firm silty clay loam. The underlying material to a depth of 66 inches is dark grayish brown silty clay loam. In places the subsoil is silt loam.

Permeability is very slow, and available water capacity is moderate to high. The surface layer is friable, and tilth is good. The subsoil is highly plastic and has a high shrink-swell potential. In most places this soil has a temporary perched water table above the silty clay subsoil during wet periods and from December through April. In most unlimed areas, the surface layer and subsoil are strongly acid.

This soil has good potential for crops, native range, and tame pasture. The potential for wildlife is good, but the potential for recreation and engineering uses is poor. The potential for trees is good. Most areas are used for crops.

Locally grown crops are suited. Corn, soybeans, grain sorghum, and wheat are the most common crops. Legumes drown out during prolonged periods of wetness. Maintaining good tilth and fertility is essential. Wetness during periods of seeding and harvest is a problem in some years. In places artificial drainage is needed.

Native grass, hay, and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Also essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is suited to trees, but only a small acreage is wooded. Improving the timber stand is important in woodland management.

This soil is limited for building site development because it is seasonally wet, is subject to flooding, and has a high shrink-swell potential. In areas that are not flooded, the harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate, the seasonal wetness, and the flooding. In areas that are not flooded or are protected, increasing the size of the filter field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons in areas that are not flooded. Capability unit IIw-1; Clay Lowland range site.

Ma—Mason silt loam. This nearly level, well drained soil is on stream terraces. It occurs as long, continuous, irregularly shaped areas adjacent to stream channels. Low areas are subject to occasional flooding.

Typically, the surface layer is very dark brown, friable silt loam about 17 inches thick. The subsoil is very dark grayish brown, friable silty clay loam about 28 inches thick. The underlying material to a depth of 63 inches is dark grayish brown silty clay loam. In places the subsoil is silt loam.

Included with this soil in mapping are small intermingled areas of Osage soils. These Osage soils generally occupy swales and concave areas. They have a silty clay loam or silty clay surface layer and a silty clay subsoil. They stay wet longer after periods of rainfall. These included areas are less than 1 acre to 2 acres in size and make up about 5 to 10 percent of this mapping unit.

Permeability is moderately slow, and available water capacity is high. The surface layer is friable, and tilth is good. The subsoil is moderately plastic and has a moderate shrink-swell potential. In unlimed areas, the surface layer and subsoil are commonly medium acid.

This soil has good potential for crops, native range, tame pasture, and wildlife. The potential for recreation and engineering uses is fair. The potential for trees is good. Most areas are used for crops.

All locally grown crops are suited. Corn, soybeans, grain sorghum, and wheat are the most common crops. Maintaining good tilth and fertility is essential. Crop residue management helps maintain good tilth and increases the organic-matter content.

Native grass, hay, and tame pasture are also suited. If the soil is used for native range, good range management, including control of undesirable plants that compete with native grasses, is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is suited to trees, but only a small acreage is wooded. Improving the timber stand is important in woodland management.

This soil is limited for building site development because of the hazard of flooding and the moderate shrink-swell potential. The hazard of flooding can be reduced by dikes and levees. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is limited for septic tank absorption fields because of a moderately slow percolation rate. Increasing the size of the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons if it is protected against flooding. Capability class I; Loamy Lowland range site.

Na—Nowata silt loam, 3 to 7 percent slopes. This moderately sloping, well drained soil is along drainageways. It occurs as long, irregularly shaped areas in the lower drainage pattern of the Marmaton River, Big Creek, and the Little Osage River. It occurs mostly above areas of limestone outcrop. Areas range from 20 to 200 acres in size.

Typically, the surface layer is very dark brown silt loam about 9 inches thick. It contains a few chert fragments. The subsoil is about 18 inches thick. The upper part is very dark brown, firm silty clay loam containing many angular chert fragments up to 7 inches in diameter, and the lower part is dark reddish brown, firm silty clay loam that is as much as 70 percent angular chert fragments up to 7 inches in diameter. Depth to the high concentration of chert rocks is 12 to 20 inches. Hard limestone is at a depth of 27 inches. In places the bedrock is shale rather than limestone. Scattered chert fragments are on the surface. In places there are few or no chert fragments.

Included with this soil in mapping are small intermingled areas of limestone outcrops. These outcrops are on the lower slopes. Included areas range from 1/2 acre to 2 acres in size and make up about 10 percent of this mapping unit.

Permeability is moderately slow, and available water capacity is low. Runoff is medium. The surface layer is friable. Tilth is poor because of the chert fragments. The subsoil is moderately plastic and has a moderate shrink-swell potential. The depth of the root zone, which is less than 40 inches, averages about 27 inches. In unlimed areas, the surface layer and the upper part of the subsoil are commonly slightly acid.

This soil has poor potential for crops, mainly because of the chert fragments. It has good potential for native range and tame pasture. The potential for recreation is fair, and the potential for wildlife is good. The potential for engineering uses is poor. Most areas are used for native range or tame pasture.

Locally grown crops are suited. Grain sorghum, wheat, and soybeans are the most common crops. If this soil is cultivated under poor management, water erosion can be a problem. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas. Conservation practices are difficult to apply, however, because of the chert fragments.

Native grass and tame pasture are better suited than other uses. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because of the depth to bedrock, the chert fragments, and the moderate shrink-swell potential. Onsite investigation is needed. Buildings can be constructed in areas of deeper soil. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand. A large spread footing is essential.

This soil is severely limited as a site for septic tank absorption fields because of a slow percolation rate, the depth to rock, and the chert fragments. Increasing the size of the absorption field can improve the functioning of septic tank systems. This soil is severely limited for sewage lagoons because of the depth to rock and the chert fragments. Small lagoons can be constructed, in areas of deeper soil, by the use of embankments. Capability unit IVe-2; Loamy Upland range site.

Oa—Olpe soils, 3 to 15 percent slopes. These moderately sloping to strongly sloping, well drained soils are on rolling hills in the northwestern part of the county and west of the valley of the Neosho River. Areas are irregularly shaped and range from 20 to 120 acres in size.

Typically, the surface layer is dark brown gravelly silt loam about 15 inches thick (fig. 10). The subsoil to a depth of more than 60 inches is dark reddish brown, firm gravelly silty clay loam over reddish brown and yellowish red, very firm gravelly silty clay. In places the upper 40 inches is less than 25 percent chert gravel. There are intermingled areas of soils that have a less clayey subsoil than is typical.

Included with these soils in mapping are small intermingled areas of limestone outcrops. These outcrops occur on the lower slopes. Included areas are 2 to 3 acres in size and make up about 15 percent of this mapping unit.

Permeability is slow, and available water capacity is low to moderate. The subsoil is moderately plastic and has a low to moderate shrink-swell potential. Runoff is rapid. In unlimed areas, the surface layer and subsoil are commonly strongly acid.

These soils have poor potential for crops. They have good potential for native range and tame pasture. The potential for recreation is fair, and the potential for wildlife is good. The potential for engineering uses is poor. The soil is a good potential source of road gravel and gravel used to insulate foundations and pavements. Nearly all areas are used for native range or tame pasture.

These soils are generally not suitable for cultivation. The best potential use is native range, hay, or tame pasture. The hazard of erosion is severe if the plant cover is removed. If the soils are used for native range, control of undesirable plants that compete with native grasses is needed. Continued heavy grazing reduces the plant composition to annual grasses, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential natural plant community. A timely season of use and a proper distribution of livestock are needed. Also, range seeding is needed to restore productivity on abandoned cropland. If these soils are used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

These soils are moderately limited for building site development. Reinforced concrete foundations are needed in places because of the shrink-swell potential. The strongly sloping areas can be a problem.

These soils are severely limited for septic tank absorption fields because of a slow percolation rate and the slope. In the less sloping areas, increasing the size of the absorption field can improve the functioning of septic tank systems. If absorption fields are installed in the more sloping areas, there is a danger of surface seepage below the site. These soils are generally unsuited to sewage lagoons because of the chert gravel and the slope. Capability unit VIe-1; Loamy Upland range site.

Ob—Osage silty clay loam. This nearly level, poorly drained soil is on low stream terraces and flood plains. Areas are irregularly shaped and range from 40 to 400 acres in size. Low areas are subject to occasional flooding.

Typically, the surface layer is very dark gray silty clay loam about 13 inches thick. The subsoil to a depth of more than 60 inches is very dark gray, firm silty clay over dark grayish brown, very firm silty clay loam. In places the surface layer is heavy silt loam. In some small areas, it is silty clay.

Permeability is very slow, and available water capacity is moderate. Runoff is slow. The surface layer is friable, and tilth is fair. The subsoil is highly plastic and has a high to very high shrink-swell potential. In most places this soil has a temporary perched water table above the silty clay subsoil during wet periods. In unlimed areas, the surface layer and subsoil are commonly medium acid.

This soil has good potential for crops, native range, or tame pasture. It has fair potential for recreation and good potential for wildlife. The potential for engineering uses is poor. The potential for trees is good. Nearly all areas are used for crops.

All locally grown crops are suited. Corn, soybeans, grain sorghum, and wheat are the most common crops. Wetness during periods of seeding and harvest is a problem in some years. A bedding system for drainage helps remove excess water. Maintaining tilth and fertility is essential. Crop residue management improves tilth and increases the organic-matter content.

Native grass, hay, and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is suited to trees, but only a small acreage is wooded. Improving the timber stand is important in woodland management.

This soil is limited for building site development because it is seasonally wet, is subject to flooding, and has a high to very high shrink-swell potential. In areas protected against flooding, the harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is generally unsuited to septic tank absorption fields because of a slow percolation rate, the seasonal wetness, and the flooding. In areas protected against flooding, it is suited to sewage lagoons. Capability unit IIw-1; Loamy Lowland range site.

Oc—Osage silty clay. The nearly level, poorly drained soil is on low stream terraces and flood plains. Areas are irregularly shaped and range from 40 to 400 acres in size. Low areas are subject to occasional flooding.

Typically, the surface layer is black silty clay about 26 inches thick. The subsoil to a depth of more than 60 inches is very dark gray, very firm silty clay. In places the surface layer is silty clay loam. In some small areas, it is silt loam.

Permeability is very slow, and available water capacity is moderate. Runoff is very slow. The surface layer is firm, and tilth is poor. The subsoil is very highly plastic and has a very high shrink-swell potential. In most places this soil has a temporary high water table during wet periods. Wetness is a moderately severe problem. The soil is sticky if worked when it is too wet and hard if worked when too dry. In unlimed areas, the surface layer and subsoil are commonly medium acid. In other areas, reaction is neutral.

This soil has fair potential for crops and good potential for native range and tame pasture. It has fair potential for recreation and good potential for wildlife. The potential for engineering uses is poor. The potential for trees is good. Nearly all areas are used for crops.

Most locally grown crops are suited. Yields are affected by prolonged wetness. Legumes drown out. Corn, soybeans, and grain sorghum are the most common crops. Adequate drainage is essential if alfalfa is grown. Wetness during periods of seeding and harvest is a problem in some years. In places artificial drainage is needed. A bedding system for drainage helps remove excess water. Maintaining and improving tilth and fertility is essential. Crop residue management improves tilth and increases the organic-matter content. In places diversion terraces are needed to control water that runs in from adjacent slopes.

Native grass, hay, and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Also essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is suited to trees, but only a small acreage is wooded. Improving the timber stand is important in woodland management.

This soil is limited for building site development because it is seasonally wet, is subject to flooding, and has a very high shrink-swell potential. In areas protected against flooding, the harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is generally unsuited to septic tank absorption fields because of a slow percolation rate, the seasonal wetness, and the flooding. In areas protected against flooding, it is suited to sewage lagoons. Capability unit IIIw-1; Clay Lowland range site.

Qa—Quarry. This mapping unit consists of areas from which the soil and much of the underlying limestone or shale have been removed. The underlying material has been removed for the production of cement or bricks. These areas generally are barren and are surrounded by vertical walls. Some quarries are filled with water. Quarries that are too small to be delineated on the soil map are identified on the map by a spot symbol. Scattered trees, shrubs, and grass border the quarries. Quarries are of limited use for agriculture. They have good potential for wildlife or recreation. Capability unit VIIIs-1; not assigned to a range site.

Ta—Talihina silty clay loam, 5 to 20 percent slopes. This moderately sloping to moderately steep, moderately well drained soil is on low hills and along drainageways. Areas are irregularly shaped and range from 20 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick (fig. 11). The subsoil is dark grayish brown, firm silty clay about 6 inches thick. The underlying material to a depth of 17 inches is grayish brown silty clay containing many unweathered shale fragments. Below this is unweathered shale. In places the surface layer contains scattered sandstone fragments. In some small areas, the depth to unweathered shale is more than 20 inches.

Included with this soil in mapping are areas of bottom land less than 200 feet wide. Also included are shale outcrops. These outcrops occur on breaks and on the steeper side slopes. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is slow, and available water capacity is low. Runoff is rapid. The subsoil is moderately plastic and has a high shrink-swell potential. The depth of the root zone, which is less than 20 inches, averages about 17 inches.

This soil has poor potential for crops and good potential for native range and tame pasture. It has fair potential for recreation and good potential for wildlife. The potential for engineering uses is poor. Nearly all areas are used for native range or tame pasture.

This soil is generally not suitable for cultivation. The best potential use is native range, hay, or tame pasture. The hazard of erosion is severe if the plant cover is removed. If the soil is used for native range, control of undesirable plants that compete with native grasses is needed. Continued heavy grazing reduces the plant composition to annual grasses, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential natural plant community. A timely season of use and a proper distribution of livestock are needed. Also, range seeding is needed to restore productivity on abandoned cropland. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because it has a high shrink-swell potential, is seasonally wet, and is moderately sloping to moderately steep. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

Limitations for septic tank absorption fields are severe because of a slow percolation rate, the depth to bedrock, the seasonal wetness, and the slope. If this soil is used for sewage absorption fields, there is a danger of surface seepage below the site. This soil is severely limited for sewage lagoons because of the depth to bedrock and the slope. Small lagoons can be constructed, in the less sloping areas, by the use of embankments. Capability unit VIs-1; Clay Upland range site.

Tb—Talihina stony silty clay loam, 8 to 25 percent slopes. This strongly sloping to steep, moderately well drained soil is on the sides of escarpments and on hills capped with limestone. Areas are narrow, long, and irregularly shaped. They are commonly dissected by small drainageways. Many stones are on the surface. They are larger and more numerous along the upper parts of slopes. Rocks are exposed on as much as 15 percent of the surface.

Typically, the surface layer is very dark grayish brown stony silty clay loam about 7 inches thick. The subsoil is dark grayish brown, firm silty clay about 6 inches thick. The underlying material to a depth of 17 inches is grayish brown silty clay containing many unweathered shale fragments. Below this is unweathered shale. In places the unweathered shale is at a depth of more than 20 inches.

Included with this soil in mapping are small intermingled areas of Zaar soils. These Zaar soils occur in swales and short drainageways. They have a black silty clay surface layer and a silty clay subsoil. Also included are outcrops of unweathered shale. These outcrops occur on breaks and on the steeper side slopes. Included areas are 2 to 3 acres in size and make up about 15 percent of this mapping unit.

Permeability is slow, and available water capacity is low. Runoff is rapid. The subsoil is moderately plastic and has a high shrink-swell potential. The depth of the root zone, which is less than 20 inches, averages about 17 inches.

This soil has poor potential for crops. It has good potential for native range and fair potential for tame pasture. The potential for recreation is fair, and the potential for wildlife is good. The potential for engineering uses is poor. Most areas are used for native range.

This soil is generally not suitable for cultivation and has limited suitability for hay and tame pasture. Maintaining pasture and harvesting hay are difficult because the rock outcrops and steep slopes hinder the use of farm machinery. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Continued heavy grazing reduces the plant composition to annual grasses, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential natural plant community because tillage is not feasible on this soil. A timely season of use and a proper distribution of livestock are needed.

This soil is limited for building site development because it has a high shrink-swell potential, is seasonally wet, and is strongly sloping to steep. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

Limitations for septic tank absorption fields are severe because of a slow percolation rate, the depth to bedrock, the seasonal wetness, and the strongly sloping to steep slopes. If this soil is used for sewage absorption fields, there is a danger of surface seepage below the site. The soil is severely limited for sewage lagoons because of the depth to bedrock and the slope. Onsite investigation is needed. Small lagoons can be constructed, in the less sloping areas, by the use of embankments. Capability unit VIIs-1; Clay Upland range site.

Va—Verdigris silt loam. This nearly level, moderately well drained soil is on stream terraces and flood plains. It occurs as long, continuous, irregularly shaped areas adjacent to stream channels. Areas range from 40 to 800 acres in size. Low areas are subject to occasional flooding.

Typically, the surface layer is very dark grayish brown silt loam about 23 inches thick. The next layer is very dark grayish brown, friable and firm heavy silt loam about 30 inches thick. Below this to a depth of more than 60 inches is very dark brown silt loam. In places the subsoil is silty clay loam. In some small areas, the surface layer is silty clay loam.

Included with this soil in mapping are small intermingled areas of Osage soils. These Osage soils generally occupy swales and concave areas. They have a silty clay loam surface layer and a silty clay subsoil. They are wet longer after periods of rainfall. These included areas are less than 2 to 3 acres in size and make up about 10 percent of the mapping unit.

Permeability is moderate, and available water capacity is high. The surface layer is friable, and tilth is good. The subsoil has a moderate shrink-swell potential. In unlimed areas, the surface layer and subsoil are commonly medium acid.

This soil has good potential for crops, native range, and tame pasture. The potential for recreation and wildlife is good. The potential for engineering uses is fair. The potential for trees is good. Nearly all areas are used for crops.

All locally grown crops are suited. Corn, soybeans, grain sorghum, and wheat are the most common crops. Maintaining good tilth and fertility is essential. Crop residue management helps maintain good tilth and increases the organic-matter content.

Native grass, hay, and tame pasture are also suited. If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. If this soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is suited to trees, but only a small acreage is wooded. Improving the timber stand is important in woodland management.

This soil is limited for building site development because of the hazard of flooding. In areas protected against flooding, it is slightly to moderately limited because of the moderate shrink-swell potential. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. For houses built on slab foundations, these harmful effects can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock.

This soil is severely limited for septic tank absorption fields because it is subject to flooding. In areas protected against flooding, it is slightly limited. It is suited to sewage lagoons if protected against flooding. Capability unit IIw-2; Loamy Lowland range site.

Vb—Verdigris silt loam, channeled. This nearly level, moderately well drained soil is on narrow flood plains that have short, moderately sloping side slopes. It is along small drainageways and adjacent to the Neosho River channel. Areas are long and are about 200 feet to 350 feet wide. They are dissected by small meandering channels. This soil is subject to frequent flooding.

Typically, the surface layer is very dark grayish brown silt loam about 23 inches thick. The next layer is very dark grayish brown, friable and firm silt loam about 30 inches thick. Below this to a depth of more than 60 inches is very dark brown silt loam. In places limestone is at a depth of 20 to 40 inches. In most areas adjacent to the Neosho River channel, the surface layer and subsoil contain more clay than is typical.

Included with this soil in mapping are small intermingled areas of Osage soils. These Osage soils have a silty clay loam surface layer and a silty clay subsoil. Also included on side slopes are soils that are similar to the upland soils through which this mapping unit extends. Included areas make up about 16 percent of the mapping unit.

Permeability is moderate, and available water capacity is high. The subsoil has a moderate shrink-swell potential. This soil is wet most of the time.

This soil has poor potential for crops, good potential for native range, and fair potential for tame pasture. It has poor potential for recreation and good potential for wildlife. The potential for engineering uses is poor. The potential for trees is good. Farm stockwater ponds are common in areas of this soil. Nearly all areas are in native grass. The soil is also used as waterways for terrace outlets.

This soil is generally not suitable for cultivation. Flooding and wet conditions hinder the use of farm machinery. Water erosion is a hazard if plant cover is lacking. The best potential use is native range or woodland. If the soil is used for native range, control of undesirable plants that compete with native grasses is needed. Continued heavy grazing reduces the plant composition to annual grasses, shrubs, and trees. Brush control in combination with deferred grazing is the best method of restoring the potential natural plant community because tillage is not feasible on this soil. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock.

This soil is suited to trees, but only a small acreage is wooded. Most areas adjacent to the Neosho River channel are wooded. Improving the timber stand is important in woodland management.

This soil is generally unsuited as a site for houses or other small structures because it is wet, is subject to flooding, and has a moderate shrink-swell potential. In areas that are drained and protected against flooding, the harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel.

This soil is generally unsuited to septic tank absorption fields because of the wetness and the frequent flooding. It is also generally unsuited to sewage lagoons. Capability unit Vw-1; Loamy Lowland range site.

Wa—Woodson silt loam. This nearly level, somewhat poorly drained soil is in broad upland areas. It occurs as large, irregularly shaped areas that range from about 40 to 1,000 acres in size.

Typically, the surface layer is very dark gray silt loam about 8 inches thick. The boundary between the surface layer and the subsoil is abrupt. The subsoil to a depth of more than 60 inches is very firm silty clay. The upper part is very dark gray, and the lower part is gray. In places the soil has a subsurface layer of friable, dark grayish brown silt loam.

Included with this soil in mapping are small intermingled areas of Zaar soils. These Zaar soils generally occur in concave areas in drainageways. They have a black silty clay surface layer and a silty clay subsoil. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is very slow, and available water capacity is moderate. Runoff is slow. The surface layer is friable, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. In most places this soil has a temporary perched water table above the clay subsoil during rainy periods. In most unlimed areas, the surface layer and subsoil are medium acid.

This soil has good potential for crops, tame pasture, and native range (fig. 12). It has poor potential for recreation and good potential for wildlife. The potential for engineering uses is poor. Most areas are used for crops.

Locally grown crops are suited. Yields are affected by prolonged wetness or by dry periods. Soybeans, grain sorghum, and wheat are the most common crops. The clay subsoil fails to release water readily for plants, and the soil is droughty during extended periods of low rainfall. Corn and other crops are sometimes damaged during these dry periods. If the soil is cultivated under poor management, water erosion and soil blowing can be problems. Maintaining tilth and the content of organic matter are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas. Some nearly level or weakly concave areas require surface drainage.

If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because it has a high shrink-swell potential and is seasonally wet. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IIs-1; Clay Upland range site.

Za—Zaar silty clay, 1 to 3 percent slopes. This gently sloping, somewhat poorly drained soil is on foot slopes below areas of limestone and along slightly concave upland drainageways. It occurs as long, irregularly shaped areas that range from 20 to 500 acres in size.

Typically, the surface layer is black, firm silty clay about 18 inches thick. The subsoil is about 39 inches thick.

The upper part is black to very dark grayish brown, firm silty clay, and the lower part is dark brown, very firm silty clay. The underlying material to a depth of more than 60 inches is mixed olive brown and dark yellowish brown silty clay. In places the surface layer is silty clay loam or silt loam.

Included with this soil in mapping are small areas of drainageways and flood plains less than 200 feet wide. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is very slow, and available water capacity is moderate. Runoff is medium. The surface layer is firm, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. This soil has a perched seasonal high water table. Cracks are common during prolonged dry periods. In most unlimed areas, the surface layer and subsoil are medium acid.

This soil has good potential for crops, native range, and tame pasture. The potential for recreation is poor, and the potential for wildlife is good. The potential for engineering uses is poor. Most areas are used for crops.

Locally grown crops are suited. Yields are affected by prolonged wetness or by dry periods. Soybeans, grain sorghum, and wheat are the most common crops. Wetness during periods of seeding and harvest is a problem in some years. The silty clay subsoil fails to release water readily for plants, and the soil is droughty during extended periods of low rainfall. Corn and other crops are sometimes damaged during these dry periods. If the soil is cultivated under poor management, water erosion and soil blowing can be problems. Maintaining tilth and the content of organic matter are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas.

If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because it has a high shrink-swell potential and is seasonally wet. Seasonal wetness can be reduced by foundation drains of tile surrounded by sand filter. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Wetness can be reduced by installing tile and sand filter drains below footings.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IIIe-3; Clay Upland range site.

Zb—Zaar silty clay, 3 to 7 percent slopes. This moderately sloping, somewhat poorly drained soil is along drainageways and on slightly concave foot slopes below areas of limestone. It occurs as irregularly shaped areas that range from 20 to 200 acres in size.

Typically, the surface layer is black, firm silty clay about 14 inches thick. The subsoil is about 36 inches thick. The upper part is black to very dark grayish brown, firm silty clay, and the lower part is dark brown, very firm silty clay. The underlying material to a depth of more than 60 inches is mixed olive brown and dark yellowish brown silty clay. In places the surface layer is silty clay loam. In a few eroded spots, the surface layer, which is high in content of organic matter, has been removed.

Included with this soil in mapping are drainageways and flood plains less than 200 feet wide. Included areas range from 2 to 4 acres in size and make up about 10 percent of this mapping unit.

Permeability is very slow, and available water capacity is moderate. Runoff is medium. The surface layer is firm, and tilth is fair. The subsoil is highly plastic and has a high shrink-swell potential. This soil has a perched seasonal high water table. Cracks are common during prolonged dry periods. In most unlimed areas, the surface layer and subsoil are medium acid.

This soil has poor potential for crops and good potential for native range and tame pasture. The potential for recreation is poor, and the potential for wildlife is good. The potential for engineering uses is poor. About half of the acreage is used for crops.

Locally grown crops are suited. Yields are affected by prolonged wetness or by dry periods. Grain sorghum, wheat, and soybeans are the most common crops. Wetness during periods of seeding and harvest is a problem in some years. The silty clay subsoil fails to release water readily for plants, and the soil is droughty during extended periods of low rainfall. Corn and other crops are sometimes damaged during these dry periods. If the soil is cultivated under poor management, water erosion and soil blowing can be problems. Increasing the content of organic matter and maintaining tilth are also concerns. Conservation practices, such as crop residue management, terracing, and contour farming, help control erosion in cultivated areas. Conservation practices are difficult to apply and maintain, however, because of the slope and the silty clay surface layer.

If this soil is used for native range, control of undesirable plants that compete with native grasses is needed. Under prolonged overgrazing, desirable tall grasses decrease and short grasses, woody plants, weeds, and trees increase. Essential in range management are a proper degree of use, a timely season of use, and a proper distribution of livestock. Also, range seeding is needed to restore productivity on abandoned cropland. If the soil is used for tame pasture, fertilization, proper stocking, rotation grazing, and a timely season of use are needed to maintain and increase forage production.

This soil is limited for building site development because it has a high shrink-swell potential and is seasonally wet. Seasonal wetness can be reduced by foundation drains of tile surrounded by a sand filter. The harmful effects of shrinking and swelling can be reduced by insulating foundations and pavements with a suitable intervening layer of sand or gravel. A large spread footing is essential. For houses built on slab foundations, the harmful effects of shrinking and swelling can be reduced by a 12- to 18-inch base of crushed rock well below the depth of seasonal expansion. For houses with basements, the harmful effects of shrinking and swelling and wetness can be reduced by proper design. The harmful effects of shrinking and swelling can be reduced by designing walls that have pilasters and are reinforced with concrete and by supporting the walls with a large spread footing. Also, the basement floor can be laid on 12 to 18 inches of crushed rock. Wetness can be reduced by installing tile and sand filter drains below footings.

This soil is severely limited for septic tank absorption fields because of a slow percolation rate and the seasonal wetness. Increasing the size of the absorption field and installing perimeter drains around the absorption field can improve the functioning of septic tank systems. This soil is suited to sewage lagoons. Capability unit IVe-3; Clay Upland 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 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, and as sites for buildings, highways and other transportation systems, sanitary facilities, parks and other recreation facilities, and 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

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 estimated 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 needed management practices. 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 300,000 acres in the survey area was used for crops, rangeland, and pasture in 1975. Of this total, about 90,000 acres was used for rangeland; 50,000 acres for hayland and tame pasture; 105,000 acres for row crops, mainly corn, soybeans, and grain sorghum; 40,000 acres for close growing crops, mainly wheat and alfalfa;

and about 11,000 acres for woodland. A small acreage was idle cropland.

The potential of the soils in Allen County for increased production of food is good. About 35,000 acres of potentially good cropland is used as rangeland and about 35,000 acres as tame pasture. Food production could also be increased considerably by extending the latest crop production technology to all cropland in the county. This soil survey can greatly facilitate the application of such technology.

The acreage in crops and pasture has gradually decreased as more and more land is used for urban development. In 1975, an estimated 27,000 acres was urban land or built-up land. The acreage under urban development has been increasing at the rate of about 100 acres per year. The use of this soil survey to help make land-use decisions that influence the future role of farming in the county is described in the section "General soil map for broad land-use planning."

Soil erosion is the major problem on most of the cropland and pasture in Allen County. If the slope is 2 percent or more, erosion is a hazard. Bates, Dennis, Eram, and Kenoma soils have slopes of 2 percent or more.

Loss of the surface layer through erosion is damaging for two reasons. Firstly, productivity is reduced if 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 with a clayey subsoil, such as Kenoma and Dennis soils, and on soils with a layer in or below the subsoil that limits the depth of the root zone. Such a layer includes the shale in Eram and Talihina soils and the bedrock in Bates, Catoosa, Collinsville, and Nowata soils. Secondly, soil erosion on farmland results in sediment entering 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.

Preparing a good seedbed and tilling are difficult in many sloping fields that have clayey or hardpan spots because the original friable surface soil has been eroded away. Such spots are common in areas of the eroded Bates and Eram soils.

Erosion control provides protective surface cover, reduces runoff, and increases infiltration. A cropping system that keeps vegetative cover on the soil surface for extended periods can restrict soil losses to an amount that will not reduce the productive capacity of the soils. On livestock farms, which require pasture and hay, legume and grass forage crops in the cropping systems not only provide nitrogen and improve tilth for the following crop but also reduce the risk of erosion on sloping soils.

Minimizing tillage and leaving crop residue on the surface help to increase the infiltration rate and reduce the hazards of runoff and erosion. They can be adapted to most soils in the survey area, but are less successful on eroded soils and on the soils that have a clayey surface layer, such as Eram and Zaar soils. No-tillage for corn, grain sorghum, and soybeans, which is common on an increasing acreage, is effective in reducing the risk of erosion on sloping soils and can be adapted to most soils in the survey area. It is less successful, however, on the soils with a clayey surface layer.

Terraces and diversions reduce the length of slopes, runoff, and the risk of erosion. They are most practical on the deep, well drained and moderately well drained soils that have regular slopes. Most arable upland soils in Allen County are suited to terraces. The other soils are less suited to terraces and diversions because of irregular slopes; chert fragments, which would be exposed in terrace channels; or bedrock within a depth of 20 inches.

Soil blowing is a hazard on the loamy Bates and Talihina soils and on the silty Catoosa 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. Vegetative cover, surface mulch, or rough surfaces resulting from proper tillage minimize the risk of soil blowing on these soils.

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

Soil fertility is low in most upland soils in the survey area. All the soils are naturally acid. The soils on flood plains and terraces are naturally higher in content of plant nutrients than most upland soils.

Many upland soils are naturally strongly acid. If they have never been limed, they require applications of ground limestone to raise the pH level sufficiently for good growth of alfalfa and other crops that grow only on nearly neutral soils. Available phosphorous and potash levels are low in most of these soils. On all soils, additions of lime and fertilizer should be based on the results of soils tests, on the needs of the crops, and on the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to apply.

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

Many of the soils used for crops in the survey area have a silt loam or silty clay loam surface layer that is low in content of organic matter. Generally, the structure of such soils is weak, and intense rainfall causes the formation of crust on the surface. The crust is hard when dry and is 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 improve soil structure and reduce crust formation.

Poor or only fair tilth is a problem in the clayey Osage and Zaar soils because these soils often stay wet until late in spring. If the soils are wet when plowed, they tend to be very cloddy when dry and a good seedbed is difficult to prepare. Fall plowing 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 commonly grown. Castor beans, sunflowers, navy beans, flax, and sweet corn can be grown if economic conditions are favorable.

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 climatically suited to the area 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; harvest of 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 three levels: capability class, subclass, and unit (*12*). 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; they 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 unit is identified in the description of each soil mapping unit in the section "Soil maps for detailed planning." Capability units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-3 or IIIe-5.

Rangeland

Much of the farm income in Allen County is from the sale of beef cattle and dairy products. The number of cattle, including calves, in the county is commonly between 45,000 and 55,000. The major source of livestock feed is native range and tame pasture, but crops and their byproducts are commonly used as supplemental feed. There are no large areas of range. Nearly all areas of range are intermingled with cultivated fields throughout the county. These areas are generally too rocky or too steep to be cultivated or are areas that have been set aside for native hay production.

The native vegetation in many parts of the survey area has been greatly depleted by continued excessive use. Much of the acreage that was once open grassland is now covered with brush, weeds, and osageorange. The amount of forage presently produced may be less than half of that originally produced. Productivity of the range can be increased by using management that is 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 predominately 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, salt content, and a seasonal high water table are also important.

Potential 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.

Common plant names of grasses, grasslike plants, forbs, and shrubs that make up most of the potential natural plant community on each soil are listed in table 6. 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. Because only major species are listed, percentages do not necessarily total 100. 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.

The major management concern on most rangeland is control of grazing so that the kinds and amounts of plants that make up the potential natural plant community are reestablished. Manipulating or reducing undesirable brush species and minimizing soil blowing are also important management concerns. Sound range management based on soil survey information and other rangeland inventory information is the basis for maintaining or improving forage production.

Woodland management and productivity

About 11,000 acres of woodland is in Allen County. Most of the wooded areas occur as small, irregularly shaped tracts along streams (fig. 13). Only a small part of the woodland is managed for timber production. Nearly all of the woodland is grazed by livestock. Wooded areas also provide food and cover for wildlife, and some areas are used for recreation. The principal native trees in the county are ash, hackberry, bur oak, red oak, white oak, pin oak, sycamore, maple, black walnut, pecan, hickory, and elm. Most of these trees are cut for saw logs when they reach adequate size. A few are cut for fuel or for fenceposts. Hedgerows and fence row plantings of osageorange are throughout the county. These trees grow extensively on overgrazed range. They are used for fenceposts.

The bottom land soils have a high potential for the production of trees that grow to timber size, but most of these soils are used for small grain, row crops, and alfalfa. The upland soils have little potential for the production of saw logs. The trees on the hilly uplands provide protection for watersheds.

Some nuts are harvested from pecan and walnut trees, but the acreage of these trees is small. In a few areas, groves of pecan trees have been cleaned of undesirable competitive trees and are managed for the production of nuts.

Table 7 contains information useful to woodland owners or forest managers planning use of soils for wood crops. Mapping unit symbols for soils suitable for wood crops are listed alphabetically by soil name.

In table 7 the soils are rated for a number of factors to be considered in management. *Slight*, *moderate*, and *severe* are used to indicate the degree of major soil limitations.

Ratings of the *erosion hazard* indicate the risk of loss of soil in well-managed woodland. The risk is *slight* if the expected soil loss is small, *moderate* if some measures are needed to control erosion during logging and road construction, and *severe* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or equipment; *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree that the soil affects expected mortality of planted tree seedlings when plant competition is not a limiting factor. Seedlings from good planting stock that are properly planted during a period of sufficient rainfall are rated. A rating of *slight* indicates that the expected mortality of the planted seedlings is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Considered in the ratings of *windthrow hazard* are characteristics of the soil that affect the development of tree roots and the ability of soil to hold trees firmly. A rating of *slight* indicates that trees in wooded areas are not expected to be blown down by commonly occurring winds; *moderate*, that some trees are blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade or grow if openings are made in the tree canopy. The invading plants compete with native plants or planted seedlings by impeding or preventing their growth. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* means that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed for the control of undesirable plants.

The *potential productivity* of merchantable or *important trees* on a soil is expressed as a *site index*. This index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. Important trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

Trees to plant are those that are suitable for commercial wood production and that are suited to the soils.

Engineering

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 section 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; table 10, for sanitary facilities; and table 11, for water management. Table 9 shows the suitability of each kind of soil as a source of construction materials.

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 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 one or more soil properties or site features 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 used for pipelines, sewerlines, telephone and power transmission lines, basements, and open ditches. Such digging or trenching is influenced by the soil wetness of a high seasonal 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 defined, 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 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 limitation.

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 AASHTO (*1*) and Unified (*2*) 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.

Construction materials

The suitability of each soil as a source of roadfill, sand, gravel, and topsoil is indicated in table 9 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. Because soil survey interpretations are oriented to local roads and streets rather than highways, the ratings given in table 9 are evaluations of the soils as sources of roadfill for low embankments, which are generally less than 6 feet high and are less exacting in design than high embankments. The upper part of the roadfill is the subgrade, or foundation, for the road. The ratings reflect the ease of excavating and working the material and the expected performance of the material after 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 soil properties that determine such performance is given in the descriptions of 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.

According to the Unified soil classification system (*2*), 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, moderate potential frost action, 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 9 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, slopes, 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.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills (*8*). 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 10 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.

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 may 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.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil is at minimum absorptive capacity.

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 could be installed or the size of the absorption field could 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 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 soils 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 thin layers of soil. 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 may 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.

In the trench type of landfill, ease of excavation also affects the suitability of a soil for this purpose, so the soil must be deep to bedrock and free of large stones and boulders. Where the seasonal water table is high, water seeps into trenches and causes problems in filling.

Unless otherwise stated, the limitations in table 10 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 weather. 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.

Water management

Many soil properties and site features that affect water management practices have been identified in this soil survey. In table 11 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.

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.

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.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of water erosion and soil blowing, texture, presence of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, available water capacity, need for drainage, and depth to the water table.

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 10, 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

ROBERT J. HIGGINS, 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, inadequate, or 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. Examples are corn, wheat, oats, and barley. 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.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bromegrass, clover, and alfalfa. 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.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds, that provide food and cover for wildlife. Examples are bluestem, switchgrass, goldenrod, ragweed, croton, wheatgrass, and grama. 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.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts, seeds, fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Examples of native plants are oak, black walnut, pecan, osageorange, poplar, hackberry, hawthorn, dogwood, willow, hickory, and cottonwood. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated good are Russian-olive, autumn-olive, cotoneaster, Nanking cherry, honeysuckle, multiflora rose, and crabapple. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness.

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. Examples are pine, arborvitae, spruce, redcedar, yew, and juniper. Soil properties that have a major effect on the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Shrubs are bushy woody plants that produce fruit, seeds, buds, twigs, bark, or foliage used by wildlife for food or that provide cover and shade for some species of wildlife. Examples are plum, sumac, blackberry, gooseberry, buckrush, buttonbush, and indigobush. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture.

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. Examples of wetland plants are smartweed, wild millet, wildrice, cordgrass, and cattail and rushes and sedges. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

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 devices in marshes or streams. Examples are marshes, waterfowl feeding areas, and ponds. 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.

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, forbs, legumes, 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, mourning dove, meadowlark, field sparrow, cottontail rabbit, ground hog, and red fox.

Woodland habitat consists of areas of hardwoods and redcedar and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, thrushes, woodpeckers, squirrels, grey fox, raccoon, ground hog, deer, and opossum.

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, muskrat, mink, and beaver.

Rangeland habitat consists of areas of wild herbaceous plants and shrubs. Wildlife attracted to rangeland include jackrabbit, prairie chicken, deer, bobwhite quail, dickcissel, and meadowlark.

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 classification, and the physical and chemical properties of each major horizon of each soil in the survey area. They also present 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. These estimates are presented as ranges in values most likely to exist in areas where the soil is mapped.

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 (*10*). 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 (*2*). 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 (*1*). 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.

When laboratory data are available, the A-1, A-2, and A-7 groups are further classified as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested in the survey area, with group index numbers in parentheses, is given in table 17. 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. Ranges 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.

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 and in the design of irrigation systems.

Soil reaction is expressed as 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. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are extremely erodible, so vegetation is difficult to establish. They are generally not suitable for crops.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible, but crops can be grown if measures to control soil blowing are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible, and crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible, and crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil 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 to deep, moderately well drained to 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 rainfall or snowmelt and water in swamps and marshes is not considered flooding. 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 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 soil mapping. The kind of bedrock and its hardness as related to ease of excavation are also shown. Rippable bedrock can be excavated with a singletooth ripping attachment on a 200-horsepower tractor, but hard bedrock generally requires blasting.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action results from the movement of soil moisture into the freezing temperature zone in the soil, which causes ice lenses to form. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Engineering test data

The results of analyses of engineering properties of several typical soils of the survey area are given in table 17.

The data presented are for soil samples that were collected from carefully selected sites. The soil profiles sampled are typical of the series discussed in the section "Soil series and morphology." The soil samples were analyzed by the Kansas Department of Transportation.

The methods used in obtaining the data are listed by code in the next paragraph. Most of the codes, in parentheses, refer to the methods assigned by the American Association of State Highway and Transportation Officials. The code for Unified classification is assigned by the American Society for Testing and Materials.

The methods and codes are AASHTO classification (M-145-66); Unified classification (D-2487-66T); mechanical analysis (T88-72); liquid limit (T89-68); plasticity index (T90-70); and moisture-density, method A (T99-74).

Morphology and classification of the soils

In this section, the soil series recognized in the survey area are described, the current system of classifying soils is defined, and the soils in the area are classified according to the current system.

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 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 (*10*). Unless otherwise noted, colors described are for moist soil.

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

Bates series

The Bates series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in material weathered from thinly bedded sandstone and interbedded sandy and silty shale. Slopes range from 1 to 7 percent.

Bates soils are similar to Collinsville and Eram soils and are adjacent to Collinsville, Dennis, and Eram soils on the landscape. Collinsville soils have a thinner solum than Bates soils and, unlike those soils, are shallow over sandstone. Dennis and Eram soils have a more clayey B2t horizon than Bates soils, and Dennis soils have a thicker solum.

Typical pedon of Bates loam, 1 to 4 percent slopes, 1,940 feet east and 500 feet north of the southwest corner of sec. 16, T. 24 S., R. 21 E.

A1—0 to 10 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; moderate medium granular structure; slightly hard, friable; many roots; slightly acid; gradual smooth boundary.

B1—10 to 15 inches; very dark grayish brown (10YR 3/2) heavy loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; common roots; medium acid; gradual smooth boundary.

B2t—15 to 23 inches; dark brown (7.5YR 3/2) clay loam, dark brown (10YR 4/3) dry; few fine distinct mottles of yellowish brown (10YR 5/6); moderate medium and fine subangular blocky structure; hard, firm; common roots; thin clay films on surfaces of peds; few small fragments of soft sandstone, about 15 percent of soil mass; strongly acid; gradual smooth boundary.

B3—23 to 32 inches; dark brown (7.5YR 4/4) light clay loam, brown (7.5YR 5/4) dry; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; hard, friable; few fine roots; many small black concretions; many sandstone and shale fragments, about 20 percent of soil mass; strongly acid; clear wavy boundary.

R—32 inches; soft sandstone interbedded with sandy and silty shale.

The solum ranges from 20 to 40 inches in thickness. The mollic epipedon ranges from 8 to 24 inches in thickness. The A horizon has hue of 10YR, value of 2 or 3 (3 to 5 dry), and chroma of 2 or 3. It is dominantly loam, but is silt loam and fine sandy loam in places. It is medium acid to neutral. The B2t horizon has hue of 10YR or 7.5YR, value of 3 to 5, and chroma of 3 to 5. It is clay loam or loam and averages between 18 and 35 percent clay. Reaction is strongly acid to slightly acid throughout the profile. Scattered sandstone fragments are throughout some pedons.

Catoosa series

The Catoosa series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in material weathered from limestone. Slopes range from 0 to 8 percent.

Catoosa soils are similar to Nowata soils and are adjacent to Dennis and Kenoma soils on the landscape. Unlike Catoosa soils, Nowata soils contain a large amount of chert throughout the solum. Dennis and Kenoma soils have a more clayey B2t horizon and a thicker solum than Catoosa soils.

Typical pedon of Catoosa silt loam, 0 to 2 percent slopes, 2,400 feet west and 300 feet south of the northeast corner of sec. 14, T. 24 S., R. 20 E.

A1—0 to 11 inches; dark reddish brown (5YR 3/3) silt loam, dark reddish gray (5YR 4/2) dry; moderate medium and fine granular structure; slightly hard, friable; common fine and medium roots; slightly acid; gradual smooth boundary.

B1—11 to 16 inches; dark reddish brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) dry; moderate medium and fine granular structure; hard, friable; common fine and medium roots; medium acid; gradual smooth boundary.

B2t—16 to 27 inches; dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) dry; moderate medium and fine subangular blocky structure; very hard, firm; common medium roots; few small black pellets; strongly acid; abrupt wavy boundary.

R—27 inches; limestone.

The solum ranges from 20 to 40 inches in thickness. The mollic epipedon ranges from 8 to 20 inches in thickness. The A horizon has hue of 10YR, 7.5YR, or 5YR; value of 2 or 3 (3 to 5 dry); and chroma of 2 or 3. It is strongly acid to neutral. The B2t horizon has hue of 5YR or 2.5YR, value of 3 or 4 (3 or 4 dry), and chroma of 3 or 4. It averages between 27 and 35 percent clay. Reaction is strongly acid to neutral throughout the profile. Limestone or chert fragments occur throughout some pedons.

Collinsville series

The Collinsville series consists of shallow, well drained soils on uplands. These soils formed in material weathered from sandstone. Permeability is moderately rapid. Slopes range from 2 to 15 percent.

Collinsville soils are similar to Bates and Talihina soils and are adjacent to Bates and Dennis soils on the landscape. Unlike Collinsville soils, Bates and Dennis soils are more than 20 inches thick and have an argillic horizon and Talihina soils are fine textured and are shallow over clayey shale.

Typical pedon of Collinsville fine sandy loam, in an area of Collinsville-Bates complex, 2 to 15 percent slopes, 400 feet north and 200 feet west of the southeast corner of sec. 3, T. 24 S., R. 21 E.

A1—0 to 7 inches; very dark grayish brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; moderate medium and fine granular structure; slightly hard, friable; many fine roots; strongly acid; gradual wavy boundary.

C—7 to 15 inches; dark brown (7.5YR 3/3) fine sandy loam, brown (7.5YR 5/2) dry; massive; slightly hard, friable; many fine roots; 20 percent of soil mass is sandstone fragments 1/4 inch to 3 inches in size; strongly acid; gradual wavy boundary.

R—15 inches; sandstone.

The solum ranges from 4 to 20 inches in thickness. The mollic epipedon is 7 to 10 inches thick. The A horizon has hue of 10YR, value of 2 or 3 (3 to 5 dry); and chroma of 2 or 3. It is fine sandy loam or loam. Reaction is slightly acid to strongly acid throughout the profile. The C horizon has hue of 7.5YR or 10YR, value of 3 or 4, and chroma of 3 or 4. In places fragments of sandstone are on the surface or are scattered throughout the solum.

Dennis series

The Dennis series consists of deep, moderately well drained, slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 1 to 7 percent.

Dennis soils are similar to Bates, Catoosa, and Kenoma soils and are adjacent to Bates, Collinsville, and Kenoma soils on the landscape. Bates and Collinsville soils have a thinner solum than Dennis soils and, unlike those soils, are less than 35 percent clay in the control section. Unlike Dennis soils, Catoosa soils have a solum that is less than 40 inches thick and Kenoma soils lack a B1 horizon.

Typical pedon of Dennis silt loam, 1 to 3 percent slopes, 2,000 feet east and 1,500 feet south of the northwest corner of sec. 23, T. 26 S., R. 17 E.

A1—0 to 10 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium and fine granular structure; slightly hard, friable; many roots; gray silt grains on ped surfaces in lower 3 inches; medium acid; gradual smooth boundary.

B1—10 to 19 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; common fine faint mottles of yellowish brown (10YR 5/6) and distinct mottles, reddish brown (5YR 4/4) moist; moderate medium and fine subangular blocky structure; slightly hard, friable; many roots; few worm casts; scattered small chert pebbles; upper 2 inches has gray silt grains on ped surfaces; strongly acid; clear smooth boundary.

B21t—19 to 26 inches; dark brown (10YR 4/3) silty clay, brown (10YR 5/3) dry; common fine and medium distinct mottles, yellowish red (5YR 4/6) moist; moderate medium and fine blocky structure; very hard, firm; many fine roots; clay films on surfaces of most peds; few black stains and masses; scattered small chert pebbles; slightly acid; gradual smooth boundary.

B22t—26 to 38 inches; brown (10YR 5/3) silty clay, pale brown (10YR 6/3) dry; common coarse faint mottles, brownish yellow (10YR 6/6) moist; moderate medium blocky structure; very hard, firm; few fine roots; clay films on surfaces of peds; many small soft black pellets; few small chert pebbles; slightly acid; gradual smooth boundary.

B31—38 to 48 inches; coarsely mottled brown (10YR 5/3), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6) silty clay, pale brown (10YR 6/3), brownish yellow (10YR 6/6), and reddish yellow (7.5YR 6/6) dry; moderate medium blocky structure; very hard, firm; mildly alkaline; gradual smooth boundary.

B32—48 to 61 inches; coarsely mottled light brownish gray (10YR 6/2) and yellowish brown (10YR 5/4) silty clay, very pale brown (10YR 7/3) and light yellowish brown (10YR 6/5) dry; weak medium blocky structure; very hard, firm; common medium black masses and stains; mildly alkaline.

The solum is more than 60 inches thick. The mollic epipedon ranges from 10 to 20 inches in thickness and in places extends into the upper part of the B1 horizon. The A horizon has hue of 10YR, value of 2 or 3 (3 to 5 dry), and chroma of 2 or 3. The B1 horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. The B2t horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 to 5. Reaction is mildly alkaline to strongly acid throughout the profile.

Eram series

The Eram series consists of moderately deep, moderately well drained, slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 1 to 7 percent.

Eram soils are similar to Bates, Kenoma, Talihina, and Zaar soils and are adjacent to Bates and Talihina soils on the landscape. Bates soils have less clay throughout the control section than Eram soils. Unlike Eram soils, Kenoma and Zaar soils have a solum that is more than 40 inches thick and Talihina soils lack a Bt horizon and are less than 20 inches deep over shale.

Typical pedon of Eram silty clay loam, 4 to 7 percent slopes, 2,000 feet east and 300 feet north of the southwest corner of sec. 34, T. 23 S., R. 19 E.

A1—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; many fine roots; slightly acid; gradual smooth boundary.

B2t—8 to 14 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; moderate medium granular and fine blocky structure; common medium distinct mottles, yellowish brown (10YR 5/6) moist; very hard, firm; common fine roots; medium acid; gradual smooth boundary.

B3—14 to 30 inches; olive brown (2.5Y 4/4) silty clay, light olive brown (2.5Y 5/4) dry; common fine distinct mottles, grayish brown (10YR 5/2) moist; weak fine subangular blocky and blocky structure; very hard, firm; few fine roots; scattered fragments of shale increasing with increasing depth; strongly acid; gradual smooth boundary.

C—30 to 43 inches; light olive brown unweathered shale.

The solum ranges from 20 to 40 inches in thickness. The mollic epipedon ranges from 8 to 20 inches in thickness. The A1 horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 2 or 3. The B2t horizon has hue of 2.5Y or 10YR, value of 3 or 4, and chroma of 2 or 3. Reaction is neutral to strongly acid throughout the profile. In some pedons, seams of calcium carbonate occur in the lower part of the B2t horizon and extend into the C horizon.

Kenoma series

The Kenoma series consists of deep, moderately well drained, very slowly permeable soils on uplands. These soils formed in material weathered from sediments high in content of silt and clay. Slopes are 1 to 3 percent.

Kenoma soils are similar to Catoosa, Dennis, Eram, Woodson, and Zaar soils and are adjacent to those soils on the landscape. Unlike Kenoma soils, Catoosa and Eram soils have a solum that is less than 40 inches thick, Dennis and Zaar soils do not have an abrupt textural change between an A1 horizon and a B2t horizon, and Woodson soils have a chroma of 1 or less in the lower part of the mollic epipedon.

Typical pedon of Kenoma silt loam, 1 to 3 percent slopes, 3,200 feet south and 200 feet west of the northeast corner of sec. 1, T. 25 S., R. 19 E.

Ap—0 to 8 inches; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak fine and medium granular structure; slightly hard, friable; many fine roots; slightly acid; abrupt smooth boundary.

B12t—8 to 15 inches; very dark grayish brown (10YR 3/2) silty clay, grayish brown (10YR 5/2) dry; few vertical streaks of very dark brown (10YR 2/2) silt loam; few fine distinct mottles, strong brown (7.5YR 5/6) moist; weak fine and very fine subangular blocky and blocky structure; hard, firm; common fine roots; clay films on ped faces; slightly acid; gradual wavy boundary.

B22t—15 to 22 inches; very dark grayish brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; few vertical streaks of very dark brown (10YR 2/2) silt loam; few fine distinct mottles, strong brown (7.5YR 5/6) moist; weak fine subangular blocky structure; very hard, very firm; common fine roots; clay films on ped faces; slightly acid; gradual smooth boundary.

B23t—22 to 32 inches; mixed brown (10YR 4/3) and dark grayish brown (10YR 4/2) silty clay, brown (10YR 5/3) and grayish brown (10YR 5/2) dry; few vertical streaks of very dark brown (10YR 2/2) silt loam; few fine distinct mottles, strong brown (7.5YR 5/6) moist; weak medium subangular blocky and blocky structure; very hard, very firm; common fine roots; thin clay films on ped faces; few black concretions; neutral; gradual wavy boundary.

B31—32 to 42 inches; mixed strong brown (7.5YR 5/6) and gray (5Y 5/1) light silty clay, reddish yellow (7.5YR 6/6) and gray (5Y 6/1) dry; few vertical streaks of very dark brown (10YR 2/2) silt loam; weak fine blocky structure; very hard, very firm; few fine roots; moderately alkaline; gradual wavy boundary.

B32—42 to 55 inches; mixed strong brown (7.5YR 5/6) and gray (5Y 5/1) light silty clay, reddish yellow (7.5YR 6/6) and gray (5Y 6/1) dry; moderate fine and very fine blocky structure; extremely hard, extremely firm; few fine roots; mildly alkaline; gradual wavy boundary.

B33—55 to 62 inches; mixed strong brown (7.5YR 5/6) and gray (5Y 5/1) light silty clay, reddish yellow (7.5YR 6/6) and gray (5Y 6/1) dry; stone line at upper boundary containing rounded chert pebbles 1/2 inch to 3 inches in size; moderate fine and very fine blocky structure; extremely hard, extremely firm; few fine roots; few black concretions; common black streaks; few rounded chert pebbles less than 1/2 inch in size scattered throughout; mildly alkaline.

The solum is more than 40 inches thick. The mollic epipedon ranges from 10 to more than 20 inches in thickness. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 3 or less. It is silt loam or silty clay loam. The B2t horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3. Reaction is strongly acid to moderately alkaline throughout the profile. Scattered fine and medium chert fragments are throughout some pedons.

Leanna series

The Leanna series consists of deep, somewhat poorly drained, very slowly permeable soils on flood plains and terraces. These soils formed in clayey alluvial sediments. Slopes are 0 to 2 percent.

Leanna soils are similar to Mason, Osage, and Verdigris soils and are adjacent to those soils on the landscape. Unlike Leanna soils, Mason and Verdigris soils have a fine silty texture and have no albic horizon. Osage soils also have no albic horizon.

Typical pedon of Leanna silt loam 400 feet east and 150 feet north of the southwest corner of sec. 23, T. 26 S., R. 17 E.

A1—0 to 7 inches; black (10YR 2/1) silt loam, gray (10YR 5/1) dry; moderate fine granular structure; slightly hard, friable; many fine and medium roots; slightly acid; clear smooth boundary.

A2—7 to 13 inches; dark gray (10YR 4/1) silt loam, gray (10YR 6/1) dry; few fine faint mottles, dark yellowish brown (10YR 4/4) moist; moderate to weak fine granular structure; slightly hard, friable; common fine and medium roots; strongly acid; clear smooth boundary.

B2t—13 to 26 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common fine faint mottles, dark yellowish brown (10YR 4/4) moist; moderate medium blocky structure; very hard, firm; few medium roots; thin clay films on surface of peds; strongly acid; gradual smooth boundary.

B3—26 to 52 inches; dark gray (10YR 4/1) heavy silty clay loam, gray (10YR 5/1) dry; common fine faint mottles, brown (10YR 5/3) moist; moderate medium blocky structure; very hard, firm; few fine and medium roots; neutral; gradual smooth boundary.

C—52 to 66 inches; dark grayish brown (2.5Y 4/2) heavy silty clay loam, grayish brown (2.5Y 5/2) dry; common medium distinct mottles, yellowish brown (10YR 5/4) and gray (10YR 6/1) moist; massive; very hard, firm; few fine roots; neutral.

The solum ranges from about 30 to 70 inches in thickness. The mollic epipedon is more than 20 inches thick. The A1 horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. The A2 horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. The A horizon is dominantly silt loam, but in places is silty clay loam. The B2t horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1. In some pedons, the C horizon is silty clay. Reaction is strongly acid to neutral throughout the profile.

Mason series

The Mason series consists of deep, well drained soils on terraces. These soils formed in silty alluvial sediments. Permeability is moderately slow. Slopes are 0 to 2 percent.

Mason soils are similar to Dennis, Leanna, Osage, and Verdigris soils and are adjacent to Osage and Verdigris soils on the landscape. Unlike Mason soils, Dennis soils are on uplands, Leanna and Osage soils have a fine textured control section, and Osage and Verdigris soils have no argillic horizon.

Typical pedon of Mason silt loam 2,000 feet west and 400 feet south of the northeast corner of sec. 2, T. 26 S., R. 17 E.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; disturbed fine granular structure; slightly hard, friable; common fine roots; scattered worm casts; slightly acid; clear smooth boundary.

A12—7 to 17 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; common fine roots; scattered worm casts; slightly acid; gradual smooth boundary.

B21t—17 to 27 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark brown (10YR 4/3) dry; moderate fine to medium subangular blocky structure; slightly hard, friable; common fine roots; few worm casts; thin clay films on surfaces of peds; medium acid; gradual smooth boundary.

B22t—27 to 45 inches; very dark grayish brown (10YR 3/2) light silty clay loam, dark brown (10YR 4/3) dry; few fine distinct mottles, strong brown (7.5YR 5/6) moist; moderate medium subangular blocky structure; slightly hard, friable; lower 5 inches contains some black stains; thin clay films on surfaces of peds; strongly acid; diffuse smooth boundary.

C—45 to 63 inches; dark grayish brown (10YR 4/2) light silty clay loam, brown (10YR 5/3) dry; few fine distinct mottles, strong brown (7.5YR 5/6) moist; massive; hard, firm; strongly acid.

The solum ranges from 40 to more than 60 inches in thickness. The mollic epipedon is more than 20 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3. It is dominantly silt loam, but in places is silty clay loam. The Bt horizon has hue of 10YR, value of 3 or 4, and chroma of 2 or 3. Reaction is strongly acid to neutral throughout the profile. The clay content of the Bt horizon is less than 35 percent.

Nowata series

The Nowata series consists of moderately deep, well drained soils on uplands. These soils formed in material weathered from limestone high in content of chert fragments. Permeability is moderately slow. Slopes are 3 to 7 percent.

Nowata soils are similar to Bates, Catoosa, Eram, and Olpe soils and are adjacent to Catoosa soils on the landscape. Unlike Nowata soils, Bates soils have a fine-loamy control section and Catoosa soils have a fine-silty control section. Eram and Olpe soils have a more clayey B2t horizon than Nowata soils, and Olpe soils have a deeper solum.

Typical pedon of Nowata silt loam, 3 to 7 percent slopes, 2,200 feet north and 200 feet west of the southeast corner of sec. 32, T. 25 S., R. 21 E.

A1—0 to 9 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; common fine and medium roots; 10 percent, by volume, angular chert rocks ranging in size from 1/2 inch to 7 inches; neutral; gradual smooth boundary.

B1—9 to 12 inches; very dark brown (7.5YR 2/2) light silty clay loam, brown (7.5YR 4/2) dry; moderate medium granular structure; hard, firm; common fine and medium roots; 20 percent, by volume, angular chert rocks ranging from 1/4 inch to 7 inches in size; medium acid; clear wavy boundary.

B21t—12 to 22 inches; mixed dark reddish brown (5YR 3/2) and reddish brown (5YR 4/4) silty clay loam, dark reddish gray (5YR 4/2) and reddish brown (5YR 4/4) dry; moderate medium and fine granular structure; very hard, firm; common fine and medium roots; few worm casts; thin clay films on surfaces of peds and chert fragments; 60 to 70 percent, by volume, angular chert rocks ranging from 1/4 to 7 inches in size, most less than 3 inches; medium acid; gradual wavy boundary.

B22t—22 to 27 inches; mixed dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) silty clay loam, reddish brown (5YR 4/3, 4/4) dry; moderate medium and fine granular structure; very hard, firm; common fine and medium roots; many black stains and accumulations; thin clay films on peds and chert fragments; 60 to 70 percent, by volume, angular chert rocks 1/4 inch to 7 inches in size; neutral; abrupt wavy boundary.

R—27 inches; fractured limestone; crack fill material between depths of 27 and 33 inches; mixed dark brown (7.5YR 4/4) and strong brown (7.5YR 5/6) silty clay; strongly alkaline.

The solum ranges from 20 to 40 inches in thickness. The mollic epipedon ranges from 10 to more than 20 inches in thickness. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3. Coarse fragments are less than 10 percent by volume. The B2t horizon has hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 3 or 4. In some pedons, unweathered shale occurs above the limestone bedrock. Scattered chert fragments generally are on the surface. Reaction is medium acid to neutral throughout the profile.

Olpe series

The Olpe series consists of deep, well drained, slowly permeable soils on uplands. These soils formed in old clayey alluvium high in content of chert gravel. Slopes range from 3 to 15 percent.

Olpe soils are similar to Nowata soils and are adjacent to Catoosa, Dennis, and Kenoma soils on the landscape. Unlike Olpe soils, Nowata soils have a loamy-skeletal control section and a solum that is less than 40 inches thick and Catoosa, Dennis, and Kenoma soils contain no chert gravel. Also, Catoosa soils have a thinner solum than Olpe soils.

Typical pedon of Olpe gravelly silt loam, in an area of Olpe soils, 3 to 15 percent slopes, 1,000 feet west and 270 feet south of the center of sec. 12, T. 26 S., R. 17 E.

A11—0 to 7 inches; dark brown (7.5YR 3/2) gravelly silt loam, brown (7.5YR 5/2) dry; moderate fine granular structure; slightly hard, friable; many roots; 15 percent, by volume, rounded chert gravel; slightly acid; gradual wavy boundary.

A12—7 to 15 inches; dark brown (7.5YR 3/2) gravelly heavy silt loam, brown (7.5YR 5/2) dry; moderate medium granular structure; slightly hard, friable; many roots; approximately 40 percent, by volume, rounded chert gravel; medium acid; gradual wavy boundary.

B1—15 to 26 inches; dark reddish brown (5YR 3/4) gravelly silty clay loam, reddish brown (5YR 4/4) dry; moderate medium subangular blocky structure; hard, firm; common roots; approximately, 85 percent by volume, rounded chert gravel; medium acid; gradual wavy boundary.

B21t—26 to 38 inches; reddish brown (5YR 4/4) gravelly silty clay, reddish brown (5YR 5/4) dry; moderate fine angular blocky structure; extremely hard, very firm; few roots; continuous clay films on surfaces of peds; approximately 85 percent rounded chert gravel; medium acid; gradual wavy boundary.

B22t—38 to 58 inches; yellowish red (5YR 4/6) gravelly silty clay, yellowish red (5YR 5/6) dry; few medium prominent mottles, light brownish gray (2.5Y 6/2) moist, in lower part; moderate medium angular blocky structure; extremely hard, very firm; very few roots; continuous clay films on surfaces of peds; approximately 80 percent, by volume, rounded chert gravel; medium acid; gradual wavy boundary.

B3—58 to 74 inches; coarsely mottled yellowish red (5YR 5/6), yellowish brown (10YR 5/6), and light brownish gray (2.5Y 6/2), moist or dry, gravelly silty clay; weak medium angular blocky structure; extremely hard, very firm; very few roots; thin patchy clay films on surfaces of peds; approximately 60 percent rounded chert gravel; medium acid.

The solum is more than 60 inches thick. The mollic epipedon ranges from 10 to 20 inches in thickness. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 to 5 dry), and chroma of 1 to 3. It is dominantly gravelly silt loam, but in places is silt loam. The B2t horizon has hue of 5YR or 7.5YR, value of 3 or 4, and chroma of 4 or 5. Reaction is strongly acid to slightly acid throughout the profile.

Osage series

The Osage series consists of deep, poorly drained, very slowly permeable soils on low terraces and flood plains. These soils formed in clayey alluvial sediments. Slopes are 0 to 2 percent.

Osage soils are similar to Woodson and Zaar soils and are adjacent to Leanna, Mason, and Verdigris soils on the landscape. Unlike Osage soils, Woodson soils have an argillic horizon and Zaar soils are on uplands. Leanna soils are lighter colored than Osage soils and also differ from those soils in having an albic horizon. Mason and Verdigris soils have less clay in the control section than Osage soils.

Typical pedon of Osage silty clay 100 feet west and 50 feet south of the northeast corner of the southeast quarter of sec. 7, T. 24 S., R. 18 E.

A11—0 to 14 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; strong fine granular structure; many fine roots; slightly acid; gradual smooth boundary.

A12—14 to 26 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; strong fine granular and fine subangular blocky structure; very hard, very firm; few fine roots; evidence of filled vertical cracks; slightly acid; gradual smooth boundary.

B21g—26 to 34 inches; very dark gray (10YR 3/1) silty clay; few faint medium mottles of dark gray (N 4/0); moderate fine and medium angular blocky structure; very hard, very firm; few fine roots; few slickensides; evidence of filled vertical cracks; neutral; diffuse smooth boundary.

B22g—34 to 46 inches; very dark gray (10YR 3/1) silty clay; common fine faint mottles of dark gray (N 4/0); weak fine and medium blocky structure; extremely hard, very firm; scattered lime concretions; few small black pellets; mildly alkaline; diffuse smooth boundary.

B23g—46 to 63 inches; very dark gray (10YR 3/1) silty clay; common medium faint mottles of dark gray (5Y 4/1); weak medium and coarse blocky structure; extremely firm; few fine lime concretions; mildly alkaline.

The solum is more than 40 inches thick. The mollic epipedon is more than 20 inches thick. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is silty clay or silty clay loam. The B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1.5 or less. Reaction is medium acid to mildly alkaline throughout the profile. Some pedons have free calcium carbonate throughout.

Talihina series

The Talihina series consists of shallow, moderately well drained, slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 5 to 25 percent.

Talihina soils are similar to Collinsville and Eram soils and are adjacent to Bates, Collinsville, and Eram soils on the landscape. Unlike Talihina soils, Collinsville soils have a loamy control section and Bates and Eram soils have an argillic horizon.

Typical pedon of Talihina silty clay loam, 5 to 20 percent slopes, 150 feet west and 50 feet north of the southeast corner of the southwest quarter of sec. 33, T. 23 S., R. 19 E.

A1—0 to 7 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; moderate medium granular structure; hard, friable; many fine roots; slightly acid; gradual wavy boundary.

B2—7 to 13 inches; dark grayish brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; common fine distinct mottles, yellowish brown (10YR 5/6) moist, in lower part; moderate medium granular and fine blocky structure; very hard, firm; many fine roots; scattered small shale fragments; evidence of vertical cracks; neutral; gradual wavy boundary.

C1—13 to 17 inches; grayish brown (2.5Y 5/2) silty clay, light gray (2.5Y 7/2) dry; common fine distinct mottles of yellowish brown (10YR 5/6) and few fine faint mottles of gray (N 5/0); massive; very hard, firm; few fine roots; many shale fragments; slightly acid, clear wavy boundary.

C2—17 to 24 inches; grayish brown (2.5Y 5/2) soft shale; lenses of calcareous material; mildly alkaline.

The solum ranges from 10 to 20 inches in thickness. The mollic epipedon is 7 to 10 inches thick. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 2 or 3. It is dominantly silty clay loam, but in places is silty clay. The B horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. Reaction is slightly acid to mildly alkaline throughout the profile. Some pedons have shale fragments throughout.

Verdigris series

The Verdigris series consists of deep, moderately well drained, moderately permeable soils on terraces and flood plains. These soils formed in silty alluvium. Slopes are 0 to 2 percent.

Verdigris soils are similar to Mason soils and are adjacent to Mason and Osage soils on the landscape. Unlike Verdigris soils, Mason soils have an argillic horizon and Osage soils are fine textured.

Typical pedon of Verdigris silt loam 3,600 feet west and 1,200 feet south of the northeast corner of sec. 7, T. 24 S., R. 18 E.

A11—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; slightly acid; gradual smooth boundary.

A12—10 to 23 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; hard, friable; slightly acid; gradual smooth boundary.

AC1—23 to 39 inches; very dark grayish brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; few fine faint mottles, dark yellowish brown (10YR 3/4) moist; moderate medium granular structure; hard, friable; neutral; gradual smooth boundary.

AC2—39 to 53 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; few fine faint mottles, dark brown (10YR 3/3) moist; weak medium granular structure; hard, firm; neutral; gradual smooth boundary.

A1b—53 to 62 inches; very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) dry; few fine faint mottles, dark brown (10YR 3/3) moist; massive; hard, firm, neutral.

The solum ranges from 30 to more than 40 inches in thickness. The mollic epipedon is more than 24 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 to 3. Texture is silt loam or light silty clay loam. Reaction is medium acid to neutral throughout the profile.

Woodson series

The Woodson series consists of deep, somewhat poorly drained, very slowly permeable soils on uplands. These soils formed in old alluvium. Slopes are 0 to 2 percent.

Woodson soils are similar to Kenoma, Osage, and Zaar soils and are adjacent to Kenoma and Zaar soils on the landscape. Unlike Woodson soils, Kenoma soils have a chroma of 2 or more in the Bt horizon, Zaar soils have no abrupt textural change between the A horizon and a Bt horizon, and Osage soils have no argillic horizon and are on nearly level flood plains.

Typical pedon of Woodson silt loam 1,420 feet east and 100 feet south of the northwest corner of sec. 23, T. 25 S., R. 19 E.

A1—0 to 8 inches; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak fine granular structure; slightly hard, friable; many fine roots; medium acid; abrupt smooth boundary.

B21t—8 to 19 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine faint mottles, dark brown (10YR 3/3) moist; moderate fine blocky structure; extremely hard, very firm; common fine roots; clay films on surface of peds; medium acid; gradual smooth boundary.

B22t—19 to 31 inches; very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) dry; many medium distinct mottles, strong brown (7.5YR 5/6) moist, and few medium distinct mottles olive brown (2.5Y 4/4) moist; moderate to weak fine and medium blocky structure; extremely hard, very firm; common fine roots, but less than horizon above; clay films on surface of peds; few fine black concretions; medium acid; gradual smooth boundary.

B31—31 to 38 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) dry; few medium distinct mottles, dark reddish brown (5YR 3/4) moist; weak medium blocky structure; extremely hard, very firm; few fine roots; clay films on surfaces of most peds; few fine black concretions; few to common fine gypsum particles; medium acid; diffuse wavy boundary.

B32—38 to 63 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) dry; many fine distinct olive (5Y 4/6) mottles; moderate fine and very fine blocky structure; extremely hard, very firm; very few roots; common fine black concretions; few fine gypsum particles; medium acid.

The solum ranges from 30 to more than 40 inches in thickness. The mollic epipedon is more than 20 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or less. It is dominantly silt loam, but in places is silty clay loam. In some pedons, a thin A2 horizon occurs. The Bt horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1.5 or less. In places the lower part of the B horizon has chroma of 2 or 3. Reaction is medium acid to neutral throughout the profile.

Zaar series

The Zaar series consists of deep, somewhat poorly drained, very slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 1 to 7 percent.

Zaar soils are similar to Kenoma, Osage, and Woodson soils and are adjacent to Catoosa, Kenoma, Eram, and Woodson soils on the landscape. Unlike Zaar soils, Catoosa, Kenoma, Eram, and Woodson soils have an argillic horizon. Also, Catoosa and Eram soils have a thinner solum than Zaar soils.

Typical pedon of Zaar silty clay, 1 to 3 percent slopes, 800 feet south and 350 feet east of the northwest corner of sec. 18, T. 25 S., R. 20 E.

Ap—0 to 9 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; disturbed strong medium granular and fine blocky structure; hard, firm; many fine roots; neutral; clear smooth boundary.

A12—9 to 18 inches; black (10YR 2/1) silty clay, dark gray (10YR 3/1) dry; moderate fine and medium blocky structure; hard, firm; many fine roots; neutral; gradual wavy boundary.

B21—18 to 26 inches; black (10YR 2/1) silty clay, dark gray (10YR 3/1) dry; few fine distinct mottles, reddish brown (5YR 4/3) moist; moderate medium blocky structure; very hard, firm; many fine roots; few small black pellets; neutral; gradual wavy boundary.

B22—26 to 44 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; common fine distinct mottles, reddish brown (5YR 4/3) moist, and few fine faint mottles, gray (N 4/0) moist; moderate medium and fine blocky structure; very hard, firm; few fine roots on ped faces; scattered small black pellets; large filled vertical cracks of darker colored material from horizons above; mildly alkaline; gradual wavy boundary.

B3—44 to 57 inches; dark brown (10YR 4/3) silty clay, brown (10YR 5/3) dry; common fine faint mottles, yellowish brown (10YR 5/6) moist; moderate medium subangular blocky structure; very hard, very firm; scattered small black pellets; scattered lime concretions up to 1/2 inch in size; large filled vertical cracks of darker colored material; mildly alkaline; gradual wavy boundary.

C—57 to 63 inches; mixed olive brown (2.5Y 4/4) and dark yellowish brown (10YR 4/6) silty clay, light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/6) dry; few fine faint mottles, yellowish brown (10YR 5/8) moist; evidence of filled vertical cracks; massive; extremely hard, firm; many lime concretions up to 3/4 of an inch in size; moderately alkaline.

The solum is more than 40 inches thick. The mollic epipedon is more than 24 inches thick. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay, but in places is silty clay loam. The B horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 3. In some pedons the lower part of the B horizon is silty clay loam. Reaction is medium acid to moderately alkaline throughout the profile.

Classification

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 the latest literature available (*9*, *11*).

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 18, 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 Mollisol.

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 Udoll (*Ud*, meaning humid, plus *oll*, from Mollisol).

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 Argiudolls (*Argi*, meaning argillic horizons, plus *udoll*, the suborder of Mollisols that have a udic 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 Argiudolls.

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 fine-silty, mixed, thermic, Typic Argiudolls.

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.

Formation of the soils

This section describes the factors of soil formation, relates them to the formation of soils in the survey area, and explains the processes of soil formation.

The characteristics of a soil at any given place are determined by the interaction of five factors of soil formation—climate, plants and other living organisms, parent material, relief, and time. Each of these factors affects the formation of all soils, and each modifies the effects of the other four. The effects of the individual factors vary from place to place.

Climate and vegetation act on the parent material and gradually change it to a natural body of soil. Relief modifies the effects of climate and vegetation, mainly through its influence on runoff and temperature. The nature of the parent material also affects the kind of soil that forms. Time is needed for changing the parent material into soil. Generally, a long period is required for distinct soil horizons to form.

The interaction among these factors is more complex for some soils than for others. The following paragraphs describe the effects of the five major factors of soil formation on the soils of the survey area.

Parent material

Parent material is the unconsolidated mass from which soil forms. It determines to a large extent the mineralogical and chemical composition of the soil and the rate at which soil-forming processes take place. It affects the texture, structure, color, natural fertility, and other properties of the soil. Parent material forms through the mechanical and chemical weathering of rocks. Among the agents of mechanical weathering are temperature changes, the freezing of water, the growth of crystals, the actions of plants and animals, wetting and drying, abrasion, and corrosion. Chemical weathering, which is more complex, generally results in the reduction of particle size; the addition of water, oxygen, and carbon dioxide; and the loss of soluble salts of such metallic elements as sodium and potassium. In a temperate climate, clay minerals commonly result from chemical weathering, which can markedly alter the color and general appearance of a deposit.

In Allen County the soils formed dominantly in material weathered from Upper Pennsylvanian rocks (*7*). The exceptions are the alluvium of more recent time and scattered areas of smooth chert gravel in the western and northwestern parts of the county. The chert gravel is Tertiary material. The parent material of Olpe soils weathered from these gravel deposits. The Pennsylvanian rocks are limestone, sandstone, and shale.

Soils formed in material weathered from shale are the most extensive in the county. Eram, Talihina, and Zaar soils formed in material weathered from clayey shale. Dennis soils formed in material weathered from shale or intermixed sandy shale and shale. Bates soils formed in material weathered from sandstone and sandy shale. Catoosa and Nowata soils formed in material weathered from limestone.

Very old alluvium deposited on the present upland is the parent material of Kenoma and Woodson soils. Recent alluvium along present streams is the parent material of Leanna, Mason, Osage, and Verdigris soils.

Climate

The climate of Allen County is continental. It varies widely from season to season. Temperatures below freezing in winter and 90 degrees F in summer are common. The average annual rainfall is about 37 inches, and the average annual air temperature is about 56 degrees. Winter snowfall ranges from light to heavy. Most of the rainfall occurs in spring and fall. July and August are the driest and hottest months. Rainfall is sufficient to leach the surface layer of many of the soils and to transport clay particles into the subsoil. The rainfall also stimulates the growth of plants, which in turn promotes the accumulation of organic matter and darkens the surface layer.

Plant and animal life

Plant and animal life distinctly affects the characteristics of the upper part of the soil profile. The climate of Allen County favors the growth of tall prairie grasses, such as big bluestem, little bluestem, switchgrass, and indiangrass. Somewhat open stands of mixed hardwood trees formerly grew along streams in the larger valleys.

Plants provide organic matter, which improves soil structure. They also provide a protective cover for the soil, which reduces runoff, improves water intake, and reduces the loss of soil moisture through evaporation. Plant cover adjusts to soil characteristics. The nature of the parent material in a specific climatic region determines to a large extent the kind of vegetation that grows. The fibrous roots of grasses, which are near the soil surface, provide the organic matter and darken the surface layer of most prairie soils. Plant residue and channels made by plant roots improve water percolation and aeration in the soil. Plant life also affects the animal life of a region by furnishing favorable conditions for soil organisms and food and cover for larger burrowing animals.

Bacteria, fungi, and other soil organisms help in the weathering of rocks and the decomposition of organic matter. They influence the chemical, physical, and biological processes of soil formation. Worms and some of the larger burrowing animals help modify the soil profile and soil formation. Worm casts are common in many of the soils in Allen County.

Relief

Relief, or the gradient, length, and shape of slopes and their pattern, influences soil formation primarily through its effect on drainage, runoff, and erosion. The movement of water on the surface and into the soil is affected by relief. The steeper soils generally have a thinner profile than the less sloping soils because much of the soil material is removed by erosion. Talihina soils are an example.

In broad areas of nearly level soils, water runs off more slowly, and, consequently, more can enter the soil. The amount of water that soaks into the soil depends on permeability. In Allen County many of the nearly level soils have well developed soil profiles and strongly contrasting horizons because water leaches clay particles and soil minerals deep into the soil. Kenoma and Woodson soils are examples. Profile development is weak or immature in the gently sloping Zaar soils because water soaks into the clayey surface layer very slowly. As a result, the effects of leaching are less. Profile development is generally moderate in the gently sloping and moderately sloping soils that formed in permeable parent material. Bates, Dennis, and Catoosa soils are examples.

Time

Time is required for parent material to be changed into a soil. Maturity of soils is expressed in terms of the degree of profile development. Soils that formed in parent material of the same age can differ in maturity. Those that show little or no evidence of profile development are immature, and those that have well expressed horizons are mature.

The soils in Allen County range from immature to mature. Those on bottom land are subject to varying degrees of overflow and receive new sediments when they are flooded. These soils generally have a somewhat thick, dark-colored surface layer, but have only weak soil structure. The continual addition of sediments has helped to retard soil formation. Verdigris soils are an example. Zaar soils, which are on uplands, are considered immature because they lack well developed horizons. Kenoma and Dennis soils, which are about the same age as Zaar soils, are considered mature soils because they have well developed horizons.

References

(1) American Association of State Highway [and Transportation] Officials. 1970. Standard specifications for highway materials and methods of sampling and testing. Ed. 10, 2 vol., illus.

(2) American Society for Testing and Materials. 1974. Method for classification of soils for engineering purposes. ASTM Stand. D 2487-69. *In* 1974 Annual Book of ASTM Standards, Part 19, 464 pp., illus.

(3) Bark, L. Dean. 1959. When to expect late-spring and early-fall freezes in Kansas. Kans. State Univ., Coll. Agric. & Appl. Sci., Kans. Agric. Exp. Stn. Bull. 415, 23 pp., illus.

(4) Bark, L. Dean. 1961. Rainfall patterns in Kansas. Kans. State Univ., Coll. Agric. & Appl. Sci., Kans. Agric. Exp. Stn., vol. 37, no. 12, pp. 6-8, illus.
(5) Kansas State Board of Agriculture. 1972. Population of Kansas. 4 pp.
(6) Kansas State Board of Agriculture. 1973-74. Fifty-seventh report. 335 pp., illus.
(7) Miller, Don E. 1969. Geology and groundwater resources of Allen County, Kansas. Univ. Kans. Publ., State Geol. Surv. of Kans., Bull. 195, 50 pp., illus.
(8) Olsen, Gerald W. 1974. Using soils of Kansas for waste disposal. Univ. Kans. Publ., State Geol. Surv. of Kans., Bull. 208, 51 pp., illus.
(9) Simonson, Roy W. 1962. Soil classification in the United States. Sci. 137: 1027-1034.
(10) 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.]
(11) United States Department of Agriculture. 1960. Soil classification, a comprehensive system, 7th approximation. Soil Conserv. Serv., 265 pp., illus. [Supplements issued March 1967, September 1968, April 1969.]
(12) United States Department of Agriculture. 1961. Land capability classification. U.S. Dep. Agric. Handb. 210, 21 pp.

Glossary

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 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bedding system. A series of elevated beds that are arranged on the surface of fields by plowing or grading and are separated by shallow ditches so that surface drainage is implemented.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

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.

Clayey soils. Sandy clay, silty clay, and clay.

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.

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).

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.

Crop residue management. Maintaining stubble, stalks, and other crop residue on the surface to help control soil blowing and water erosion, to conserve water, and to decrease evaporation.

Crop rotation. A planned sequence of crops grown in a regular recurring succession, as contrasted with one crop grown year after year and with different crops grown in a haphazard order.

Depth to rock. Bedrock at a depth that adversely affects the specified use.

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."

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 fines. Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Excess salts. Excess water soluble salts. Excessive salts restrict the growth of most plants.

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.

Frost action. Freezing and thawing of soil moisture. Frost action can damage structures and plant roots.

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. Containing an appreciable amount of gravel.

Green manure (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

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.

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.

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.

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.

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.

Loamy soils. Soils of intermediate texture between coarse-textured, or sandy, soils and fine-textured, or clayey, soils. Sandy loam, loam, silt loam, and clay loam.

Low strength. Inadequate strength for supporting loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

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).

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Pan. A compact, dense layer in a soil. A pan impedes the movement of water and the growth of roots. The word "pan" is commonly combined with other words that more explicitly indicate the nature of the layer; for example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan.*

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 characteristic 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 forms 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.

Poorly graded. Refers to soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor outlets. Surface or subsurface drainage outlets difficult or expensive to install.

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 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

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.

Sandy soils. Loamy sand and sand.

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.

Shear strength. Resistance to sliding within the soil mass.

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.

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.

Slow intake. The slow movement of water into 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.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *very coarse sand* (2.0 millimeters to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.005 to 0.002 millimeter); and *clay* (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

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.

Surface layer. Technically, the A1 or Ap horizon.

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."

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.

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.

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.

Well graded. Refers to a soil or soil material consisting of particles well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Illustrations

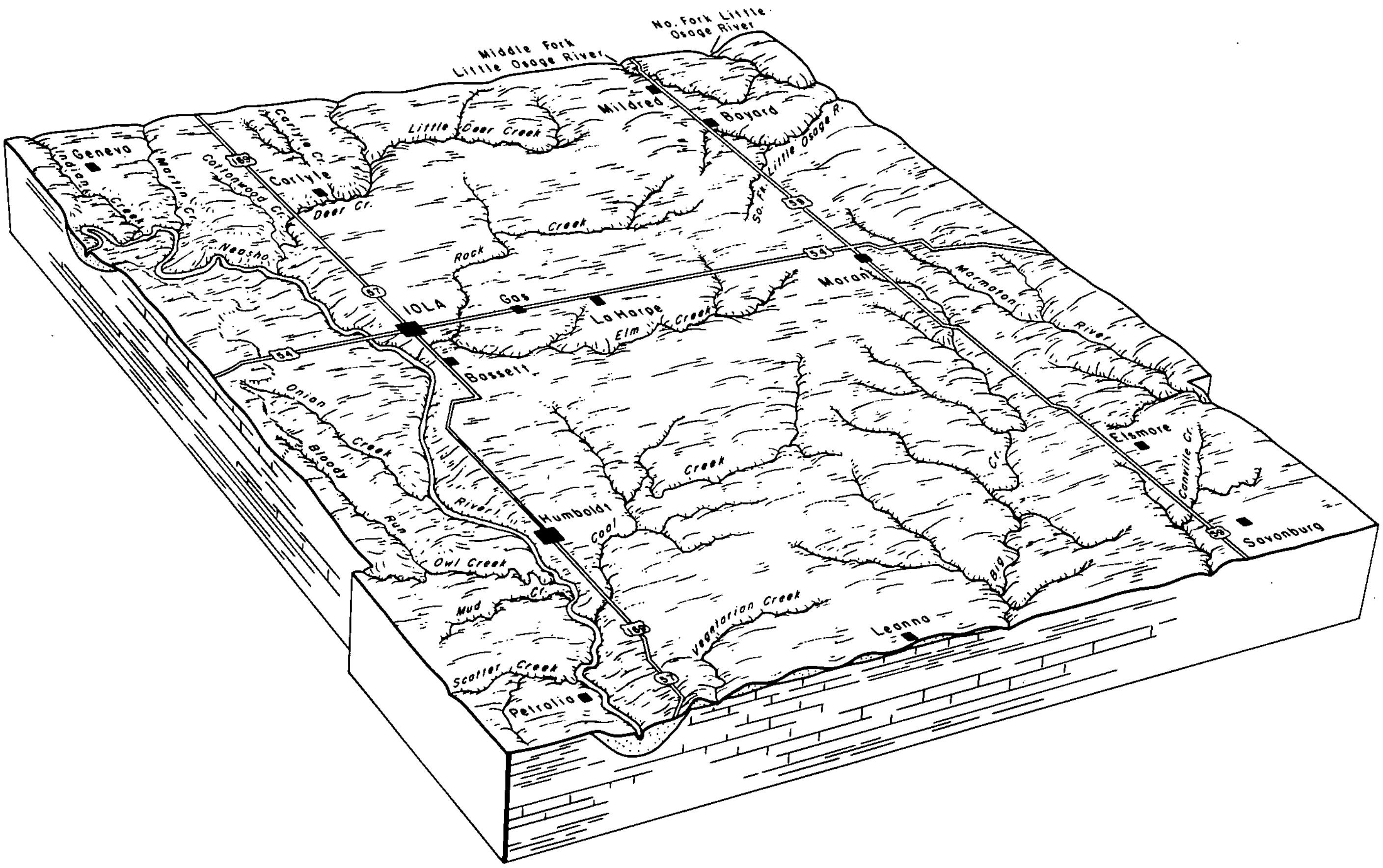


Figure 1.—Relief and drainage in Allen County.

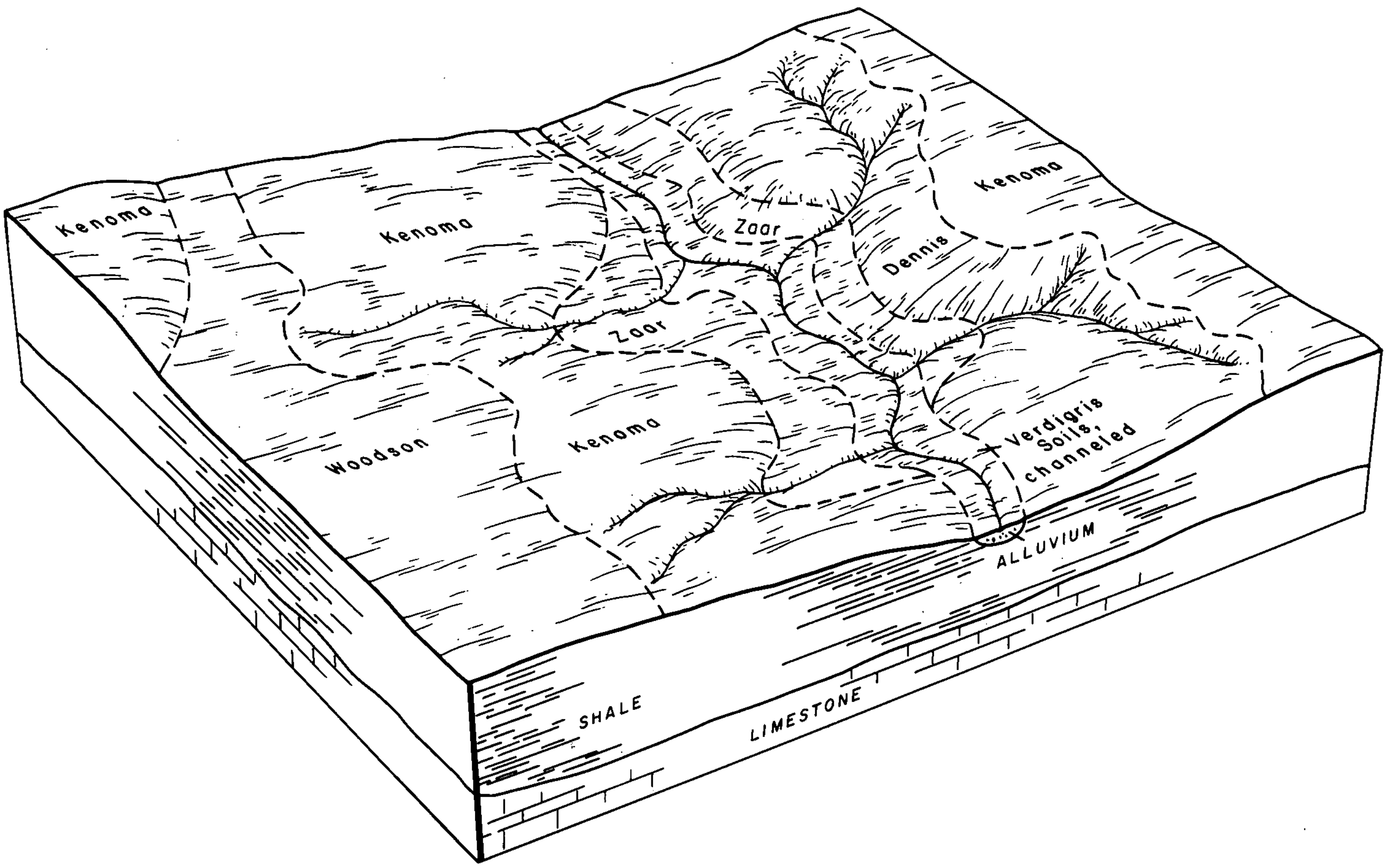


Figure 2.—Typical pattern of soils in the Kenoma-Woodson-Dennis unit.

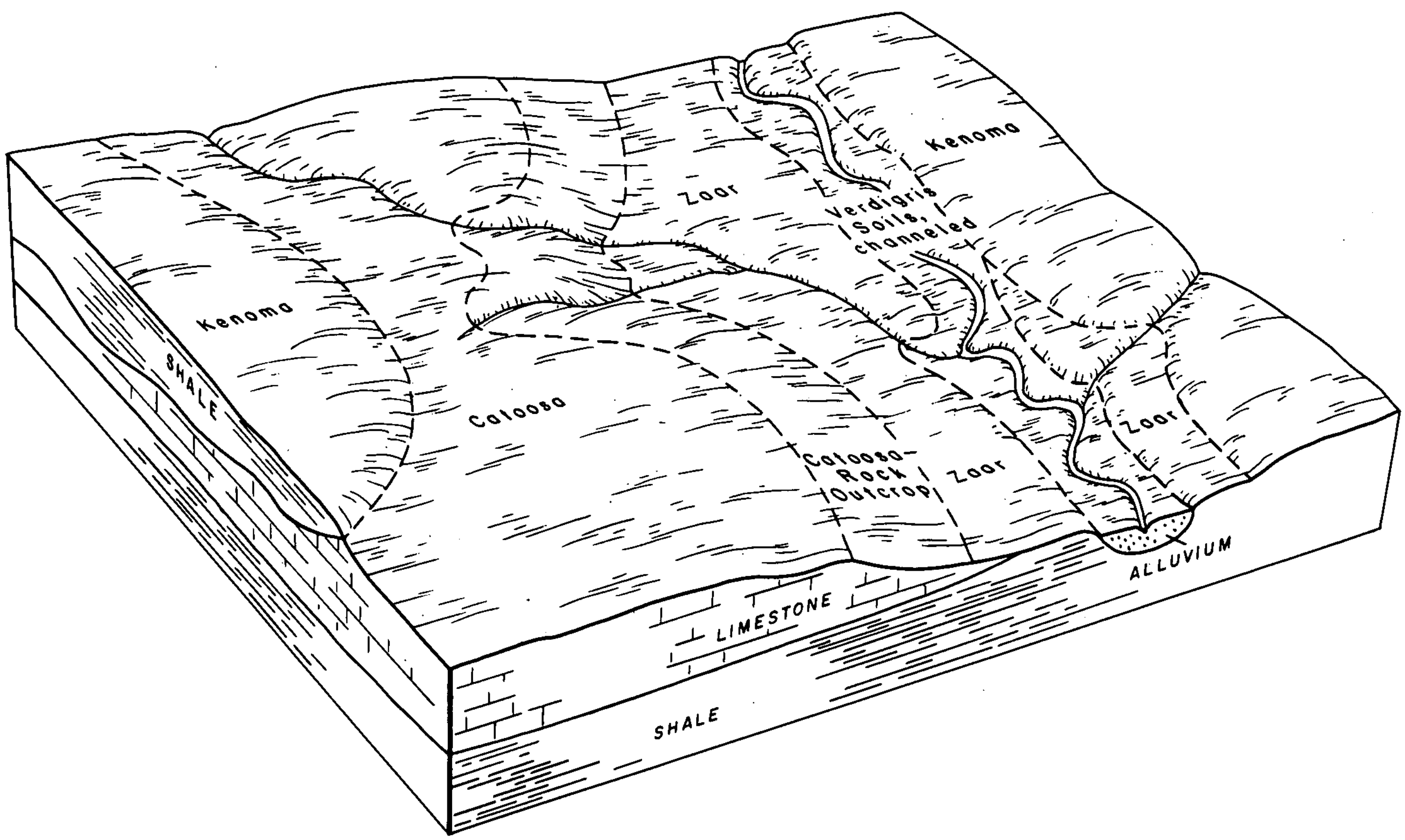


Figure 3.—Typical pattern of soils in the Catoosa-Kenoma-Zaar unit.

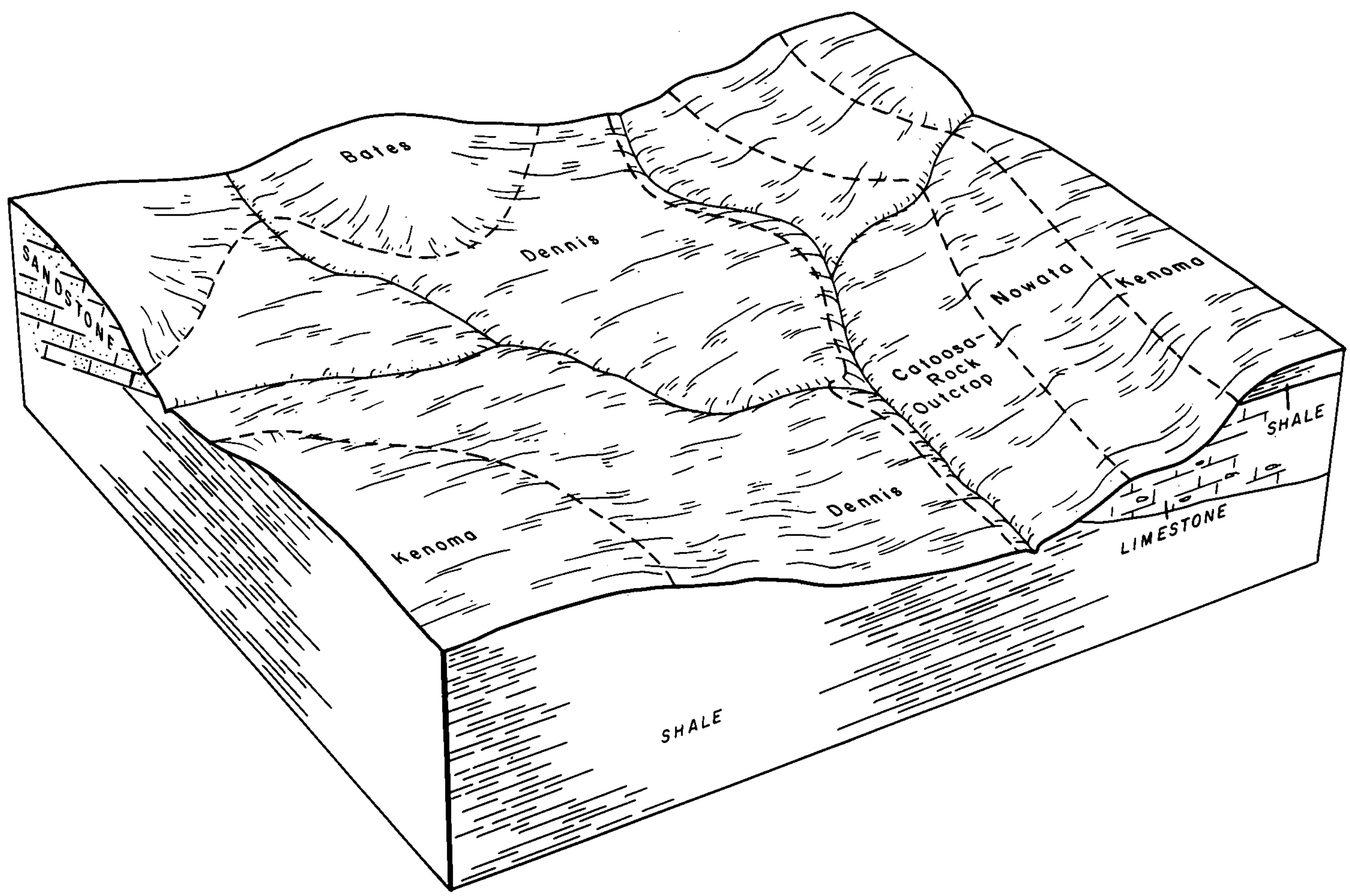


Figure 4.—Typical pattern of soils in the Bates-Dennis-Kenoma unit.

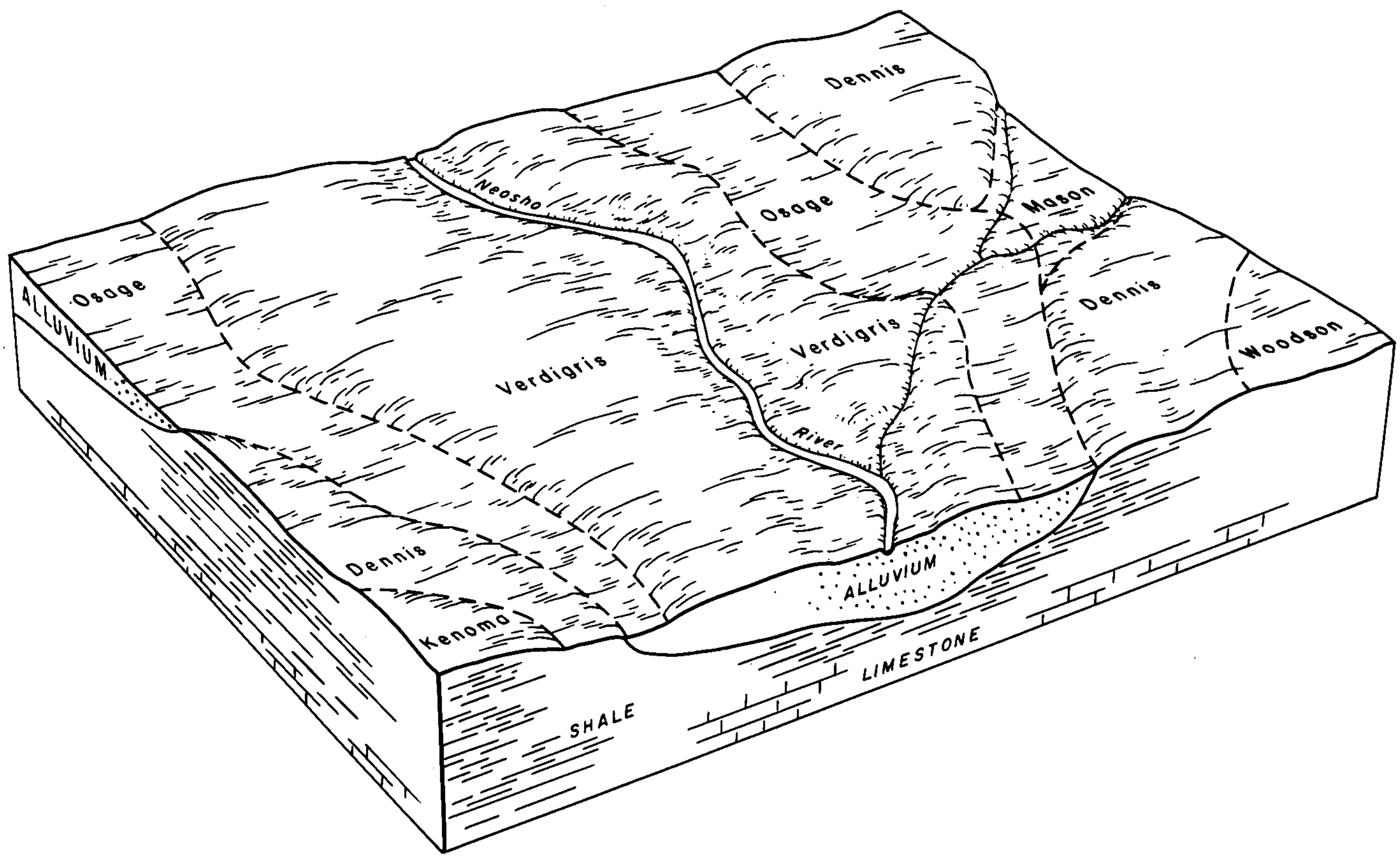


Figure 5.—Typical pattern of soils in the Verdigris-Osage-Mason unit.

Figure 6.—Profile of Bates loam, 1 to 4 percent slopes. Depth is indicated in feet.

Figure 7.—Profile of Catoosa silt loam in an area of Catoosa-Rock outcrop complex, 1 to 8 percent slopes. Hard limestone is at a depth of 27 inches.

Figure 8.—Area of Eram silty clay loam, 2 to 7 percent slopes, eroded.

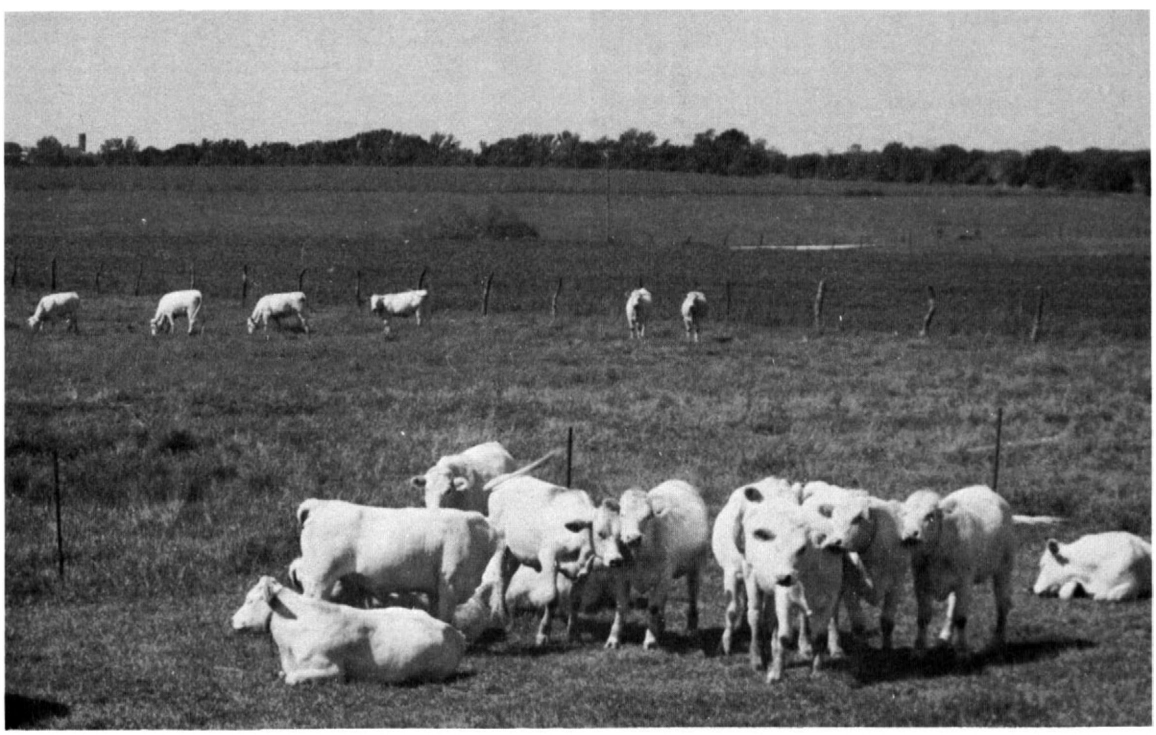


Figure 9.—Tame pasture of tall fescue grass on Kenoma silt loam, 1 to 3 percent slopes.

Figure 10.—Typical profile of Olpe gravelly silt loam in an area of Olpe soils, 3 to 15 percent slopes. Depth is indicated in feet.

Figure 11.—Typical profile of Talihina silty clay loam, 5 to 20 percent slopes. Depth is indicated in feet.

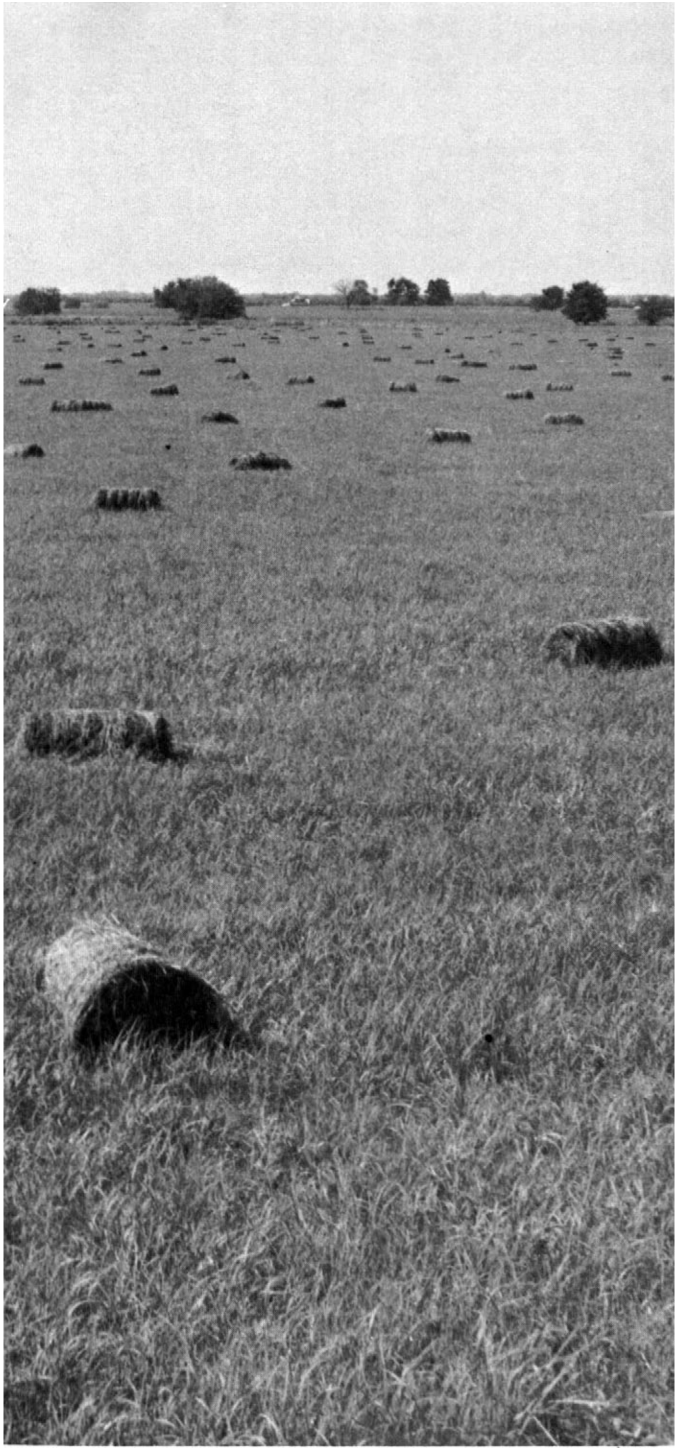


Figure 12.—Bales of native grass hay in an area of Woodson silt loam.

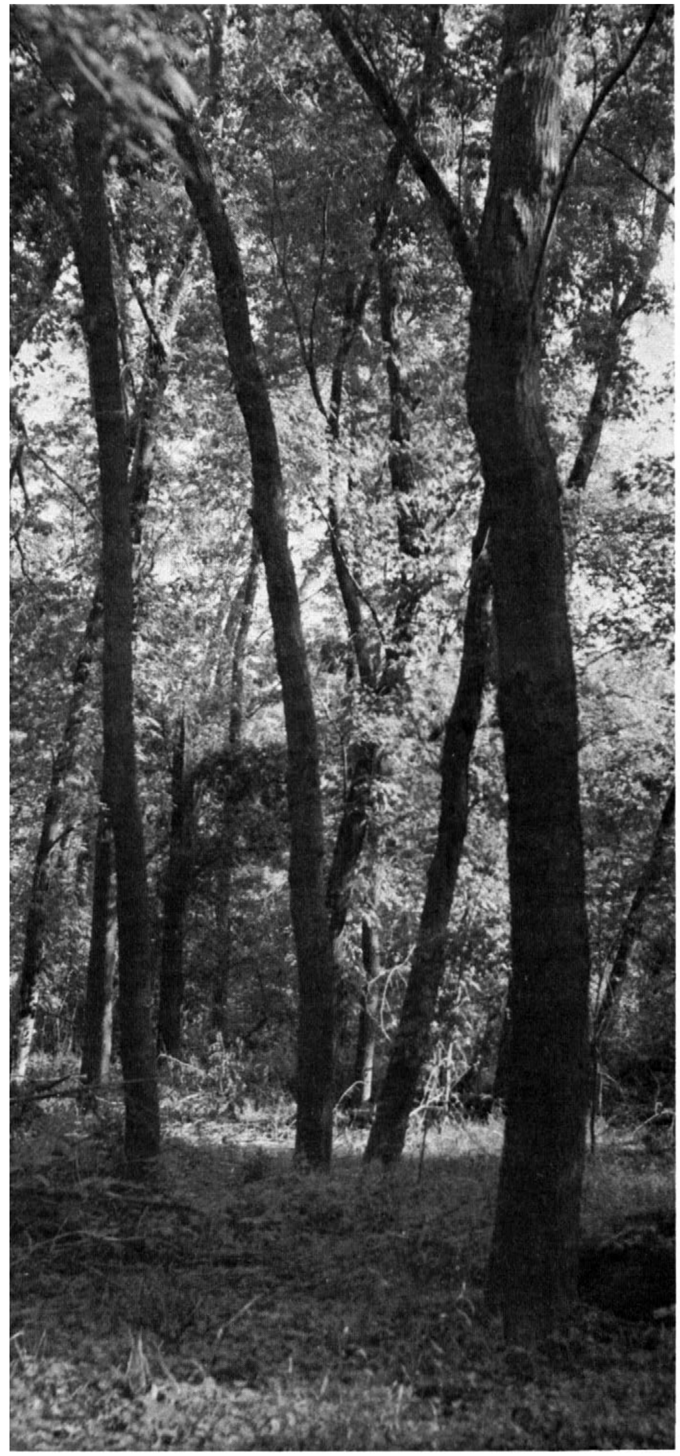


Figure 13.—Wooded area along the Neosho River.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION DATA

Month	Temperature[1]					Precipitation[1]				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	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	In	In	In		In
January-----	41.2	20.1	30.7	71	-8	1.06	0.29	1.30	2	3.6
February----	46.8	24.9	35.9	71	2	1.08	0.41	1.85	2	2.3
March-------	56.1	32.2	44.2	85	4	2.14	1.13	2.91	5	2.1
April-------	70.5	46.0	58.3	90	26	3.87	2.09	5.74	5	.0
May---------	78.0	56.2	67.0	92	33	4.81	2.49	6.12	7	.0
June--------	85.1	64.1	74.6	97	49	5.58	2.62	8.40	8	.0
July--------	90.3	68.5	79.5	104	53	4.50	1.60	6.68	7	.0
August------	89.3	66.7	78.0	104	52	3.01	1.08	4.95	4	.0
September---	80.8	58.9	69.9	95	40	5.04	1.97	8.34	6	.0
October-----	71.7	48.0	59.8	89	27	2.89	0.67	4.91	5	.0
November----	57.2	35.1	46.2	78	10	1.61	0.11	3.06	3	0.3
December----	44.6	25.5	35.1	68	-2	1.28	0.60	2.21	3	2.0
Year------	67.6	45.5	56.6	104	-8	36.45	27.98	42.28	56	12.1

[1]Recorded in the period 1941-70 at Iola, Kansas.

TABLE 2.--FREEZE DATES IN SPRING AND FALL

Probability	Minimum 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--	April 6	April 14	April 25
2 years in 10 later than--	April 1	April 9	April 20
5 years in 10 later than--	March 23	March 30	April 10
First freezing temperature in fall:			
1 year in 10 earlier than--	October 28	October 19	October 9
2 years in 10 earlier than--	November 3	October 24	October 15
5 years in 10 earlier than--	November 13	November 2	October 25

[1]Recorded in the period 1941-70 at Iola, Kansas.

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	214	196	179
8 years in 10	222	203	186
5 years in 10	239	217	200
2 years in 10	255	230	213
1 year in 10	264	237	220

[1]Recorded in the period 1941-70 at Iola, Kansas.

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
Ba	Bates loam, 1 to 4 percent slopes	9,200	2.8
Bb	Bates loam, 4 to 7 percent slopes	5,550	1.7
Bc	Bates loam, 2 to 7 percent slopes, eroded	1,150	0.4
Ca	Catoosa silt loam, 0 to 2 percent slopes	42,750	13.2
Cb	Catoosa-Rock outcrop complex, 1 to 8 percent slopes	22,750	7.0
Cc	Collinsville-Bates complex, 2 to 15 percent slopes	3,650	1.1
Da	Dennis silt loam, 1 to 3 percent slopes	25,000	7.7
Db	Dennis silt loam, 3 to 7 percent slopes	5,850	1.8
Dc	Dennis-Kenoma silt loams, 0 to 2 percent slopes	1,300	0.4
Ea	Eram silty clay loam, 1 to 4 percent slopes	1,850	0.6
Eb	Eram silty clay loam, 4 to 7 percent slopes	4,500	1.4
Ec	Eram silty clay loam, 2 to 7 percent slopes, eroded	1,300	0.4
Ka	Kenoma silt loam, 1 to 3 percent slopes	76,500	23.8
La	Leanna silt loam	2,050	0.6
Ma	Mason silt loam	9,500	2.9
Na	Nowata silt loam, 3 to 7 percent slopes	5,200	1.6
Oa	Olpe soils, 3 to 15 percent slopes	3,250	1.0
Ob	Osage silty clay loam	4,350	1.4
Oc	Osage silty clay	3,800	1.2
Qa	Quarry	790	0.2
Ta	Talihina silty clay loam, 5 to 20 percent slopes	1,100	0.4
Tb	Talihina stony silty clay loam, 8 to 25 percent slopes	1,150	0.4
Va	Verdigris silt loam	12,900	4.0
Vb	Verdigris silt loam, channeled	13,500	4.2
Wa	Woodson silt loam	29,250	9.1
Za	Zaar silty clay, 1 to 3 percent slopes	29,500	9.1
Zb	Zaar silty clay, 3 to 7 percent slopes	4,250	1.3
	Water	910	0.3
	Made land	169	([1])
	Borrow pit	117	([1])
	Total	323,136	100.0

[1]Less than 0.1 percent.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[All yields were estimated for a high level of management in 1974. Absence of a yield figure indicates the crop is seldom grown or is not suited]

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Wheat	Alfalfa hay	Smooth bromegrass	Tall fescue
	Bu	Bu	Bu	Bu	Ton	AUM[1]	AUM[1]
Bates:							
Ba	56	62	28	35	3.5	---	6.0
Bb	51	56	22	30	3.0	---	5.5
Bc	39	39	19	22	2.5	---	4.5
Catoosa:							
Ca	56	51	28	39	3.0	---	6.0
[2]Cb	---	---	---	---	---	---	---
Collinsville:							
[2]Cc	---	---	---	---	---	---	---
Dennis:							
Da	67	79	35	40	4.5	---	6.5
Db	60	70	30	35	4.0	---	6.0
[2]Dc	60	65	25	30	3.5	---	4.5
Eram:							
Ea	50	50	25	25	3.0	---	6.0
Eb	45	39	20	20	2.5	---	5.0
Ec	35	35	18	18	2.0	---	4.5
Kenoma:							
Ka	65	75	30	35	3.5	5.0	5.5
Leanna:							
[3]La	70	75	30	35	3.0	7.0	7.0
Mason:							
Ma	84	84	39	40	4.5	---	7.5
Nowata:							
Na	40	39	22	28	2.0	---	4.5
Olpe:							
[2]Oa	---	---	---	---	---	---	---
Osage:							
Ob	70	75	35	35	4.0	---	7.0
Oc	60	65	30	28	2.0	---	6.0
Talihina:							
Ta, Tb	---	---	---	---	---	---	---
Verdigris:							
Va	79	79	39	40	4.5	---	8.0
Vb	---	---	---	---	---	---	---
Woodson:							
Wa	65	80	30	33	3.5	5.0	5.5
Zaar:							
Za	65	70	32	35	4.0	6.5	7.0
Zb	52	60	28	30	3.5	6.0	6.0

[1]Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.
[2]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.
[3]Yields are for areas protected from flooding.

TABLE 6.--RANGE PRODUCTIVITY AND COMPOSITION

[Soils not listed are not in range sites; such soils can be used for grazing if grass cover is established]

Soil name and map symbol	Range site name	Potential production: Kind of year	Potential production: Dry weight	Common plant name	Composition
			Lb/acre		Pct
Bates:					
Ba, Bb, Bc	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	12
				Switchgrass	5
				Leadplant	5
				Flameleaf sumac	4
				Jersey-tea	3
				Purpletop	3
				Tall dropseed	2
				Sedge	2
				Blackberry	2
				Scribner panicum	1
				Heath aster	1
Catoosa:					
Ca[1], [2], Cb	Loamy Upland	Favorable	6,500	Little bluestem	25
		Normal	5,000	Big bluestem	20
		Unfavorable	4,000	Indiangrass	10
				Switchgrass	10
				Canada wildrye	5
				Sideoats grama	5
				Blue grama	5
				Tall dropseed	5
				Lespedeza	5
				Dotted gayfeather	5
				Other shrubs	5
Collinsville:					
[1]Cc:					
Collinsville part	Shallow Savannah	Favorable	3,500	Little bluestem	30
		Normal	2,300	Big bluestem	15
		Unfavorable	1,500	Indiangrass	10
				Switchgrass	10
				Sideoats grama	10
				Tall dropseed	5
				Longspike tridens	5
				Pale echinacea	5
				Heath aster	5
				Other shrubs	5
Bates part	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	12
				Switchgrass	5
				Leadplant	5
				Flameleaf sumac	4
				Jersey-tea	3
				Purpletop	3
				Tall dropseed	2
				Sedge	2
				Blackberry	2
				Scribner panicum	1
				Heath aster	1
Dennis:					
Da, Db	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Switchgrass	15
		Unfavorable	4,500	Little bluestem	10
				Indiangrass	10
				Scribner panicum	5
				Purpletop	5
				Tall dropseed	5
				Catclaw sensitivebrier	5
				Goldenrod	5
				Other shrubs	5

See footnote at end of table.

TABLE 6.--RANGE PRODUCTIVITY AND COMPOSITION--Continued

Soil name and map symbol	Range site name	Potential production: Kind of year	Potential production: Dry weight	Common plant name	Composition
			Lb/acre		Pct
Dennis:					
[1]Dc:					
Dennis part	Loamy Upland	Favorable	7,000	Bigbluestem	35
		Normal	5,500	Switchgrass	15
		Unfavorable	4,500	Little bluestem	10
				Indiangrass	10
				Scribner panicum	5
				Purpletop	5
				Tall dropseed	5
				Catclaw sensitivebrier	5
				Goldenrod	5
				Other shrubs	5
Kenoma part	Clay Upland	Favorable	6,000	Big bluestem	25
		Normal	4,500	Little bluestem	20
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	15
				Tall dropseed	5
				Sideoats grama	5
				Heath aster	3
				Sedge	3
				Scribner panicum	2
				Leadplant	2
				Stiff goldenrod	2
				Compassplant	2
				Maximilian sunflower	1
Eram:					
Ea, Eb, Ec	Clay Upland	Favorable	6,000	Big bluestem	30
		Normal	4,200	Little bluestem	15
		Unfavorable	3,000	Switchgrass	15
				Indiangrass	10
				Scribner panicum	5
				Purpletop	5
				Tall dropseed	5
				Catclaw sensitivebrier	5
				Goldenrod	5
				Other shrubs	5
Kenoma:					
Ka	Clay Upland	Favorable	6,000	Big bluestem	25
		Normal	4,500	Little bluestem	20
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	15
				Tall dropseed	5
				Sideoats grama	5
				Heath aster	3
				Sedge	3
				Scribner panicum	2
				Leadplant	2
				Stiff goldenrod	2
				Compassplant	2
				Maximilian sunflower	1
Leanna:					
La	Clay Lowland	Favorable	10,000	Prairie cordgrass	25
		Normal	8,000	Eastern gamagrass	20
		Unfavorable	5,000	Big bluestem	15
				Indiangrass	10
				Switchgrass	5
				Sedge	5
				Knotroot bristlegrass	5
				Maximilian sunflower	5
				Other trees	10

See footnote at end of table.

TABLE 6.--RANGE PRODUCTIVITY AND COMPOSITION--Continued

Soil name and map symbol	Range site name	Potential production: Kind of year	Potential production: Dry weight	Common plant name	Composition
			Lb/acre		Pct
Mason:					
Ma	Loamy Lowland	Favorable	10,500	Big bluestem	25
		Normal	9,000	Indiangrass	20
		Unfavorable	7,000	Switchgrass	15
				Little bluestem	10
				Eastern gamagrass	5
				Beaked panicum	5
				Sedge	5
				Florida paspalum	5
				Compassplant	5
				Other trees	5
Nowata:					
Na	Loamy Upland	Favorable	5,000	Little bluestem	25
		Normal	3,300	Big bluestem	20
		Unfavorable	2,200	Indiangrass	10
				Switchgrass	10
				Scribner panicum	5
				Other perennial grasses	15
				Other perennial forbs	10
				Other shrubs	5
Olpe:					
[1]Oa	Loamy Upland	Favorable	7,000	Big bluestem	30
		Normal	5,500	Little bluestem	20
		Unfavorable	4,000	Indiangrass	15
				Switchgrass	10
				Leadplant	5
				Tall dropseed	5
				Sideoats grama	3
				Heath aster	3
				Sedge	2
				Maximilian sunflower	2
				Jersey-tea	2
				Other shrubs	3
Osage:					
Ob	Loamy Lowland	Favorable	9,000	Switchgrass	30
		Normal	8,000	Indiangrass	15
		Unfavorable	6,000	Big bluestem	15
				Eastern gamagrass	10
				Little bluestem	10
				Prairie cordgrass	10
				Sunflower	5
				Eastern cottonwood	5
Oc	Clay Lowland	Favorable	9,000	Switchgrass	30
		Normal	8,000	Indiangrass	15
		Unfavorable	6,000	Big bluestem	15
				Eastern gamagrass	10
				Little bluestem	10
				Prairie cordgrass	10
				Sunflower	5
				Eastern cottonwood	5
Talihina:					
Ta, Tb	Clay Upland	Favorable	4,000	Little bluestem	20
		Normal	3,000	Big bluestem	15
		Unfavorable	2,000	Indiangrass	10
				Switchgrass	10
				Tall dropseed	5
				Sideoats grama	5
				Other perennial grasses	25
				Other perennial forbs	10

See footnote at end of table.

TABLE 6.--RANGE PRODUCTIVITY AND COMPOSITION--Continued

Soil name and map symbol	Range site name	Potential production: Kind of year	Potential production: Dry weight	Common plant name	Composition
			Lb/acre		Pct
Verdigris:					
Va, Vb	Loamy Lowland	Favorable	10,000	Big bluestem	40
		Normal	8,500	Indiangrass	20
		Unfavorable	6,000	Switchgrass	10
				Eastern gamagrass	8
				Little bluestem	5
				Prairie cordgrass	3
				Maximilian sunflower	3
				Wholeleaf rosinweed	2
				Tall dropseed	1
				Sedge	1
				Coralberry	1
				Canada goldenrod	1
				Other trees	5
Woodson:					
Wa	Clay Upland	Favorable	6,000	Big bluestem	25
		Normal	4,500	Little bluestem	20
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	15
				Tall dropseed	5
				Sideoats grama	5
				Heath aster	3
				Sedge	3
				Scribner panicum	2
				Leadplant	2
				Stiff goldenrod	2
				Compassplant	2
				Maximilian sunflower	1
Zaar:					
Za, Zb	Clay Upland	Favorable	6,000	Big bluestem	25
		Normal	4,500	Little bluestem	20
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	15
				Tall dropseed	5
				Sideoats grama	5
				Heath aster	3
				Sedge	3
				Scribner panicum	2
				Leadplant	2
				Stiff goldenrod	2
				Compassplant	2
				Maximilian sunflower	1

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

[2]Rock outcrop not rated.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

[Only the soils suitable for production of commercial trees are listed in this table. Absence of an entry in a column means the information was not available]

Soil name and map symbol	Management concerns					Potential productivity		Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Important trees	Site index	
Leanna:								
La	Slight	Severe	Moderate	Moderate	Severe	Pin oak	80	Pecan,
						Eastern cottonwood	85	green ash,
						Pecan	---	American sycamore,
						Hackberry	---	eastern cottonwood.
						Green ash	75	
Mason:								
Ma	Slight	Slight	Moderate	Slight	Moderate	Sweetgum	---	Sweetgum,
						Northern red oak	---	bur oak,
						Green ash	---	green ash,
						Black walnut	---	black walnut,
						Eastern cottonwood	90	pecan,
								American sycamore.
Osage:								
Ob	Slight	Moderate	Moderate	Moderate	Severe	Pin oak	75	Pin oak,
						Pecan	50	pecan.
						Eastern cottonwood	65	
Oc	Slight	Moderate	Severe	Moderate	Severe	Pin oak	75	Pin oak,
						Pecan	50	pecan.
						Eastern cottonwood	65	
Verdigris:								
Va, Vb	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood	87	Eastern cottonwood,
						Pin oak	85	American sycamore,
						Shagbark hickory	73	pin oak.
						Hackberry	69	
						Black walnut	70	
						Silver maple	61	
						Green ash	60	
						White oak	56	

TABLE 8.--BUILDING SITE DEVELOPMENT

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Bates:					
Ba, Bb, Bc	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.
Catoosa:					
Ca	Severe: depth to rock.	Moderate: low strength, depth to rock, shrink-swell.	Severe: depth to rock.	Moderate: low strength, depth to rock, shrink-swell.	Severe: low strength.
[1]Cb	Severe: depth to rock.	Moderate: low strength, depth to rock, shrink-swell.	Severe: depth to rock.	Moderate: slope, shrink-swell, depth to rock.	Severe: low strength.
Collinsville:					
[1]Cc:					
Collinsville part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.
Bates part	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.
Dennis:					
Da, Db	Severe: wetness, too clayey.	Severe: shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: low strength, shrink-swell.
[1]Dc:					
Dennis part	Severe: wetness, too clayey.	Severe: shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: low strength, shrink-swell.
Kenoma part	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Eram:					
Ea, Eb, Ec	Severe: too clayey, wetness.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength.	Severe: low strength, shrink-swell.
Kenoma:					
Ka	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Leanna:					
La	Severe: wetness, floods, too clayey.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, low strength.
Mason:					
Ma	Moderate: too clayey, floods.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, shrink-swell.

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
Nowata:					
Na	Severe: depth to rock.	Moderate: depth to rock, shrink-swell, low strength.	Severe: depth to rock.	Moderate: depth to rock, shrink-swell, low strength.	Severe: low strength.
Olpe:					
[1]Oa	Moderate: small stones.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: slope.	Moderate: shrink-swell.
Osage:					
Ob, Oc	Severe: wetness, floods, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.
Talihina:					
Ta, Tb	Severe: wetness, too clayey.	Severe: shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: shrink-swell, low strength, slope.	Severe: low strength, shrink-swell.
Verdigris:					
Va	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Vb	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Woodson:					
Wa	Severe: too clayey, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength.
Zaar:					
Za, Zb	Severe: too clayey, wetness.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

TABLE 9.--CONSTRUCTION MATERIALS

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," and "unsuited"]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Bates:				
Ba, Bb, Bc	Poor: thin layer.	Unsuited	Unsuited	Good.
Catoosa:				
Ca, [1] [2]Cb	Poor: low strength.	Unsuited	Unsuited	Fair: thin layer.
Collinsville:				
[1]Cc:				
Collinsville part	Poor: thin layer.	Unsuited	Unsuited	Poor: thin layer, area reclaim.
Bates part	Poor: thin layer.	Unsuited	Unsuited	Good.
Dennis:				
Da, Db	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
[1]Dc:				
Dennis part	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
Kenoma part	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Poor: thin layer.
Eram:				
Ea, Eb, Ec	Poor: low strength, shrink-swell, thin layer.	Unsuited	Unsuited	Fair: thin layer, too clayey.
Kenoma:				
Ka	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Poor: thin layer.
Leanna:				
La	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Mason:				
Ma	Fair: low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
Nowata:				
Na	Poor: low strength.	Unsuited	Poor: excess fines.	Fair: small stones.
Olpe:				
[1]Oa	Moderate: shrink-swell.	Unsuited	Unsuited	Poor: small stones.

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Osage:				
Ob, Oc	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness.
Talihina:				
Ta, Tb	Poor: low strength, shrink-swell, thin layer.	Unsuited	Unsuited	Poor: too clayey, area reclaim.
Verdigris:				
Va, Vb	Fair: low strength.	Unsuited	Unsuited	Good.
Woodson:				
Wa	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
Zaar:				
Za, Zb	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Poor: too clayey.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

[2]Rock outcrop not rated.

TABLE 10.--SANITARY FACILITIES

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "severe," and other terms used to rate soils]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Bates:					
Ba, Bb, Bc	Severe: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.	Slight	Fair: thin layer.
Catoosa:					
Ca, [1]Cb	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Fair: thin layer.
Collinsville:					
[1]Cc:					
Collinsville part	Severe: depth to rock.	Severe: seepage, depth to rock, slope.	Severe: seepage, depth to rock.	Severe: seepage.	Poor: thin layer.
Bates part	Severe: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.	Slight	Fair: thin layer.
Dennis:					
Da, Db	Severe: percs slowly, wetness.	Moderate: slope.	Severe: too clayey.	Severe: wetness.	Poor: thin layer.
[1]Dc:					
Dennis part	Severe: percs slowly, wetness.	Slight	Severe: too clayey.	Severe: wetness.	Poor: thin layer.
Kenoma part	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey.
Eram:					
Ea, Eb, Ec	Severe: percs slowly, wetness, depth to rock.	Severe: depth to rock.	Severe: too clayey.	Severe: wetness.	Poor: thin layer.
Kenoma:					
Ka	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey.
Leanna:					
La	Severe: percs slowly, wetness, floods.	Slight	Severe: floods, wetness, too clayey.	Severe: wetness, floods.	Poor: wetness, thin layer.
Mason:					
Ma	Severe: percs slowly.	Slight	Moderate: floods, too clayey.	Moderate: floods.	Fair: thin layer.
Nowata:					
Na	Severe: percs slowly, depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: small stones.
Olpe:					
[1]Oa	Severe: percs slowly.	Severe: small stones.	Severe: small stones, too clayey.	Moderate: slope.	Poor: small stones.

See footnote at end of table.

TABLE 10.--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
Osage:					
Ob	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Oc	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Talihina:					
Ta, Tb	Severe: percs slowly, wetness, depth to rock.	Severe: depth to rock, slope.	Severe: too clayey.	Severe: wetness.	Poor: thin layer.
Verdigris:					
Va	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
Vb	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
Woodson:					
Wa	Severe: percs slowly, wetness.	Slight	Severe: too clayey.	Moderate: wetness.	Poor: too clayey.
Zaar:					
Za, Zb	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

TABLE 11.--WATER MANAGEMENT

["Seepage" and some of the other terms that describe restrictive soil features are defined in the Glossary]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Bates:						
Ba, Bb, Bc	Depth to rock, erodes easily.	Thin layer	Not needed	Slope, rooting depth, erodes easily.	Slope, depth to rock, erodes easily.	Slope, erodes easily, rooting depth.
Catoosa:						
Ca, [1]Cb	Depth to rock	Unstable fill, piping, thin layer.	Not needed	Rooting depth, droughty.	Depth to rock, rooting depth, droughty.	Rooting depth, droughty.
Collinsville:						
[1]Cc:						
Collinsville part	Seepage, depth to rock.	Thin layer, area reclaim.	Not needed	Rooting depth	Not needed	Not needed.
Bates part	Depth to rock, erodes easily.	Thin layer	Not needed	Slope, rooting depth, erodes easily.	Slope, depth to rock, erodes easily.	Slope, erodes easily, rooting depth.
Dennis:						
Da, Db	Favorable	Unstable fill, compressible, piping.	Percs slowly	Slow intake	Percs slowly	Percs slowly.
[1]Dc:						
Dennis part	Favorable	Unstable fill, compressible, piping.	Percs slowly	Slow intake	Percs slowly	Percs slowly.
Kenoma part	Depth to rock	Low strength, shrink-swell.	Favorable	Slow intake, excess salt.	Percs slowly	Percs slowly.
Eram:						
Ea, Eb, Ec	Favorable	Unstable fill, thin layer.	Percs slowly	Slow intake	Percs slowly	Percs slowly.
Kenoma:						
Ka	Depth to rock	Low strength, shrink-swell.	Favorable	Slow intake, excess salt.	Percs slowly	Percs slowly.
Leanna:						
La	Favorable	Shrink-swell, low strength.	Floods, wetness, poor outlets.	Floods, percs slowly, wetness.	Not needed	Wetness.
Mason:						
Ma	Seepage	Unstable fill, piping, compressible.	Not needed	Favorable	Not needed	Not needed.
Nowata:						
Na	Depth to rock	Thin layer, low strength.	Not needed	Slope, droughty.	Rooting depth	Droughty.
Olpe:						
[1]Oa	Small stones	Low strength, shrink-swell.	Not needed	Slope droughty.	Complex slope, erodes easily.	Complex slope, erodes easily.

See footnote at end of table.

TABLE 11.--WATER MANAGEMENT--Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Osage:						
Ob, Oc	Favorable	Shrink-swell, low strength, compressible.	Floods, percs slowly, wetness.	Slow intake, wetness, floods.	Percs slowly, wetness.	Percs slowly, wetness.
Talihina:						
Ta, Tb	Depth to rock	Thin layer	Not needed	Slope, rooting depth, slow intake.	Not needed	Rooting depth.
Verdigris:						
Va, Vb	Seepage	Low strength, piping.	Floods	Floods	Floods	Favorable.
Woodson:						
Wa	Favorable	Low strength, shrink-swell.	Wetness, percs slowly.	Slow intake, wetness.	Wetness, percs slowly.	Percs slowly, wetness.
Zaar:						
Za, Zb	Depth to rock	Low strength, shrink-swell.	Wetness, percs slowly.	Slow intake, wetness, slope.	Percs slowly, wetness.	Percs slowly, wetness.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

TABLE 12.--RECREATIONAL DEVELOPMENT

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Bates:				
Ba, Bb, Bc	Slight	Slight	Moderate: slope.	Slight.
Catoosa:				
Ca	Slight	Slight	Moderate: depth to rock.	Slight.
[1]Cb	Slight	Slight	Moderate: depth to rock, slope.	Slight.
Collinsville:				
[1]Cc:				
Collinsville part	Moderate: slope.	Moderate: slope.	Severe: depth to rock, slope.	Slight.
Bates part	Slight	Slight	Moderate: slope.	Slight.
Dennis:				
Da, Db	Moderate: wetness, percs slowly.	Slight	Moderate: percs slowly, slope, wetness.	Slight.
[1]Dc:				
Dennis part	Moderate: wetness, percs slowly.	Slight	Moderate: percs slowly, wetness.	Slight.
Kenoma part	Severe: percs slowly.	Slight	Severe: percs slowly.	Slight.
Eram:				
Ea, Eb, Ec	Moderate: percs slowly, too clayey, wetness.	Moderate: too clayey.	Moderate: slope, percs slowly, wetness.	Moderate: too clayey.
Kenoma:				
Ka	Severe: percs slowly.	Slight	Severe: percs slowly.	Slight.
Leanna:				
La	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, percs slowly.	Severe: wetness.
Mason:				
Ma	Severe: floods.	Moderate: floods.	Moderate: percs slowly, floods.	Slight.
Nowata:				
Na	Moderate: percs slowly.	Slight	Moderate: percs slowly, depth to rock.	Slight.
Olpe:				
[1]Oa	Moderate: small stones, percs slowly.	Moderate: small stones.	Severe: slope.	Moderate: small stones.

See footnote at end of table.

TABLE 12.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Osage:				
Ob	Severe: floods, wetness, percs slowly.	Severe: wetness, floods.	Severe: wetness, floods, percs slowly.	Severe: wetness.
Oc	Severe: floods, wetness, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: wetness, too clayey.
Talihina:				
Ta, Tb	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey, depth to rock.	Severe: too clayey.
Verdigris:				
Va	Severe: floods.	Severe: floods.	Moderate: floods.	Slight.
Vb	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods, wetness.
Woodson:				
Wa	Severe: percs slowly.	Moderate: wetness.	Severe: percs slowly.	Moderate: wetness.
Zaar:				
Za, Zb	Severe: percs slowly, too clayey.	Severe: too clayey.	Severe: percs slowly, too clayey.	Severe: too clayey.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

TABLE 13.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor"]

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
Bates:												
Ba, Bb, Bc	Good	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.	Good.
Catoosa:												
Ca, [1], [2]Cb	Fair	Good	Good	Good	Good	Fair	Poor	Very poor.	Good	Good	Very poor.	Good.
Collinsville:												
[1]Cc:												
Collinsville part	Poor	Poor	Fair	Poor	Poor	Fair	Very poor.	Very poor.	Poor	Poor	Very poor.	Good.
Bates part	Good	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.	Good.
Dennis:												
Da	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	Good.
Db	Good	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.	Good.
[1]Dc:												
Dennis part	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	Good.
Kenoma part	Good	Good	Fair	Fair	Fair	Fair	Poor	Fair	Good	Fair	Poor	Fair.
Eram:												
Ea	Good	Good	Fair	Good	Good	Good	Poor	Poor	Good	Good	Poor	Good.
Eb	Fair	Good	Fair	Good	Good	Good	Poor	Very poor.	Fair	Good	Very poor.	Good.
Ec	Good	Good	Fair	Good	Good	Fair	Poor	Very poor.	Good	Good	Very poor.	Fair.
Kenoma:												
Ka	Good	Good	Fair	Fair	Fair	Fair	Poor	Fair	Good	Fair	Poor	Fair.
Leanna:												
La	Poor	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair	Poor.
Mason:												
Ma	Good	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.	Poor.
Nowata:												
Na	Fair	Good	Good	Good	Good	Fair	Poor	Very poor.	Good	Good	Very poor.	Fair.
Olpe:												
[1]Oa	Fair	Good	Good	Poor	Fair	Fair	Poor	Very poor.	Good	Poor	Very poor.	Fair.
Osage:												
Ob	Fair	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good	Poor.
Oc	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Good	Fair	Fair	Fair	Poor.
Talihina:												
Ta, Tb	Poor	Poor	Fair	Poor	Poor	Fair	Very poor.	Very poor.	Poor	Poor	Very poor.	Fair.
Verdigris:												
Va	Good	Good	Good	Good	Good	Good	Poor	Fair	Good	Good	Poor	Poor.

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
Verdigris:												
Vb	Poor	Fair	Fair	Good	Good	Good	Poor	Fair	Fair	Good	Poor	Fair.
Woodson:												
Wa	Fair	Good	Poor	Poor	Poor	Good	Poor	Good	Fair	Poor	Fair	Fair.
Zaar:												
Za	Fair	Fair	Fair	Good	Good	Good	Poor	Fair	Fair	Fair	Poor	Fair.
Zb	Fair	Fair	Fair	Good	Good	Good	Poor	Very poor.	Fair	Fair	Very poor.	Fair.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

[2]Rock outcrop not rated.

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS

[The symbol < means less than; > means greater than. Absence of an entry means data were not estimated]

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	
Bates:											
Ba, Bb, Bc	0-15	Loam	ML, CL	A-4	0	100	100	90-100	55-90	20-40	3-15
	15-32	Loam, clay loam, sandy clay loam.	ML, CL	A-4, A-6	0	100	100	90-100	50-85	25-40	3-30
	32	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Catoosa:											
Ca, [1], [2]Cb	0-11	Silt loam	ML, CL	A-4, A-6	0	100	100	96-100	65-97	30-37	9-13
	11-16	Silt loam, loam, clay loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	96-100	65-98	30-43	9-20
	16-27	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
Collinsville:											
[1]Cc:											
Collinsville part	0-7	Fine sandy loam	SM, SC, ML, CL	A-4	0-3	80-100	60-100	60-95	36-75	<30	[3]NP-10
	7-15	Fine sandy loam, loam, extremely stony fine sandy loam.	SM, SC, ML, CL	A-4	3-40	80-100	60-100	60-95	36-75	<30	NP-10
	15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Bates part	0-15	Loam	ML, CL	A-4	0	100	100	90-100	55-90	20-40	3-15
	15-32	Loam, clay loam, sandy clay loam.	ML, CL	A-4, A-6	0	100	100	90-100	50-85	25-40	3-30
	32	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Dennis:											
Da, Db	0-10	Silt loam	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	20-37	1-15
	10-19	Silty clay loam, clay loam.	CL	A-6, A-7	0	98-100	98-100	94-100	75-98	33-48	13-25
	19-60	Clay, silty clay, silty clay loam.	CL, CH, ML, MH	A-7, A-6	0	98-100	98-100	94-100	75-98	37-65	15-35
[1]Dc:											
Dennis part	0-10	Silt loam	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	20-37	1-15
	10-19	Silty clay loam, clay loam.	CL	A-6, A-7	0	98-100	98-100	94-100	75-98	33-48	13-25
	19-60	Clay, silty clay, silty clay loam.	CL, CH, ML, MH	A-7, A-6	0	98-100	98-100	94-100	75-98	37-65	15-35
Kenoma part	0-8	Silt loam	ML, CL	A-4, A-6	0	85-100	85-100	85-100	85-100	25-40	5-20
	8-32	Silty clay, clay	CH	A-7	0	85-100	85-100	85-100	85-100	50-65	30-45
	32-60	Silty clay, silty clay loam.	CL, CH	A-7	0	85-100	85-100	75-100	75-95	45-60	25-40
Eram:											
Ea, Eb, Ec	0-8	Silty clay loam	ML, CL	A-6, A-7	0	85-100	85-100	85-100	75-95	33-48	12-25
	8-30	Clay, silty clay, clay loam.	ML, CL, CH, MH	A-7, A-6	0	95-100	95-100	90-100	85-98	37-65	15-35
	30	Weathered bedrock.	---	---	---	---	---	---	---	---	---

See footnotes 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	
Kenoma:											
Ka	0-8	Silt loam	ML, CL	A-4, A-6	0	85-100	85-100	85-100	85-100	25-40	5-20
	8-32	Silty clay, clay	CH	A-7	0	85-100	85-100	85-100	85-100	50-65	30-45
	32-60	Silty clay, silty clay loam.	CL, CH	A-7	0	85-100	85-100	75-100	75-95	45-60	25-40
Leanna:											
La	0-13	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	30-40	5-15
	13-26	Silty clay, silty clay loam, clay.	CH, CL	A-7	0	100	100	95-100	90-100	45-65	25-40
	26-60	Silty clay loam, silty clay.	CL, CH	A-6, A-7	0	100	100	95-100	90-100	35-55	25-40
Mason:											
Ma	0-17	Silt loam	ML, CL	A-4, A-6	0	100	100	96-100	65-98	20-35	1-13
	17-60	Silty clay loam, clay loam, silt loam.	CL, ML	A-6, A-4, A-7	0	98-100	98-100	96-100	65-98	30-43	9-20
Nowata:											
Na	0-9	Silt loam	CL	A-4, A-6	0-15	85-100	80-100	75-95	70-95	30-37	8-13
	9-12	Silt loam, silty clay loam, gravelly silt loam.	CL, GC, SC	A-2, A-4, A-6	0-30	40-90	35-90	35-85	30-85	30-40	8-18
	12-27	Gravelly silty clay loam, very gravelly silty clay loam, cherty silty clay loam.	GC, GP-GC	A-2, A-6, A-7	0-65	15-50	10-50	10-45	5-40	33-42	12-19
	27	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Olpe:											
[1]Oa	0-15	Gravelly silt loam.	GC, SC	A-2-4, A-4	0	30-65	25-60	20-55	15-50	15-30	7-10
	15-26	Gravelly silty clay loam, gravelly silty clay.	GC, SC	A-2-6, A-6, A-7	0	30-65	25-60	20-55	15-50	25-45	11-22
	26-60	Gravelly silty clay, gravelly clay, gravelly silty clay loam.	GC, SC	A-2-7, A-7, A-6	0	30-65	25-60	20-55	15-50	40-60	25-40
Osage:											
Ob	0-18	Silty clay loam	CL, CH	A-6, A-7	0	100	100	100	95-100	30-50	10-25
	18-60	Silty clay, clay	CH	A-7	0	100	100	100	95-100	50-80	30-55
Oc	0-26	Silty clay	CH	A-7	0	100	100	100	95-100	50-75	30-55
	26-60	Silty clay, clay	CH	A-7	0	100	100	100	95-100	50-80	30-55
Talihina:											
Ta, Tb	0-17	Silty clay, silty clay loam.	CH, CL, MH, ML	A-7, A-6	0-15	87-100	87-100	85-100	70-98	35-65	15-35
	17	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Verdigris:											
Va, Vb	0-23	Silt loam	ML, CL	A-4, A-6, A-7	0	100	100	96-100	65-98	30-45	8-20
	23-60	Silt loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	96-100	80-98	30-45	8-25

See footnotes 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	
Woodson:											
Wa	0-8	Silt loam	ML, CL	A-4, A-6	0	100	100	90-100	85-100	25-40	5-20
	8-31	Silty clay, clay	CH	A-7-6	0	100	95-100	95-100	90-100	50-65	30-45
	31-60	Silty clay, clay, silty clay loam.	CH, CL	A-7-6, A-6	0	100	95-100	95-100	90-100	45-60	25-40
Zaar:											
Za, Zb	0-18	Silty clay	CH	A-7	0	100	100	95-100	90-95	50-70	25-40
	18-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	95-100	90-95	50-70	25-40

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.
[2]Rock outcrop part not rated.
[3]Nonplastic.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[Dashes indicate data were not available. The symbol < means less than; > means greater than. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not estimated]

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						
Bates:											
Ba, Bb, Bc	0-15	0.6-2.0	0.20-0.22	5.1-6.5	<2	Low	Low	Moderate	0.28	3-2	5
	15-32	0.6-2.0	0.15-0.19	5.1-6.5	<2	Moderate	Low	Moderate	0.28		
	32	---	---	---	---	---	---	---	---		
Catoosa:											
Ca, [1], [2]Cb	0-11	0.60-2.0	0.15-0.24	5.6-6.5	<2	Low	Low	Moderate	0.32	2	---
	11-16	0.60-2.0	0.15-0.24	5.6-6.5	<2	Moderate	Moderate	Moderate	---		
	16-27	0.60-2.0	0.15-0.22	5.1-7.3	<2	Moderate	Moderate	Moderate	---		
Collinsville:											
[1]Cc:											
Collinsville part	0-7	2.0-6.0	0.12-0.16	5.1-6.5	<2	Low	Low	Moderate	0.24	2	---
	7-15	2.0-6.0	0.09-0.13	5.1-6.5	<2	Low	Low	Moderate	---		
	15	---	---	---	---	---	---	---	---		
Bates part	0-15	0.6-2.0	0.20-0.22	5.1-6.5	<2	Low	Low	Moderate	0.28	3-2	5
	15-32	0.6-2.0	0.15-0.19	5.1-6.5	<2	Moderate	Low	Moderate	0.28		
	32	---	---	---	---	---	---	---	---		
Dennis:											
Da, Db	0-10	0.6-2.0	0.15-0.20	5.1-6.0	<2	Low	Low	Moderate	0.37	5	---
	10-19	0.2-0.6	0.15-0.20	5.1-6.0	<2	Moderate	Moderate	Moderate	---		
	19-60	0.06-0.2	0.15-0.20	5.1-8.4	<2	High	High	Moderate	---		
[1]Dc:											
Dennis part	0-10	0.6-2.0	0.15-0.20	5.1-6.0	<2	Low	Low	Moderate	0.37	5	---
	10-19	0.2-0.6	0.15-0.20	5.1-6.0	<2	Moderate	Moderate	Moderate	---		
	19-60	0.06-0.2	0.15-0.20	5.1-8.4	<2	High	High	Moderate	---		
Kenoma part	0-8	0.2-0.6	0.22-0.24	5.1-6.5	<2	Low	Moderate	Low	0.43	4	6
	8-32	<0.06	0.12-0.15	5.1-7.8	<2	High	High	Moderate	0.32		
	32-60	0.06-0.2	0.18-0.20	6.1-8.4	<4	High	High	Moderate	0.32		
Eram:											
Ea, Eb, Ec	0-8	0.2-0.6	0.15-0.19	5.6-6.5	<2	Moderate	High	Moderate	0.43	3	---
	8-30	0.06-0.2	0.14-0.18	5.1-7.3	<2	High	High	Moderate	---		
	30	---	---	---	---	---	---	---	---		
Kenoma:											
Ka	0-8	0.2-0.6	0.22-0.24	5.1-6.5	<2	Low	Moderate	Low	0.43	4	6
	8-32	<0.06	0.12-0.15	5.1-7.8	<2	High	High	Moderate	0.32		
	32-60	0.06-0.2	0.18-0.20	6.1-8.4	<4	High	High	Moderate	0.32		
Leanna:											
La	0-13	0.2-0.6	0.22-0.24	5.1-6.5	<2	Low	High	Moderate	---	---	6
	13-26	<0.06	0.11-0.18	5.1-6.5	<2	High	High	Moderate	---		
	26-60	0.06-2.0	0.11-0.18	5.6-7.3	<2	High	High	Low	---		
Mason:											
Ma	0-17	0.6-2.0	0.16-0.20	5.1-7.3	<2	Low	Low	Moderate	0.32	5	---
	17-60	0.2-0.6	0.16-0.20	5.1-7.3	<2	Moderate	Moderate	Moderate	---		
Nowata:											
Na	0-9	0.6-2.0	0.15-0.22	5.6-6.5	<2	Low	Low	Low	0.37	2	---
	9-12	0.6-2.0	0.11-0.16	5.6-6.5	<2	Low	Moderate	Moderate	0.37		
	12-27	0.2-0.6	0.08-0.12	5.6-7.3	<2	Moderate	Moderate	Moderate	0.32		
	27	---	---	---	---	---	---	---	---		
Olpe:											
[1]Oa	0-15	0.6-2.0	0.06-0.13	5.1-6.5	<2	Low	Low	Moderate	0.24	3	8
	15-26	0.2-0.6	0.04-0.10	5.1-6.5	<2	Low	Moderate	Moderate	0.24		
	26-60	<0.2	0.04-0.10	5.6-6.5	<2	Moderate	High	Low	0.24		

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						
Osage:											
Ob	0-18	<0.06	0.21-0.23	5.6-7.3	<2	High	High	Moderate	---	---	4
	18-60	<0.06	0.08-0.12	5.6-7.8	<2	Very high	High	Moderate	---		
Oc	0-26	<0.06	0.12-0.14	5.6-7.3	<2	Very high	High	Moderate	---	---	4
	26-60	<0.06	0.08-0.12	5.6-7.8	<2	Very high	High	Moderate	---		
Talihina:											
Ta, Tb	0-17	0.06-0.2	0.15-0.19	6.1-7.8	<2	High	High	Moderate	0.37	2	---
	17	---	---	---	---	---	---	---	---		
Verdigris:											
Va, Vb	0-23	0.6-2.0	0.22-0.24	5.6-7.3	<2	Moderate	Low	Low	---	---	6
	23-60	0.6-2.0	0.17-0.22	5.6-7.3	<2	Moderate	Low	Low	---		
Woodson:											
Wa	0-8	0.2-0.6	0.22-0.24	5.6-6.5	<2	Low	Moderate	Low	0.43	4-3	6
	8-31	<0.06	0.12-0.15	5.6-7.3	<2	High	High	Low	0.32		
	31-60	<0.2	0.10-0.15	6.1-7.3	<2	High	High	Moderate	0.32		
Zaar:											
Za, Zb	0-18	<0.06	0.12-0.18	5.6-6.5	<2	High	High	Moderate	0.32	4	4
	18-60	<0.06	0.12-0.18	6.6-8.4	<2	High	High	Low	0.32		

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.
[2]Rock outcrop part not rated.

TABLE 16.--SOIL AND WATER FEATURES

[Absence of an entry indicates the feature is not a concern. See text for descriptions of symbols and such terms as "rare," "brief," and "perched." The symbol < means less than; > means greater than]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	
					Ft			In		
Bates: Ba, Bb, Bc	B	None	---	---	>6.0	---	---	20-40	Rip-pable	Moderate.
Catoosa: Ca, [1]Cb	B	None	---	---	>6.0	---	---	20-40	Hard	---
Collinsville: [1]Cc:										
Collinsville part	C	None	---	---	>6.0	---	---	4-20	Hard	---
Bates part	B	None	---	---	>6.0	---	---	20-40	Rip-pable	Moderate.
Dennis: Da, Db	C	None	---	---	2.0-3.0	Perched	Dec-Apr	>60	---	---
[1]Dc:										
Dennis part	C	None	---	---	2.0-3.0	Perched	Dec-Apr	>60	---	---
Kenoma part	D	None	---	---	>6.0	---	---	>40	Hard	Low.
Eram: Ea, Eb, Ec	C	None	---	---	2.0-3.0	Perched	Dec-Apr	20-40	Rip-pable	---
Kenoma: Ka	D	None	---	---	>6.0	---	---	>40	Hard	Low.
Leanna: La	D	Occasional	Very brief	Jan-Dec	0.5-2.0	Perched	Dec-Jun	>60	---	Low.
Mason: Ma	B	Rare	Very brief	Dec-Apr	>6.0	---	---	>60	---	---
Nowata: Na	B	None	---	---	>6.0	---	---	20-40	Hard	---
Olpe: [1]Oa	C	None	---	---	>6.0	---	---	>60	---	Low.
Osage: Ob, Oc	D	Common	Brief to long.	Nov-May	0-1.0	Perched	Nov-May	>60	---	Low.
Talihina: Ta, Tb	D	None	---	---	2.0	Perched	Mar-Jun	10-20	Rip-pable	---
Verdigris: Va, Vb	B	Rare to common.	Very brief	Dec-Jun	>6.0	---	---	>60	---	Low.
Woodson: Wa	D	None	---	---	0.5-2.0	Perched	Dec-Apr	>60	---	Low.
Zaar: Za, Zb	D	None	---	---	1.0-2.0	Perched	Dec-Apr	>45	Rip-pable	Low.

[1]This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior of the whole mapping unit.

TABLE 17.--ENGINEERING TEST DATA[1]

Soil name and location	Parent material	Report number	Depth	Moisture density[2]: Maximum dry density	Moisture density[2]: Optimum moisture	Percentage less than 3 inches passing sieve--[3]: No. 10	No. 40	No. 200	Percentage smaller than--[3]: 0.05 mm	0.02 mm	0.005 mm	0.002 mm	Liquid limit	Plasticity index	Classification[4]: AASHTO	Unified
			In	Lb/cu ft	Pct								Pct			
Kenoma silt loam: 3,200 feet south and 200 feet west of the northeast corner of sec. 1, T. 25 S., R. 19 E. State Plane Coordinates N. 464,700, E. 2,933,900. (Modal)	Old clayey alluvium.	S73-Kans-1-2-1	0-8	101	17	100	100	96	91	67	29	19	38	15	A-6(16)	CL
		1-2-3	15-22	95	24	100	100	98	95	82	55	44	58	30	A-7-6 (35)	CH
		1-2-7	55-71	98	24	99	97	93	90	74	51	40	60	36	A-7-6 (38)	CH
Woodson silt loam: 100 feet south and 1,420 feet east of the northwest corner of sec. 23, T. 25 S., R. 19 E. State Plane Coordinates N. 451,600, E. 2,925,400. (Modal)	Old clayey alluvium.	S73-Kans-1-3-1	0-8	89	22	100	98	96	94	76	31	17	48	19	A-7-6 (22)	ML
		1-3-4	19-31	93	23	100	100	99	97	87	65	54	61	34	A-7-6 (40)	CH
		1-3-6	38-52	97	23	100	100	99	97	81	54	44	56	34	A-7-6 (38)	CH
Osage silty clay: 1,700 feet south and 250 feet west of the northeast corner of sec. 7, T. 24 S., R. 18 E. State Plane Coordinates N. 490,800, E. 2,874,700. (Nonmodal; more lime than is typical)	Clayey alluvium.	S73-Kans-1-4-1	0-14	95	23	100	100	96	94	78	46	30	57	33	A-7-6 (44)	CH
		1-4-4	28-41	102	20	100	100	96	94	81	51	36	58	35	A-7-6 (38)	CH
		1-4-6	57-71	103	19	100	100	98	96	87	57	39	57	36	A-7-6 (40)	CH

[1]Tests performed by the Kansas Department of Transportation, in accordance with standard procedures of the American Association of State Highway and Transportation Officials (AASHTO) except for the differences specified in footnotes 2 and 3 and those described as follows: (1) AASHTO Designation T87-72 (1) is used, but all material is crushed in a laboratory steel jawed crusher; (2) the method for determining Atterberg limits differs from AASHTO Designations T89-68 and T90-70 (1) in procedures for running the test. Kansas Test Procedure KT-10 describes the test.

[2]Based on Kansas Test Procedure KT-12, which differs from AASHTO Designation T99-74 (1). The Kansas procedure utilizes separate sample portions to determine points on the curve and has variations in the aging period.

[3]Mechanical analysis differs from AASHTO Designation T88-72 (1) as follows: (1) no presoaking is given samples prior to dispersion; (2) dispersing time is 5 minutes at 7 psi. using an Iowa air tube; (3) AASHTO T133-74 (1) is followed except for sample size to obtain SpG for the hydrometer analysis. In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the Soil Conservation Service soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculation of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[4]AASHTO classification based on AASHTO Designation M145-66 (1); Unified, on ASTM Designation D-2487-66T (2).

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