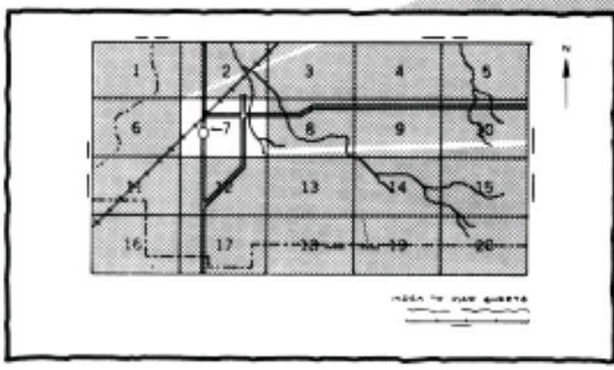
Soil Survey of

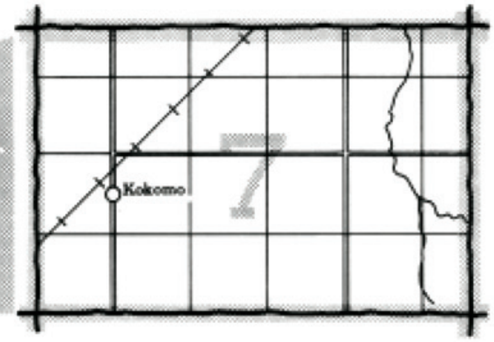
Linn and Miami Counties, Kansas

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

HOW TO USE

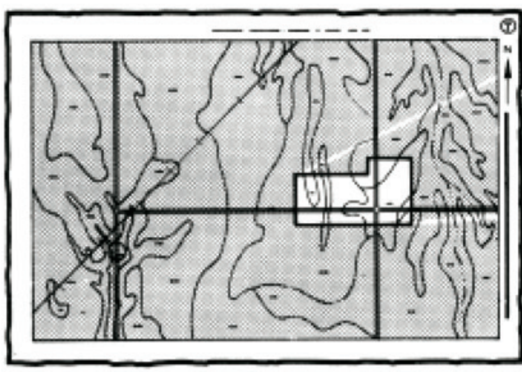
1. Locate your area of interest on the "Index to Map Sheets"

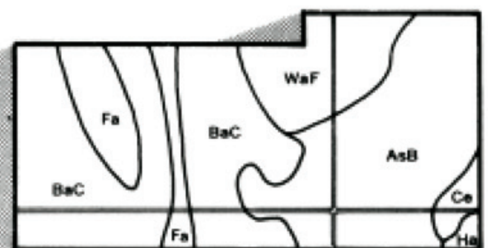




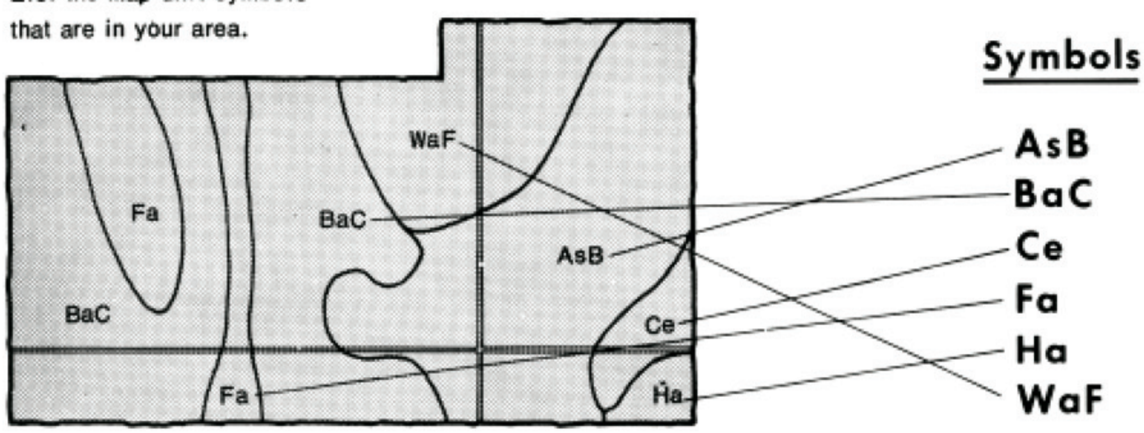
2. Note the number of the map sheet and turn to that sheet.

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



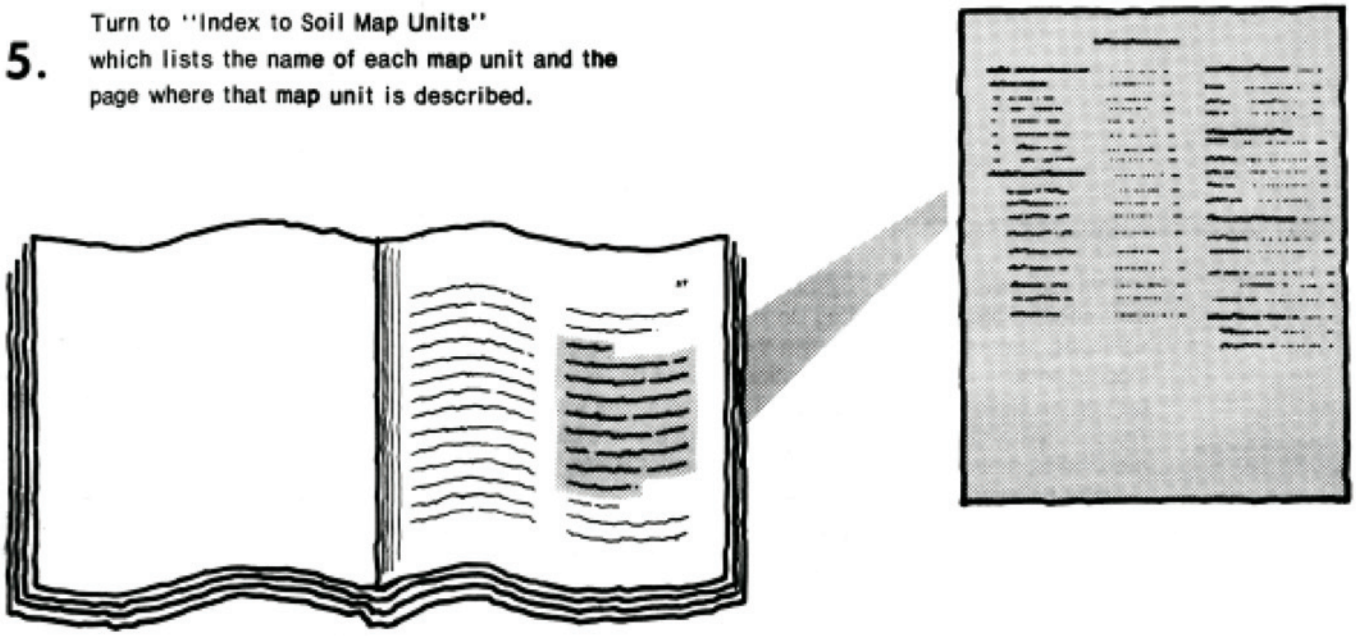


4. List the map unit symbols that are in your area.

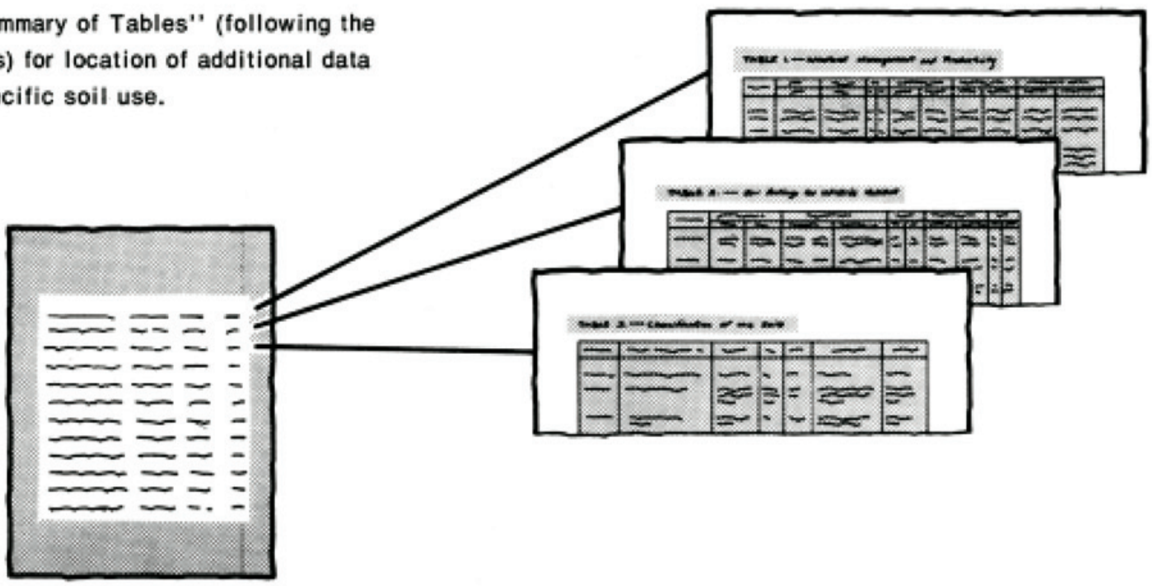


THIS SOIL SURVEY

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



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



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

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. 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.

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 Linn County Conservation District and County Commission and the Miami County Conservation District and County Commission. The Miami County Commission provided some of the personnel for the fieldwork, and the Linn County Commission provided financial assistance. Major fieldwork was performed in the period 1975-1978. Soil names and descriptions were approved in 1979. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1979.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: This typical farm scene is in an area dominated by Summit silty clay loam, 1 to 4 percent slopes. This area is used as tame pasture. Bromegrass is the main pasture grass.

contents

soil series

Issued June 1981

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summary of tables

foreword

This soil survey contains information that can be used in land-planning programs in Linn and Miami Counties. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations inherent in the soil or hazards that adversely affect the soil, improvements needed to overcome the limitations or reduce the hazards, and the impact of selected land uses on the environment.

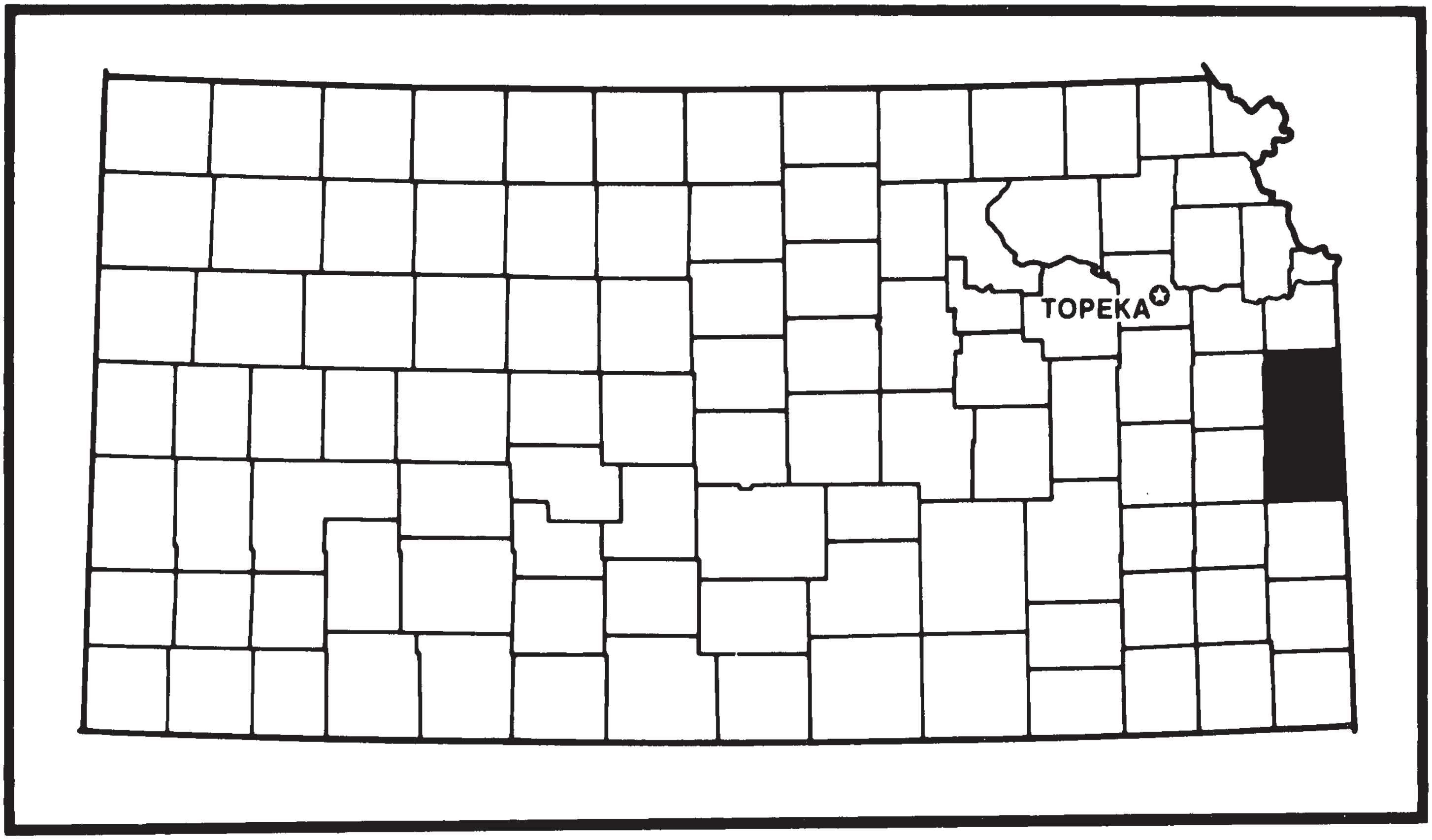
This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as 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 soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

John W. Tippie

John W. Tippie
State Conservationist
Soil Conservation Service



Location of Linn and Miami Counties in Kansas.

soil survey of
Linn and Miami Counties, Kansas

By Harold L. Penner, Soil Conservation Service

Fieldwork by Harold L. Penner, Jim R. Fortner, Jerome Zimmerman and Elbert R. Bell, Soil Conservation Service, and William R. Christense and David Laird, Miami County

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

Linn and Miami Counties are in the east-central part of Kansas. They have a total area of 1,200 square miles, or 768,000 acres. Of this, about 330,000 acres is used for cropland, 250,000 acres for pasture, 76,000 acres for rangeland, 88,000 acres for woodland, and 24,000 acres for urban uses. In 1979, Miami County had a population of 22,080, and Paola, the county seat, had a population of 4,831. Linn County had a population of 8,293, and Mound City, the county seat, had a population of 797.

All the survey area is in the Cherokee Prairie Land Resource Area. The topography is a slightly dissected plain. The plain is interrupted by a series of low ridges with southeast-facing escarpments. The soils are moderately deep and deep, and they have a silty and clayey subsoil. The elevation ranges from 1,150 to 780 feet above sea level.

Most of the survey area is drained by the Marais des Cygnes River and its tributaries. The southern part is drained by the Little Osage River.

The main enterprise in the survey area is farming. Numerous small commercial and industrial enterprises provide many jobs.

The descriptions, names, and delineations of soils in this survey do not fully agree with those on soil maps for adjacent counties. The differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, or the extent of the soils within the survey area.

general nature of the survey area

This section gives information concerning the climate and natural resources in the counties.

climate

By L. Dean Bark, climatologist, Kansas Agricultural Experiment Station, Manhattan, Kansas.

Linn and Miami Counties have a continental climate typical of the interior of a large land mass in the middle latitudes. Such a climate is characterized by large daily and annual variations in temperature. Winters are cold because of the frequent outbreaks of air from the polar regions. Winter lasts only from December through February. Warm summer temperatures last for about 6 months every year, and the transition seasons, spring and fall, are fairly short. The warm temperatures provide a long growing season for crops.

Linn and Miami Counties are in the path of a fairly dependable current of moisture-laden air from the Gulf of Mexico. Precipitation is heaviest late in spring and early in summer. Much of it occurs as late-evening or nighttime thunderstorms. Although the total precipitation is generally adequate for any crop, its distribution may cause problems in some years. Prolonged dry periods of several weeks duration are not uncommon during the growing season. A surplus of precipitation often produces muddy fields and a delay in planting and harvesting.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Mound City in the period 1951 to 1976. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on average length of the growing season.

In winter the average temperature is 34.4 degrees F, and the average daily minimum temperature is 23.5 degrees. The lowest temperature on record, which occurred at Pleasanton on February 13, 1905, is -23 degrees. In summer the average temperature is 77.4 degrees, and the average daily maximum temperature is 89.7 degrees. The highest recorded temperature, which occurred at Mound City on July 14, 1954, is 117 degrees.

The total annual precipitation is 38.53 inches. Of this, 26.38 inches, or 68 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 17.67 inches. The heaviest 1-day rainfall was 8.23 inches at Paola on November 16, 1928.

Average seasonal snowfall is 17.5 inches. The greatest snowfall, 36.5 inches, occurred during the winter of 1958-1959. On an average of 20 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The sun shines 72 percent of the time possible in summer and 56 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 12 miles per hour, in March.

Tornadoes and severe thunderstorms occur occasionally in Linn and Miami Counties. These storms are usually local in extent and of short duration; therefore, damage is slight. Hailstorms occur during the warmer part of the year, but they are infrequent and local in extent. Crop damage by hail is less in this part of the state than it is in the western part.

natural resources

Soil is the most important natural resource in the survey area. It supports the grassland that marketable livestock graze, and it supports marketable crops.

Ground water is available in only small quantities and usually is not sufficient for domestic purposes. Rural residents depend on rural water districts or ponds for their water supply.

Coal is mined in Linn County, and oil production occurs in both counties. Limestone is quarried and is used as concrete aggregate and building stone, or it is crushed for use as agricultural lime and riprap. Small deposits of sand and gravel are along the Marias des Cygnes River. Also, some deposits of chert gravel are in the uplands.

how this survey was made

Soil scientists made this survey to learn what soils are in the survey area, where they are, and how they can be used. 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; and the kinds of rock. They dug many holes to study 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 plant roots.

The soil scientists recorded the characteristics of the profiles they studied and compared those profiles with others in nearby counties and in more distant places. They classified and named the soils according to nationwide uniform procedures. They drew the boundaries of the soils on aerial photographs. These photographs show trees, buildings, fields, roads, and other details that help in drawing boundaries accurately. The soil maps at the back of this publication were prepared from aerial photographs.

The areas shown on a soil map are called map units. Most map units are made up of one kind of soil. Some are made up of two or more kinds. The map units in this survey area are described under "General soil map units" and "Detailed soil map units."

While a soil survey is in progress, samples of some soils are taken for laboratory measurements and for engineering tests. All soils are field tested to determine their characteristics. Interpretations of those characteristics may be modified during the survey. Data are assembled from other sources, such as test results, records, field experience, and state and local specialists. For example, data on crop yields under defined management 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 can be used by farmers, rangeland and woodland managers, engineers, planners, developers and builders, home buyers, and others.

general soil map units

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

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map 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 soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

soil descriptions

1. Woodson-Summit association

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

This association consists of soils on ridgetops and side slopes that are dissected by drainageways. The slope range is 1 to 4 percent.

This association makes up about 5 percent of the survey area. It is about 60 percent Woodson soils, 30 percent Summit soils, and 10 percent soils of minor extent (fig. 1).

The deep, somewhat poorly drained Woodson soils formed in old clayey alluvium. These soils are on broad ridgetops. The surface layer is very dark gray silt loam about 7 inches thick. The subsoil is about 33 inches thick. The upper part of the subsoil is black, mottled, very firm silty clay; the middle part is dark gray, mottled, very firm silty clay; and the lower part is gray, mottled, very firm silty clay. The substratum to a depth of about 60 inches is gray, mottled silty clay.

The deep, moderately well drained Summit soils formed in residuum or colluvium from clay or shale on side slopes and foot slopes. The surface layer is black silty clay loam about 11 inches thick. The subsoil to a depth of about 60 inches is black, very firm silty clay in the upper part, dark grayish brown, mottled, extremely firm silty clay in the middle part, and olive brown, very dark grayish brown, and dark gray, coarsely mottled, extremely firm silty clay in the lower part.

Of minor extent in this association are Catoosa, Grundy, Kenoma, and Verdigris soils. The moderately deep Catoosa soils and the deep Grundy and Kenoma soils are on ridgetops. The deep, moderately well drained Verdigris soils are on flood plains along drainageways.

The soils in this association are used mainly for cultivated crops and tame pasture. Corn, grain sorghum, soybeans, and small grain are the main crops. Water erosion is a hazard in the gently sloping areas. Controlling erosion and maintaining soil tilth and fertility are concerns in management.

2. Catoosa-Clareson-Summit association

Moderately deep and deep, nearly level to strongly sloping, well drained and moderately well drained soils that have a silty and clayey subsoil; on uplands

This association is made up of soils on ridgetops, side slopes, and foot slopes that are dissected by drainageways and small creeks. The slope range is 2 to 15 percent.

This association makes up about 62 percent of the survey area. It is about 20 percent Catoosa soils, 15 percent Clareson soils, 15 percent Summit soils, and 50 percent soils of minor extent (fig. 2).

The moderately deep, well drained Catoosa soils formed in residuum of limestone on ridgetops. The surface soil is dark brown silt loam about 12 inches thick. The subsoil is about 17 inches thick. The upper part of the subsoil is dark reddish brown, firm and very firm silty clay loam, and the lower part is dark red, very firm silty clay. Limestone is at a depth of about 29 inches.

The moderately deep, well drained Clareson soils formed in residuum of limestone on points of ridges and on the upper part of side slopes. The surface soil is very dark brown silty clay loam about 11 inches thick. The subsoil is about 22 inches thick. The upper part of the subsoil is dark reddish brown, firm flaggy silty clay loam; the middle part is dark reddish brown, very firm flaggy silty clay; and the lower part is dark reddish brown and reddish brown, very firm flaggy silty clay. Limestone is at a depth of about 33 inches.

The deep, moderately well drained Summit soils

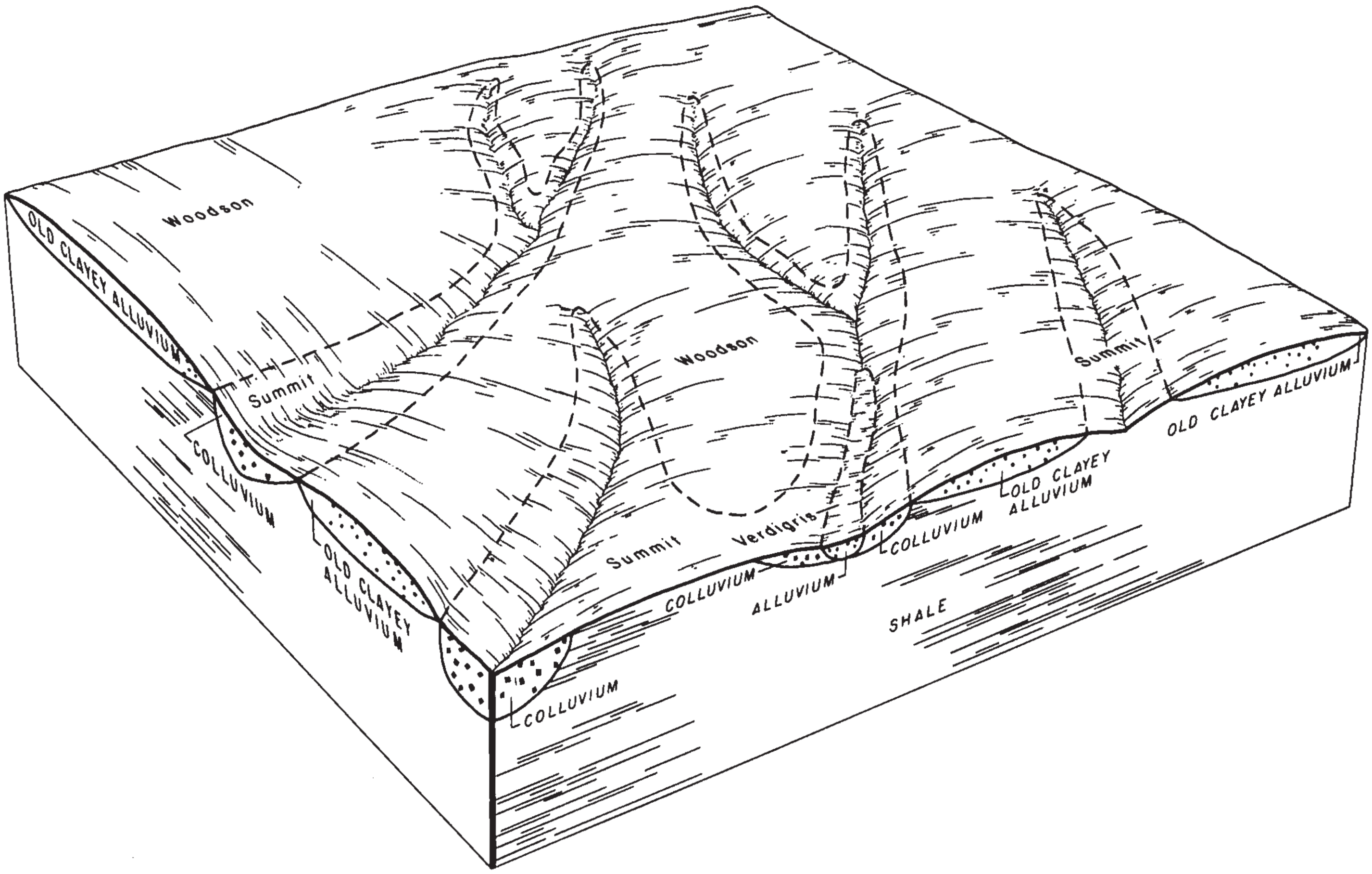


Figure 1.—Typical pattern of soils in the Woodson-Summit association.

formed in residuum or colluvium from clay or shale. These soils are on side slopes and foot slopes. The surface soil is black silty clay loam about 11 inches thick. The subsoil to a depth of about 60 inches is black, very firm silty clay in the upper part, dark grayish brown, mottled, extremely firm silty clay in the middle part, and olive brown and dark gray, coarsely mottled, extremely firm silty clay in the lower part.

Of minor extent in this association are Eram, Kenoma, Lebo, and Verdigris soils. The moderately deep Eram and Lebo soils are in the steeper areas. The deep Kenoma soils are on ridgetops. The deep Verdigris soils are on flood plains along drainageways.

On about half the acreage of this association, the soils are used for cultivated crops. On most of the rest of the acreage, they are used for tame pasture. Corn, grain sorghum, soybeans, small grain, and red clover are the main crops. Bromegrass and tall fescue are the main tame grasses. On cultivated cropland, erosion is a hazard. Controlling erosion and maintaining soil tilth and fertility are concerns in management. On pastureland, maintaining and improving grass production are concerns in management. Brush management is of particular concern.

3. Dennis-Parsons association

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

This association consists of soils on broad ridgetops and side slopes that are dissected by drainageways. It occurs only in Linn County. The slope range is 1 to 6 percent.

This association makes up about 11 percent of the survey area. It is about 40 percent Dennis soils, 20 percent Parsons soils, and 40 percent soils of minor extent (fig. 3).

The deep, moderately well drained Dennis soils formed in residuum or colluvium from shale. These soils are on side slopes and foot slopes. The surface layer is dark brown silt loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark brown, mottled, firm silty clay loam; the middle part is yellowish brown, mottled, very firm silty clay; and the lower part is dark brown and yellowish brown, mottled, very firm silty clay.

The deep, somewhat poorly drained Parsons soils formed in old clayey alluvium on broad ridgetops. The surface layer is very dark grayish brown, faintly mottled silt loam about 9 inches thick. The subsurface layer is dark grayish brown, mottled silt loam about 4 inches thick. The subsoil to a depth of 60 inches is dark grayish brown, mottled, very firm silty clay.

Of minor extent in this association are Bates, Kenoma, Summit, and Woodson soils. The moderately deep Bates soils are on side slopes. The deep Kenoma and Woodson soils are on similar positions on the landscape. The deep Summit soils are on foot slopes adjacent to drainageways.

The soils in this association are used mainly for cultivated crops. In some areas they are used for hay or pasture. Corn, grain sorghum, soybeans, small grain, and red clover are the main crops. Water erosion is a hazard in the gently sloping areas. Controlling erosion and maintaining soil tilth and fertility are concerns in management.

4. Verdigris-Osage-Lanton association

Deep, nearly level, moderately well drained to poorly drained soils that have a silty and clayey subsoil; on flood plains

This association consists of soils on flood plains along major streams. The slope range is 0 to 2 percent.

This association makes up about 12 percent of the survey area. It is about 45 percent Verdigris soils, 35 percent Osage soils, 10 percent Lanton soils, and 10 percent soils of minor extent.

The deep, moderately well drained Verdigris soils formed in silty alluvium on flood plains. The surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is very dark grayish brown silt loam about 23 inches thick. The next layer is dark brown, firm silt loam about 20 inches thick. The substratum to a depth of about 60 inches is dark yellowish brown silt loam.

The deep, poorly drained Osage soils formed in clayey alluvium. These soils are on flood plains and in backwater areas. The surface soil is black silty clay about 23 inches thick. The subsoil is about 21 inches thick. The upper part of the subsoil is very dark gray, mottled, very firm silty clay, and the lower part is dark

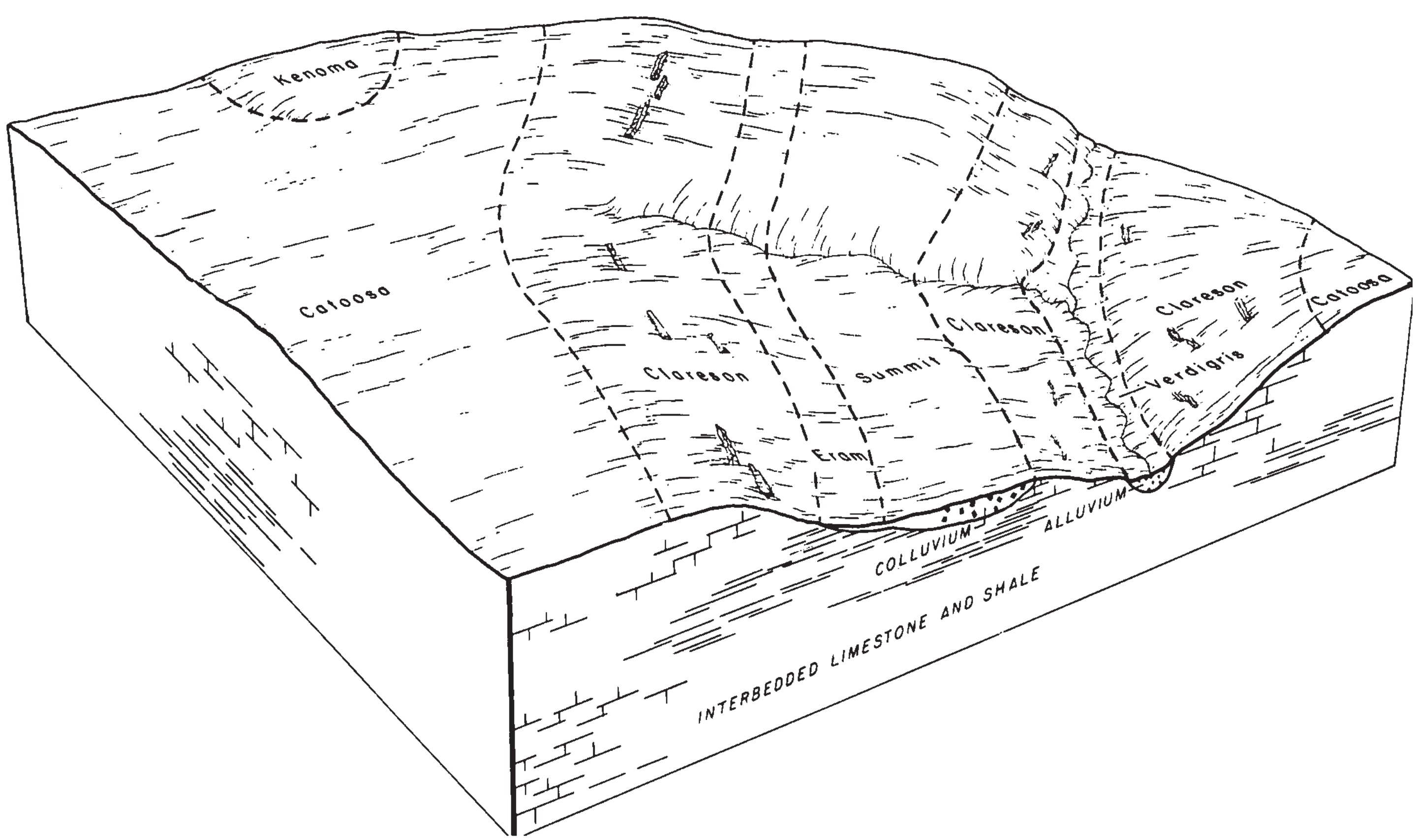


Figure 2.—Typical pattern of soils in the Catoosa-Clareson-Summit association.

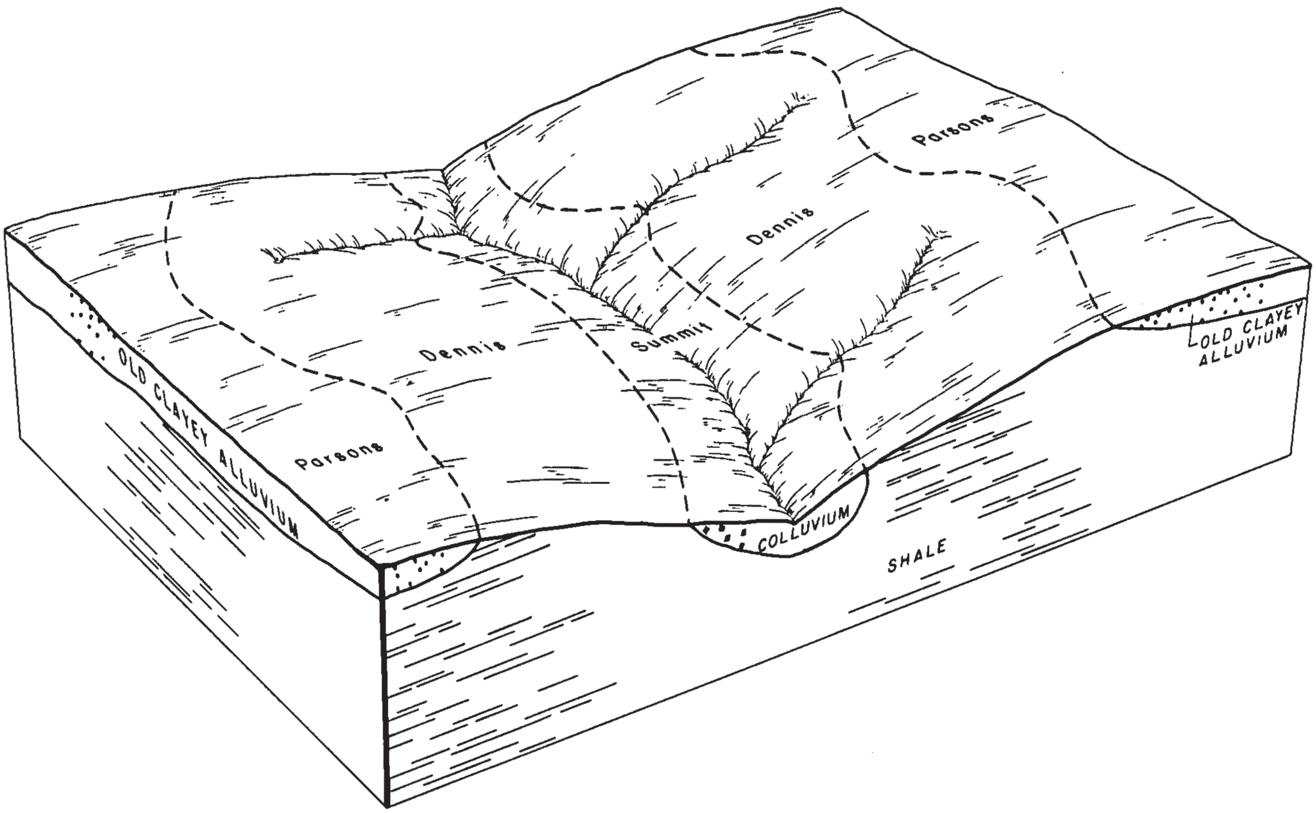


Figure 3.—Typical pattern of soils in the Dennis-Parsons association.

gray, mottled, extremely firm silty clay. The substratum to a depth of about 60 inches is gray, mottled clay.

The deep, somewhat poorly drained Lanton soils formed in silty alluvium on flood plains. The surface soil is very dark grayish brown silt loam about 14 inches thick. The next layer is dark grayish brown, mottled, friable silt loam about 24 inches thick. The substratum to a depth of about 60 inches is dark grayish brown, mottled silt loam in the upper part and very dark gray, mottled silty clay loam in the lower part.

Of minor extent in this association are Hepler, Mason, and Summit soils. The somewhat poorly drained Hepler soils are on stream terraces above the Verdigris soils. The well drained Mason soils are on rarely flooded terraces. The moderately well drained Summit soils are on foot slopes of adjacent uplands.

The soils in this association are used mainly for cultivated crops, but in some small areas they are used as pasture, woodland, and wildlife habitat. Corn, grain sorghum, soybeans, and small grain are the main crops. Flooding and wetness are the main management concerns.

5. Eram-Dennis-Bates association

Moderately deep and deep, gently sloping and moderately sloping, moderately well drained and well drained soils that have a clayey, silty, and loamy subsoil; on uplands

This association consists of soils on ridgetops and side slopes that are dissected by drainageways and creeks. The slope range is 1 to 8 percent.

This association makes up about 5 percent of the survey area. It is about 60 percent Eram soils, 15 percent Dennis soils, 10 percent Bates soils, and 15 percent soils of minor extent (fig. 4).

The moderately deep, moderately well drained Eram soils are on side slopes. These soils formed in material weathered from shale. The surface layer is very dark grayish brown silty clay loam about 9 inches thick. The subsoil is dark grayish brown, mottled, very firm silty clay about 18 inches thick. Clayey shale is at a depth of about 27 inches.

The deep, moderately well drained Dennis soils formed in residuum or colluvium from shale. These soils are on side slopes and foot slopes. The surface layer is dark brown silt loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark brown, mottled, firm silty clay loam; the middle part is yellowish brown, mottled, very firm silty clay; and the lower part is dark brown and yellowish brown, mottled, very firm silty clay.

The moderately deep, well drained Bates soils formed in residuum of sandstone and silty shale. These soils are on ridgetops and the upper part of side slopes. The surface layer is very dark brown loam about 10 inches thick. The subsoil is firm clay loam about 21 inches thick. The upper part is dark brown, and the lower part is brown. Fine-grained, acid sandstone is at a depth of about 31 inches.

Of minor extent in this association are Kenoma, Lebo, and Summit soils. The deep, clayey Kenoma soils are on ridgetops. The deep, clayey Summit soils are on side slopes and foot slopes. The moderately deep Lebo soils have a channery subsoil and are on side slopes.

The soils in this association are used mainly for range and pasture, but in some small areas they are used for cultivated crops. Tall fescue and bromegrass are the main grasses used for tame pasture. Erosion is a hazard. Maintaining and improving grass production and controlling erosion are concerns in management. Brush management is of particular concern.

6. Newtonia-Grundy association

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

This association consists of soils on ridgetops and side slopes that are dissected by drainageways. It occurs only in Miami County. The slope range is 0 to 8 percent.

This association makes up about 5 percent of the survey area. It is about 45 percent Newtonia soils, 40 percent Grundy soils, and 15 percent soils of minor extent (fig. 5).

The deep, well drained Newtonia soils formed in silty and clayey sediments. These soils are on ridgetops and side slopes. The surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is dark brown silt loam about 4 inches thick. The subsoil to a depth of about 60 inches consists of dark reddish brown, friable and firm silty clay loam in the upper part, reddish brown, very firm silty clay loam in the middle part, and yellowish red, very firm silty clay in the lower part.

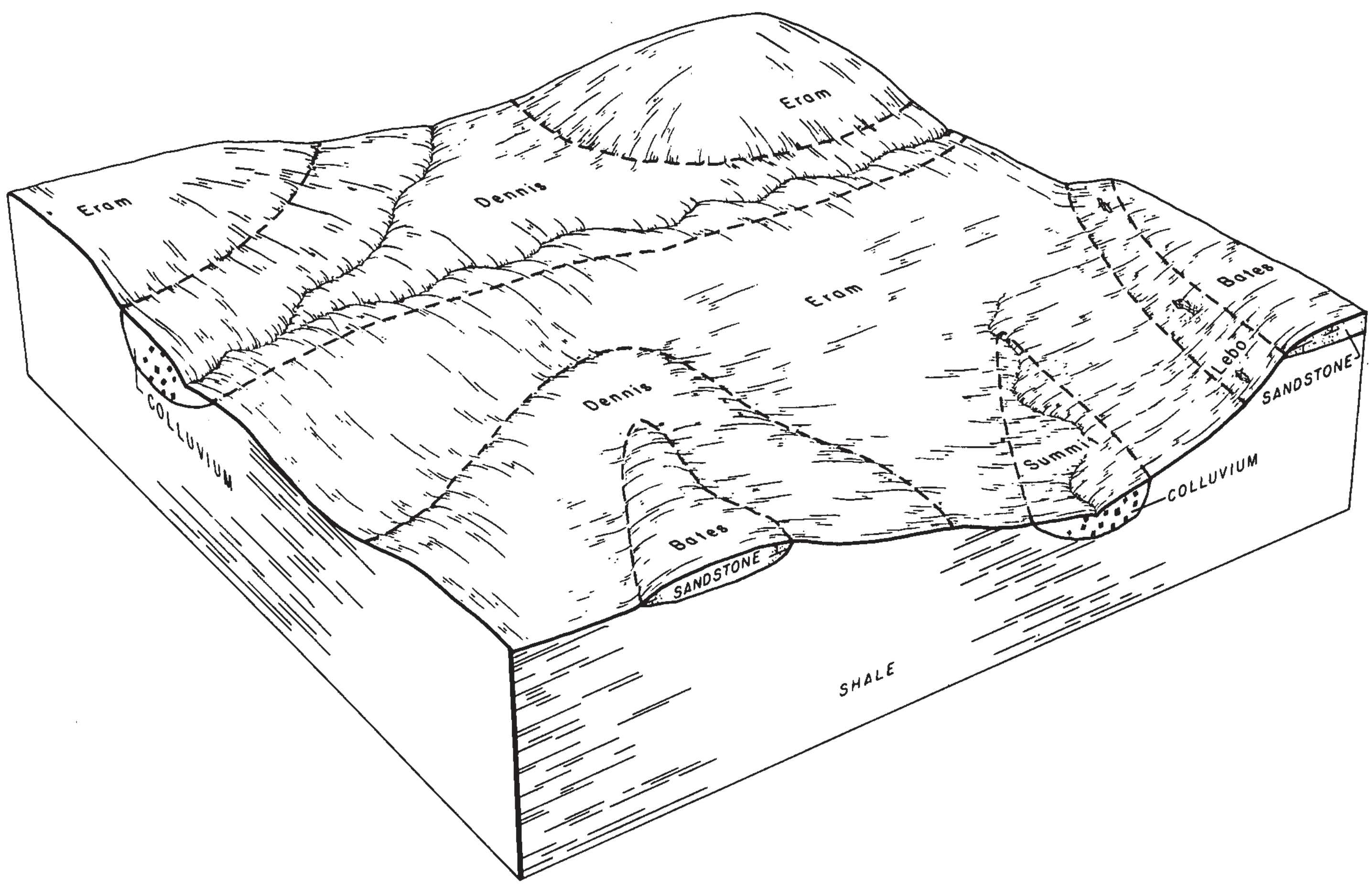


Figure 4.—Typical pattern of soils in the Eram-Dennis-Bates association.

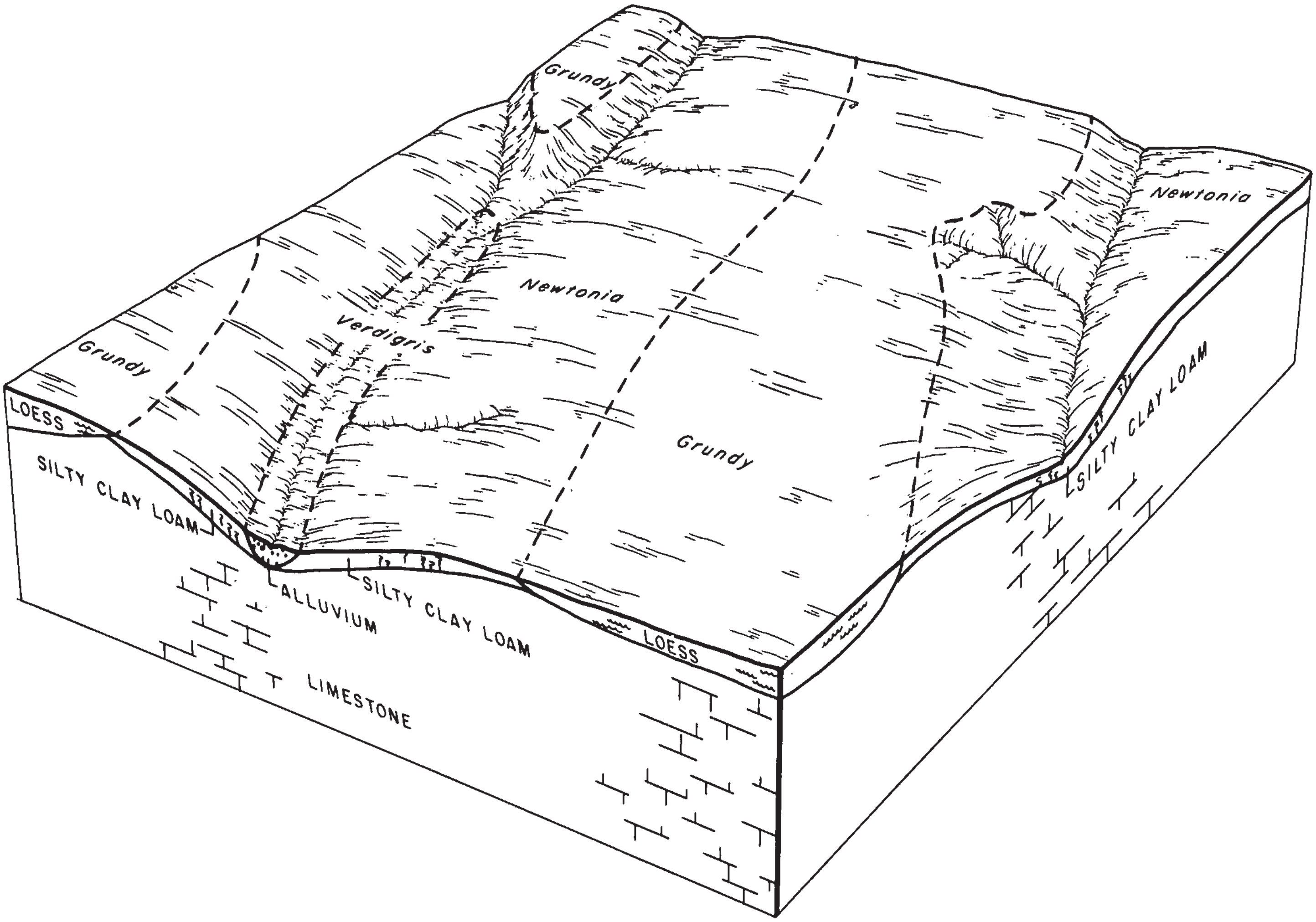


Figure 5.—Typical pattern of soils in the Newtonia-Grundy association.

The deep, somewhat poorly drained Grundy soils formed in loess. These soils are on broad ridgetops and on the upper part of side slopes. The surface layer is black silt loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is black, firm silty clay loam; the middle part is very dark gray and dark grayish brown, mottled, very firm silty clay; and the lower part is olive brown and grayish brown, mottled, very firm silty clay.

Of minor extent in this association are Catoosa, Verdigris, and Woodson soils. The moderately deep Catoosa soils are on narrow ridgetops. The deep Woodson soils are in nearly level areas. The deep, moderately well drained Verdigris soils are on flood plains along drainageways.

The soils in this association are used mainly for cultivated crops and pasture. Corn, grain sorghum, soybeans, and small grain are the main crops. Water erosion is a hazard in the gently sloping and moderately sloping areas. Controlling erosion and maintaining soil tilth and fertility are concerns in management.

Urban expansion is occurring in this association.

detailed soil map units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and management of the soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Osage silty clay is one of several phases in the Osage series.

Some map units are made up of two or more major soils. These map units are called *soil complexes*. A soil complex consists of two or more soils that occur as areas so intricately mixed or so small that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Eram-Lebo silty clay loams, 5 to 20 percent slopes, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. These dissimiliar soils are described in each map unit. Also, some of the more unusual or strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes some *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, quarries, is an example. Some miscellaneous areas are large enough to be delineated on the soil maps. Some that are too small to be delineated are identified by a special symbol on the soil maps.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

soil descriptions

Bb—Bates loam, 1 to 4 percent slopes. This soil is moderately deep, gently sloping, and well drained. It is on ridgetops and short side slopes. Areas are irregular in shape and range from 20 to 300 acres in size.

Typically, the surface layer is very dark brown loam about 10 inches thick. The subsoil is firm clay loam about 21 inches thick. The upper part of the subsoil is dark brown, and the lower part is brown. Fine-grained, acid sandstone is at a depth of about 31 inches.

Included in mapping, and making up about 10 percent of the map unit, are small areas of sandstone outcrop and Dennis and Eram soils. The deep, moderately well drained Dennis soils are on higher positions. The moderately well drained Eram soils are on foot slopes. They are more clayey than the Bates soil. Sandstone crops out in the steeper areas.

Permeability is moderate, and surface runoff is medium. The available water capacity is moderate. The organic-matter content also is moderate. The surface layer is friable and is easily tilled. Root development is restricted by the sandstone at a depth of about 31 inches. Reaction in the surface layer and the upper part of the subsoil is strongly acid.

In most areas this soil is used for cultivated crops or tame grass pasture. It is suited to soybeans, small grain, grain sorghum, and grasses for hay or pasture, such as bromegrass and tall fescue. It is poorly suited to corn and alfalfa because of the seasonal droughtiness and the moderate available water capacity. If cultivated crops are grown, erosion is a hazard. Contour farming, minimum tillage, winter cover crops, terraces, and waterways help to prevent excessive soil loss. Returning crop residue to the surface or the regular addition of organic material helps to improve fertility and to increase water infiltration.

The use of this soil for pasture or hay also helps to control erosion. Overgrazing, however, reduces plant vigor and increases runoff. Proper stocking, fertilization, pasture rotation, and timely deferment of grazing help to keep the pasture and the soil in good condition.

The use of this soil as a site for dwellings with basements is moderately limited by the depth to rock. In most places, the rock can be excavated without difficulty.

The use of this soil as a site for local roads and streets is moderately limited by the low strength of the soil. Strengthening or replacing the base material helps to offset this limitation.

This soil is generally not suited to use as septic tank absorption fields or sewage lagoons because of the depth to rock. The included soils that are deeper are better suited to sewage lagoons.

This map unit is in capability subclass IIe.

Bc—Bates loam, 4 to 8 percent slopes. This soil is moderately deep, moderately sloping, and well drained. It is on side slopes. Areas are long and narrow and range from 20 to 100 acres.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsoil is firm clay loam about 24 inches thick. The upper part of the subsoil is dark brown, and the lower part is brown. Fine-grained, acid sandstone is at a depth of about 31 inches. In some places on the steeper slopes, part of the subsoil has been mixed with the original surface layer by plowing. In some places, the soil is less than 20 inches deep to bedrock.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Dennis, Eram, and Lebo soils and sandstone outcrop. The deep, moderately well drained Dennis soils and the moderately deep, moderately well drained Eram soils are on the lower part of foot slopes. The moderately deep, well drained Lebo soils have a shaly silty clay loam subsoil and occur in narrow bands on the steeper slopes. Sandstone crops out throughout the map unit.

Permeability is moderate, and surface runoff is medium. The available water capacity is moderate. The organic-matter content is moderate. The surface layer is friable and is easily tilled. Root development is restricted by the sandstone at a depth of about 31 inches. Reaction in the surface layer and the upper part of the subsoil is strongly acid.

In most areas this soil is used for cultivated crops or tame grass pasture. In a few areas it is used as rangeland. This soil is suited to small grain and cool-season grasses. It is poorly suited to corn, alfalfa, grain sorghum, and soybeans. If cultivated crops are grown, erosion is a hazard. Minimum tillage, winter cover crops, terraces, and waterways help to prevent excessive soil loss. Returning crop residue to the surface and the addition of other organic material help to maintain fertility.

The use of this soil for pasture also helps to control erosion. Overgrazing reduces plant vigor and increases runoff. Proper stocking, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The use of this soil as a site for dwellings with basements is moderately limited by the depth to rock. In most places, the rock can be excavated without difficulty.

The use of this soil as a site for local roads and streets is moderately limited by the low strength of the soil. Strengthening or replacing the base material helps to offset this limitation.

This soil is generally not suited to use as septic tank absorption fields or sewage lagoons because of the depth to rock. The included soils that are deeper and are on foot slopes are better suited to sewage lagoons.

This map unit is in capability subclass IIIe.

Cb—Catoosa silt loam, 1 to 3 percent slopes. This moderately deep, gently sloping, well drained soil is on convex ridgetops and side slopes. Areas are irregular in shape and range from 10 to more than 600 acres in size.

Typically, the surface soil is dark brown silt loam about 12 inches thick. The subsoil is about 17 inches thick. The upper part of the subsoil is dark reddish brown, firm and very firm silty clay loam. The lower part is dark red, very firm silty clay. Limestone is at a depth of about 29 inches. In some places, the subsoil is thicker and the depth to limestone is more than 40 inches. In some places, the soil is cherty.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Clareson, Eram, Kenoma, and Summit soils. The Clareson soils have a flaggy silty clay subsoil, and they are in narrow bands, typically on mid-slope positions. The moderately well drained Eram and Summit soils are on foot slopes. The deep, moderately well drained, more clayey Kenoma soils are on ridgetops. Rock outcrop is in isolated areas.

Permeability is moderate in the upper part of the subsoil and is moderately slow in the lower part. Surface runoff is medium. The available water capacity and the organic-matter content are moderate. The surface layer is friable and is easily tilled. The subsoil has moderate shrink-swell potential. Root development is restricted by the hard limestone at a depth of about 29 inches. Reaction in the surface layer and the upper part of the subsoil is slightly acid and medium acid.

In most areas this soil is used as cultivated cropland or tame grass pasture. In a few areas it is used as rangeland. This soil is suited to small grain, grain sorghum, soybeans, and grasses for hay or pasture. It is poorly suited to corn or alfalfa because of seasonal droughtiness. If cultivated crops are grown, erosion is a hazard. Minimum tillage, winter cover crops, contour farming, terraces, and waterways help to prevent excessive soil loss. Returning crop residue to the surface or the regular addition of organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture helps to control erosion. This soil is well suited to bromegrass. Proper stocking, fertilization, pasture rotation, and timely deferment of grazing help to keep the grass and the soil in good condition. In many areas the resting or reseeding of pasture and brush control are needed to help improve the grass condition.

The use of this soil as a site for dwellings without basements is moderately limited by the depth to rock and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage to dwellings caused by the shrinking and swelling.

The use of the soil as a site for local roads and streets is severely limited by the low strength of the soil material. Strengthening or replacing the base material can help to overcome this limitation.

The soil is not suited to use as septic tank absorption fields or to use as sewage lagoons. The moderate depth to rock is a severe limitation to those uses. The included soils that are deeper and are on foot slopes or ridgetops are more suitable for sewage lagoons.

This map unit is in capability subclass IIe.

Cm—Clareson-Rock outcrop complex, 2 to 15 percent slopes. This complex consists of moderately deep, well drained soils and Rock outcrop on ridgetops and side slopes. The soils are gently sloping to strongly sloping. Areas are typically long and narrow and range from 5 to more than 600 acres.

This complex is about 60 to 80 percent Clareson soils and 10 to 20 percent Rock outcrop. The Clareson soils are typically on the ridgetops. Rock outcrop is on the ridge breaks and the lower part of side slopes.

Typically, the Clareson soils have a surface soil that is very dark brown silty clay loam about 11 inches thick. The subsoil is about 22 inches thick. The upper part of the subsoil is dark reddish brown, firm, flaggy silty clay loam; the middle part is dark reddish brown, very firm flaggy silty clay; and the lower part is dark reddish brown and reddish brown, very firm flaggy silty clay. Limestone is at a depth of about 33 inches (fig. 6). In some places, it is at a depth of 10 to 20 inches.

Typically, the Rock outcrop is exposed limestone. It is fractured and platy or rounded and massive.

Included in mapping, and making up about 20 percent of this complex, are small areas of Catoosa, Eram, Lebo, and Summit soils and soils that are less than 10 inches deep to bedrock. The moderately deep, well drained, less clayey Catoosa soils are on narrow ridgetops above the Clareson soils. The moderately deep, moderately well drained Eram soils and the deep, moderately well drained Summit soils are on foot slopes. The moderately

Figure 6.—This profile of Clareson silty clay loam shows the flaggy silty clay subsoil. This Clareson soil is the major upland soil in the survey area. Depth is marked in feet.

deep, well drained, less clayey Lebo soils are on the steeper side slopes.

The Clareson soils have moderately slow permeability and low available water capacity. Surface runoff is medium, and the content of organic matter is moderate. Root development is restricted to a depth of about 30 inches. The shrink-swell potential in the subsoil is moderate. Reaction in the surface layer and upper part of the subsoil is slightly acid.

The Clareson soils are used mainly for range and tame grass pasture. In some of the less rocky areas, they have been cleared of brush and seeded to tame grasses.

These soils are best suited to rangeland. The major concerns of management are the hazard of erosion, the low available water capacity, and the brush and trees.

Overgrazing reduces the growth and vigor of the grasses and increases runoff and growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help keep the range in good condition. Potential pond sites are limited to a few areas of included soils where clayey material is available for construction.

The Clareson soils are generally not suited to use as sites for dwellings with basements. The moderate depth to rock and the large stones are severe limitations to this use.

The use of the soils as sites for local roads and streets is severely limited by the low strength of the soil material and by the large stones. Strengthening or replacing the base material can help to overcome these limitations.

The soils are not suited to use as septic tank absorption fields or to use as sites for sewage lagoons. The moderate depth to rock and the large stones are severe limitations to these uses. The included soils that are deeper and less sloping and are on foot slopes are more suitable for sewage lagoons.

This complex is in capability subclass VIe.

De—Dennis silt loam, 1 to 3 percent slopes. This soil is deep, gently sloping, and moderately well drained. It is on upland divides, side slopes, and foot slopes. Areas are irregular in shape and range from 10 to more than 100 acres in size.

Typically, the surface layer is dark brown silt loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark brown, mottled, firm silty clay loam; the middle part is yellowish brown, mottled, very firm silty clay; and the lower part is dark brown and yellowish brown, mottled, very firm silty clay. In some places, the subsoil is redder and is less clayey than is typical. In some places, the surface layer is thinner and is lighter colored.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Bates, Eram, and Kenoma soils. The well drained Bates soils and the moderately well drained Eram soils are moderately deep. They are on the lower part of foot slopes. The deep Kenoma soils, on ridgetops, are clayey in the upper part of the subsoil.

Permeability is slow, and surface runoff is medium. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. This soil has high shrink-swell potential. A perched water table is at a depth of 2 to 3 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is strongly acid.

In most areas this soil is used for cultivated crops. In a few areas it is used for tame grass pasture. It is suited to small grain, legumes, grain sorghum, soybeans, corn, and tame grasses for hay or pasture. If cultivated crops are grown, erosion is a hazard. Contour farming, terraces, waterways, minimum tillage, and returning crop residue to the surface help to prevent excessive soil loss.

The use of this soil for pasture can also help to control erosion. This soil is well suited to bromegrass and tall fescue. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and excessive runoff. Proper stocking, fertilization, pasture rotation, and deferred grazing help to keep the grass and the soil in good condition.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential of the soil material. Strengthening or replacing the base material helps to offset these limitations.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and wetness. It is moderately limited for use as sewage lagoons because of the gentle slope. The less sloping sites are more favorable for sewage lagoons.

This map unit is in capability subclass IIe.

Df—Dennis silt loam, 3 to 6 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on side slopes and foot slopes. Areas are irregular in shape and range from 5 to 60 acres in size.

Typically, the surface layer is dark brown silt loam about 10 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark brown, mottled, firm silty clay loam; the middle part is yellowish brown, mottled, very firm silty clay; and the lower part is dark brown and yellowish brown, mottled, very firm silty clay. In some places, because plowing has mixed the upper part of the subsoil with the original surface layer, the present surface layer is silty clay loam. In some places, the soil has a subsurface layer of light brownish gray or light gray silt loam.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Bates, Eram, and Kenoma soils. The Bates and Eram soils are on side slopes. The well drained, less clayey Bates soils are moderately deep over sandstone. The moderately well drained Eram soils are moderately deep over shale. Kenoma soils are clayey in the upper part of the subsoil and are on similar landscapes.

Permeability is slow, and surface runoff is medium. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential is high. A perched water table is at a depth of 2 to 3 feet from December to

April in most years. Reaction in the surface layer and the upper part of the subsoil is strongly acid.

In most areas this soil is used for cultivated crops or is seeded to tame grasses for hay and pasture. It is suited to small grain, grain sorghum, legumes, soybeans, corn, and tame grasses. If cultivated crops are grown, erosion is a hazard. Terraces, waterways, contour farming, minimum tillage, and returning crop residue to the surface help to prevent excessive soil loss.

The use of this soil for pasture also helps to control erosion. This soil is well suited to bromegrass and tall fescue. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and excessive runoff. Proper stocking, fertilization, pasture rotation, and deferred grazing help to keep the grass and the soil in good condition.

The use of this soil as rangeland also helps to control erosion. Overgrazing reduces the growth and vigor of the grasses, and it increases runoff and the growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition. Reseeding may be needed to establish desirable mid and tall grasses.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential of the soil. Strengthening or replacing the base material helps to offset these limitations.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and the wetness. It is moderately limited for use as sewage lagoons because of the slope. The less sloping sites are more favorable for sewage lagoons.

This map unit is in capability subclass IIIe.

Ec—Eram silty clay loam, 1 to 4 percent slopes. This soil is moderately deep, gently sloping, and moderately well drained. It is on ridgetops and side slopes. Areas are irregular in shape and range from 5 to more than 80 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 10 inches thick. The subsoil is dark grayish brown, mottled, very firm silty clay about 20 inches thick. Clayey shale is at a depth of about 30 inches. In some areas, because the upper part of the subsoil has been mixed with the original surface layer by plowing, the surface layer is dark grayish brown silty clay. In some places, the soil is cherty. In places, the subsoil is calcareous.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Bates, Catoosa, Dennis, and Summit soils. The well drained, less clayey Bates and Catoosa soils are in narrow bands on side slopes. The deep Dennis and Summit soils are adjacent to drainageways on foot slopes.

Permeability is slow, and surface runoff is medium. The available water capacity is low. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential is high. Root development is restricted by clayey shale at a depth of 27 inches. A perched water table is at a depth of 2 to 3 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is slightly acid.

In most areas this soil is used for cultivated crops or tame grass pasture. In a few areas it is used as rangeland. This soil is well suited to small grain, grain sorghum, soybeans, and grasses for hay or pasture. It is poorly suited to corn and alfalfa because of seasonal droughtiness. If the soil is used for cultivated crops, erosion is a hazard. Minimum tillage, winter cover crops, contour farming, terraces, and waterways help to prevent excessive soil loss. Returning crop residue to the surface or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture can help to control erosion. Proper stocking, fertilization, pasture rotation, and timely deferment of grazing help to keep the soil in good condition.

The use of this soil for range can also help to control erosion. Overgrazing reduces the growth and vigor of the grasses and increases runoff and the growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition. Reseeding may be needed to establish desirable mid and tall grasses.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential of the soil. Strengthening or replacing the base material helps to offset these limitations.

This soil is generally not suited to use as septic tank absorption fields because of the depth to rock, the slow permeability, and the wetness. The soil is severely limited for use as sewage lagoons because of the depth to rock. The included soils that are deeper, less sloping, and on foot slopes are more suitable for sewage lagoons.

This map unit is in capability subclass IIIe.

Ed—Eram silty clay loam, 4 to 8 percent slopes. This soil is moderately deep, moderately sloping, and moderately well drained. It is on ridgetops and side slopes. Areas are irregular in shape and range from 10 to more than 80 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 9 inches thick. The subsoil is dark grayish brown, mottled, very firm silty clay about 18 inches thick. Clayey shale is at a depth of about 27 inches. In some places, the surface layer is dark grayish brown silty clay because the upper part of the subsoil has been mixed with the original surface layer by plowing. In some places, the soil is cherty. In places, the subsoil is calcareous.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Bates, Dennis, Lebo, and Summit soils. The well drained, less clayey Bates and Lebo soils occur on ridgetops or in narrow bands on side slopes. The deep Dennis and Summit soils are adjacent to drainageways on foot slopes.

Permeability is slow, and surface runoff is medium. The available water capacity is low. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential is high. Root development is restricted by the clayey shale at a depth of about 27 inches. A perched water table is at a depth of 2 to 3 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is slightly acid.

In most areas this soil is used for tame grass pasture or native grass. In a few small areas it is used for cultivated crops. This soil is suited to small grain and grasses for hay or pasture. It is poorly suited to corn, grain sorghum, soybeans, and alfalfa because of seasonal droughtiness. If the soil is used for cultivated crops, erosion is a hazard. Minimum tillage, close-growing crops, winter cover crops, contour farming, and terrace systems with protected outlets help to prevent excessive soil loss. Returning crop residue to the surface or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture can help to control erosion. Proper stocking, fertilization, pasture rotation, and timely deferment of grazing help to keep the soil and the grass in good condition.

The use of this soil for range also helps to control erosion. Overgrazing reduces the growth and vigor of the grasses, and it increases runoff and the growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition. Reseeding may be needed to establish desirable mid and tall grasses.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential. Strengthening or replacing the base material helps to offset these limitations.

This soil is generally not suited to use as septic tank absorption fields because of the depth to rock, the slow permeability, and the wetness. The soil is severely limited for use as sewage lagoons because of the depth to rock. The included soils that are deeper, less sloping, and on foot slopes are more suitable for sewage lagoons.

This map unit is in capability subclass IVe.

Ef—Eram-Lebo silty clay loams, 5 to 20 percent slopes. This complex consists of moderately deep, moderately sloping to moderately steep soils. The soils are on side slopes, and they are moderately well drained and well drained. Areas are irregular in shape and range from 20 to more than 400 acres in size.

This complex is about 50 to 60 percent Eram silty clay loam and 30 to 40 percent Lebo silty clay loam. The Eram soil is on the less sloping, lower part of side slopes and foot slopes, and the Lebo soil is on the more sloping upper part of side slopes.

Typically, the Eram soil has a surface layer that is very dark grayish brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown, mottled, very firm silty clay about 19 inches thick. In most places, clayey shale is at a depth of about 27 inches. In some places, it is at a depth of more than 40 inches. In some places, the subsoil is calcareous.

Typically, the Lebo soil has a surface soil that is very dark grayish brown silty clay loam about 12 inches thick. The subsoil is about 16 inches thick. The upper part of the subsoil is dark grayish brown, friable channery silty clay loam, and the lower part is grayish brown, friable shaly silty clay loam. The substratum, which extends to a depth of about 38 inches, is grayish brown shaly silty clay loam. Silty shale is at a depth of about 38 inches. In some places, the surface layer is stony silty clay loam. Also, in some places, the subsoil is clay loam and is underlain by sandstone.

Included in mapping, and making up about 15 to 25 percent of the complex, are small areas of Clareson and Dennis soils. The flaggy Clareson soils are on the upper part of side slopes and ridgetops and are well drained. The deep Dennis soils are on foot slopes and are moderately well drained. Limestone and sandstone crop out in the steeper areas.

Permeability is slow in the Eram soil and is moderate in the Lebo soil. Surface runoff is rapid. The Eram soil has a perched water table at a depth of 2 to 3 feet in most years. The shrink-swell potential of the subsoil is high in the Eram soil and moderate in the Lebo soil. The available water capacity is low, and the organic-matter content is moderate. The root zone extends to shale bedrock. Reaction in the surface layer is slightly acid for the Eram soil and neutral for the Lebo soil.

On most of the acreage, the soils are used as rangeland. In some of the less rocky areas, they have been cleared of brush and have been seeded to tame grass, mainly tall fescue. In a few small areas they have been farmed but are now used for tame grass pasture.

The soils are best suited to range. In most areas the range is in fair to poor condition. In many areas brush and trees have invaded. The major concerns of range management are the low available water capacity of the soil, the hazard of erosion, and seasonal droughtiness. Maintaining a good vegetative cover and proper stocking can help to reduce soil loss. Proper stocking, uniform grazing, timely deferment of grazing, and brush management help to keep the grass and the soil in good condition. The number of potential pond sites is adequate.

The use of the Eram soil as a site for dwellings with basements is severely limited by the wetness and shrink-swell potential. The Lebo soil is severely limited for that use by the slope. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of the Eram soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential. The Lebo soil is severely limited by the low strength and the slope. Strengthening or replacing the base material can partly offset the low strength and the shrinking and swelling.

The Eram and Lebo soils are generally not suited to use as septic tank absorption fields. The moderate depth to rock is a severe limitation. The Eram soils are also limited by the wetness and the slow permeability, and Lebo soils are also limited by the slope.

The use of the soils as sites for sewage lagoons is severely limited by the moderate depth to rock and the slope. The deeper, less sloping soils on foot slopes are more suitable for sewage lagoons.

This complex is in capability subclass VIe.

Gc—Grundy silt loam, 1 to 3 percent slopes. This soil is deep, gently sloping, and somewhat poorly drained. It is on ridgetops. Areas are irregular in shape and range from 10 to more than 800 acres in size.

Typically, the surface layer is black silt loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is black, firm silty clay loam; the middle part is very dark gray and dark grayish brown, mottled, very firm silty clay; and the lower part is olive brown and grayish brown, mottled, very firm silty clay. In some places, the upper part of the subsoil is clayey. In places, the surface layer is silty clay loam.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Kenoma and Newtonia soils. The Kenoma soils are on the adjacent uplands. They are browner than the Grundy soil and are moderately well drained. The Newtonia soils are on the steeper part of side slopes. They are less clayey than the Grundy soil and are well drained.

Permeability is slow, and surface runoff is medium. The available water capacity is moderate. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has high shrink-swell potential. A perched water table is at a depth of 1 to 3 feet from March to May in most years. Reaction in the surface layer and the upper part of the subsoil is medium acid to neutral.

In most areas this soil is used for cultivated crops. It is well suited to small grain, grain sorghum, corn, soybeans, and alfalfa. If it is used for cultivated crops, erosion is a hazard. Terraces, waterways, contour farming, returning crop residue to the surface, and minimum tillage help to reduce erosion and to maintain the organic-matter content and good tilth.

The use of this soil for pasture also helps to control erosion. This soil is well suited to bromegrass. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and excessive runoff. Proper stocking, fertilization, pasture rotation, and deferred grazing help to keep the grass and the soil in good condition.

The use of this soil as a site for dwellings with basements is severely limited by the wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage to buildings caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential. Strengthening or replacing the base material can help to overcome these limitations.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and wetness. It is moderately limited for use as sewage lagoons because of the slope. The less sloping sites are more favorable for sewage lagoons.

This map unit is in capability subclass IIe.

Hp—Hepler silt loam. This soil is deep, nearly level, and somewhat poorly drained. It is on terraces along small creeks and drainageways, and it is occasionally flooded for brief periods. Areas are irregular in shape and range from 5 to 60 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is mottled dark grayish brown and pale brown silt loam about 16 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark grayish brown, mottled, firm silty clay loam; the middle part is strong brown, coarsely mottled, firm silty clay loam; and the lower part is grayish brown, coarsely mottled, very firm silty clay loam. In some places, the surface layer is lighter colored, and in places, the subsurface layer is darker colored.

Included in mapping, and making up about 10 percent of the map unit, are small areas of the Mason soils. These well drained soils have a darker surface layer than the Hepler soil and are on terraces that are rarely flooded.

Permeability is moderately slow, and the available water capacity is high. Surface runoff is slow. The organic-matter content is moderately low. The surface layer is friable and is easily tilled. It is slightly acid to strongly acid. An apparent water table is at a depth of 1 to 3 feet from November to March in most years. The shrink-swell potential of the subsoil is moderate.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture or woodland. This soil is well suited to small grain, grain sorghum, corn, and soybeans. The hazard of flooding and wetness are limitations to the use of the soil for cultivated crops. Some areas have been protected from flooding by dikes. Crops are sometimes damaged when the soil is saturated with water during the growing season. Drainage ditches can help to reduce wetness. Minimum tillage and returning crop residue to the surface help to maintain good tilth and to increase moisture infiltration.

This soil is also well suited to pasture. It receives extra moisture when the water table is high for support of vigorous growth of grasses. On pastureland, proper stocking, uniform grazing distribution, and timely fertilization help to keep the pasture and the soil in good condition. This soil is well suited to reed canarygrass.

This soil is well suited to trees, and a few small areas remain in native hardwoods. It is moderately limited for use as woodland because of plant competition. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling can control the undesirable vegetation.

This soil is generally not suited to use as a site for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding is a severe limitation, and it is difficult to overcome without major control measures.

This map unit is in capability subclass IIw.

Ke—Kenoma silt loam, 1 to 4 percent slopes. This soil is deep, gently sloping, and moderately well drained. It is on ridgetops, knolls, and side slopes. Areas are irregular in shape and range from 10 to more than 400 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 10 inches thick. The subsoil is about 48 inches thick. The upper part is very dark grayish brown, firm silty clay; the middle part is dark yellowish brown, mottled, very firm silty clay; and the lower part is dark brown, mottled, very firm silty clay. The substratum to a depth of about 60 inches is pale brown, coarsely mottled silty clay. In some places, because the upper part of the subsoil has been mixed with the original surface layer by plowing, the surface layer is silty clay loam. In some places, the subsoil is grayer.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Catoosa, Dennis, and Eram soils. These soils and the Kenoma soil are in similar positions on the landscape. The Catoosa soils are moderately deep to limestone. They are less clayey than the Kenoma soil and are well drained. The Dennis soils are less clayey in the upper part of the subsoil than the Kenoma soil. The Eram soils are moderately deep to shale.

Permeability is very slow, and surface runoff is medium. The available water capacity is moderate. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has high shrink-swell potential. Reaction in the surface layer and the upper part of the subsoil is slightly acid.

In most areas this soil is used for cultivated crops and tame grass pasture. In a few areas it is in native grass. This soil is well suited to small grain, grasses, grain sorghum, soybeans, and alfalfa. It is poorly suited to corn because of the seasonal droughtiness. The silty clay subsoil does not release water readily, and crop yields are reduced during long dry periods. If this soil is used for cultivated crops, erosion is a hazard. Contour farming, minimum tillage, terraces, waterways, and improved cropping systems help to prevent excessive soil loss. Returning crop residue to the surface and the addition of other organic matter to the soil help to maintain the fertility and tilth.

The use of this soil for pasture is also very effective in erosion control. Overgrazing or haying and grazing when the soil is wet, however, cause surface compaction, excessive runoff, and poor tilth. Proper stocking, pasture rotation, fertilization, timely deferment of grazing, and restricted use during wet periods help to keep the soil and the grass in good condition.

The use of this soil for range also helps to control erosion. Overgrazing reduces the growth and vigor of the grasses, and it increases runoff and the growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition. Reseeding may be needed to establish desirable mid and tall grasses.

The use of this soil as a site for dwellings is severely limited by the shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage to buildings caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and shrink-swell potential. Strengthening or replacing the base material can help to overcome these limitations.

This soil is severely limited for use as septic tank absorption fields because of the very slow permeability. It is moderately limited for use as sewage lagoons because of the slope. The less sloping sites are more suitable for sewage lagoons.

This map unit is in capability subclass IIIe.

La—Lanton silt loam. This soil is deep, nearly level, and somewhat poorly drained. It is on flood plains along major streams and small creeks. It is occasionally flooded. Areas are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface soil is very dark grayish brown silt loam about 14 inches thick. The next layer is dark grayish brown, mottled, friable silt loam about 24 inches thick. The upper part of the substratum is dark grayish brown, mottled silt loam. The lower part is very dark gray, mottled silty clay loam to a depth of about 60 inches. In some places, the surface soil is thicker and is not mottled. In some places, the substratum is clayey.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Osage soils. The poorly drained Osage soils are in the swales and backwater areas. These soils are more clayey than the Lanton soil.

Permeability is moderately slow, and the available water capacity is high. Surface runoff is slow. An apparent water table is at a depth of 1 to 2 feet from January to June in most years. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential of the subsoil is moderate. Reaction in the surface layer is slightly acid or neutral.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture or woodland. This soil is well suited to corn, soybeans, and grain sorghum. It is poorly suited to small grain and alfalfa because of seasonal wetness and flooding. The hazard of flood damage and wetness are limitations to the use of the soil for cultivated crops. Drainage ditches help to reduce wetness. Minimum tillage and returning crop residue to the surface help to maintain good tilth and increase moisture infiltration.

This soil is well suited to pasture and range. It receives extra moisture from a water table. Overgrazing reduces the growth and vigor of grasses, and it increases the growth of weeds and brush. Proper stocking, uniform grazing distribution, fertilization, deferred grazing, and brush management help to keep the range and the pasture in good condition. This soil is well suited to reed canarygrass.

This soil is well suited to trees, and a few small areas remain in native hardwoods. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling can control the undesirable vegetation.

This soil is generally unsuitable for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding is a severe limitation. It is difficult to overcome without use of major control measures.

This map unit is in capability subclass IIw.

Lb—Lebo channery silty clay loam, 15 to 30 percent slopes. This soil is moderately deep, steep, and well drained. It is on side slopes. Areas are long and narrow and range from 20 to several hundred acres.

Typically, the surface soil is very dark grayish brown channery silty clay loam about 11 inches thick. The subsoil is about 17 inches thick. The upper part of the subsoil is dark grayish brown, friable channery silty clay loam, and the lower part is grayish brown, friable shaly silty clay loam. The substratum is grayish brown shaly silty clay loam. Silty shale is at a depth of about 38 inches (fig. 7). In some places, the surface soil is stony silty clay loam, and in some places, the subsoil is clay loam that is underlain by sandstone.

Included in mapping, and making up 10 to 15 percent of the map unit, are small areas of Clareson and Eram soils and limestone and shale outcrops. The moderately deep, flaggy Clareson soils are on the upper part of side slopes. The moderately deep, moderately well drained Eram soils are on foot slopes. Limestone and shale crop out on the steeper slopes.

Permeability is moderate. The available water capacity is moderate, and surface runoff is rapid. The subsoil has moderate shrink-swell potential. Root development is restricted to a depth of about 38 inches. The surface layer is neutral, and it has moderate organic-matter content.

In most areas this soil is used as range. In a few small areas, it has been cleared and seeded to tame grasses.

This soil is well suited to range. The major concerns of management are the hazard of erosion and the moderate available water capacity of the soil. Overgrazing reduces the growth and vigor of the grasses, and it increases runoff and the growth of brush and trees. Maintaining an adequate vegetative cover can help to reduce runoff, prevent encroachment of brush, and reduce excessive soil and water losses. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition.

This soil is generally not suited to use as sites for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons because of the steep slope.

This map unit is in capability subclass VIe.

Mb—Mason silt loam. This soil is deep, nearly level, and well drained. It is on stream terraces that are rarely flooded. Areas are irregular in shape and range from 5 to more than 100 acres in size.

Figure 7.—Profile of Lebo channery silty clay loam, 15 to 30 percent slopes.

Typically, the surface layer is very dark brown silt loam about 8 inches thick. The subsurface layer is very dark grayish brown silt loam about 10 inches thick. The subsoil is about 32 inches thick. It is very dark grayish brown, firm silty clay loam in the upper part and is dark brown, firm silty clay loam in the lower part. The substratum to a depth of about 60 inches is dark yellowish brown and dark gray silty clay loam.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Hepler, Osage, and Verdigris soils. The somewhat poorly drained Hepler soils are on lower terraces that are occasionally flooded. The poorly drained, clayey Osage soils are in swales and depressions. The moderately well drained Verdigris soils are on flood plains that are occasionally flooded. These soils are less clayey than the Mason soil.

Permeability is moderately slow, and surface runoff is slow. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. Reaction in the surface layer and the upper part of the subsoil is slightly acid. The shrink-swell potential in the subsoil is moderate.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture or woodland. This soil is well suited to small grain, grain sorghum, corn, soybeans, and alfalfa. The main concern of management is to maintain fertility and tilth. Minimum tillage, crop rotations, and returning crop residue to the surface help to maintain good tilth and fertility.

This soil is suited to trees, and a few small areas remain in native hardwoods. It is moderately limited by the seedling mortality and plant competition. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling helps to control undesirable vegetation.

The use of this soil for hay or pasture also helps to keep the soil in good condition. Proper stocking, fertilization, pasture rotation, and deferred grazing help to keep the soil and the grass in good condition.

This soil is severely limited for use as a site for dwellings because of the hazard of flooding. Dikes, levees, or other structures can reduce this hazard.

The use of this soil as a site for local roads and streets is severely limited because of the low strength. Strengthening or replacing the base material helps to offset this limitation.

This soil is severely limited for use as septic tank absorption fields because of the moderately slow permeability. Increasing the size of the absorption field helps to offset this limitation. This soil is suited to sewage lagoons.

This map unit is in capability class I.

Nf—Newtonia silt loam, 0 to 1 percent slopes. This soil is deep, nearly level, and well drained. It is on ridgetops and terraces. Areas are irregular in shape and range from 5 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 10 inches thick. The subsurface layer is dark brown silt loam about 4 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark reddish brown, friable and firm silty clay loam; the middle part is reddish brown, very firm silty clay loam; and the lower part is yellowish red, very firm silty clay. In some places, the depth to limestone is less than 60 inches. In some places, the upper part of the subsoil is silty clay. In places, it is dark brown.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Grundy and Kenoma soils. The somewhat poorly drained Grundy soils and the moderately well drained Kenoma soils have a more clayey subsoil than the Newtonia soil and are on ridgetops.

Permeability is moderate, and surface runoff is slow. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential in the subsoil is moderate. Reaction in the surface layer and the upper part of the subsoil is slightly acid and medium acid.

In most areas this soil is used for cultivated crops. It is well suited to small grain, corn, grain sorghum, soybeans, and grasses for hay or pasture. The main concern of management is to maintain fertility and tilth. Minimum tillage, returning crop residue to the surface, and the addition of other organic matter to the soil help to maintain good tilth and fertility.

The use of the soil for pasture or hay can also help to maintain a good soil condition. This soil is well suited to bromegrass. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

The use of this soil as a site for dwellings with basements is moderately limited by the shrink-swell potential. Using properly designed and reinforced walls and footings and backfilling with porous material help to reduce damage to buildings caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength of the soil. Strengthening or replacing the base material helps to offset this limitation.

This soil is moderately limited for use as septic tank absorption fields because of the moderate permeability. Increasing the size of the absorption field can improve the functioning of the septic system. This soil is moderately limited for use as sewage lagoons because of seepage. Sealing the lagoon helps to reduce seepage.

This map unit is in capability class I.

Ng—Newtonia silt loam, 1 to 4 percent slopes. This soil is deep, gently sloping, and well drained. It is on ridgetops and side slopes. Areas are irregular in shape and range from 5 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 10 inches thick. The subsurface layer is dark brown silt loam about 3 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark reddish brown, friable and firm silty clay loam; the middle part is reddish brown, very firm silty clay loam; and the lower part is yellowish red, very firm silty clay. In some places, the depth to limestone is less than 60 inches. In some places, the upper part of the subsoil is silty clay, and in places, it is dark brown.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Grundy and Welda soils. The somewhat poorly drained Grundy soils have a more clayey subsoil and are on ridgetops. The more clayey Welda soils have a lighter colored subsurface layer and are on ridgetops.

Permeability is moderate, and surface runoff is medium. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has moderate shrink-swell potential. Reaction in the surface layer and the upper part of the subsoil is slightly acid and medium acid.

In most areas this soil is used for cultivated crops. In some, it is used for tame grass pasture. It is well suited to small grain, corn, grain sorghum, soybeans, and tame grasses for hay or pasture. If it is used for cultivated crops, erosion is a hazard. Minimum tillage, returning crop residue to the surface, terraces, waterways, and contour farming help to prevent soil loss.

The use of this soil for pasture also helps to control erosion. This soil is well suited to bromegrass. Overgrazing or grazing when the soil is too wet, however, results in surface compaction, excessive runoff, and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the grass and the soil in good condition.

The use of this soil as a site for dwellings with basements is moderately limited by the shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength of the soil. Strengthening or replacing the base material helps to offset this limitation.

This soil is moderately limited for use as septic tank absorption fields because of the moderate permeability. Increasing the size of the absorption field can improve the functioning of the septic system.

This soil is moderately limited for use as sewage lagoons because of the slope and seepage. Sealing the lagoon helps to reduce seepage.

This map unit is in capability subclass IIe.

Nh—Newtonia silt loam, 4 to 8 percent slopes. This soil is deep, moderately sloping, and well drained. It is on side slopes and foot slopes. Areas are irregular in shape and range from 5 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsurface layer is dark brown silt loam about 4 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark reddish brown, friable silty clay loam; the middle part is reddish brown, very firm silty clay loam; and the lower part is yellowish red, very firm silty clay. In some places, the depth to limestone is less than 60 inches. In some places, because the upper part of the subsoil has been mixed with the original surface layer by plowing, the surface layer is dark reddish brown silty clay loam. In some places, the subsoil is dark brown.

Included in mapping, and making up about 15 percent of the map unit, are small areas of the Grundy soils. The somewhat poorly drained Grundy soils have a more clayey subsoil than the Newtonia soil and are on the upper part of side slopes.

Permeability is moderate, and surface runoff is medium. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has moderate shrink-swell potential. Reaction in the surface layer and the upper part of the subsoil is slightly acid and medium acid.

In most areas this soil is used for cultivated crops. In some areas it is in tame grass pasture. This soil is suited to small grain, grain sorghum, corn, soybeans, and tame grass for hay or pasture. If the soil is cultivated, erosion is a hazard. Minimum tillage, contour farming, terraces, and waterways help to prevent excessive erosion. Returning crop residue to the surface or the regular addition of other organic material helps to improve and maintain fertility, reduce crusting, and improve water infiltration.

The use of this soil for pasture can also help to control erosion. This soil is well suited to bromegrass. Overgrazing or grazing when the soil is too wet, however, results in increased runoff and erosion. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the grass and the soil in good condition.

The use of this soil as a site for dwellings with basements is moderately limited by the shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength. Strengthening or replacing the base material helps to offset this limitation.

This soil is moderately limited for use as septic tank absorption fields because of the moderate permeability. Increasing the size of the absorption field can improve the functioning of the septic system. This soil is moderately limited for use as sewage lagoons because of the slope and seepage. Sealing the lagoon helps to reduce seepage.

This map unit is in capability subclass IIIe.

Oh—Okemah silt loam, 0 to 3 percent slopes. This soil is deep, nearly level, and moderately well drained. It is on foot slopes and stream terraces. Areas are irregular in shape and range from 10 to 160 acres in size.

Typically, the surface soil is black silt loam about 12 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is very dark gray, firm silty clay loam; the middle part is very dark grayish brown and dark grayish brown, mottled, very firm silty clay; and the lower part is gray and dark yellowish brown, mottled, very firm silty clay. In some places, the surface soil is silty clay loam.

Included in mapping, and making up about 10 percent of the map unit, are small areas of the Woodson soils. These soils are on similar positions on the landscape. They are somewhat poorly drained, and they have a surface layer less than 9 inches thick.

Permeability and surface runoff are slow. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has high shrink-swell potential. This soil has a perched water table at a depth of 2 to 3 feet from March to June in most years. Reaction in the surface layer and the upper part of the subsoil is slightly acid or neutral.

In most areas this soil is used for cultivated crops. It is well suited to wheat, corn, grain sorghum, soybeans, and alfalfa. If it is used for cultivated crops, erosion is a hazard because of surface runoff from the adjoining soils. Contour farming, returning crop residue to the surface, and minimum tillage help to maintain the organic-matter content and good tilth. Diversions help to control surface runoff from adjoining soils. The soil is well suited to tame grass pasture. Both bromegrass and fescue do well if proper stocking and fertilization are used.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength of the soil material. Strengthening or replacing the base material helps to offset this limitation.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and the wetness. It is suitable for sewage lagoons.

This map unit is in capability class I.

Om—Orthents, hilly. This map unit is an area of moderately sloping to steep soils on uplands. This area was strip mined. It is irregular in shape and ranges from 4 to 1,000 acres in size. It is mainly in the Pleasanton and La Cygne area of Linn County. The slope range is 4 to 50 percent.

No one profile is typical of this map unit, but in many places, the soil material is olive brown and dark grayish brown shaly silty clay loam. In some places the texture is shaly silty clay or silty clay.

Included in mapping, and making up about 5 to 10 percent of the map unit, are areas of water, coal fragments, limestone, sandstone, and shale.

Surface runoff is rapid on the slopes and is ponded in low areas. The organic-matter content and the available water capacity are low. Depth of the root zone varies. Reaction ranges from strongly acid to moderately alkaline.

In most areas these soils are used as idle land. In other areas they are used for wildlife habitat and recreation sites. A few small areas are used by livestock for grazing. The vegetation is weeds, annual grasses, and trees. In many areas there is no vegetation. A few small areas have been seeded to lespedeza.

These soils are generally not suited to cultivated crops because of the steep slope and rock fragments. Unless the slopes are extensively graded and shaped, it is difficult to establish desirable grasses or trees.

These soils are generally not suited to use for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. Onsite investigation is needed to determine the suitability of the soil for specific uses.

This map unit is in capability subclass VIIs.

Op—Orthents, sloping. This map unit is an area of gently sloping to strongly sloping soils on uplands. This area was strip mined and then smoothed and shaped. It is rectangular and is about 280 acres. The slope range is 2 to 15 percent.

No one pedon is typical of this map unit, but in many places, the soil material is olive brown and dark grayish brown shaly silty clay loam. In some places, the texture is shaly silty clay or silty clay. In places, fragments of coal, limestone, and shale are exposed on the surface. Scattered throughout the map unit are small areas of the original subsoil and underlying material.

Surface runoff is rapid on the slopes and is ponded in the swales. The organic-matter content and the available water capacity are low. The soil material in the upper 7 inches is compacted and is poor in tilth. Depth of the root zone varies. Reaction ranges from strongly acid to moderately alkaline.

These soils have been seeded to sudangrass, wheat, and alfalfa. They are suited to native grasses. They are generally not suited to cultivated crops because of the slope and the low available water capacity.

The major concerns of management for tame grass pasture are the undesirable plants, the hazard of erosion, and the low production of grass. Deferred grazing, fertilization, proper stocking, rotation grazing, timely season of use, and brush management help to maintain and increase forage production.

These soils are generally not suited to dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. Onsite investigation is needed to determine the suitability of the soil for specific uses.

This map unit is in capability subclass VIs.

Ot—Osage silty clay loam. This soil is deep, nearly level, and poorly drained. It is on flood plains and is occasionally flooded. Areas are irregular in shape and range from 10 to more than 200 acres in size.

Typically, the surface soil is very dark gray silty clay loam about 15 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is very dark gray, very firm silty clay. The lower part is dark gray, extremely firm silty clay. In some places, the surface layer is silty clay.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Lanton and Verdigris soils. The somewhat poorly drained, less clayey Lanton soils are on slightly higher positions on the landscape. The moderately well drained, less clayey Verdigris soils are nearer the stream.

Permeability is very slow, and surface runoff is slow. The available water capacity is moderate. The organic-matter content is moderate. The shrink-swell potential is very high. The surface layer is friable and is easily tilled. A perched water table is within a depth of 1 foot from November to May in most years. Reaction in the surface layer and the upper part of the subsoil is neutral.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture and trees. This soil is suited to small grain, grain sorghum, corn, soybeans, and alfalfa. If it is used for cultivated crops, the flooding and wetness can delay farming operations and reduce yields. Drainage ditches and bedding can help to reduce wetness. Minimum tillage, returning crop residue to the surface, and crop rotations help to maintain good tilth and fertility.

The use of this soil for hay or pasture also helps to keep the soil in good condition. Overgrazing or haying and grazing during wet periods, however, cause surface compaction and poor tilth. Proper stocking, fertilization, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the soil and the grass in good condition. This soil is well suited to tall fescue and reed canarygrass.

This soil is moderately well suited to trees, and a few areas remain in native hardwoods. The use of this soil as woodland is moderately limited by equipment limitations and seedling mortality and severely limited by plant competition. Harvesting equipment can be used during the dry season. Tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling helps to control the undesirable vegetation.

This soil is generally unsuitable for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding and wetness are severe limitations. Flooding is difficult to overcome without major control measures.

This map unit is in capability subclass IIw.

Ov—Osage silty clay. This soil is deep, nearly level, and poorly drained. It is on flood plains and is occasionally flooded. Areas are irregular in shape and range from 10 to 300 acres or more in size.

Typically, the surface soil is black silty clay about 23 inches thick. The subsoil is about 21 inches thick. The upper part of the subsoil is very dark gray, mottled, very firm silty clay, and the lower part is dark gray, mottled, extremely firm silty clay. The substratum to a depth of about 60 inches is gray, mottled clay. In some places, the surface layer is silty clay loam.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Lanton and Verdigris soils. The somewhat poorly drained, less clayey Lanton soils are on slightly higher positions on the landscape. The moderately well drained, less clayey Verdigris soils are nearer the stream.

Permeability is very slow, and surface runoff is slow. The available water capacity and the organic-matter content are moderate. The shrink-swell potential is very high. The surface layer is very firm and is difficult to till. This soil has a perched water table within a depth of 1 foot from November to May in most years. Reaction in the surface layer and the upper part of the subsoil is mildly alkaline or neutral.

On most of the acreage, this soil is used for cultivated crops or tame grass pasture. On most of the rest of the acreage, it is used for native grass or woodland (fig. 8). This soil is suited to grain sorghum, corn, soybeans, and wheat. If it is used for cultivated crops, the wetness and flooding can delay farming operations and reduce yields. Drainage ditches and bedding help to reduce wetness. Minimum tillage, returning crop residue to the surface, and crop rotations help to maintain tilth and fertility.

The use of this soil for hay or pasture also helps to keep the soil in good condition. Overgrazing or haying and grazing during wet periods, however, cause surface compaction and poor tilth. Proper stocking, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the soil and grass in good condition. This soil is well suited to reed canarygrass and tall fescue. Some areas in Boicourt, in Linn County, have been developed for migratory bird habitat (fig. 9).

This soil is moderately well suited to trees, and a few areas remain in native hardwoods. The use of this soil as woodland is moderately limited by equipment limitations and seedling mortality and severely limited by plant competition. Harvesting equipment can be used during the dry season. Tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling helps to control the undesirable vegetation.

This soil is generally unsuitable for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding and wetness are severe limitations. Flooding is difficult to overcome without use of major control measures.

This map unit is in capability subclass IIIw.

Pc—Parsons silt loam. This soil is deep, nearly level, and somewhat poorly drained. It is on broad uplands. Areas are irregular in shape and range from 20 to 1,200 acres in size.

Typically, the surface layer is very dark grayish brown, faintly mottled silt loam about 9 inches thick. The subsurface layer is dark grayish brown, mottled silt loam about 4 inches thick. The subsoil to a depth of 60 inches is dark grayish brown, mottled, very firm silty clay. In some places, the surface layer is lighter in color because the original surface layer has been mixed with the subsurface layer by plowing. In some areas this soil does not have a grayish brown subsurface layer.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Dennis soils. The Dennis soils are on the lower part of side slopes. They are less clayey in the upper part of the subsoil than the Parsons soil, and they are moderately well drained.

Permeability is very slow, and surface runoff is slow. The available water capacity and the organic-matter content are moderate. The surface layer is friable and is easily tilled. The subsoil has high shrink-swell potential. This soil has a perched water table at a depth of 1/2 to 1 1/2 feet from December to April in most years. Root development is restricted by the compact subsoil at a depth of about 13 inches. Reaction in the surface layer and subsurface layer is medium acid.

In most areas this soil is used for cultivated crops. It is suited to soybeans (fig. 10), small grain, corn, and sorghum. Crop yields can be reduced by wetness. The surface layer remains wet for extended periods after heavy rains. The clayey subsoil does not release water readily, and crop yields are reduced during dry periods. Maintaining tilth and the organic-matter content are concerns. Minimum tillage and returning crop residue to the surface help to maintain the organic-matter content and tilth of the soil.

The use of this soil for pasture and hay can also help to keep the soil in good condition. Overgrazing or grazing during wet periods, however, causes surface compaction and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the pasture plants and the soil in good condition. This soil is well suited to tall fescue.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced

Figure 8.—Pecan grove on Osage silty clay.

walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength and wetness of the soil. Strengthening or replacing the base material helps to offset these limitations.

This soil is severely limited for use as septic tank absorption fields because of the very slow permeability and the wetness. It is suitable for sewage lagoons.

This map unit is in capability subclass IIs.

Figure 9.—This area of Osage silty clay near Boicourt has been diked and flooded for use as habitat for ducks.

Po—Pits, quarries. This miscellaneous area consists of open excavations that expose the underlying bedrock, mainly limestone, which is used as construction material. The pits are 4 to more than 20 feet deep. The areas are rectangular and are 10 to 140 acres. Included in mapping are piles of crushed rock and areas of water.

Quarries are generally not suited to cultivated crops or pasture. Some areas may be suited to a limited extent to wildlife habitat development.

This miscellaneous area is not assigned to a capability group.

Sn—Summit silty clay loam, 1 to 4 percent slopes. This soil is deep, gently sloping, and moderately well drained. It is on upland foot slopes and side slopes. Areas are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is black silty clay loam about 11 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is black, very firm silty clay; the middle part is dark grayish brown, mottled, extremely firm silty clay; and the lower part is olive brown, very dark grayish brown, and dark gray, mottled, extremely firm silty clay. In some places, the surface layer is silt loam. In some places, shale is at a depth of 20 to 40 inches.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Catoosa soils. The moderately deep, well drained Catoosa soils are less clayey than this soil and are in narrow bands on mid slope positions.

Permeability is slow, and surface runoff is medium. The available water capacity and the organic-matter content are moderate. The surface layer is friable and is easily tilled throughout a narrow range of moisture conditions. The subsoil has high shrink-swell potential. The soil has a perched water table at a depth of 2 or 3 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is neutral.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture. This soil is suited to small grain, grain sorghum, soybeans, corn, and tame grasses for hay and pasture. If the soil is used for cultivated crops, erosion is a hazard. Contour farming, terraces, waterways, and minimum tillage help to prevent excessive soil loss. Returning crop residue to the surface or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay can also help to control erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the soil and the grass in good condition. This soil is well suited to bromegrass (fig. 11) and tall fescue.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential (fig. 12). Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength. Strengthening or replacing the base material helps to offset this limitation.

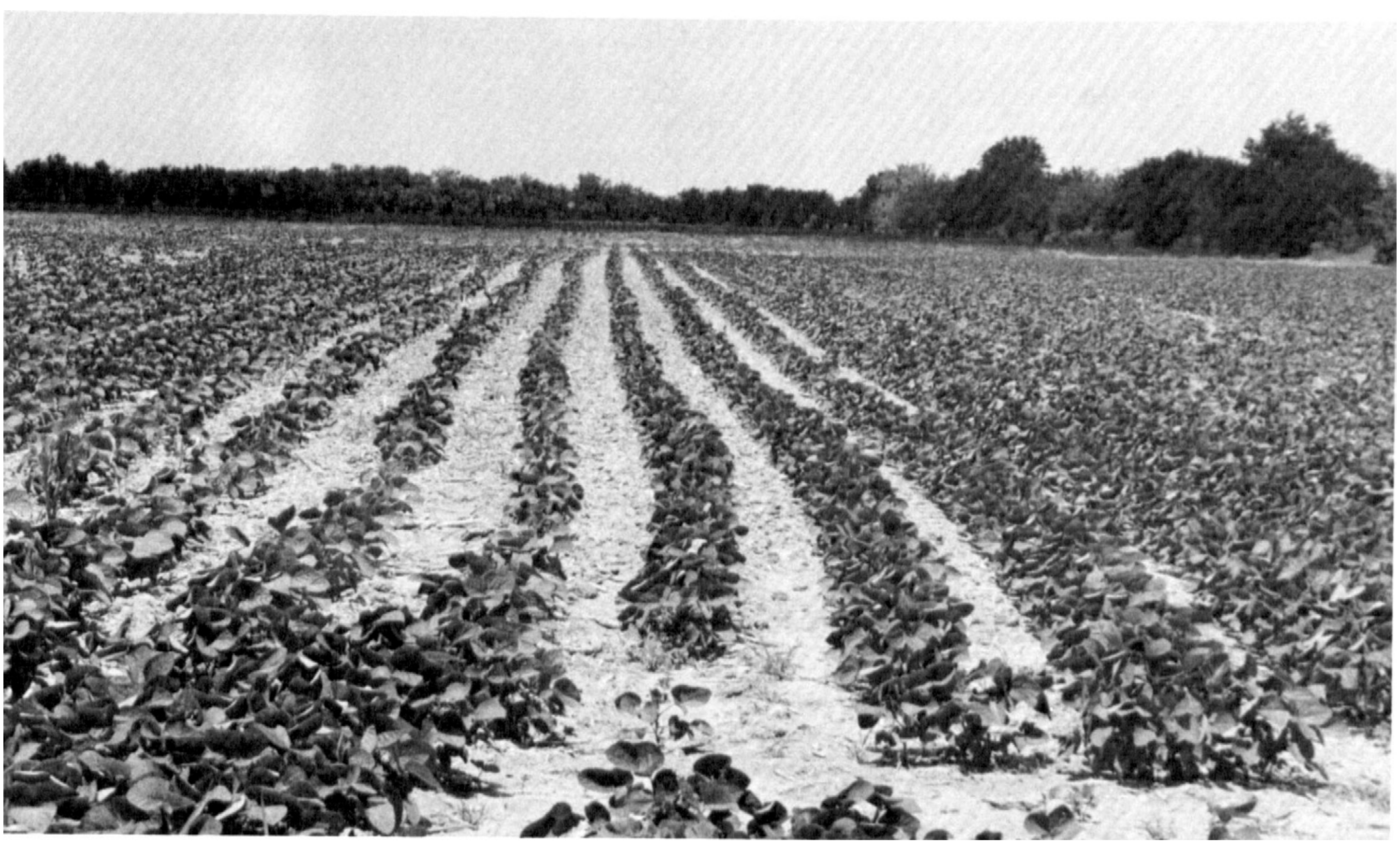


Figure 10.—A field of soybeans on Parsons silt loam.

Figure 11.—This area of Summit silty clay loam, 1 to 4 percent slopes, is used for bromegrass pasture, which is one of the common land uses in the survey area.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and wetness. It is moderately limited for use as a site for sewage lagoons because of slope. The less sloping sites are more suitable for sewage lagoons.

This map unit is in capability subclass IIe.

So—Summit silty clay loam, 4 to 8 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on foot slopes and side slopes. Areas are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part is black, very firm silty clay; the middle part is dark grayish brown, mottled, extremely firm silty clay; and the lower part is olive brown, very dark grayish brown, and dark gray, extremely firm silty clay. In some places, the surface layer is black silty clay. In places, shale is at a depth of 20 to 40 inches.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Catoosa and Dennis soils. The Catoosa soils are less clayey than the Summit soil, are well drained and moderately deep, and are in narrow bands on mid slopes. The Dennis soils have a silt loam surface layer and are on similar positions on the landscape. They have a browner subsoil and are moderately well drained.

Permeability is slow, and surface runoff is medium. The available water capacity and the organic-matter content are moderate. The surface layer is friable and is easily tilled throughout a narrow range of moisture conditions. The subsoil has high shrink-swell potential. This soil has a perched water table at a depth of 2 to 3 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is neutral.

In most areas this soil is used for tame grass pasture. It is suited to tall fescue and bromegrass. The use of the soil for pasture or hay helps to control erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

In some areas this soil is used for cultivated crops. It is suited to small grain, grain sorghum, soybeans, and corn. If this soil is used for cultivated crops, erosion is a hazard. Minimum tillage, contour farming, terraces, and waterways help to prevent excessive soil loss. Diversions help to control surface runoff from adjoining soils.

Returning crop residue to the surface or the addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil as a site for dwellings with basements is severely limited by wetness and shrink-swell potential. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil that is adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength of the soil. Strengthening or replacing the base material helps to offset this limitation.

This soil is severely limited for use as septic tank absorption fields because of the slow permeability and

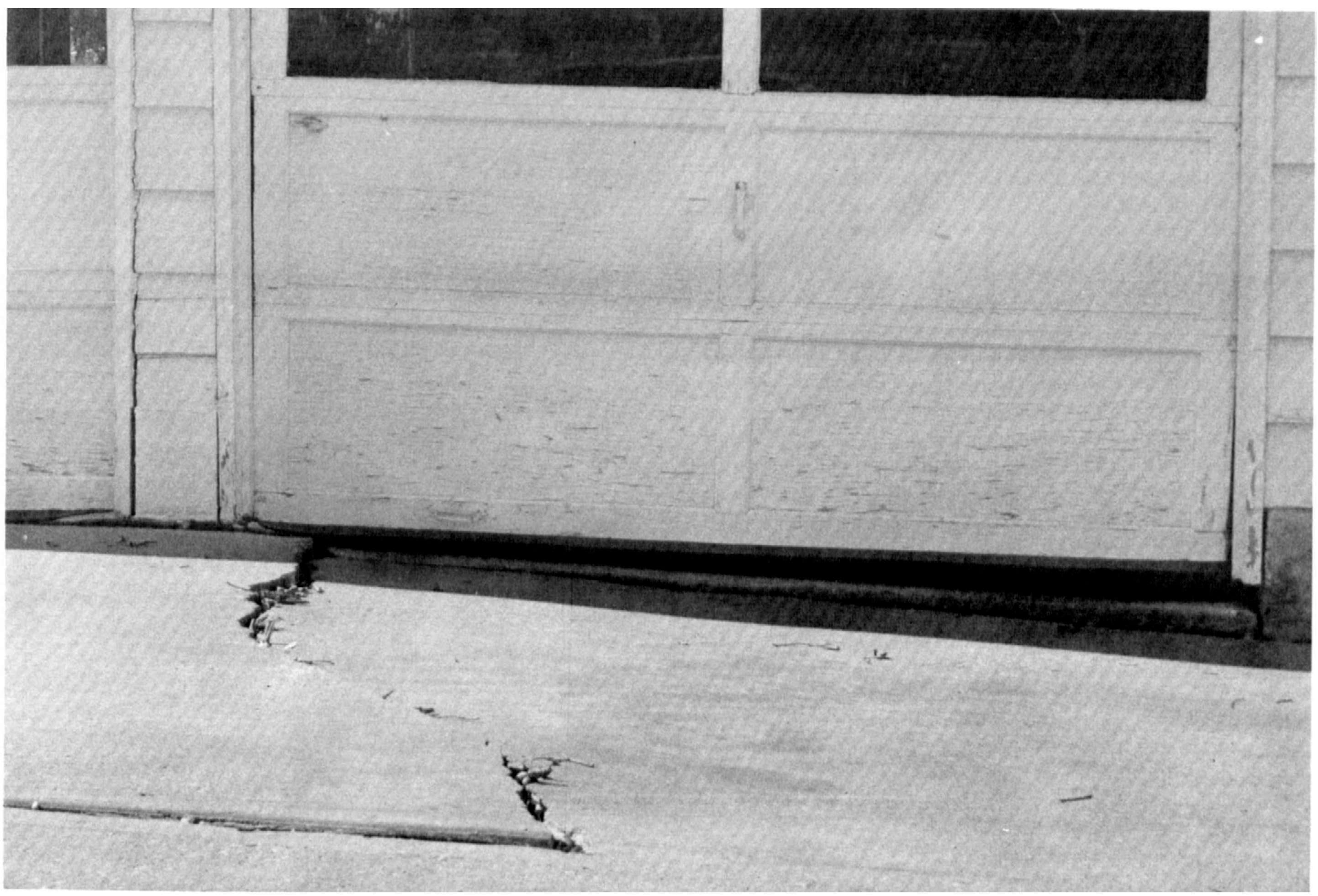


Figure 12.—This foundation on Summit silty clay loam, 1 to 4 percent slopes, failed because of the shrinking and swelling of the soil.

the wetness. It is moderately limited for sewage lagoons because of the slope. The included or adjacent less sloping soils are more suitable for sewage lagoons.

This map unit is in capability subclass IIIe.

Vb—Verdigris silt loam. This soil is deep, nearly level, and moderately well drained. It is on flood plains and is occasionally flooded. Areas are irregular in shape and range from 10 to more than 300 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is very dark grayish brown silt loam about 23 inches thick. The next layer is dark brown, firm silt loam about 20 inches thick. The substratum to a depth of about 60 inches is dark yellowish brown silt loam. In some places, the soil is mottled at a depth less than 18 inches. In some places, the subsurface layer is lighter colored. In places, the subsoil is silty clay loam.

Included in mapping, and making up about 10 percent of the map unit, are small areas of the poorly drained Osage soils in swales and depressions. These soils are more clayey than the Verdigris soil.

Permeability is moderate, and surface runoff is slow. The available water capacity is high. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The shrink-swell potential is moderate. Reaction in the surface layer is neutral or slightly acid.

In most areas this soil is used for cultivated crops. In some areas it is used for tame grass pasture and woodland. This soil is suited to small grain, grain sorghum, soybeans, corn, alfalfa, and tame grasses for hay and pasture. Occasional flooding of short duration does not generally cause serious crop damage. Maintaining tilth and the organic-matter content are concerns. Minimum tillage, returning crop residue to the surface, and crop rotations help to maintain the soil tilth and the organic-matter content.

The use of this soil for hay or pasture can also help to keep the soil in good condition. Overgrazing or haying and grazing during wet periods, however, cause surface compaction and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the soil and the grass in good condition.

This soil is well suited to trees. A few small areas remain in native hardwoods. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling helps to control the undesirable vegetation. Flooding and plant competition are concerns in management.

This soil is generally unsuitable for dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding is a severe limitation. It is difficult to overcome without use of major control measures.

This map unit is in capability subclass IIw.

Vc—Verdigris silt loam, frequently flooded. This deep, nearly level, moderately well drained soil is on narrow flood plains that have meandering stream channels. It is frequently flooded for brief periods. Most areas are in upland drainageways. In some places, the channels are deeply entrenched. In places, short, steep side slopes are included. Areas are narrow and irregular in shape and range from 150 to 600 feet in width.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is very dark grayish brown silt loam about 23 inches thick. The next layer is dark brown, firm silt loam about 20 inches thick. The substratum to a depth of about 60 inches is dark yellowish brown silt loam. In some places, the soil is mottled at depths less than 18 inches. In some places, the soil is moderately deep over limestone. In some places, the soil has a silty clay loam subsoil.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Osage and Summit soils. These soils are more clayey than the Verdigris soil. The poorly drained Osage soils are in swales. The moderately well drained Summit soils are on foot slopes.

Permeability is moderate, and surface runoff is slow. The available water capacity is high. The surface layer is friable and is easily tilled. The organic-matter content and the shrink-swell potential are moderate. Reaction in the surface layer is neutral or slightly acid.

In most areas this soil is used for grass or trees. It is generally not suited to cultivated crops because of the frequent flooding. In some areas it has been seeded to tame grass. The main concern of management is maintaining or improving the desirable mid and tall grasses. Overgrazing reduces the growth and vigor of the grasses, and it increases the growth of brush and trees. Proper stocking, uniform grazing distribution, deferred grazing, and brush management help to keep the range in good condition. Reseeding may be needed to establish desirable mid and tall grasses.

This soil is well suited to trees, and a few small areas remain in native hardwoods. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling helps to control the undesirable vegetation. Flooding and plant competition are concerns in management.

This soil is generally not suited to dwellings, local roads and streets, septic tank absorption fields, and sewage lagoons. The hazard of flooding is a severe limitation. It is difficult to overcome without use of major control measures.

This map unit is in capability subclass Vw.

We—Welda silt loam, 2 to 5 percent slopes. This soil is deep, gently sloping, and well drained. It is on terraces and uplands. Areas are irregular in shape and range from 5 to about 80 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 4 inches thick. The subsurface layer is brown silt loam about 3 inches thick. The subsoil extends to a depth of about 60 inches. The upper part of the subsoil is brown and reddish brown, firm silty clay loam; the middle part is yellowish red and reddish brown, very firm silty clay; and the lower part is grayish brown, yellowish red, and brown, firm silty clay loam. In some places, the surface layer is thicker and darker. In some places, the lower part of the subsoil has chert or limestone fragments.

Included in mapping, and making up about 10 percent of the map unit, are small areas of Catoosa soils. The Welda and Catoosa soils are on similar positions on the landscape. The Catoosa soils are moderately deep, are well drained, and do not have a subsurface layer.

Permeability is moderately slow, and surface runoff is medium. The available water capacity is high. The surface layer is friable and is easily tilled. The organic-matter content is low. The subsoil has moderate shrink-swell potential. Reaction in the surface layer and the subsurface layer is neutral. In the upper part of the subsoil, it is strongly acid.

In most areas this soil is used for tame grass pasture or trees. The use of this soil for tame grasses or trees helps to control erosion. Overgrazing or grazing when the soil is wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking, fertilization, pasture rotation, and deferred grazing help to keep the soil and the grass in good condition. This soil is well suited to bromegrass and tall fescue.

This soil is suited to small grain, grain sorghum, soybeans, and corn. If cultivated crops are grown, erosion is a hazard. Contour farming, terraces, grassed waterways, minimum tillage, and crop rotations help to prevent excessive soil loss. Returning crop residue to the surface and adding other organic material to the soil help to maintain fertility and good tilth.

This soil is well suited to trees, and some areas remain in native hardwoods. The tree seeds, cuttings, and seedlings grow well if competing vegetation is controlled or removed. Site preparation, controlled burning, spraying, cutting, or girdling can control undesirable vegetation.

The use of this soil as a site for dwellings is moderately limited by the shrink-swell potential. Using properly designed and reinforced walls and footings and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

The use of this soil as a site for local roads and streets is severely limited by the low strength. Strengthening or replacing the base material can help to overcome this limitation.

This soil is severely limited for use as septic tank absorption fields by the moderately slow permeability. Increasing the size of the absorption field helps to improve the functioning of the septic system.

The use of the soil for sewage lagoons is moderately limited by seepage and slope. Sealing the lagoon can help to reduce seepage. The included soils that are less sloping are more suitable for sewage lagoons.

This map unit is in capability subclass IIe.

Wo—Woodson silt loam, 0 to 2 percent slopes. This soil is deep, nearly level, and somewhat poorly drained. It is on uplands. Some areas along the Marais des Cygnes River are on terraces that are rarely flooded. Areas are irregular in shape and range from 10 to 300 or more acres in size.

Typically, the surface layer is very dark gray silt loam about 7 inches thick. The subsoil is about 33 inches thick. The upper part of the subsoil is black, mottled, very firm silty clay; the middle part is dark gray, mottled, very firm silty clay; and the lower part is gray, mottled, very firm silty clay. The substratum to a depth of about 60 inches is gray, mottled silty clay. In some places, the subsoil is browner. In some places, the soil has a dark grayish brown subsurface layer. In some places, the upper part of the subsoil is silty clay loam.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Okemah and Summit soils. The moderately well drained Okemah and Summit soils are on foot slopes.

Permeability is very slow, and surface runoff is slow. the available water capacity is moderate. The organic-matter content is moderate. The surface layer is friable and is easily tilled. The subsoil has high shrink-swell potential. The soil has a perched water table at a depth of 1/2 foot to 2 feet from December to April in most years. Reaction in the surface layer and the upper part of the subsoil is slightly acid.

In most areas this soil is used for cultivated crops and tame grasses (fig. 13). A few small areas are in native grass. This soil is suited to small grain, grain sorghum, soybeans, and alfalfa. It generally is poorly suited to corn because of seasonal droughtiness. Crop yields can be reduced by wetness. The clayey subsoil does not release water readily, and crop yields are reduced during droughts. Maintaining tilth and the organic-matter content are concerns. Crop rotations, terraces, waterways, minimum tillage, and returning crop residue to the surface help to maintain good tilth and fertility.

The use of this soil for tame grasses or native grasses for hay or pasture can also help to keep the soil in good condition. This soil is well suited to tall fescue and bromegrass. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Proper stocking, fertilization, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the soil and the grass in good condition.

The use of this soil as a site for dwellings is severely limited by the shrink-swell potential and wetness. Using properly designed and reinforced walls and footings, installing footing drains, and backfilling with porous material help to reduce damage caused by the shrinking and swelling of the soil. Wetting the soil adjacent to the basement wall to the depth of seasonal drying reduces the shrinking and swelling.

Figure 13.—Tall fescue in an area of Woodson silt loam, 0 to 2 percent slopes.

The use of this soil as a site for local roads and streets is severely limited by the low strength and wetness. Strengthening or replacing the base material helps to offset these limitations.

This soil is severely limited for use as septic tank absorption fields because of the very slow permeability and the wetness. It is suitable for sewage lagoons.

This map unit is in capability subclass IIs.

prime farmland

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to economically produce a sustained high yield of crops if acceptable farming methods are used. Prime farmland produces the highest yields with minimal inputs of energy and economic resources, and farming it results in the least damage to the environment. Prime farmland is of major importance in providing the nation's short- and long-range needs for food and fiber. The supply of high quality farmland is limited, and it should be used with wisdom and foresight.

Prime farmland may now be in crops, pasture, woodland, or other uses, but not in urban or built-up land or water areas. It must either be currently used for producing food or fiber or must be available for these uses.

Prime farmland usually has an adequate and dependable supply of moisture from precipitation or irrigation. It has favorable temperature, growing season, and acceptable reaction. It has few or no rocks and is permeable to water and air. Prime farmland is not excessively erodible or saturated with water for long periods, and it is not flooded during the growing season. The slope ranges mainly from 0 to 8 percent.

In Linn and Miami Counties about 536,000 acres, or nearly 70 percent of the acreage, is prime farmland. Only in scattered areas in map units 2 and 5 on the general soil map do the soils not meet the requirements for prime farmland. Approximately 320,000 acres of the prime farmland is used for crops, mainly soybeans and sorghum. The crops grown on this acreage account for about seven-eighths of the total annual income from crops in the survey area.

A recent trend in land use in some parts of Miami County has been the loss of some prime farmland to urban uses. The loss of prime farmland puts pressure on marginal lands, which generally are more erodible, droughty, and difficult to cultivate and are usually less productive.

Following is a list of the map units that are prime farmland in Linn and Miami Counties. If the map unit is considered prime farmland only when drained, a qualification is added after the map unit name.

Bb—Bates loam, 1 to 4 percent slopes
Bc—Bates loam, 4 to 8 percent slopes
Cb—Catoosa silt loam, 1 to 3 percent slopes
De—Dennis silt loam, 1 to 3 percent slopes
Df—Dennis silt loam, 3 to 6 percent slopes
Ec—Eram silty clay loam, 1 to 4 percent slopes
Gc—Grundy silt loam, 1 to 3 percent slopes
Hp—Hepler silt loam (where drained)
Ke—Kenoma silt loam, 1 to 4 percent slopes
La—Lanton silt loam (where drained)
Mb—Mason silt loam
Nf—Newtonia silt loam, 0 to 1 percent slopes
Ng—Newtonia silt loam, 1 to 4 percent slopes
Nh—Newtonia silt loam, 4 to 8 percent slopes
Oh—Okemah silt loam, 0 to 3 percent slopes
Ot—Osage silty clay loam (where drained)
Ov—Osage silty clay (where drained)
Pc—Parsons silt loam
Sn—Summit silty clay loam, 1 to 4 percent slopes
Vb—Verdigris silt loam
We—Welda silt loam, 2 to 5 percent slopes
Wo—Woodson silt loam, 0 to 2 percent slopes

The extent of each map unit is shown in table 4. The soil qualities that affect use and management are described in the section "Detailed soil map units."

use and management of the soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

crops and pasture

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; 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 listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed soil map units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

crops

Earl J. Bondy, conservation agronomist, Soil Conservation Service, helped to prepare this section.

According to the Kansas State Board of Agriculture, crops were harvested on about 45 percent of the acreage in Linn and Miami Counties in the period 1967-77 (*3*). Of that acreage, about 28 percent was used for soybeans, 25 percent was used for sorghum, 20 percent was used for corn, 17 percent was used for wheat, and the remaining 10 percent was used for alfalfa, oats, barley, and rye.

Compared with the acreage used in the period 1957-67, this was an increase of 66 percent in the acreage used for soybeans and an increase of 58 percent in the acreage used for sorghum; but it was a decrease in the acreage of all other crops and a decrease of 3 percent in the total acreage used for crops.

Soil erosion is the major problem on about 50 percent of the acreage in cropland in the survey area. Where the slope is more than 2 percent, erosion is a hazard. Bates, Catoosa, Dennis, Eram, Grundy, Kenoma, Newtonia, and Summit soils have slopes of more than 2 percent.

Loss of the surface layer through erosion is damaging for two reasons. First, productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the plow layer. Loss of the surface layer is especially damaging to soils that have a loamy surface layer and a clayey subsoil, such as Grundy, Kenoma, and Woodson soils. It is also damaging to soils with a limited root zone, such as Bates and Catoosa soils. Erosion also reduces productivity on soils that tend to be droughty, such as Bates loam. Second, soil erosion results in the sedimentation of streams. Control of erosion minimizes the pollution of streams by sediment and improves the water quality for municipal use, for recreation, and for fish and wildlife.

On many sloping fields, preparing a good seedbed and tilling are difficult because the original, friable surface soil has been eroded away and clayey spots are exposed. Such spots are common in areas of Kenoma and Eram soils.

Erosion control practices provide a protective surface cover, reduce runoff, and increase infiltration. A cropping system that keeps vegetative cover on the soil for extended periods helps to reduce soil losses to amounts that will not reduce the productivity of the soil. On livestock farms, which require pasture and hay, the legumes and tame grasses in the cropping system reduce erosion on the sloping land and also provide nitrogen and improve tilth for the following crop.

Terraces and diversions reduce the length of the slope and thereby reduce runoff and erosion. They are most practical on deep, well drained soils that have smooth, uniform slopes. Dennis, Grundy, Kenoma, and Summit soils are suitable for terraces.

Contouring is well suited to soils that have smooth, uniform slopes, such as the Okemah and Woodson soils and, in some areas, Dennis and Summit soils.

If some soils are fall plowed, soil blowing can be a hazard. The soils most susceptible to blowing are the Catoosa, Dennis, Newtonia, Osage, and Parsons soils. Maintaining a vegetative cover, a surface mulch, or a rough surface through proper tillage minimizes soil blowing on these soils.

Drainage is the major management need on the poorly drained Osage soils and the somewhat poorly drained Hepler, Grundy, Lanton, Parsons, and Woodson soils. Unless artificially drained, these soils may have reduced yields. In some areas of Grundy and Woodson soils, surface drainage is not needed because of the slope.

The design of surface drainage systems varies with the kind of soil. Drains have to be more closely spaced in slowly permeable and very slowly permeable soils than in the more permeable soils. The major problem in designing drainage systems is in locating an adequate outlet.

Fertility is medium in most upland soils and is high in most bottom land soils. Most soils in the survey area have a slightly to medium acid surface layer unless they have been limed. Applying lime can increase the growth of legumes, such as alfalfa and red clover, and other crops that are more productive on neutral soils. The available potash levels are usually moderate. On all soils, additions of lime and fertilizer should be based on the results of soil tests, on the needs of the crop, 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 an important factor in the germination of seeds and in the infiltration of water into the soil. Soils that have good tilth are granular and porous.

The surface layer of most of the soils used for crops in the survey area is silt loam or silty clay loam. It is dark in color and moderately low in organic-matter content. Intense rainfall may cause crusting of the surface, which may reduce infiltration and increase runoff. Additions of crop residue, manure, and other organic material can help to improve soil structure and reduce crusting.

Fall plowing is generally not a good practice in this survey area because of the crust that forms during winter and spring. Many of the soils are nearly as dense and hard at planting time after fall plowing as they were before they were plowed. Also, soil blowing and water erosion are hazards because the freezing and thawing tend to pulverize the surface layer.

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

Field crops suited to the soils and climate of the survey area include many that are not commonly grown. Corn, soybeans, and grain sorghum are the principal row crops. Sunflowers, popcorn, and castor beans and similar crops can be grown if economic conditions are favorable.

Wheat and oats are the common close-growing crops. Red clover has nearly replaced alfalfa. Sweet clover could be grown but seldom is planted. Bromegrass and tall fescue are planted for hay, pasture, and seed. Reed canarygrass is well suited to soils that have drainage problems, such as Hepler, Lanton, Osage, Woodson, and the frequently flooded Verdigris soils.

Special crops grown commercially in the area include apples, peaches, pecans, walnuts, and some vegetable crops. The pecans are grown almost exclusively on Osage silty clay. In the northeastern part of Miami County, there is a considerable acreage in turf farms. Zoysia and bluegrass are the main grasses grown. Most turf farms are irrigated from water supplied by ponds.

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

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

pasture

Earl J. Bondy, conservation agronomist, Soil Conservation Service, helped to prepare this section.

About 33 percent of the survey area is pasture. It is in cool-season tame grasses, such as tall fescue, reed canarygrass, and bromegrass. Tame grasses occur throughout both counties. Some areas are entirely tame grasses, and others are tame and native grasses.

The main considerations in managing these areas of grass are maintaining or improving the quality and quantity of forage, providing soil protection, and reducing water loss. Leaf development, root growth, food storage in the roots, and forage regrowth are processes in the development and growth of grass. All are essential if maximum yields of forage are to be maintained.

The requirements for maintaining a good stand of tame grasses are described in the following paragraphs.

Proper stocking rate. Adjust the numbers of livestock to the expected yield of pasture grass. For a mature cow, for example, farmers can allow 40 pounds of forage per day for continuous seasonal grazing or 35 pounds per day for rotation grazing.

Grazing management. Delay grazing in spring until the soil is dry and firm so that the cattle do not trample the grass and compact the soil. Tame grasses should not be grazed during their mid-summer dormancy. If rotation grazing is practiced, the farmer provides an adequate number of pastures with sufficient acreage in ratio to the number of livestock to allow the grasses to make a satisfactory recovery between each grazing.

Water and salt. Provide adequate water and salt at enough locations to encourage uniform grazing by the livestock.

Fertilizing. Base the kind and amount of fertilizer on the results of soil tests, on field observation, and on the level of production desired.

Mowing and controlling unwanted vegetation. Mow pasture if it is grazed unevenly or there is an excess of forage. Mowing and spraying with herbicides control invading trees, brush, low-quality grass, and broad-leaved weeds.

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.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; 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 residue, barnyard manure, and green-manure crops; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil 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 listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils.

land capability classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

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

Class I soils have slight 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 miscellaneous areas 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 very cold or very 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. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The capability classification of each map unit is given in the section "Detailed soil map units."

rangeland

Lynn Gibson, range conservationist, Soil Conservation Service, helped to prepare this section.

About 10 percent of the acreage in Linn and Miami Counties can be classified as rangeland, based on the kinds and amounts of plants. In other areas the trees and an understory of grass are used for livestock grazing and have good potential for forage production. Few ranchers depend entirely on native vegetation to feed livestock. Range vegetation often contributes significant amounts of forage during the summer months when it is high in protein and food value. Tame pasture and crop residue provide most of the livestock forage in the area.

Most of the rangeland is in the western part of Linn County, in the Centerville-Blue Mound area. Small blocks of rangeland, usually less than 100 acres, are throughout the survey area. In most of these small blocks the forage has been greatly depleted because of improper grazing management and the invasion of woody or weedy vegetation. The amount of forage produced on this land is generally less than half of that originally produced.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

Table 6 shows, for each soil, the range site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. Only those soils that are used as or are suited to rangeland are listed. Explanation of the column headings in table 6 follows.

A *range site* is a distinctive kind of rangeland that produces a characteristic natural plant community that differs from natural plant communities on other range sites in kind, amount, and proportion of range plants. The relationship between soils and vegetation was ascertained during this survey; thus, range sites generally can be determined directly from the soil map. Soil properties that affect moisture supply 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.

Total production is the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. 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 make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Dry weight is the total annual yield per acre reduced to a common percent of air-dry moisture.

Characteristic vegetation—the grasses, forbs, and shrubs that make up most of the potential natural plant community on each soil—is listed by common name. Under *composition*, the expected percentage of the total annual production is given for each species making up the characteristic vegetation. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season.

Range management requires a knowledge of the kinds of soil and of the potential natural plant community. It also requires an evaluation of the present range condition. 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. Range condition is an ecological rating only. It does not have a specific meaning that pertains to the present plant community in a given use.

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 optimum production of vegetation, reduction of undesirable brush species, conservation of water, and control of water erosion and soil blowing. Sometimes, however, a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

In both counties a considerable acreage is in brush, weedy-type trees, and other vegetation that provide poor-quality herbage for grazing. Bates, Catoosa, Clareson, and Eram soils make up some of this acreage. These soils can support good quantities of good quality herbage.

The major concerns on rangeland are grazing management and brush management. Brush management is needed to reduce competition from woody vegetation. Grazing management is needed to reestablish the kinds and amounts of plants that make up the potential plant community. Range management based on soil survey information and rangeland inventories is the basis for maintaining or improving forage production.

woodland management and productivity

Gerald F. Bratton, area extension forester Department of Forestry, Kansas State University, helped to prepare this section.

About 11 percent of the survey area is woodland. Only a small part of the woodland is managed for commercial tree production. Most is grazed by livestock.

The principal native trees in the counties are black walnut, bur oak, red oak, green ash, hackberry, sycamore, cottonwood, American elm, hickory, maple, and pecan. All of these species are cut for sawlogs or veneer logs after maturing to an adequate size. Many of the species listed as well as others are also used for fuel wood, posts, and various other woodland products or for nut production.

The soils on bottom land and some of the soils on uplands have high potential for forest products. At present, many upland sites are converting from grassland to woodland through natural ecological succession because of the absence of fire. Some sites have potential for high-quality timber production. Others have low potential and will not produce commercial timber. Much of the upland woodland does, however, have potential for use as windbreaks and for watershed protection and wildlife habitat.

Table 7 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The table lists the ordination (woodland suitability) symbol for each soil. Soils assigned the same ordination symbol require the same general management and have about the same potential productivity.

The first part of the *ordination symbol*, a number, indicates the potential productivity of the soils for important trees. The number 1 indicates very high productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *x* indicates stoniness or rockiness; *w*, excessive water in or on the soil; *t*, toxic substances in the soil; *d*, restricted root depth; *c*, clay in the upper part of the soil; *s*, sandy texture; *f*, high content of coarse fragments in the soil profile; and *r*, steep slopes. The letter *o* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: x, w, t, d, c, s, f, and r.

In table 7, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

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 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 in equipment; and *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 to which the soil affects the mortality of tree seedlings. Plant competition is not considered in the ratings. The ratings apply to seedlings from good stock that are properly planted during a period of sufficient rainfall. A rating of *slight* indicates that the expected mortality is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade where there are openings in the tree canopy. The invading plants compete with native plants or planted seedlings. 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* indicates that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed to control undesirable plants.

The *potential productivity* of merchantable or *common 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. Commonly grown 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 suited to the soils and to commercial wood production.

windbreaks and environmental plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

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

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

Table 8 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 8 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a nursery.

recreation

Robert J. Higgins, biologist, Soil Conservation Service, helped to prepare this section.

Miami and Linn Counties have many scenic, geologic, and historic areas of interest. Several municipal lakes, state lakes, farm ponds, and the Marais des Cygnes River provide water-based recreation. Facilities for hunting, fishing, camping, and picnicking are numerous throughout the survey area.

The Marais des Cygnes waterfowl and wildlife area, in the northeastern part of Linn County, attracts hunters and bird watchers from a broad area. Several privately owned waterfowl hunting areas near the refuge are leased to hunters during duck season. The scenic quality of this part of the state, with its rolling topography and wooded streams and hillsides, makes it attractive. The demand for recreation has increased greatly in both counties over the past several years.

The soils of the survey area are rated in table 9 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 9, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that 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 9 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the 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 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 campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for 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 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 and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

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

wildlife habitat

Robert J. Higgins, biologist, Soil Conservation Service, helped to prepare this section.

The chief game species in Miami and Linn Counties are bobwhite quail, mourning dove, cottontail rabbit, fox squirrel, white-tailed deer, and several species of waterfowl. The Marais des Cygnes Waterfowl Refuge and several privately owned marshes provide good duck and goose hunting opportunities.

Nongame species of wildlife in the county are numerous because of the diverse number of habitat types. Cropland, woodland, and grassland are intermixed throughout the survey area. These habitat types create the desirable "edge" effect that is conducive to many species. Each type provides a home for a particular group of species. Bird watchers and wildlife observers frequently use the refuge area.

Furbearers are common in the waterfowl refuge and along the Marais des Cygnes River and its tributaries. Trapping is done on a limited basis.

Stockwater ponds, the Marais des Cygnes, and several lakes provide good to excellent fishing. Species commonly caught in the counties are bass, bluegill, crappie, channel cat, bullhead catfish, and flathead catfish.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 10, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in 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* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

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

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, grain sorghum, soybeans, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are the bluestems, switchgrass, indiangrass, goldenrod, ragweed, sunflowers, wheatgrass, and native legumes.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, sycamore, cottonwood, black walnut, hackberry, green ash, elm, mulberry, and hickory. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, plum, fragrant sumac, winterberry, and crabapple.

Coniferous plants furnish browse, seeds, and cones. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are eastern redcedar, pine, and spruce.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, cattails, prairie cordgrass, buttonbush, indigobush, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite quail, mourning dove, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include owls, hawks, thrushes, woodpeckers, squirrels, opossum, raccoon, and white-tailed deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, redwinged blackbirds, muskrat, mink, and beaver.

Developing habitat for wildlife requires proper location of the various types of plant cover on suitable soils. Technical assistance in planning wildlife developments and in determining suitable vegetation for plantings can be obtained from the office of the Soil Conservation Service. Additional information and assistance can be obtained from the Kansas Fish and Game Commission and from the Extension Service.

engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

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

building site development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

sanitary facilities

Table 12 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 12 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock, and flooding affect absorption of the effluent. Large stones and bedrock interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to effectively filter the effluent. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the 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.

Table 12 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope and bedrock can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 12 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

construction materials

Table 13 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 13, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to

40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

water management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances, such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

soil properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics. These results are reported in table 18.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

engineering index properties

Table 15 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and their morphology."

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

Classification of the soils is determined according to the Unified soil classification system (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (*1*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as Pt. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups 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 (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 18.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

physical and chemical properties

Table 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It 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 nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

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

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion 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. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion 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. Crops can be grown if measures to control wind erosion 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. 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. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 16, the estimated content of organic matter of the plow layer is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

soil and water features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive 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 mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

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

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of 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 clays 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, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt and water in swamps and marshes is not considered flooding.

Table 17 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal 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.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered is local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. Only saturated zones within a depth of about 6 feet are indicated. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 17 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. A water table that is seasonally high for less than 1 month is not indicated in table 17.

An apparent water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An artesian water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A perched water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations generally can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavations.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

engineering index test data

Table 18 shows laboratory test data for several pedons sampled at carefully selected sites in the survey area. The pedons are typical of the series and are described in the section "Soil series and their morphology." The soil samples were tested by the Kansas Department of Transportation.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM).

The tests and methods are: AASHTO classification—M-145-66; Unified classification—D-2487-66T (ASTM); Mechanical analysis—T-88-72; Liquid limit—T89-68; Plasticity index—T90-70; and Moisture density, Method A—T99-74.

classification of the soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*5*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. In table 19, the soils of the survey area are classified according to the system. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that 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 development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Argiudolls (*Argi*, meaning argillic horizons, plus *udoll*, the suborder of the Mollisols that have an udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group 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 typifies the great group. An example is Typic Argiudolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-silty, mixed, thermic Typic Argiudolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

soil series and their morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (*4*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*5*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed soil map units."

Bates series

The Bates series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in residuum of sandstone and silty shale. The slope ranges from 1 to 8 percent.

Bates soils are similar to Catoosa soils and are commonly adjacent to Dennis, Eram, and Lebo soils on the landscape. Catoosa and Bates soils are on similar landscapes. Catoosa soils have a more silty subsoil than Bates soils, and they formed over limestone. Lebo soils do not have an argillic horizon. Dennis and Eram soils have a clayey subsoil. Dennis, Lebo, and Eram soils are on slopes below Bates soils.

Typical pedon of Bates loam, 1 to 4 percent slopes, 2,000 feet south and 100 feet east of the NW. corner of sec. 20, T. 22 S., R. 25 E.

A1—0 to 10 inches; very dark brown (10YR 2/2) loam, dark brown (7.5YR 4/2) dry; weak fine and medium granular structure; slightly hard, very friable; common fine roots; strongly acid; gradual smooth boundary.

B1—10 to 14 inches; dark brown (7.5YR 3/2) clay loam, dark brown (7.5YR 4/2) dry; few fine faint reddish yellow (5YR 6/6) mottles; weak fine and medium granular structure; slightly hard, firm; few fine roots; few open pores; thin patchy clay films; strongly acid; gradual smooth boundary.

B2t—14 to 21 inches; dark brown (7.5YR 3/3) clay loam, brown (7.5YR 5/4) dry; common medium faint yellowish red (5YR 5/6) mottles; weak fine subangular blocky structure; hard, firm; few fine roots; few open pores; thin patchy clay films; few fine black concretions; 3 percent sandstone fragments in lower part; strongly acid; clear smooth boundary.

B3—21 to 31 inches; brown (7.5YR 4/4) clay loam, strong brown (7.5YR 5/6) dry; common faint reddish yellow (5YR 6/6) and yellowish red (5YR 5/6) mottles; weak medium subangular blocky structure; hard, firm; very few fine roots; few open pores; few dark brown streaks; common black concretions; 20 percent sandstone fragments; strongly acid; clear smooth boundary.

Cr—31 inches; soft, fine grained, acid sandstone.

The thickness of the solum and the depth to sandstone range from 20 to 40 inches. The mollic epipedon is 8 to 24 inches thick. The solum ranges from slightly acid to strongly acid.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 to 5 dry), and chroma of 2 or 3. It commonly is loam, but the range includes fine sandy loam or silt loam.

The B2 horizon has hue of 10YR or 7.5YR, value of 3 to 5 (4 to 6 dry), and chroma of 3 to 6. It is clay loam, loam, or sandy clay loam.

The B3 horizon has hue of 10YR or 7.5YR, value of 4 or 5 (5 to 7 dry), and chroma of 4 to 6. It is clay loam, loam, or sandy clay loam. In some pedons, this horizon has streaks of mottles that have value of 4 or higher and chroma of 2 or less.

Catoosa series

The Catoosa series consists of moderately deep, well drained soils on uplands. These soils are moderately permeable in the upper part of the subsoil and are moderately slowly permeable in the lower part. They formed in residuum of limestone. The slope ranges from 1 to 3 percent.

Catoosa soils are similar to Bates soils and the deep Newtonia soils, and they occur on similar positions on the landscape. Catoosa soils are commonly adjacent to Clareson, Kenoma, Newtonia, and Summit soils. Bates soils are less silty than Catoosa soils. Clareson soils are on side slopes below Catoosa soils and have more coarse fragments. The deep Kenoma soils have a clayey subsoil, and they are above Catoosa soils. The deep Summit soils have a clayey subsoil. They are on side slopes below Catoosa soils or are adjacent to small drainageways.

Typical pedon of Catoosa silt loam, 1 to 3 percent slopes, 1,150 feet east and 50 feet north of the SW. corner of sec. 20, T. 18 S., R. 22 E.

Ap—0 to 8 inches; dark brown (7.5YR 3/2) silt loam, brown (7.5YR 4/2) dry; moderate fine granular structure; hard, friable; common fine roots; slightly acid; clear smooth boundary.

A12—8 to 12 inches; dark brown (7.5YR 3/2) silt loam, brown (7.5YR 4/2) dry; strong medium granular structure; hard, friable; common fine roots; slightly acid; clear smooth boundary.

B1—12 to 18 inches; dark reddish brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/4) dry; strong medium subangular blocky structure; hard, firm; common fine roots; few fine black concretions; medium acid; gradual smooth boundary.

B21t—18 to 25 inches; dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) dry; strong medium subangular blocky structure; very hard, very firm; common fine roots; few fine black concretions; medium acid; gradual smooth boundary.

B22—25 to 29 inches; dark red (2.5YR 3/6) silty clay, red (2.5YR 4/6) dry; moderate fine and medium subangular blocky structure; extremely hard, very firm; few fine roots; few black concretions; 2 percent chert fragments less than 1/2 inch in diameter by volume; medium acid; abrupt smooth boundary.

R—29 inches; hard limestone.

The thickness of the solum and the depth to limestone range from 20 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3. The reaction is slightly acid or medium acid.

The B2t horizon has hue of 7.5YR to 2.5YR, value of 2 to 4, and chroma of 2 to 6. The reaction is medium acid to neutral. The content of chert and limestone fragments in the lower part of the solum does not exceed 20 percent by volume.

Clareson series

The Clareson series consists of moderately deep, well drained, moderately slowly permeable soils on uplands. These soils formed in residuum of limestone. The slope ranges from 2 to 15 percent.

Clareson soils are commonly adjacent to Catoosa, Eram, Lebo, and Welda soils on the landscape. Catoosa soils do not have coarse fragments in the subsoil, and they are on ridgetops above Clareson soils. Eram soils have a clayey subsoil and are on the lower part of side slopes. Lebo soils have a loamy skeletal subsoil and are on the steeper, lower part of side slopes. Welda soils do not have a mollic epipedon and are on ridgetops.

Typical pedon of Clareson silty clay loam in an area of Clareson-Rock outcrop complex, 2 to 15 percent slopes, 1,400 feet west and 50 feet south of the NE. corner of sec. 22, T. 18 S., R. 22 E.

A1—0 to 11 inches; very dark brown (7.5YR 2/2) silty clay loam, dark brown (7.5YR 3/2) dry; strong fine and medium granular structure; very hard, firm; common fine roots; slightly acid; gradual smooth boundary.

B1—11 to 16 inches; dark reddish brown (5YR 3/2) dry or moist, flaggy silty clay loam; strong fine subangular blocky structure; very hard, firm; common fine roots; thin patchy clay films; 30 to 40 percent limestone fragments by volume; slightly acid; gradual smooth boundary.

B2t—16 to 28 inches; dark reddish brown (5YR 3/3) dry or moist; flaggy silty clay; strong medium subangular blocky structure; extremely hard, very firm; common fine roots; 40 to 60 percent limestone fragments by volume; thin continuous clay films; neutral; gradual wavy boundary.

B3—28 to 33 inches; dark reddish brown (5YR 3/4) and reddish brown (7.5YR 4/3) dry or moist, flaggy silty clay; strong fine subangular blocky structure; extremely hard, very firm; few fine roots; 40 to 60 percent limestone fragments by volume; neutral; abrupt wavy boundary.

R—33 inches; limestone.

The thickness of the solum and the depth to limestone range from 20 to 40 inches. Reaction ranges from medium acid to neutral throughout the solum.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3. It is dominantly silty clay loam, but the range includes silt loam, flaggy silty clay loam, and flaggy silt loam.

The B2t horizon has hue of 7.5YR, 5YR, or 2.5YR; value of 3 or 4; and chroma of 2 to 6. It is 35 to 85 percent limestone fragments.

Dennis series

The Dennis series consists of deep, moderately well drained, slowly permeable soils on uplands. These soils developed in residuum or colluvium from shale. The slope ranges from 1 to 6 percent.

Dennis soils are similar to Newtonia, Okemah, and Welda soils, and they are on similar positions on the landscape. Dennis soils are commonly adjacent to Bates, Eram, Kenoma, and Parsons soils. In Newtonia soils, the subsoil is less clayey than in Dennis soils, and it does not have wetness mottles in the upper part. The subsoil of Okemah soils has chroma of 2 or less. Welda soils do not have a mollic epipedon. Bates soils are above Dennis soils. They are moderately deep and have a less clayey subsoil than those soils. Eram soils are on the lower part of side slopes, and they have shale at a depth of 20 to 40 inches. Kenoma and Parsons soils are clayey in the upper part of the subsoil. Parsons soils are in the less sloping areas.

Typical pedon of Dennis silt loam, 1 to 3 percent slopes, 1,680 feet west and 2,000 feet north of the SE. corner of sec. 30, T. 21 S., R. 24 E.

Ap—0 to 11 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; moderate fine granular structure; hard, friable; common fine roots; strongly acid; clear smooth boundary.

B1—11 to 17 inches; dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; common fine faint yellowish brown (10YR 5/6) mottles; moderate fine subangular blocky structure; hard, firm; common fine roots; strongly acid; gradual smooth boundary.

B21t—17 to 25 inches; yellowish brown (10YR 5/4) silty clay, light yellowish brown (10YR 6/4) dry; common medium prominent red (2.5YR 4/6) and few fine faint dark grayish brown (10YR 4/2) mottles; strong fine subangular blocky structure; very hard, very firm; thin patchy clay films; common fine roots; few fine black stains and masses; very strongly acid; clear smooth boundary.

B22t—25 to 36 inches; dark brown (10YR 4/3) silty clay, brown (10YR 5/3) dry; many medium prominent red (2.5YR 4/6) and medium faint dark grayish brown (10YR 4/2) mottles; moderate fine blocky structure; extremely hard, very firm; thick continuous clay films; common fine roots; few fine black stains and masses; medium acid; gradual smooth boundary.

B23t—36 to 48 inches; dark brown (10YR 4/3) and strong brown (7.5YR 5/6) silty clay, brown (10YR 5/3) and reddish yellow (7.5YR 6/6) dry; few fine distinct red (2.5YR 4/6) mottles; moderate fine blocky structure; extremely hard, very firm; thick continuous clay films; few fine roots; common black stains and concretions; slightly acid; gradual smooth boundary.

B3—48 to 60 inches; yellowish brown (10YR 5/6) silty clay, brownish yellow (10YR 6/6) dry; common fine distinct dark grayish brown (10YR 4/2) mottles; moderate fine blocky structure; very hard, very firm; thin patchy clay films; few fine roots; common black stains and concretions; neutral.

The solum is more than 60 inches thick. The thickness of the mollic epipedon ranges from 10 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3. It is medium acid or strongly acid. Some pedons have an A2 horizon.

The B1 horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 3 or 4. The reaction ranges from medium acid to very strongly acid. The B2t horizon has hue of 10YR, 7.5YR, or 2.5Y, value of 4 or 5, and chroma of 3 to 6. It has common fine and medium mottles in shades of gray, brown, red, and yellow. It is silty clay loam, silty clay, or clay. The reaction ranges from slightly acid to very strongly acid.

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. The slope ranges from 1 to 10 percent.

Eram soils are commonly adjacent to Bates, Clareson, Dennis, Lebo, and Summit soils. Lebo soils have coarse fragments in the subsoil, and they are on steeper slopes above Eram soils. Bates soils have a less clayey subsoil than Eram soils, and they are underlain by sandstone and silty shale at a depth of 20 to 40 inches. Bates soils occur above Eram soils on the landscape. Clareson soils have coarse fragments in the subsoil. They formed in residuum of limestone and are above Eram soils on the landscape. Dennis and Summit soils have shale at a depth of more than 40 inches and are below Eram soils.

Typical pedon of Eram silty clay loam, 1 to 4 percent slopes, 2,340 feet west and 100 feet south of the NE. corner of sec. 28, T. 18 S., R. 23 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; strong fine and medium granular structure; very hard, friable; common fine roots; slightly acid; clear smooth boundary.

B21t—9 to 18 inches; dark grayish brown (10YR 4/2) silty clay, brown (10YR 4/3) dry; common fine distinct yellowish red (5YR 5/6) and strong brown (7.5YR 5/6) mottles; moderate medium blocky structure; extremely hard, very firm; common fine roots; less than 5 percent sandstone fragments; few fine black concretions; slightly acid; gradual smooth boundary.

B22t—18 to 27 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; common medium distinct strong brown (7.5YR 5/6) mottles; moderate fine and medium blocky structure; very hard, very firm; few fine roots; 5 percent fine shale fragments; few fine black concretions; neutral; gradual smooth boundary.

Cr—27 inches; gray and olive clayey shale.

The thickness of the solum and the depth to shale range from 20 to 40 inches. The thickness of the mollic epipedon ranges from 7 to 15 inches.

The A horizon has hue of 10YR, 7.5YR, or 2.5Y, value of 2 or 3, and chroma of 2 or 3. It is dominantly silty clay loam, but the range includes silt loam and clay loam. The reaction is slightly acid or medium acid.

The B2t horizon has hue of 10YR, 7.5YR, or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It is clay loam, silty clay loam, silty clay, or clay. The reaction ranges from strongly acid to neutral. The Cr horizon is shale or compacted clay beds.

Grundy series

The Grundy series consists of deep, somewhat poorly drained, slowly permeable soils on uplands. These soils formed in loess. The slope ranges from 1 to 3 percent.

Grundy soils are similar to Okemah, Summit, and Woodson soils, and they are commonly adjacent to Kenoma, Newtonia, Summit, and Woodson soils on the landscape. Okemah soils are on foot slopes. They have a thicker silty A horizon than Grundy soils. The clay content of the solum does not decrease in Okemah soils. In the Summit soils, the A horizon is silty clay loam, and the clay content of the solum does not decrease with depth. Summit soils are adjacent to small drainageways on foot slopes. Kenoma soils are clayey in the upper part of the subsoil. Kenoma and Grundy soils are in similar positions on the landscape. Newtonia soils are on slopes below Grundy soils and have a less clayey subsoil than those soils. Woodson soils are in the less sloping areas, and they are clayey in the upper part of the subsoil.

Typical pedon of Grundy silt loam, 1 to 3 percent slopes, 1,900 feet east and 75 feet north of the SW. corner of sec. 20, T. 16 S., R. 25 E.

Ap—0 to 11 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; slightly hard, friable; few fine roots; neutral; gradual smooth boundary.

B1—11 to 16 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; strong fine subangular blocky structure; hard, firm; few fine roots; thin continuous clay films; slightly acid; gradual smooth boundary.

B21t—16 to 21 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common fine faint very dark grayish brown (10YR 3/2) mottles; moderate fine blocky struature; extremely hard, very firm; few fine roots; thick continuous clay films; neutral; gradual smooth boundary.

B22t—21 to 32 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; many medium distinct strong brown (7.5YR 5/6) mottles; some very dark brown streaks in cracks; moderate fine blocky structure; extremely hard, very firm; few fine roots; few fine black concretions; thick continuous clay films; neutral; gradual smooth boundary.

B23t—32 to 48 inches; mottled olive brown (2.5Y 4/4), yellowish brown (10YR 5/6), and grayish brown (10YR 5/2) silty clay, light olive brown (2.5Y 5/4), brownish yellow (10YR 6/6), and light brownish gray

(10YR 6/2) dry; weak medium blocky structure; extremely hard, very firm; few fine roots; few fine black concretions; thick continuous clay films; neutral; gradual smooth boundary.

B3—48 to 60 inches; grayish brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; common fine distinct yellowish brown (10YR 5/6) mottles; weak medium blocky structure; extremely hard, very firm; few fine black concretions; neutral.

The thickness of the solum ranges from 40 to about 60 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The reaction ranges from medium acid to neutral.

The B2t horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2 in the lower part. The mottles have hue of 10YR to 5YR, value of 4 or 5, and chroma of 2 to 6. Texture is silty clay or silty clay loam. The reaction ranges from medium acid to neutral.

Some pedons have a C horizon that has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2. It is silty clay loam. The reaction is slightly acid or neutral. The mottles are similar to those of the B horizon.

Hepler series

The Hepler series consists of deep, somewhat poorly drained, moderately slowly permeable soils on low stream terraces. These soils formed in silty alluvial sediment. The slope ranges from 0 to 2 percent.

Hepler soils are similar to Lanton and Verdigris soils, and they are commonly adjacent to Lanton, Mason, and Verdigris soils on the landscape. Lanton, Mason, and Verdigris soils have a mollic epipedon and do not have an albic horizon. Lanton and Verdigris soils are adjacent to stream channels. Mason soils are on terraces.

Typical pedon of Hepler silt loam, 1,325 feet west and 25 feet south of the NE. corner of sec. 15, T. 19 S., R. 24 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; common fine roots; slightly acid; abrupt smooth boundary.

A21—9 to 16 inches; dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) silt loam, light brownish gray (10YR 6/2) and light gray (10YR 7/2) dry; weak fine granular structure; hard, friable; common fine roots; medium acid; clear smooth boundary.

A22—16 to 25 inches; mottled brown (10YR 5/3), pale brown (10YR 6/3), and yellowish brown (10YR 5/6) silt loam, pale brown (10YR 6/3), very pale brown (10YR 7/3), and brownish yellow (10YR 6/6) dry; weak medium granular structure; hard, friable; few fine roots; medium acid; gradual wavy boundary.

B21t—25 to 29 inches; dark grayish brown (10YR 4/2) silty clay loam, grayish brown (10YR 5/2) dry; common medium distinct brown (7.5YR 5/4) mottles; weak medium subangular blocky structure; extremely hard, firm; few fine roots; very strongly acid; gradual smooth boundary.

B22t—29 to 40 inches; coarsely mottled strong brown (7.5YR 5/6) and dark grayish brown (10YR 4/2) silty clay loam, reddish yellow (7.5YR 6/6) and grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very hard, firm; few fine roots; few black concretions; strongly acid; gradual smooth boundary.

B3—40 to 60 inches; coarsely mottled grayish brown (10YR 5/2) and strong brown (7.5YR 6/6) silty clay loam, light brownish gray (10YR 6/2) and reddish yellow (7.5YR 6/6) dry; weak fine subangular blocky structure; very hard, very firm; few fine black concretions; slightly acid.

The thickness of the solum is 40 to more than 60 inches.

The A1 horizon has hue of 10YR, value of 3 or less, and chroma of 1 or 2. It is less than 10 inches thick. The reaction ranges from slightly acid to strongly acid. The A2 horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 3. The reaction ranges from medium acid to very strongly acid.

The B2t horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 1 or 2. It is mottled, mostly with colors of higher chroma than in the soil matrix. The reaction is strongly acid or very strongly acid.

The B3 horizon is silty clay loam, and in some pedons it has strata of silty clay.

Kenoma series

The Kenoma series consists of deep, moderately well drained, very slowly permeable soils on terraces and uplands. These soils formed in old alluvial sediment. The slope ranges from 1 to 4 percent.

Kenoma soils are similar to Parsons and Woodson soils, and they are commonly adjacent to Catoosa, Dennis, Grundy, and Woodson soils on the landscape. Parsons soils have an A2 horizon. Parsons and Kenoma soils are on similar positions on the landscape. Woodson soils have chroma of 1 or less in the lower part of the mollic epipedon, and they are in the less sloping areas. The moderately deep Catoosa soils are on slopes below Kenoma soils. They are less clayey than Kenoma soils. The grayer Grundy soils are on ridgetops above Kenoma soils. Dennis soils are less clayey in the upper part of the subsoil, and they have a solum that is more than 60 inches thick. Dennis soils occur below Kenoma soils.

Typical pedon of Kenoma silt loam, 1 to 4 percent slopes, 1,200 feet north and 50 feet west of the SE. corner of sec. 8, T. 19 S., R. 22 E.

Ap—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable; common fine roots; slightly acid; abrupt smooth boundary.

B21t—10 to 22 inches; very dark grayish brown (10YR 3/2) silty clay, dark brown (10YR 4/3) dry; many fine faint dark brown (10YR 3/3) mottles; weak fine subangular blocky structure; very hard, firm; common fine roots; thin continuous clay films; few fine black stains and concretions; slightly acid; clear smooth boundary.

B22t—22 to 30 inches; dark yellowish brown (10YR 3/4) silty clay, dark yellowish brown (10YR 4/4) dry; common fine faint brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; very hard, very firm; few fine roots; few fine black concretions; few vertical cracks filled with very dark grayish brown silty clay; mildly alkaline; gradual smooth boundary.

B23t—30 to 44 inches; dark brown (7.5YR 4/4) silty clay, strong brown (7.5YR 5/6) dry; few fine distinct yellowish red (5YR 4/8) mottles; weak fine subangular blocky structure; extremely hard, very firm; few fine roots; few fine chert fragments; few fine lime concretions; few fine black concretions; mildly alkaline; gradual smooth boundary.

B3—44 to 58 inches; dark brown (10YR 4/3) and brown (7.5YR 4/4) silty clay, brown (10YR 5/3) and strong brown (7.5YR 5/6) dry; very weak fine subangular blocky structure; extremely hard, very firm; few black stains; 2 percent chert fragments; mildly alkaline; gradual smooth boundary.

C—58 to 60 inches; pale brown (10YR 6/3) silty clay, very pale brown (10YR 7/3) dry; many coarse distinct strong brown (7.5YR 4/8) mottles; massive; extremely hard, very firm; few slickensides; common coarse black stains; 2 percent chert fragments; mildly alkaline.

The thickness of the solum ranges from about 30 to 60 inches. The thickness of the mollic epipedon ranges from 10 to 30 inches. Depth to limestone or shale is more than 40 inches. In some pedons, less than 15 percent of the volume of any horizon is waterworn chert gravel.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. It is dominantly silt loam, but the range includes silty clay loam. The reaction ranges from strongly acid to slightly acid.

The B2t horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3 in the upper part. In the lower part, value is 3 to 6, and chroma is 2 to 6. Texture is silty clay or clay. The reaction ranges from medium acid to mildly alkaline.

The C horizon has hue of 5YR to 5Y, value of 4 to 6, and chroma of 2 to 6. It is mottled with browns, reds, grays, and yellows. Texture is silty clay or silty clay loam. The reaction ranges from slightly acid to moderately alkaline.

Lanton series

The Lanton series consists of deep, somewhat poorly drained, moderately slowly permeable soils on flood plains. These soils formed in silty alluvium. The slope ranges from 0 to 2 percent.

In this survey area the Lanton soils have a thinner mollic epipedon than is defined in the range for the series, but this difference does not alter use and behavior of the soils.

Lanton soils are similar to Hepler and Verdigris soils, and they are in similar positions on the landscape. They are commonly adjacent to Hepler, Mason, Osage, and Verdigris soils. Hepler soils have an albic horizon. Verdigris soils do not have wetness mottles within 16 inches of the surface. Mason soils have an argillic horizon, and they are on terraces above Lanton soils. Osage soils have a clayey subsoil, and they are in swales and backwater areas.

Typical pedon of Lanton silt loam, 1,300 feet west and 2,000 feet north of the SE. corner of sec. 31, T. 19 S., R. 24 E.

Ap—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable; common fine roots; neutral; clear smooth boundary.

A12—10 to 14 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few fine distinct yellowish brown (10YR 5/4) mottles; weak fine granular structure; slightly hard, friable; common fine roots; neutral; clear smooth boundary.

AC—14 to 38 inches; coarsely mottled dark grayish brown (10YR 4/2), yellowish brown (10YR 5/6), and light brownish gray (10YR 6/2) silt loam, grayish brown (10YR 5/2), brownish yellow (10YR 6/6), and light gray (10YR 7/2) dry; weak fine granular structure; slightly hard, friable; few fine roots; neutral; gradual smooth boundary.

Cg—38 to 53 inches; coarsely mottled dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2), dark yellowish brown (10YR 4/4), and pale brown (10YR 6/3) silt loam, grayish brown (10YR 5/2), dark grayish brown (10YR 4/2), yellowish brown (10YR 5/4), and very pale brown (10YR 7/3) dry; massive; slightly hard, friable; few fine roots; neutral; clear smooth boundary.

Ab—53 to 60 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; common fine faint grayish brown (10YR 5/2), yellowish brown (10YR 5/4), and pale brown (10YR 6/3) mottles; massive; hard, friable; few open pores; neutral.

The thickness of the solum ranges from 30 to more than 50 inches. The thickness of the mollic epipedon ranges from 10 to 19 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The reaction is neutral or slightly acid. The middle and lower parts of this horizon are mottled with various shades of grays and browns.

The Cg horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. In most pedons, it is silt loam or silty clay loam, but in some pedons, it is silty clay below 35 inches. It is faintly to prominently mottled with shades of browns and grays. The reaction is neutral or slightly acid. Buried dark horizons are common.

Lebo series

The Lebo series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in residuum of shale interbedded with sandstone. The slope ranges from 8 to 30 percent.

Lebo soils are commonly adjacent to Bates, Clareson, and Eram soils on the landscape. Bates, Clareson, and Eram soils all have an argillic horizon. Bates and Clareson soils are in the less sloping areas on ridgetops above Lebo soils. Eram soils are in the less sloping areas below Lebo soils.

Typical pedon of Lebo channery silty clay loam, 15 to 30 percent slopes, 1,450 feet south and 50 feet east of the NW. corner of sec. 36, T. 19 S., R. 24 E.

A1—0 to 11 inches; very dark grayish brown (10YR 3/2) channery silty clay loam, dark grayish brown (10YR 4/2) dry; strong medium granular structure; hard, friable; common fine roots; 20 percent, by volume, limestone fragments 1 inch to 3 inches in diameter; neutral; gradual wavy boundary.

B2—11 to 18 inches; dark grayish brown (10YR 4/2) channery silty clay loam, grayish brown (10YR 5/2) dry; strong fine subangular blocky structure; hard, friable; common fine roots; by volume, 10 percent shale and 20 percent sandstone fragments 1/4 inch to 2 inches in diameter and about 1/16 to 1/4 inch thick; neutral; gradual wavy boundary.

B3—18 to 28 inches; grayish brown (10YR 5/2) shaly silty clay loam, light brownish gray (10YR 6/2) dry; moderate fine subangular blocky structure; hard, friable; common fine roots; 25 percent grayish brown shale fragments that are soft and silty and are the same size as in the B2 horizon; neutral; clear wavy boundary.

C—28 to 38 inches; grayish brown (2.5Y 5/2) shaly silty clay loam, light brownish gray (2.5Y 6/2) dry; massive; hard, friable; few fine roots; 80 percent soft silty shales with thin seams of sandstone; soil material is between shale plates and in seams and pockets; neutral; gradual smooth boundary.

Cr—38 inches; soft silty shale with thin seams of sandstone.

The thickness of the solum and the depth to weathered silty shale bedrock range from 20 to 40 inches. The mollic epipedon ranges from 7 to 18 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3. It is dominantly channery silty clay loam, but the range includes silty clay loam, silt loam, channery silt loam, and shaly silt loam. The reaction ranges from slightly acid to mildly alkaline.

The B2 horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It is shaly silty clay loam, silty clay loam, or silt loam.

The C horizon has the same colors as the B2 horizon.

Mason series

The Mason series consists of deep, well drained, moderately slowly permeable soils on terraces. These soils formed in silty alluvium. The slope ranges from 0 to 2 percent.

Mason soils are similar to Newtonia soils and are commonly adjacent to Hepler, Lanton, and Verdigris soils on the landscape. Newtonia soils have a redder subsoil and are on uplands. Lanton and Verdigris soils do not have an argillic horizon and occur on flood plains. Hepler soils do not have a mollic epipedon. Hepler and Mason soils are on similar positions on the landscape.

Typical pedon of Mason silt loam, 1,050 feet west and 100 feet south of the NE. corner of sec. 16, T. 18 S., R. 24 E.

Ap—0 to 8 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate fine and very fine granular structure; hard, friable; common fine roots; slightly acid; clear smooth boundary.

A12—8 to 18 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 4/3) dry; moderate fine and coarse granular structure; slightly hard, friable; common fine roots; slightly acid; gradual smooth boundary.

B21t—18 to 23 inches; very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 4/3) dry; moderate fine subangular blocky structure; hard, firm; few fine roots; slightly acid; gradual smooth boundary.

B22t—23 to 41 inches; dark brown (10YR 3/3) silty clay loam, dark yellowish brown (10YR 4/4) dry; moderate fine and medium subangular blocky structure; hard, firm; few fine roots; slightly acid; gradual smooth boundary.

B3—41 to 50 inches; dark brown (10YR 3/3) silty clay loam, dark yellowish brown (10YR 5/3) dry; weak fine and medium subangular blocky structure; hard, firm; few fine roots; slightly acid; gradual smooth boundary.

C—50 to 60 inches; dark yellowish brown (10YR 4/4) and dark gray (10YR 4/1) silty clay loam, dark yellowish brown (10YR 5/3) and grayish brown (10YR 5/2) dry; common medium distinct yellowish brown (10YR 5/4) mottles; weak medium blocky structure; hard, firm; neutral.

The thickness of the solum ranges from 40 to more than 60 inches. The thickness of the mollic epipedon is more than 20 inches. The reaction is neutral to medium acid throughout.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3.

The B2t horizon has hue of 7.5YR or 10YR, value of 3 or 4, and chroma of 2 to 4. It is silty clay loam, clay loam, or silt loam.

The C horizon is variable. In some pedons, it is mottled, stratified silty clay loam, silt loam, clay loam, or loam.

Newtonia series

The Newtonia series consists of deep, well drained, moderately permeable soils on uplands. These soils formed in silty and clayey sediment. The slope ranges from 0 to 8 percent.

Newtonia soils are similar to Catoosa, Dennis, and Mason soils and are commonly adjacent to Catoosa, Grundy, and Welda soils. Catoosa soils are underlain by limestone bedrock at a depth of 20 to 40 inches, and they are below Newtonia soils. Dennis and Newtonia soils are on similar positions on the landscape. Dennis soils have a more clayey subsoil, and they have wetness mottles in the upper 20 inches of the subsoil. Mason soils are browner than Newtonia soils and are on terraces. Grundy soils have a more clayey subsoil, and they have darker colored A and B1 horizons. Grundy and Welda soils are on ridgetops. Welda soils do not have a mollic epipedon.

Typical pedon of Newtonia silt loam, 1 to 4 percent slopes, 2,100 feet east and 150 feet north of the center of sec. 36, T. 18 S., R. 21 E.

Ap—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, dark brown (10YR 4/3) dry; medium fine granular structure; hard, very friable; common fine roots; slightly acid; clear smooth boundary.

A12—10 to 13 inches; dark brown (7.5YR 3/2) silt loam, brown (7.5YR 4/2) dry; strong medium granular structure; hard, friable; common fine roots; slightly acid; gradual smooth boundary.

B1—13 to 26 inches; dark reddish brown (5YR 3/3) silty clay loam, dark brown (7.5YR 3/2) dry; moderate fine subangular blocky structure; hard, friable; few fine roots; medium acid; gradual smooth boundary.

B21t—26 to 40 inches; dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/3) dry; strong fine subangular blocky structure; very hard, firm; few fine roots; few fine black concretions; less than 1 percent chert and limestone fragments less than 1/4 inch in diameter; medium acid; gradual smooth boundary.

B22t—40 to 49 inches; reddish brown (5YR 4/4) silty clay loam, reddish brown (5YR 5/4) dry; moderate medium and fine subangular blocky structure; very hard, very firm; common black concretions; less than 1 percent chert fragments less than 1/4 inch in diameter; medium acid; gradual smooth boundary.

B3—49 to 60 inches; yellowish red (5YR 4/6) silty clay, yellowish red (5YR 5/6) dry; weak fine subangular blocky structure; extremely hard, very firm; few fine black concretions and stains; medium acid.

The thickness of the solum is more than 60 inches. The thickness of the mollic epipedon ranges from 15 to 30 inches.

The A horizon has hue of 10YR and 7.5YR, value of 2 or 3, and chroma of 1 to 3. The reaction is slightly acid or medium acid.

The B1 horizon has hue of 7.5YR and 5YR, value of 3 and 4, and chroma of 2 to 4. It is silt loam or silty clay loam. The reaction is slightly acid or medium acid.

The B2t horizon has hue of 2.5YR or 5YR, value of 3 or 4, and chroma of 3 to 6. The upper part is silty clay loam, and the lower part is silty clay loam or silty clay. The reaction is medium acid or strongly acid.

The B3 horizon has hue of 2.5YR or 5YR, value of 3 or 4, and chroma of 6 to 8. It is silty clay loam or silty clay. Some pedons have mottles in shades of brown or yellow. The reaction ranges from strongly acid to neutral.

Okemah series

The Okemah series consists of deep, moderately well drained, slowly permeable soils on foot slopes and on uplands. These soils formed in residuum or colluvium from noncalcareous shaly clay loam or clay. The slope ranges from 0 to 3 percent.

Okemah soils are similar to Dennis, Grundy, and Summit soils and are commonly adjacent to Summit, Verdigris, and Woodson soils on the landscape. In Dennis soils, the subsoil matrix has chroma of 3 or more. Okemah and Dennis soils are on similar positions on the landscape. Grundy soils, on ridgetops, have a clay content that decreases with depth. Summit soils have a silty clay loam A horizon. They are less mottled than Okemah soils, and they are on steeper slopes above those soils. Verdigris soils have a less clayey subsoil than Okemah soils and are on flood plains. Woodson soils have a thinner A1 horizon than Okemah soils, and they are clayey in the upper part of the subsoil. Woodson and Okemah soils are on similar positions on the landscape.

Typical pedon of Okemah silt loam, 0 to 3 percent slopes, 2,400 feet west and 500 feet south of the NE. corner of sec. 20, T. 17 S., R. 23 E.

Ap—0 to 8 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; hard, friable; few fine roots; slightly acid; clear smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; moderate medium granular structure; hard, friable; few fine roots; neutral; gradual smooth boundary.

B1—12 to 18 inches; very dark gray (10YR 3/1) silty clay loam, dark grayish brown (10YR 4/2) dry; few fine distinct brown (7.5YR 4/4) mottles; moderate fine subangular blocky structure; hard, firm; few fine roots; medium acid; gradual smooth boundary.

B21t—18 to 24 inches; very dark grayish brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; common fine prominent yellowish red (5YR 4/6) mottles; moderate fine blocky structure; very hard, very firm; few fine roots; few black concretions; medium acid; gradual smooth boundary.

B22t—24 to 52 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; common coarse prominent yellowish red (5YR 4/6) mottles; weak medium blocky structure; extremely hard, very firm; few black streaks and splotches; few very fine roots; slightly acid; gradual smooth boundary.

B3—52 to 60 inches; gray (10YR 5/1) and dark yellowish brown (10YR 4/6) silty clay, gray (10YR 6/1) and yellowish brown (10YR 5/6) dry; many coarse prominent yellowish red (5YR 4/6) mottles; weak coarse subangular blocky structure; very hard, very firm; few black streaks; neutral.

The thickness of the solum is more than 60 inches. The thickness of the mollic epipedon ranges from 15 to 28 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The reaction is medium acid to neutral.

The B2t horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. It is mottled in shades of gray to red. Where the B2t horizon does not have a dominant matrix color, it has coarse mottles in shades of brown, gray, olive, or red. The reaction is medium acid to mildly alkaline.

Osage series

The Osage series consists of deep, poorly drained, very slowly permeable soils on flood plains. These soils formed in clayey alluvium. The slope ranges from 0 to 2 percent.

Osage soils are similar to Summit soils, and they are commonly adjacent to Lanton, Summit, and Verdigris soils on the landscape. Summit soils have an argillic horizon and are on foot slopes. The somewhat poorly drained Lanton soils and the well drained Verdigris soils have a less clayey subsoil than Osage soils and are adjacent to stream channels.

Typical pedon of Osage silty clay, 1,250 feet south and 500 feet west of the NE. corner of sec. 17, T. 19 S., R. 25 E.

Ap—0 to 8 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; weak medium granular structure; very hard, very firm; few fine roots; neutral; clear smooth boundary.

A12—8 to 23 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure; very hard, very firm; few fine roots; neutral; gradual smooth boundary.

B21g—23 to 38 inches; very dark gray (10YR 3/1) silty clay, grayish brown (2.5Y 5/2) dry; few fine distinct yellowish brown (10YR 5/6) mottles; weak fine and medium blocky structure; extremely hard, very firm; few fine lime concretions in lower part; few fine roots; neutral; diffuse smooth boundary.

B22g—38 to 44 inches; dark gray (2.5Y 4/1) silty clay, gray (2.5Y 5/1) dry; few fine faint yellowish brown (10YR 5/6) mottles; weak fine blocky structure; extremely hard, extremely firm; few fine and medium lime concretions; neutral; gradual smooth boundary.

C—44 to 60 inches; gray (2.5Y 5/1) clay, light gray (10YR 6/1) dry; common medium distinct light olive brown (2.5Y 5/4) mottles; massive; extremely hard, extremely firm; many soft fine and medium lime concretions; mildly alkaline.

The thickness of the solum ranges from 40 to more than 60 inches. The thickness of the mollic epipedon ranges from 24 to 40 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay, but the range includes silty clay loam. The reaction ranges from strongly acid to neutral.

The upper part of the B horizon has hue of 10YR or 2.5Y, value of 3, and chroma of 2 or less. The lower part of the B horizon has hue of 2.5Y or neutral, value of 3 to 5, and chroma of 1.5 or less. It contains mottles of higher chroma. The B horizon is silty clay or clay. The reaction ranges from medium acid to mildly alkaline. Some pedons are calcareous at depths of more than 36 inches, or they contain gypsum crystals in the lower part of the B or C horizon.

Parsons series

The Parsons series consists of deep, somewhat poorly drained, very slowly permeable soils on uplands. These soils formed in old clayey alluvium. The slope ranges from 0 to 2 percent.

Parsons soils are similar to Kenoma and Woodson soils and are on similar positions on the landscape. They are commonly adjacent to Dennis and Woodson soils. Kenoma and Woodson soils do not have an A2 horizon. Dennis soils have a B1 horizon, and they do not have the abrupt textural change between the A and B horizons. They are on side slopes below Parsons soils.

Typical pedon of Parsons silt loam, 200 feet north and 100 feet east of the SW. corner of sec. 32, T. 21 S., R. 25 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few fine faint dark yellowish brown (10YR 3/4) mottles in the lower 4 inches; weak medium granular structure; slightly hard, friable; common fine roots; medium acid; clear smooth boundary.

A2—9 to 13 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; few fine distinct dark brown (7.5YR 4/4) mottles; weak medium granular structure; slightly hard, friable; common fine roots; medium acid; abrupt smooth boundary.

B21tg—13 to 29 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) silty clay, grayish brown (2.5Y 5/2) and dark grayish brown (10YR 4/2) dry; many medium prominent reddish brown (5YR 5/4) mottles; weak medium and coarse blocky structure; very hard, very firm; thin clay films; few fine roots; slightly acid; gradual smooth boundary.

B22tg—29 to 42 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) silty clay, grayish brown (2.5Y 5/2) and dark grayish brown (10YR 4/2) dry; many medium prominent reddish brown (5YR 4/4) mottles; weak coarse blocky structure; very hard, very firm; thin clay films; few fine dark concretions; neutral; gradual smooth boundary.

B3—42 to 60 inches; dark grayish brown (10YR 4/2) and yellowish red (5YR 4/6) silty clay, grayish brown (10YR 5/2) and yellowish red (5YR 5/6) dry; weak coarse blocky structure; very hard, very firm; less than 1 percent siltstone fragments about 1/4 inch in diameter; few fine black concretions; neutral.

The thickness of the solum ranges from 40 to more than 60 inches.

The A horizon has hue of 10YR, value of 3 or 4, and chroma of 2. The A2 horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. The A horizon is less than 16 inches thick, and it ranges from slightly acid to strongly acid.

The B2 horizon has hue of 10YR, value of 3 to 5, and chroma of 1 or 2, and it is mottled in shades of gray, brown, or red. It is clay, clay loam, silty clay, or silty clay loam. The reaction ranges from neutral to strongly acid.

Summit series

The Summit series consists of deep, moderately well drained, slowly permeable soils on uplands. These soils formed in residuum or colluvium from clay or shale. The slope ranges from 1 to 8 percent.

Summit soils are similar to Grundy, Okemah, and Osage soils, and they are commonly adjacent to Catoosa, Eram, Grundy, and Woodson soils on the landscape. In Grundy soils, the clay content decreases with depth. Grundy soils are on ridgetops. In Okemah soils, the surface layer is thick silt loam, and the solum is more than 60 inches thick. These soils are on foot slopes below Summit soils. Osage soils do not have an argillic horizon, and they are in backwater areas on flood plains. Catoosa soils have limestone bedrock at a depth of 20 to 40 inches and are on ridgetops. Eram soils have shale at a depth of 20 to 40 inches. Eram and Summit soils are on similar positions on the landscape. Woodson soils have a silt loam surface layer and an abrupt boundary between the A horizon and the Bt horizon. They are in less sloping areas.

Typical pedon of Summit silty clay loam, 1 to 4 percent slopes, 1,100 feet east and 850 feet north of the SW. corner of sec. 19, T. 18 S., R. 25 E.

Ap—0 to 5 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; strong medium granular structure; hard, friable; common fine roots; neutral; clear smooth boundary.

A12—5 to 11 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; strong medium subangular blocky structure; hard, firm; common fine roots; neutral; clear smooth boundary.

B1—11 to 24 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; few fine distinct olive (5Y 5/4) mottles in the lower part; strong fine and medium subangular blocky structure; very hard, very firm; common fine roots; neutral; gradual boundary.

B21t—24 to 33 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; common medium distinct light olive brown (2.5Y 5/4) mottles; moderate medium blocky structure; extremely hard, extremely firm; clay films on faces of peds; few fine roots; neutral; gradual smooth boundary.

B22t—33 to 42 inches; coarsely mottled olive brown (2.5Y 4/4) and very dark grayish brown (1.5Y 3/2) silty clay, light olive brown (2.5Y 5/6) and grayish brown (2.5Y 5/2) dry; weak fine subangular blocky structure; extremely hard, extremely firm; few fine roots; few black stains and concretions; neutral; gradual smooth boundary.

B3—42 to 60 inches; dark gray (N 4/0) silty clay, light brownish gray (2.5Y 6/2) dry; common coarse faint light olive brown (2.5Y 5/4) mottles; very weak fine subangular blocky structure; extremely hard, extremely firm; common black stains and soft black organic accumulations; few soft accumulations of lime; mildly alkaline.

The solum thickness is 50 to more than 60 inches. The mollic epipedon is more than 18 inches thick.

The A1 horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silty clay. The reaction ranges from medium acid to neutral.

The B1 horizon has the same colors as the A horizon. It is silty clay loam or silty clay and contains more clay than the A horizon.

The B2 horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 4. Texture is silty clay or clay. The reaction ranges from medium acid to neutral in the upper part of the B2 horizon and from slightly acid to moderately alkaline in the lower part.

Verdigris series

The Verdigris series consists of deep, moderately well drained, moderately permeable soils on flood plains. These soils formed in silty alluvium. The slope ranges from 0 to 2 percent.

Verdigris soils are similar to Hepler, Lanton, and Mason soils, and they are commonly adjacent to Hepler, Lanton, Mason, Okemah, and Osage soils on the landscape. Hepler soils do not have a mollic epipedon and are on flood plains above Verdigris soils. Lanton soils have wetness mottles within 16 inches of the surface. Lanton and Verdigris soils are in similar positions on the landscape. Mason soils have an argillic horizon and are on terraces. Okemah soils have a more clayey subsoil than Verdigris soils and are on foot slopes. Osage soils are more clayey, are in swales and backwater areas of the flood plain, and are poorly drained.

Typical pedon of Verdigris silt loam, 200 feet west and 50 feet south of the center of sec. 22, T. 17 S., R. 23 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; hard, friable; few fine roots; slightly acid; clear smooth boundary.

A12—9 to 27 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine and medium granular structure; hard, friable; few fine roots; neutral; gradual smooth boundary.

A13—27 to 32 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few ped faces covered with light brownish gray (10YR 6/2) dry; moderate fine and medium granular structure; very hard, firm; few fine roots; neutral; diffuse smooth boundary.

AC—32 to 52 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak fine granular structure; very hard, firm; few fine roots; neutral; gradual smooth boundary.

C—52 to 60 inches; dark yellowish brown (10YR 4/4) silt loam, light yellowish brown (10YR 6/4) dry; massive; very hard, firm; few fine roots; neutral.

The thickness of the solum ranges from 30 to 55 inches. The thickness of the mollic epipedon ranges from 24 to more than 50 inches. Free carbonates do not occur within a depth of 50 inches. The soil to a depth of 50 inches or more ranges from medium acid to neutral.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. It is dominantly silt loam, but the range includes silty clay loam. The AC horizon has the same range in color and texture as the A horizon. In some pedons, faint mottles that have higher chroma or lower value, or both, are below a depth of 20 inches.

The C horizon has hue of 7.5YR or 10YR, value of 4 to 6, and chroma of 2 to 4. It is silt loam or silty clay loam.

Welda series

The Welda series consists of deep, well drained, moderately slowly permeable soils on terraces and uplands near larger streams. These soils formed in reddish silty material presumed to be loess. The slope ranges from 2 to 5 percent.

The Welda soils are similar to Dennis soils and are commonly adjacent to Clareson and Newtonia soils on the landscape. Dennis soils have a mollic epipedon. Welda and Dennis soils are on similar positions on the landscape. Clareson and Newtonia soils have a mollic epipedon. Clareson soils are on side slopes below Welda soils. Newtonia soils are on ridgetops above Welda soils.

Typical pedon of Welda silt loam, 2 to 5 percent slopes, 1,330 feet west and 300 feet north of the SE. corner of sec. 7, T. 17 S., R. 25 E.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; strong fine granular structure; hard, friable; common fine roots; neutral; abrupt smooth boundary.

A2—4 to 7 inches; brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak fine granular structure; hard, very friable; common fine roots; neutral; clear smooth boundary.

B1—7 to 10 inches; brown (10YR 4/3) and reddish brown (5YR 4/4) silty clay loam, pale brown (10YR 6/3) and reddish brown (5YR 5/4) dry; strong fine subangular blocky structure; very hard, firm; common fine roots; strongly acid; clear smooth boundary.

B21t—10 to 20 inches; yellowish red (5YR 4/6) silty clay, yellowish red (5YR 5/6) dry; strong fine subangular blocky structure; very hard, very firm; common fine roots; strongly acid; clear smooth boundary.

B22t—20 to 35 inches; reddish brown (5YR 4/4) silty clay, reddish brown (5YR 5/4) dry; common fine faint dark grayish brown (10YR 4/2) mottles; moderate fine blocky structure; extremely hard, very firm; few fine roots; few fine black concretions; medium acid; gradual smooth boundary.

B3—35 to 60 inches; yellowish red (5YR 4/6), grayish brown (10YR 5/2), and brown (10YR 5/3) silty clay loam, yellowish red (5YR 5/6), light brownish gray (10YR 6/2), and pale brown (10YR 6/3) dry; weak fine subangular blocky structure parting to strong fine granular; very hard, firm; few fine roots; common fine black stains and concretions; strongly acid.

The solum thickness ranges from 32 to 60 inches.

The A1 horizon ranges from 3 to 6 inches in thickness and has hue of 10YR or 7.5YR and value and chroma of 2 or 3. In some pedons there is an Ap horizon, which has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 2 or 3. The reaction ranges from medium acid to neutral.

The B2t horizon has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 3 to 6. It is silty clay loam or silty clay. The reaction ranges from strongly acid to slightly acid.

Woodson series

The Woodson series consists of deep, somewhat poorly drained, very slowly permeable soils. These soils are on terraces and uplands. They formed in old clayey alluvium. The slope ranges from 0 to 2 percent.

Woodson soils are similar to Grundy, Kenoma, and Parsons soils and are commonly adjacent to Grundy, Kenoma, Okemah, Parsons, and Summit soils on the landscape. Grundy soils have a B1 horizon and a decrease in content of clay in the lower part of the solum. They occur in the more sloping areas. In Kenoma soils, the subsoil has chroma of 2 or more. Kenoma soils are in the more sloping areas. Parsons soils have an albic horizon and are on similar positions on the landscape. The clay content of Okemah and Summit soils increases less than 20 percent within 3 inches of the upper boundary of the argillic horizon. Okemah and Summit soils occur below Woodson soils adjacent to drainageways and on foot slopes.

Typical pedon of Woodson silt loam, 0 to 2 percent slopes, 75 feet north and 150 feet east of the SW. corner of sec. 11, T. 16 S., R. 22 E.

Ap—0 to 7 inches; very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; moderate fine and medium granular structure; slightly hard, friable; common fine roots; slightly acid; abrupt smooth boundary.

B21t—7 to 24 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; few fine distinct strong brown (7.5YR 4/6) and olive brown (2.5Y 4/4) mottles; weak fine blocky structure; extremely hard, very firm; common fine roots, mostly oriented on ped faces; slightly acid; gradual smooth boundary.

B22t—24 to 30 inches; dark gray (2.5Y 4/1) silty clay, light brownish gray (2.5Y 6/2) dry; common fine and medium distinct grayish brown (2.5Y 5/2) and few fine distinct strong brown (7.5YR 5/6) mottles; weak medium and fine blocky structure; extremely hard, very firm; few fine black concretions; few fine roots; neutral; gradual smooth boundary.

B3—30 to 40 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) dry; few fine distinct strong brown (7.5YR 5/6) mottles; few vertical streaks of very dark gray (10YR 3/1); very weak fine blocky structure; extremely hard, very firm; few fine roots; mildly alkaline; gradual smooth boundary.

C—40 to 60 inches; gray (10YR 5/1) silty clay, light gray (10YR 6/1) dry; few fine and medium distinct strong brown (7.5YR 5/6) mottles that increase with depth; few vertical streaks of very dark gray (10YR 3/1); massive; extremely hard, very firm; very few fine roots; few gypsum crystals in lower part; mildly alkaline.

The thickness of the solum ranges from about 30 to 60 inches. The thickness of the mollic epipedon ranges from about 16 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or less. Texture is dominantly silt loam, but the range includes silty clay loam. The reaction is medium acid or slightly acid in unlimed areas.

The upper part of the B2t horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1.5 or less. It is silty clay or clay. Some pedons have gray silt coatings on ped faces. The lower part of the B2t horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of less than 1.5. It is silty clay or clay. The reaction of the B2t horizon ranges from medium acid to neutral.

The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 3. It is silty clay or silty clay loam.

formation of the soils

This section discusses the factors of soil formation and relates them to the formation of soils in the survey area.

factors 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 every soil, and each modifies the effects of the other four. The relative 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 is formed. Time is needed for changing the parent material into soil. Generally, a long period is required for distinct soil horizons to develop.

parent material

Parent material is the weathered rock or other material in which the soil forms. Rock is weathered through physical processes such as freezing and thawing, wetting and drying, and abrasion and through chemical processes. Parent material affects the texture, structure, color, natural fertility, and many other properties of the soil. The texture of the parent material, which affects the rate of the downward movement of water, greatly influences soil formation. The composition of the geologic material largely determines the mineral composition of the soil and hence its natural chemical fertility. This material is the chief source of all plant nutrients except nitrogen.

The soils in Linn and Miami Counties formed in material weathered from Pennsylvanian limestone, sandstone, and shale and in loess, old alluvium, and recent alluvium of the Quaternary and Tertiary Systems. In most places, the bedrock is derived from sediment deposited in marine or mixed marine-nonmarine environments.

Bates soils formed in material weathered from sandstone and silty shale. The sand fraction is presumably derived from the weathered sandstone.

Dennis, Eram, Lebo, Okemah, and Summit soils formed in residuum and colluvium, mostly from shale. These soils have a loamy surface layer and a loamy or clayey subsoil. The depth to parent material and bedrock varies. For example, depth to bedrock in the Eram and Lebo soils ranges from 20 to 40 inches, and in Dennis, Okemah, and Summit soils, bedrock is below a depth of 60 inches.

Catoosa, Clareson, and Newtonia soils formed in material weathered from limestone. These soils vary in depth to bedrock. They have a reddish silty or clayey subsoil. They are more permeable than comparable soils of the area and, therefore, dry more quickly and warm up sooner in spring. As a result, tillage, cultivation, and harvesting generally are earlier following a rain than on most other soils.

Woodson and Kenoma soils formed in old clayey alluvium. Woodson soils are in broad, nearly level areas on terraces and uplands. Kenoma soils are in more sloping areas of the terraces and uplands. The old clay beds contain interspersed pockets of waterworn chert pebbles.

The more recent alluvium is in the stream valleys. Osage soils formed in the more clayey alluvial sediment in the Marais des Cygnes Valley. Lanton soils, along Pottawatomie Creek and the Marais des Cygnes River, have a fluctuating high water table. Verdigris soils, which are on flood plains, receive recent deposits in many places. Mason soils formed in alluvium on the higher, rarely flooded stream terraces. The light colored Hepler soils are above Verdigris soils on low terraces along some of the smaller tributaries of the soil survey area.

climate

Climate influences both physical and chemical weathering processes and the biological forces at work in the parent material. The downward movement of water is a major factor in transforming the material into a soil that has distinct horizons. The amount of water that percolates through the soils depends on temperature, type and intensity of precipitation, humidity, relief, and nature of the soil material. Soil-forming processes are most active when the soil is warm and moist. Soil structure is modified by freezing and thawing. Alternate wetting and drying, which occurs frequently in the subhumid climate of the survey area, is an important process in creating soil structure.

Climate is an important factor affecting differences among soils over a wide region but not in a small area such as the survey area.

plant and animal life

Plants and animals greatly affect soil formation. In turn, changes in soil features affect the habitat supporting the plants and animals. In a given climate region, the particular kinds of plant and animal life are determined by the other factors of soil formation.

Plants cover the soil and protect it from erosion, provide food for the animals in and on the soil, and bring nutrients from lower layers to the surface layer. Plants are decomposed by plant and animal micro-organisms to form organic matter. Organic matter physically and chemically influences the color, structure, and other soil properties, and it creates a more favorable environment for biological activity within the soil. Most of the soils in the survey area formed under the influence of tall prairie grasses. Some of the soils, for example, the Clareson soils, formed under the influence of a combination of tall and mid prairie grasses. The soils that formed in recent alluvium were influenced by a combination of tall prairie grasses and hardwood trees. Welda soils formed under a canopy of hardwood trees on uplands.

Animals influence soil formation by aiding in decomposition of organic materials and weathering of the parent material. Worms, for example, influence the color and structure of the soils.

Man has a great effect on the development of soils. The use of soils by man in most places has increased erosion, increased or decreased organic-matter content, and changed the relief by land leveling and industrial or urban development. Thereby, he has changed or offset the normal processes of soil formation.

relief

Relief influences soil formation through its effect on drainage, runoff, and erosion. The amount of water that moves into the soil depends partly on relief. Generally, the steep soils receive less water than the gently sloping soils and lose more soil material by erosion. The level or depressional soils generally receive extra water from higher lying soils. Because of this additional water, the upper layers of the soil profile are gray or mottled and are thicker. Level or gently sloping soils, such as Kenoma and Summit soils, generally have a more strongly developed profile than steeper soils, such as Lebo soils. Runoff is slowed on the level soils, and more water can percolate through the soil or pond on it. On most of the nearly level soils that formed in alluvium, additional sediment has been deposited during flooding.

time

The length of time needed for soil formation depends largely on the other factors of soil formation. Water moves through the soil profile, and soluble matter and fine particles are leached gradually from the surface layer and are deposited in the subsoil. The amount of leaching depends on the amount of time that has elapsed and the amount of water that penetrates the soil. For example, Verdigris soils, which formed in recent alluvium, are young soils and show very little horizon development other than a slight darkening of the surface layer. Woodson soils, which were exposed to soil-forming processes for thousands of years, are older and have well-defined soil horizons.

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glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). 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 map 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	9 to 12
Very high	more than 12

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

Bottom land. The normal flood plain of a stream, subject to flooding.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Channery soil. A soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches along the longest axis. A single piece is called a fragment.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compact layers to depths below normal plow depth.

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 coating, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

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. 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 that part of the soil profile between depths of 10 inches and 40 or 80 inches.

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.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Drainage class (natural). Refers to the removal of water from the soil. Drainage classes are determined on the basis of an overall evaluation of water removal as influenced by climate, slope, and position on the landscape. Precipitation, runoff, amount of moisture infiltrating the soil, and rate of water movement through the soil affect the degree and duration of wetness. Seven classes of natural soil drainage are recognized:
Excessively drained.—Water is removed from the soil very rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow, very porous, or steep, or a combination of these.
Somewhat excessively drained.—Water is removed from the soil rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow or moderately deep, very porous, or steep, or a combination of these.
Well drained.—Water is removed from the soil so readily that the upper 40 inches generally does not have the mottles or dull colors related to wetness.
Moderately well drained.—Water is removed from the soil so slowly that the upper 20 to 40 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.
Somewhat poorly drained.—Water is removed from the soil so slowly that the upper 10 to 20 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.
Poorly drained.—Water is removed so slowly that either the soil is periodically saturated or the upper 10 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.
Very poorly drained.—Water is removed from the soil so slowly that free water is at or on the surface most of the time. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Drainage, surface. Runoff, or surface flow of water, from an area.

Edge habitat. The zone of transition from one type of plant cover to another.

Erosion. The wearing away of the land surface by 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 the surface.

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

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 soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist, 6 to 15 inches (15 to 37.5 centimeters) long.

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.

Forb. Any herbaceous plant not a grass or a sedge.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

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

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon 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.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have 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 in which the solum 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.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Low strength. The soil is not strong enough to support loads.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

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

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Parent material. The unconsolidated organic and mineral material in which soil forms.

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 (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated 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 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through 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.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Poorly graded. Refers to a coarse grained soil or 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.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor, on the basis of how much the present plant community has departed from the potential.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Sinkhole. A depression in the landscape where limestone has been dissolved.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slick spot. 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 (in tables). Slope is great enough that special practices are required to insure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Soil. A natural, three-dimensional body at the earth's surface. It 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 mm in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in 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 plant and animal activities are largely confined to the solum.

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

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

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

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil (A1, A2, or A3) below the surface layer.

Surface layer. 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."

Surface soil. The A horizon. Includes all subdivisions of this horizon (A1, A2, and A3).

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

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 water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or 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 loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

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

tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[All data except the average snowfall data were recorded at Mound City, Kansas, in the period 1951-76. The average snowfall data were recorded at Garnett, Kansas, in the period 1941-70]

Month	Temperature					Precipitation				
	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----	42.1	20.2	31.2	71	-9	1.25	.48	1.88	3	5.3
February---	48.2	25.4	36.8	75	-1	1.32	.41	2.27	3	3.4
March------	56.8	32.4	44.6	85	5	2.82	1.37	4.10	5	3.6
April------	69.6	44.4	57.0	90	21	3.69	2.05	5.59	6	0.2
May--------	78.3	53.8	66.1	94	32	4.64	2.93	6.18	7	0.0
June-------	86.6	62.8	74.7	98	46	4.77	1.63	7.37	7	0.0
July-------	91.7	67.1	79.4	106	48	3.85	1.48	6.57	6	0.0
August-----	90.9	65.2	78.1	104	50	4.12	1.62	7.42	5	0.0
September--	82.6	56.7	69.7	99	35	5.31	2.12	8.80	7	0.0
October----	72.4	46.2	59.3	92	23	3.33	.91	5.93	5	0.0
November---	56.8	33.8	45.3	79	7	1.91	.19	3.65	4	0.7
December---	45.4	25.0	35.2	70	-5	1.52	.67	2.56	4	4.3
Year-----	68.5	44.4	56.5	106	-9	38.53	27.47	46.41	62	17.5

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[For the southern part of Linn County, spring dates will be slightly earlier and fall dates a little later than those shown. For the northern part of Miami County, spring dates will be slightly later and fall dates a little earlier than those shown]

Probability	Temperature		
	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 17	April 28
2 years in 10 later than--	April 1	April 12	April 23
5 years in 10 later than--	March 23	April 2	April 13
First freezing temperature in fall:			
1 year in 10 earlier than--	October 28	October 19	October 9
2 years in 10 earlier than--	November 1	October 24	October 13
5 years in 10 earlier than--	November 11	November 2	October 23

TABLE 3.--GROWING SEASON

[The data were averaged for the two counties. The values for the southern part of Linn County are slightly higher than those shown. The values for the northern part of Miami County are a little lower]

Probability	Daily minimum temperature		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	212	194	173
8 years in 10	219	201	180
5 years in 10	233	214	193
2 years in 10	246	227	206
1 year in 10	254	234	213

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

Map symbol	Soil name	Linn County	Miami County	Total-- Area	Extent
		Acres	Acres	Acres	Pct
Bb	Bates loam, 1 to 4 percent slopes	4,760	580	5,340	0.7
Bc	Bates loam, 4 to 8 percent slopes	2,200	1,020	3,220	0.4
Cb	Catoosa silt loam, 1 to 3 percent slopes	52,800	40,000	92,800	12.1
Cm	Clareson-Rock outcrop complex, 2 to 15 percent slopes	43,700	41,500	85,200	11.1
De	Dennis silt loam, 1 to 3 percent slopes	20,250	14,050	34,300	4.4
Df	Dennis silt loam, 3 to 6 percent slopes	2,950	2,650	5,600	0.7
Ec	Eram silty clay loam, 1 to 4 percent slopes	13,050	9,250	22,300	2.9
Ed	Eram silty clay loam, 4 to 8 percent slopes	12,650	23,550	36,200	4.7
Ef	Eram-Lebo silty clay loams, 5 to 20 percent slopes	17,550	9,450	27,000	3.5
Gc	Grundy silt loam, 1 to 3 percent slopes	0	19,500	19,500	2.5
Hp	Hepler silt loam	330	2,400	2,730	0.4
Ke	Kenoma silt loam, 1 to 4 percent slopes	48,800	35,600	84,400	11.0
La	Lanton silt loam	4,700	4,650	9,350	1.2
Lb	Lebo channery silty clay loam, 15 to 30 percent slopes	12,370	6,450	18,820	2.5
Mb	Mason silt loam	2,600	3,200	5,800	0.8
Nf	Newtonia silt loam, 0 to 1 percent slopes	520	700	1,220	0.2
Ng	Newtonia silt loam, 1 to 4 percent slopes	9,700	25,300	35,000	4.6
Nh	Newtonia silt loam, 4 to 8 percent slopes	1,770	16,100	17,870	2.3
Oh	Okemah silt loam, 0 to 3 percent slopes	5,970	10,300	16,270	2.1
Om	Orthents, hilly	3,345	0	3,345	0.4
Op	Orthents, sloping	280	0	280	*
Ot	Osage silty clay loam	5,300	6,500	11,800	1.5
Ov	Osage silty clay	15,650	4,950	20,600	2.7
Pc	Parsons silt loam	18,150	445	18,595	2.4
Po	Pits, quarries	230	275	505	0.1
Sn	Summit silty clay loam, 1 to 4 percent slopes	28,500	36,850	65,350	8.5
So	Summit silty clay loam, 4 to 8 percent slopes	8,750	16,300	25,050	3.3
Vb	Verdigris silt loam	10,100	13,100	23,200	3.0
Vc	Verdigris silt loam, frequently flooded	14,490	9,850	24,340	3.2
We	Welda silt loam, 2 to 5 percent slopes	205	660	865	0.1
Wo	Woodson silt loam, 0 to 2 percent slopes	23,050	23,100	46,150	6.0
	Water	4,400	600	5,000	0.7
	Total	389,120	378,880	768,000	100.0

* Less than 0.1 percent.

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

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Grain sorghum	Winter wheat	Soybeans	Cool season grasses
	Bu	Bu	Bu	Bu	AUM*
Bb------------------------ Bates	50	55	36	26	5.0
Bc------------------------ Bates	45	50	34	20	5.0
Cb------------------------ Catoosa	55	60	38	24	5.0
Cm------------------------ Clareson-Rock outcrop	---	---	---	---	3.5
De------------------------ Dennis	70	75	40	30	5.5
Df------------------------ Dennis	65	70	36	28	5.5
Ec------------------------ Eram	50	55	28	22	4.5
Ed------------------------ Eram	45	50	24	18	4.5
Ef------------------------ Eram-Lebo	---	---	---	---	4.0
Gc------------------------ Grundy	90	95	38	32	6.5
Hp------------------------ Hepler	95	100	38	34	7.0
Ke------------------------ Kenoma	60	65	36	26	4.5
La------------------------ Lanton	95	100	35	34	7.0
Lb------------------------ Lebo	---	---	---	---	3.5
Mb------------------------ Mason	100	105	44	36	7.0
Nf------------------------ Newtonia	85	90	42	30	6.0
Ng------------------------ Newtonia	80	85	40	28	6.0
Nh------------------------ Newtonia	75	80	38	24	6.0
Oh------------------------ Okemah	85	90	40	32	7.0
Om, Op. Orthents					
Ot------------------------ Osage	80	85	35	34	6.5
Ov------------------------ Osage	60	65	30	26	6.0

See footnote at end of table.

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

Soil name and map symbol	Corn	Grain sorghum	Winter wheat	Soybeans	Cool season grasses
	Bu	Bu	Bu	Bu	AUM*
Pc----- Parsons	65	70	36	30	5.5
Po. Pits					
Sn----- Summit	70	75	38	30	5.5
So----- Summit	65	70	34	28	5.5
Vb----- Verdigris	95	100	40	34	7.0
Vc----- Verdigris	---	---	---	---	7.0
We----- Welda	70	75	36	26	5.0
Wo----- Woodson	65	70	35	28	4.5

* 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 30 days.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES

[Only the soils that support rangeland vegetation suitable for grazing are listed]

Soil name and map symbol	Range site	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
Bb, Bc: Bates	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	10
				Switchgrass	10
Cb: Catoosa	Loamy Upland	Favorable	6,500	Big bluestem	30
		Normal	5,000	Little bluestem	25
		Unfavorable	4,000	Indiangrass	10
				Switchgrass	10
				Sideoats grama	5
Cm*:					
Clareson	Shallow Flats	Favorable	5,000	Little bluestem	30
		Normal	4,000	Big bluestem	15
		Unfavorable	2,500	Sideoats grama	15
				Indiangrass	10
				Switchgrass	5
				Tall dropseed	5
Rock outcrop.					
De, Df: Dennis	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	10
				Switchgrass	5
Ec, Ed: Eram	Clay Upland	Favorable	6,000	Big bluestem	30
		Normal	4,200	Little bluestem	25
		Unfavorable	3,000	Switchgrass	10
				Indiangrass	10
				Sideoats grama	5
Ef*:					
Eram	Clay Upland	Favorable	6,000	Big bluestem	30
		Normal	4,200	Little bluestem	25
		Unfavorable	3,000	Switchgrass	10
				Indiangrass	10
				Sideoats grama	5
Lebo	Loamy Upland	Favorable	6,000	Big bluestem	25
		Normal	5,000	Little bluestem	20
		Unfavorable	4,000	Indiangrass	15
				Switchgrass	5
Gc: Grundy	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	15
				Switchgrass	10
Hp: Hepler	Loamy Lowland	Favorable	10,000	Big bluestem	40
		Normal	8,000	Indiangrass	20
		Unfavorable	6,000	Switchgrass	10
				Eastern gamagrass	10
Ke: Kenoma	Clay Upland	Favorable	6,000	Big bluestem	25
		Normal	4,500	Little bluestem	25
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	10
				Tall dropseed	5
				Sideoats grama	5
La: Lanton	Loamy Lowland	Favorable	10,000	Big bluestem	30
		Normal	8,000	Indiangrass	20
		Unfavorable	6,000	Switchgrass	15
				Eastern gamagrass	5

See footnote at end of table.

TABLE 6.--RANGELAND PRODUCTIVITY AND CHARACTERISTIC PLANT COMMUNITIES--Continued

Soil name and map symbol	Range site name	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Compo- sition
			Lb/acre		Pct
Lb: Lebo	Loamy Upland	Favorable	6,000	Big bluestem	25
		Normal	5,000	Little bluestem	20
		Unfavorable	4,000	Indiangrass	15
				Switchgrass	5
Mb: Mason	Loamy Lowland	Favorable	10,000	Big bluestem	30
		Normal	9,000	Indiangrass	20
		Unfavorable	7,000	Switchgrass	10
				Eastern gamagrass	10
				Prairie cordgrass	5
Nf, Ng, Nh: Newtonia	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	15
				Switchgrass	10
				Scribner panicum	5
Oh: Okemah	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Switchgrass	15
		Unfavorable	4,500	Little bluestem	10
				Indiangrass	10
				Scribner panicum	5
Ot, Ov: Osage	Clay Lowland	Favorable	9,000	Prairie cordgrass	40
		Normal	8,000	Switchgrass	15
		Unfavorable	6,000	Big bluestem	15
				Eastern gamagrass	10
				Sedge	5
				Indiangrass	5
Pc: Parsons	Clay Upland	Favorable	6,000	Little bluestem	25
		Normal	4,500	Big bluestem	20
		Unfavorable	2,500	Switchgrass	15
				Indiangrass	10
				Tall dropseed	5
				Sedge	5
Sn, So: Summit	Loamy Upland	Favorable	7,000	Big bluestem	35
		Normal	5,500	Little bluestem	25
		Unfavorable	4,500	Indiangrass	15
				Switchgrass	5
Vb, Vc: Verdigris	Loamy Lowland	Favorable	10,000	Big bluestem	40
		Normal	8,500	Indiangrass	20
		Unfavorable	6,000	Switchgrass	10
				Eastern gamagrass	10
				Little bluestem	5
We: Welda	Savannah	Favorable	5,500	Little bluestem	25
		Normal	4,500	Big bluestem	20
		Unfavorable	3,500	Indiangrass	10
				Post oak	10
				Switchgrass	5
Wo: Woodson	Clay Upland	Favorable	6,000	Big bluestem	30
		Normal	4,500	Little bluestem	25
		Unfavorable	2,500	Indiangrass	15
				Switchgrass	10

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

[Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available]

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Plant competition	Potential productivity: Common trees	Potential productivity: Site index	Trees to plant
Ef*:								
Eram.								
Lebo	5o	Slight	Slight	Slight	Slight	White oak	50	White oak, green ash.
						Shagbark hickory	50	
						Black walnut	50	
						Chinkapin oak	50	
Hp: Hepler	3o	Slight	Slight	Slight	Moderate	Eastern cottonwood	90	Pecan, green ash, American sycamore.
						Northern red oak	67	
						Common hackberry	76	
						Green ash	73	
						Pin oak	80	
La: Lanton	2o	Slight	Slight	Slight	Slight	Green ash	75	Green ash, American sycamore, eastern cottonwood, sweetgum.
						Eastern cottonwood	85	
						Pin oak	80	
						Common hackberry	60	
Lb: Lebo	5o	Slight	Slight	Slight	Slight	White oak	50	White oak, green ash.
						Shagbark hickory	50	
						Black walnut	50	
						Chinkapin oak	50	
Mb: Mason	3o	Slight	Slight	Slight	Moderate	Northern red oak	65	Bur oak, green ash, black walnut, pecan, eastern cottonwood.
						Green ash	75	
						Black walnut	70	
						Eastern cottonwood	90	
Ot, Ov: Osage	4w	Slight	Moderate	Moderate	Severe	Pin oak	75	Pin oak, pecan, common hackberry, green ash.
						Pecan	50	
						Eastern cottonwood	65	
						Green ash	70	
Vb, Vc: Verdigris	3o	Slight	Slight	Slight	Slight	Eastern cottonwood	87	Eastern cottonwood, American sycamore, bur oak, black walnut, pecan.
						Bur oak	65	
						Common hackberry	69	
						Black walnut	70	
						Silver maple	61	
						Green ash	60	
						White oak	56	
We: Welda	4o	Slight	Slight	Slight	Slight	Black walnut	55	Black walnut, green ash, common hackberry, white oak.
						Common hackberry	60	
						White oak	51	
						Green ash	60	

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
Bb, Bc: Bates	Lilac, Peking cotoneaster, American plum, fragrant sumac.	Amur maple	Eastern redcedar, green ash, Russian mulberry, common hackberry, honeylocust.	Austrian pine, Scotch pine.	---
Cb: Catoosa	American plum, fragrant sumac, Peking cotoneaster, lilac.	---	Flowering dogwood, Russian mulberry, common hackberry, eastern redcedar, green ash.	Honeylocust, Austrian pine, Scotch pine.	---
Cm*:					
Clareson	Fragrant sumac, Peking cotoneaster.	Flowering dogwood, Amur maple, eastern redbud.	Eastern redcedar, green ash, common hackberry, bur oak, northern red oak, honeylocust.	Siberian elm	---
Rock outcrop.					
De, Df: Dennis	American plum, fragrant sumac, Peking cotoneaster, lilac.	---	Flowering dogwood, Russian mulberry, common hackberry, eastern redcedar, green ash.	Honeylocust, Austrian pine, Scotch pine.	---
Ec, Ed: Eram	Lilac, American plum, common chokecherry, fragrant sumac.	Autumn-olive	Eastern redcedar, pin oak, common hackberry, Russian-olive.	Green ash, honeylocust, Austrian pine.	---
Ef*:					
Eram	Lilac, American plum, common chokecherry, fragrant sumac.	Autumn-olive	Eastern redcedar, pin oak, common hackberry, Russian-olive.	Green ash, honeylocust, Austrian pine.	---
Lebo	Amur honeysuckle, common chokecherry.	Autumn-olive, midwest Manchurian crabapple, Russian-olive.	Eastern redcedar, Russian mulberry, green ash, common hackberry.	Austrian pine, honeylocust, Scotch pine.	---
Gc: Grundy	American plum, fragrant sumac, Peking cotoneaster, lilac.	Autumn-olive	Eastern redcedar, Russian mulberry, common hackberry, green ash.	Honeylocust, Austrian pine, Scotch pine.	---
Hp: Hepler	American plum, redosier dogwood.	Autumn-olive, common chokecherry, eastern redbud.	Eastern redcedar	Russian mulberry, golden willow, American sycamore, green ash.	Eastern cottonwood, silver maple.
Ke: Kenoma	Lilac, fragrant sumac, American plum, Peking cotoneaster.	---	Flowering dogwood, eastern redcedar, common hackberry, Russian mulberry, pin oak, green ash.	Austrian pine, Siberian elm.	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
La----------------- Lanton	Fragrant sumac, redosier dogwood.	American plum, Peking cotoneaster.	Russian mulberry	Austrian pine, honeylocust, green ash, Scotch pine, common hackberry.	Pecan, silver maple.
Lb----------------- Lebo	Amur honeysuckle, common chokecherry.	Autumn-olive, midwest Manchurian crabapple, Russian-olive.	Eastern redcedar, Russian mulberry, green ash, common hackberry.	Austrian pine, honeylocust, Scotch pine.	---
Mb----------------- Mason	Fragrant sumac----	American plum, Peking cotoneaster.	Russian mulberry	Austrian pine, honeylocust, green ash, pin oak, Scotch pine, common hackberry.	Pecan, silver maple.
Nf, Ng, Nh--------- Newtonia	American plum, fragrant sumac, Peking cotoneaster, lilac.	---	Flowering dogwood, Russian mulberry, common hackberry, eastern redcedar, green ash.	Honeylocust, Austrian pine, Scotch pine.	---
Oh----------------- Okemah	American plum, redosier dogwood.	Common chokecherry	Eastern redcedar	Northern red oak, honeylocust, Russian mulberry, silver maple, green ash.	Eastern cottonwood, pecan, baldcypress.
Om*, Op*. Orthents					
Ot, Ov------------- Osage	American plum, redosier dogwood.	Common chokecherry	Eastern redcedar, eastern redbud.	Russian-olive, green ash, honeylocust, golden willow.	Silver maple, eastern cottonwood
Pc----------------- Parsons	Lilac, American plum, common chokecherry, fragrant sumac.	Autumn-olive------	Eastern redcedar, pin oak, common hackberry, Russian-olive.	Green ash, honeylocust, Austrian pine.	---
Po*. Pits					
Sn, So------------- Summit	Lilac, American plum, common chokecherry, fragrant sumac.	Autumn-olive------	Eastern redcedar, pin oak, common hackberry, Russian-olive.	Green ash, honeylocust, Austrian pine.	---
Vb, Vc------------- Verdigris	Fragrant sumac, redosier dogwood.	American plum, Peking cotoneaster.	Russian-olive, Russian mulberry, eastern redcedar.	Austrian pine, honeylocust, green ash, common hackberry, Scotch pine.	Silver maple.
We----------------- Welda	Fragrant sumac, common chokecherry.	Amur maple, autumn-olive.	Green ash, common hackberry, eastern redcedar, honeylocust, Russian mulberry.	Pin oak, Siberian elm, Austrian pine.	---
Wo----------------- Woodson	Fragrant sumac, lilac.	Russian-olive, autumn-olive, common chokecherry.	Flowering dogwood, common hackberry, eastern redcedar, green ash.	Austrian pine, Scotch pine, honeylocust.	---

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Bb: Bates	Slight	Slight	Moderate: slope, small stones, depth to rock.	Slight.
Bc: Bates	Slight	Slight	Severe: slope.	Slight.
Cb: Catoosa	Slight	Slight	Moderate: slope, depth to rock.	Severe: erodes easily.
Cm*:				
Clareson	Moderate: percs slowly, slope.	Moderate: slope, percs slowly.	Moderate: percs slowly.	Slight.
Rock outcrop.				
De, Df: Dennis	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: slope, wetness, percs slowly.	Severe: erodes easily.
Ec, Ed: Eram	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: slope, small stones, wetness.	Severe: erodes easily.
Ef*:				
Eram	Moderate: slope, wetness, percs slowly.	Moderate: slope, wetness, percs slowly.	Severe: slope.	Severe: erodes easily.
Lebo	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Gc: Grundy	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Severe: erodes easily.
Hp: Hepler	Severe: floods, wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.
Ke: Kenoma	Severe: percs slowly.	Severe: percs slowly.	Severe: percs slowly.	Severe: erodes easily.
La: Lanton	Severe: floods, wetness.	---	---	Moderate: wetness.
Lb: Lebo	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Moderate: slope.
Mb: Mason	Severe: floods.	Moderate: percs slowly.	Moderate: percs slowly.	Severe: erodes easily.
Nf: Newtonia	Slight	Slight	Slight	Severe: erodes easily.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Ng: Newtonia	Slight	Slight	Moderate: slope.	Severe: erodes easily.
Nh: Newtonia	Slight	Slight	Severe: slope.	Severe: erodes easily.
Oh: Okemah	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Severe: erodes easily.
Om*, Op*. Orthents				
Ot: Osage	Severe: floods, wetness, percs slowly.	Severe: wetness, percs slowly.	---	Severe: wetness.
Ov: Osage	Severe: floods, wetness, percs slowly.	Severe: wetness, too clayey, percs slowly.	---	Severe: wetness, too clayey.
Pc: Parsons	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, erodes easily.
Po*. Pits				
Sn, So: Summit	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Severe: erodes easily.
Vb: Verdigris	Severe: floods.	Slight	Moderate: floods.	Slight.
Vc: Verdigris	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.
We: Welda	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight.
Wo: Woodson	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WILDLIFE HABITAT

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Bb, Bc-------------- Bates	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Cb------------------ Catoosa	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Cm*:										
Clareson-----------	Fair	Good	Good	Fair	Fair	Very poor.	Very poor.	Good	Fair	Very poor.
Rock outcrop.										
De------------------ Dennis	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Df------------------ Dennis	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Ec------------------ Eram	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Ed------------------ Eram	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Ef*:										
Eram---------------	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Lebo---------------	Poor	Poor	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Gc------------------ Grundy	Fair	Good	Fair	Good	Good	Fair	Fair	Fair	Good	Fair.
Hp------------------ Hepler	Fair	Good	Good	Good	Good	Good	Fair	Good	Good	Fair.
Ke------------------ Kenoma	Good	Good	Fair	Fair	Fair	Poor	Fair	Good	Fair	Poor.
La------------------ Lanton	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
Lb------------------ Lebo	Poor	Poor	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Mb------------------ Mason	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Nf, Ng, Nh---------- Newtonia	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Oh------------------ Okemah	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Om*, Op*. Orthents										
Ot------------------ Osage	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT--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	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Ov----------------- Osage	Fair	Fair	Fair	Fair	Fair	Poor	Good	Fair	Fair	Fair.
Pc----------------- Parsons	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
Po*. Pits										
Sn----------------- Summit	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
So----------------- Summit	Fair	Good	Fair	Good	Good	Poor	Very poor.	Fair	Good	Very poor.
Vb----------------- Verdigris	Good	Good	Good	Good	Good	Poor	Fair	Good	Good	Poor.
Vc----------------- Verdigris	Poor	Fair	Fair	Good	Good	Poor	Fair	Fair	Good	Poor.
We----------------- Welda	Good	Good	Good	Good	Good	Very poor.	Poor	Good	Good	Very poor.
Wo----------------- Woodson	Good	Good	Fair	Poor	Poor	Poor	Good	Fair	Fair	Fair.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Bb: Bates	Moderate: depth to rock.	Slight	Moderate: depth to rock.	Slight	Moderate: low strength.
Bc: Bates	Moderate: depth to rock.	Slight	Moderate: depth to rock.	Moderate: slope.	Moderate: low strength.
Cb: Catoosa	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: low strength.
Cm*:					
Clareson	Severe: depth to rock, large stones.	Severe: large stones.	Severe: depth to rock, large stones.	Severe: slope, large stones.	Severe: low strength, large stones.
Rock outcrop.					
De, Df: Dennis	Moderate: too clayey, wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Ec, Ed: Eram	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Ef*:					
Eram	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, shrink-swell.
Lebo	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.
Gc: Grundy	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, shrink-swell.
Hp: Hepler	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength, floods.
Ke: Kenoma	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
La: Lanton	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength, floods.
Lb: Lebo	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.
Mb: Mason	Slight	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength.
Nf, Ng, Nh: Newtonia	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Oh----------------- Okemah	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Om*, Op*. Orthents					
Ot, Ov------------- Osage	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: low strength, wetness, floods.
Pc----------------- Parsons	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, shrink-swell.
Po*. Pits					
Sn, So------------- Summit	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Vb, Vc------------- Verdigris	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
We----------------- Welda	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.
Wo----------------- Woodson	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, low strength, wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Bb, Bc-------------- Bates	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
Cb----------------- Catoosa	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
Cm*:					
Clareson-----------	Severe: depth to rock, percs slowly, large stones.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, too clayey, large stones.	Severe: depth to rock.	Poor: area reclaim, too clayey, hard to pack.
Rock outcrop.					
De, Df-------------- Dennis	Severe: percs slowly, wetness.	Moderate: slope.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
Ec, Ed-------------- Eram	Severe: depth to rock, wetness, percs slowly.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: area reclaim, too clayey, hard to pack.
Ef*:					
Eram---------------	Severe: depth to rock, wetness, percs slowly.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: area reclaim, too clayey, hard to pack.
Lebo---------------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Gc----------------- Grundy	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Hp----------------- Hepler	Severe: floods, wetness, percs slowly.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: too clayey, hard to pack, wetness.
Ke----------------- Kenoma	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.
La----------------- Lanton	Severe: floods, wetness, percs slowly.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, thin layer.
Lb----------------- Lebo	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Mb----------------- Mason	Severe: percs slowly.	Slight-----------	Moderate: floods, too clayey.	Moderate: floods.	Fair: too clayey.
Nf----------------- Newtonia	Moderate: percs slowly.	Moderate: seepage.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.

See footnote at end of table.

TABLE 12.--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
Ng, Nh: Newtonia	Moderate: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
Oh: Okemah	Severe: wetness, percs slowly.	Slight	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
Om*, Op*. Orthents					
Ot, Ov: Osage	Severe: floods, wetness, percs slowly.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: too clayey, hard to pack, wetness.
Pc: Parsons	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Po*. Pits					
Sn, So: Summit	Severe: wetness, percs slowly.	Moderate: slope.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
Vb, Vc: Verdigris	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Fair: too clayey.
We: Welda	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey.
Wo: Woodson	Severe: percs slowly, wetness.	Slight	Severe: too clayey, wetness.	Severe: wetness.	Poor: too clayey, wetness, hard to pack.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Bb, Bc: Bates	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, small stones, thin layer.
Cb: Catoosa	Poor: area reclaim, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, thin layer.
Cm*:				
Clareson	Poor: area reclaim, low strength, large stones.	Improbable: excess fines, large stones.	Improbable: excess fines, large stones.	Poor: large stones.
Rock outcrop.				
De, Df: Dennis	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, thin layer.
Ec, Ed: Eram	Poor: area reclaim, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Ef*:				
Eram	Poor: area reclaim, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Lebo	Poor: area reclaim, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, slope.
Gc: Grundy	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Hp: Hepler	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
Ke: Kenoma	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
La: Lanton	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
Lb: Lebo	Poor: area reclaim, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, slope.
Mb: Mason	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Nf, Ng, Nh: Newtonia	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
Oh: Okemah	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Om*, Op*. Orthents				
Ot--------------------- Osage	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
Ov--------------------- Osage	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
Pc--------------------- Parsons	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
Po*. Pits				
Sn, So----------------- Summit	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Vb, Vc----------------- Verdigris	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
We--------------------- Welda	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Wo--------------------- Woodson	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Features affecting-- Drainage	Features affecting-- Irrigation	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
Bb: Bates	Moderate: seepage, depth to rock.	Severe: piping.	Deep to water	Depth to rock	Depth to rock	Depth to rock.
Bc: Bates	Moderate: seepage, depth to rock, slope.	Severe: piping.	Deep to water	Depth to rock, slope.	Depth to rock	Depth to rock.
Cb: Catoosa	Moderate: seepage, depth to rock.	Severe: thin layer.	Deep to water	Depth to rock, rooting depth.	Depth to rock, erodes easily.	Erodes easily, depth to rock, rooting depth.
Cm*:						
Clareson	Severe: slope.	Severe: large stones.	Deep to water	Large stones, droughty, percs slowly.	Slope, large stones, depth to rock.	Large stones, slope, droughty.
Rock outcrop.						
De: Dennis	Slight	Moderate: hard to pack, wetness.	Percs slowly	Wetness, percs slowly, rooting depth.	Erodes easily, wetness, percs slowly.	Erodes easily, rooting depth, percs slowly.
Df: Dennis	Moderate: slope.	Moderate: hard to pack, wetness.	Percs slowly, slope.	Wetness, percs slowly, rooting depth.	Erodes easily, wetness, percs slowly.	Erodes easily, rooting depth, percs slowly.
Ec: Eram	Moderate: depth to rock.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, depth to rock.	Wetness, percs slowly, depth to rock.	Depth to rock, erodes easily.	Erodes easily, depth to rock.
Ed: Eram	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, depth to rock, slope.	Wetness, percs slowly, depth to rock.	Depth to rock, erodes easily.	Erodes easily, depth to rock.
Ef*:						
Eram	Severe: slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, depth to rock, slope.	Wetness, percs slowly, depth to rock.	Slope, depth to rock, erodes easily.	Slope, erodes easily, depth to rock.
Lebo	Severe: slope.	Moderate: thin layer.	Deep to water	Depth to rock, slope.	Slope, depth to rock.	Slope, depth to rock.
Gc: Grundy	Slight	Severe: hard to pack.	Percs slowly, frost action.	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
Hp: Hepler	Moderate: seepage.	Severe: wetness.	Floods	Wetness, erodes easily, floods.	Erodes easily, wetness.	Wetness, erodes easily.
Ke: Kenoma	Slight	Severe: hard to pack.	Deep to water	Percs slowly, erodes easily.	Erodes easily, percs slowly.	Erodes easily, percs slowly.
La: Lanton	Slight	Severe: piping, wetness.	Percs slowly, floods.	Wetness, percs slowly, erodes easily.	Erodes easily, wetness.	Wetness, erodes easily, percs slowly.
Lb: Lebo	Severe: slope.	Moderate: thin layer.	Deep to water	Depth to rock, slope.	Slope, depth to rock.	Slope, depth to rock.
Mb: Mason	Slight	Severe: piping.	Deep to water	Erodes easily	Erodes easily	Erodes easily.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
Nf, Ng: Newtonia	Moderate: seepage.	Moderate: hard to pack.	Deep to water	Erodes easily	Erodes easily	Erodes easily.
Nh: Newtonia	Moderate: seepage, slope.	Moderate: hard to pack.	Deep to water	Slope, erodes easily.	Erodes easily	Erodes easily.
Oh: Okemah	Moderate: seepage.	Severe: hard to pack.	Percs slowly	Wetness, percs slowly.	Erodes easily, wetness, percs slowly.	Erodes easily, percs slowly.
Om*, Op*. Orthents						
Ot: Osage	Slight	Severe: hard to pack, wetness.	Percs slowly, floods.	Wetness	Wetness, percs slowly.	Wetness, percs slowly.
Ov: Osage	Slight	Severe: hard to pack, wetness.	Percs slowly, floods.	Wetness, droughty, slow intake.	Wetness, percs slowly.	Wetness, droughty, percs slowly.
Pc: Parsons	Slight	Severe: wetness.	Percs slowly	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily percs slowly.
Po*. Pits						
Sn: Summit	Slight	Severe: hard to pack.	Percs slowly	Wetness, percs slowly.	Erodes easily, wetness.	Erodes easily, percs slowly.
So: Summit	Moderate: slope.	Severe: hard to pack.	Percs slowly, slope.	Wetness, percs slowly.	Erodes easily, wetness.	Erodes easily, percs slowly.
Vb, Vc: Verdigris	Moderate: seepage.	Moderate: piping.	Deep to water	Floods	Favorable	Favorable.
We: Welda	Moderate: seepage, slope.	Severe: thin layer.	Deep to water	Slope	Favorable	Favorable.
Wo: Woodson	Slight	Severe: wetness.	Percs slowly	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Percs slowly, wetness, erodes easily.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--ENGINEERING INDEX PROPERTIES

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

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Bb---------------- Bates	0-10	Loam-------------	ML, CL, CL-ML	A-4, A-6	0	90-100	85-100	80-100	55-90	20-40	3-15
	10-31	Loam, clay loam, sandy clay loam.	ML, CL, SC, SM	A-4, A-6, A-7	0	85-100	85-100	80-100	45-85	25-45	3-20
	31	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Bc---------------- Bates	0-7	Loam-------------	ML, CL, CL-ML	A-4, A-6	0	90-100	85-100	80-100	55-90	20-40	3-15
	7-31	Loam, clay loam, sandy clay loam.	ML, CL, SC, SM	A-4, A-6, A-7	0	85-100	85-100	80-100	45-85	25-45	3-20
	31	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Cb---------------- Catoosa	0-12	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	12-25	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	25-29	Silty clay-------	CL, CH	A-7	0	100	100	96-100	80-98	48-52	25-28
	29	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Cm*: Clareson---------	0-11	Silty clay loam	CL	A-4, A-6	0-25	90-100	90-100	85-95	85-95	30-40	8-18
	11-16	Silty clay loam, flaggy silty clay loam.	CL	A-6, A-7	0-65	90-100	90-100	85-95	85-95	35-45	11-20
	16-33	Flaggy silty clay, flaggy silty clay loam.	CL, CH	A-7	50-85	85-100	85-100	80-95	80-95	41-60	18-35
	33	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
De, Df------------ Dennis	0-11	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	20-37	1-15
	11-17	Silty clay loam, clay loam.	CL	A-6, A-7	0	98-100	98-100	94-100	75-98	33-48	13-25
	17-60	Clay, silty clay, silty clay loam.	CL, CH	A-7, A-6	0	98-100	98-100	94-100	75-98	37-65	15-35
Ec, Ed------------ Eram	0-9	Silty clay loam	CL	A-6, A-7	0	85-100	85-100	85-100	75-95	33-48	12-25
	9-27	Clay, silty clay, clay loam.	CL, CH	A-7, A-6	0	95-100	95-100	90-100	85-98	37-65	15-35
	27	Weathered bedrock	---	---	---	---	---	---	---	---	---
Ef*: Eram-------------	0-8	Silty clay loam	CL	A-6, A-7	0	85-100	85-100	85-100	75-95	33-48	12-25
	8-27	Clay, silty clay, clay loam.	CL, CH	A-7, A-6	0	95-100	95-100	90-100	85-98	37-65	15-35
	27	Weathered bedrock	---	---	---	---	---	---	---	---	---
Lebo-------------	0-12	Silty clay loam	CL	A-6, A-7, A-7-6	0-5	95-100	90-100	90-100	80-95	35-50	15-25
	12-28	Channery silty clay loam, shaly silty clay loam, silty clay loam.	CL	A-6, A-7-6	0-5	75-95	55-95	55-85	50-80	35-50	15-25
	28-38	Very shaly silty clay loam, very shaly silt loam.	SC	A-2-7	0-5	50-75	10-50	5-40	5-35	35-50	15-25
	38	Weathered bedrock	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
Gc--------------- Grundy	0-11	Silt loam--------	CL	A-6, A-7	0	100	100	95-100	90-100	30-45	10-20
	11-16	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	95-100	90-100	45-55	25-35
	16-60	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	90-100	50-70	30-45
Hp--------------- Hepler	0-25	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	75-95	20-35	2-115
	25-40	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	85-95	35-50	15-25
	40-60	Silty clay loam, silty clay.	CL, CH	A-6, A-7	0	100	100	95-100	85-95	35-50	15-30
Ke--------------- Kenoma	0-10	Silt loam--------	CL, CL-ML, ML	A-4, A-6	0	85-100	85-100	85-100	85-100	25-40	3-18
	10-58	Silty clay, clay	CH	A-7	0	85-100	85-100	85-100	85-100	50-75	30-48
	58-60	Silty clay, silty clay loam.	CL, CH	A-7	0	85-100	85-100	75-100	75-95	45-65	25-44
La--------------- Lanton	0-14	Silt loam--------	ML, CL	A-4, A-6	0	100	95-100	90-100	80-95	25-38	8-15
	14-53	Silt loam, silty clay loam.	ML, CL	A-4, A-6	0	100	95-100	85-100	80-95	30-38	8-16
	53-60	Clay, silty clay, silty clay loam.	MH, CH, CL	A-6, A-7	0	100	95-100	85-100	75-95	40-55	18-28
Lb--------------- Lebo	0-11	Channery silty clay loam.	CL	A-6, A-7	0-5	75-95	55-75	55-70	50-65	35-50	15-25
	11-28	Channery silty clay loam, shaly silty clay loam, silty clay loam.	CL	A-6, A-7-6	0-5	75-95	55-95	55-85	50-80	35-50	15-25
	28-38	Very shaly silty clay loam, very shaly silt loam.	SC	A-2-7	0-5	50-75	10-50	5-40	5-35	35-50	15-25
	38	Weathered bedrock	---	---	---	---	---	---	---	---	---
Mb--------------- Mason	0-18	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-98	20-35	1-13
	18-60	Silty clay loam, clay loam, silt loam.	CL	A-6, A-4, A-7	0	98-100	98-100	96-100	65-98	30-43	9-20
Nf, Ng, Nh------- Newtonia	0-13	Silt loam--------	CL, ML	A-4, A-6	0	100	100	96-100	65-97	30-37	9-14
	13-40	Silty clay loam	CL	A-6, A-7	0	100	100	98-100	90-98	33-42	12-19
	40-60	Silty clay loam, silty clay, clay.	CL, CH	A-6, A-7	0	100	100	96-100	90-98	37-60	15-34
Oh--------------- Okemah	0-12	Silt loam--------	CL, ML	A-4, A-6, A-7	0	98-100	98-100	96-100	80-98	20-47	1-23
	12-18	Silty clay, clay, silty clay loam.	CL, CH, MH, ML	A-7	0	98-100	98-100	96-100	80-99	45-70	19-44
	18-60	Silty clay, clay, silty clay loam.	CL, CH, MH, ML	A-7	0	98-100	98-100	96-100	90-99	48-65	21-38
Om*, Op*. Orthents											
Ot--------------- Osage	0-15	Silty clay loam	CL	A-7	0	100	100	100	95-100	40-50	16-25
	15-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	100	95-100	50-80	30-55
Ov--------------- Osage	0-23	Silty clay--------	CH	A-7	0	100	100	100	95-100	50-75	30-55
	23-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	100	95-100	50-80	30-55
Pc--------------- Parsons	0-13	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	96-100	96-100	80-97	20-37	1-12
	13-60	Clay loam, silty clay loam, silty clay.	CL, CH	A-6, A-7	0	100	96-100	96-100	80-99	37-70	15-40

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--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	
Po*. Pits											
Sn, So----------- Summit	0-11	Silty clay loam	CL, CH, ML, MH	A-6, A-7	0	100	100	96-100	80-99	35-60	11-30
	11-60	Clay, silty clay	CH, MH, CL	A-7	0	98-100	98-100	96-100	80-98	41-70	18-40
Vb, Vc----------- Verdigris	0-32	Silt loam--------	CL, CL-ML, ML	A-4, A-6	0	100	100	95-100	65-100	22-38	2-13
	32-60	Silt loam, silty clay loam.	CL	A-4, A-6, A-7	0	100	100	95-100	80-100	30-45	8-23
We--------------- Welda	0-7	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	90-100	75-100	25-35	5-15
	7-35	Silty clay loam, silty clay.	CL	A-7-6, A-6	0	100	100	95-100	85-100	38-50	20-30
	35-60	Silty clay loam, silt loam.	ML, CL	A-6, A-4, A-7-6	0	100	100	90-100	75-100	30-45	7-20
Wo--------------- Woodson	0-7	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	90-100	85-100	25-40	5-20
	7-40	Silty clay, clay	CH	A-7-6	0	100	95-100	95-100	90-100	50-65	30-45
	40-60	Silty clay, clay, silty clay loam.	CH, CL	A-7-6	0	100	95-100	95-100	90-100	45-65	20-40

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH	Mmhos/cm					Pct
Bb---------------- Bates	0-10	15-27	1.40-1.50	0.6-2.0	0.20-0.24	5.1-6.5	<2	Low--------	0.28	4	6	1-4
	10-31	18-35	1.50-1.60	0.6-2.0	0.15-0.19	5.1-6.5	<2	Low--------	0.28			
	31	---	---	---	---	---	---	-----------	-----			
Bc---------------- Bates	0-7	15-27	1.40-1.50	0.6-2.0	0.20-0.24	5.1-6.5	<2	Low--------	0.28	4	6	1-4
	7-31	18-35	1.50-1.60	0.6-2.0	0.15-0.19	5.1-6.5	<2	Low--------	0.28			
	31	---	---	---	---	---	---	-----------	-----			
Cb---------------- Catoosa	0-12	10-20	1.30-1.50	0.6-2.0	0.15-0.24	5.6-6.5	<2	Low--------	0.32	3	6	1-2
	12-25	27-35	1.45-1.75	0.6-2.0	0.15-0.22	5.1-7.3	<2	Moderate	0.32			
	25-29	40-45	1.45-1.75	0.2-0.6	0.14-0.15	5.1-7.3	<2	Moderate	0.32			
	29	---	---	---	---	---	---	-----------	-----			
Cm*:												
Clareson---------	0-11	15-30	1.25-1.35	0.6-2.0	0.16-0.22	5.6-7.3	<2	Moderate	0.32	2	7	---
	11-16	27-40	1.30-1.40	0.2-2.0	0.09-0.21	5.6-7.3	<2	Moderate	0.24			
	16-33	35-50	1.35-1.45	0.06-0.6	0.04-0.07	5.6-7.3	<2	Moderate	0.24			
	33	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
De, Df------------ Dennis	0-11	10-27	1.30-1.55	0.6-2.0	0.15-0.20	5.1-6.0	<2	Low--------	0.37	4	6	1-3
	11-17	27-35	1.45-1.70	0.2-0.6	0.15-0.20	4.5-6.0	<2	Moderate	0.37			
	17-60	35-55	1.35-1.65	0.06-0.2	0.15-0.20	5.1-8.4	<2	High-------	0.37			
Ec, Ed------------ Eram	0-9	27-32	1.30-1.60	0.2-0.6	0.15-0.19	5.6-6.5	<2	Moderate	0.37	3	7	1-3
	9-27	35-55	1.45-1.75	0.06-0.2	0.14-0.18	5.1-7.3	<2	High-------	0.37			
	27	---	---	---	---	---	---	-----------	-----			
Ef*:												
Eram-------------	0-8	27-32	1.30-1.60	0.2-0.6	0.15-0.19	5.6-6.5	<2	Moderate	0.37	3	7	1-3
	8-27	35-55	1.45-1.75	0.06-0.2	0.14-0.18	5.1-7.3	<2	High-------	0.37			
	27	---	---	---	---	---	---	-----------	-----			
Lebo-------------	0-12	22-35	1.35-1.45	0.6-2.0	0.21-0.23	5.6-7.8	<2	Moderate	0.32	4	7	---
	12-28	22-35	1.40-1.50	0.6-2.0	0.15-0.18	5.6-7.8	<2	Moderate	0.24			
	28-38	22-35	1.45-1.65	0.6-2.0	0.07-0.10	5.6-7.8	<2	Moderate	0.24			
	38	---	---	---	---	---	---	-----------	-----			
Gc---------------- Grundy	0-11	12-27	1.35-1.50	0.6-2.0	0.22-0.24	5.6-7.3	<2	Moderate	0.37	4	6	2-4
	11-16	32-45	1.35-1.45	0.2-0.6	0.18-0.20	5.6-6.5	<2	High-------	0.37			
	16-60	40-50	1.30-1.40	0.06-0.2	0.11-0.13	5.1-7.3	<2	High-------	0.37			
Hp---------------- Hepler	0-25	12-27	1.25-1.35	0.6-2.0	0.22-0.24	4.5-6.5	<2	Low--------	0.37	5	6	.5-1
	25-40	27-35	1.35-1.45	0.6-2.0	0.18-0.20	4.5-6.5	<2	Moderate	0.37			
	40-60	27-42	1.35-1.45	0.2-0.6	0.14-0.17	4.5-6.5	<2	Moderate	0.37			
Ke---------------- Kenoma	0-10	18-29	1.35-1.45	0.2-0.6	0.22-0.24	5.1-6.5	<2	Low--------	0.43	4	6	2-4
	10-58	40-60	1.40-1.50	<0.06	0.10-0.15	5.1-7.8	<2	High-------	0.32			
	58-60	30-50	1.35-1.45	0.06-0.2	0.18-0.20	6.1-8.4	<4	High-------	0.32			
La---------------- Lanton	0-14	20-30	1.30-1.55	0.6-2.0	0.18-0.22	6.1-7.3	<2	Low--------	0.32	5	7	2-6
	14-53	20-35	1.40-1.60	0.2-0.6	0.17-0.22	6.1-7.3	<2	Low--------	0.43			
	53-60	20-35	1.40-1.60	0.06-0.6	0.12-0.18	6.1-7.3	<2	Moderate	0.32			
Lb---------------- Lebo	0-11	27-35	1.35-1.45	0.6-2.0	0.17-0.19	5.6-7.8	<2	Moderate	0.24	4	8	---
	11-28	22-35	1.40-1.50	0.6-2.0	0.15-0.18	5.6-7.8	<2	Moderate	0.24			
	28-38	22-35	1.45-1.65	0.6-2.0	0.07-0.10	5.6-7.8	<2	Moderate	0.24			
	38	---	---	---	---	---	---	-----------	-----			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH	Mmhos/cm					Pct
Mb---------------- Mason	0-18	20-30	1.30-1.60	0.6-2.0	0.16-0.20	5.1-7.3	<2	Low--------	0.32	5	6	1-3
	18-60	20-35	1.40-1.70	0.2-0.6	0.16-0.20	4.5-7.8	<2	Moderate	0.32			
Nf, Ng, Nh-------- Newtonia	0-13	10-24	1.30-1.55	0.6-2.0	0.15-0.24	5.6-6.5	<2	Low--------	0.32	5	6	1-3
	13-40	27-35	1.45-1.70	0.6-2.0	0.18-0.22	5.1-6.0	<2	Moderate	0.32			
	40-60	32-45	1.35-1.65	0.6-2.0	0.12-0.20	5.1-6.0	<2	Moderate	0.32			
Oh---------------- Okemah	0-12	20-27	1.30-1.50	0.2-2.0	0.16-0.20	5.6-7.3	<2	Low--------	0.37	4	6	1-3
	12-18	35-55	1.40-1.65	0.06-0.2	0.15-0.19	5.6-7.8	<2	High-------	0.37			
	18-60	35-55	1.40-1.65	0.06-0.2	0.15-0.19	6.6-8.4	<2	High-------	0.37			
Om*, Op*. Orthents												
Ot---------------- Osage	0-15	35-40	1.45-1.65	<0.06	0.21-0.23	5.1-7.3	<2	High-------	0.37	5	4	1-4
	15-60	35-60	1.50-1.70	<0.06	0.08-0.12	5.6-7.8	<2	Very high	0.28			
Ov---------------- Osage	0-23	40-50	1.40-1.60	<0.06	0.12-0.14	5.1-7.3	<2	Very high	0.28	5	4	1-4
	23-60	35-60	1.50-1.70	<0.06	0.08-0.12	5.6-7.8	<2	Very high	0.28			
Pc---------------- Parsons	0-13	15-25	1.30-1.50	0.6-2.0	0.16-0.24	5.1-6.5	<2	Low--------	0.43	4	6	.5-1
	13-60	35-60	1.40-1.70	<0.6	0.14-0.22	5.1-7.8	<2	High-------	0.43			
Po*. Pits												
Sn, So------------ Summit	0-11	27-45	1.25-1.50	0.2-0.6	0.16-0.20	5.6-7.3	<2	Moderate	0.37	4	7	1-3
	11-60	40-60	1.35-1.60	0.06-0.2	0.10-0.18	5.6-8.4	<2	High-------	0.32			
Vb, Vc------------ Verdigris	0-32	15-27	1.30-1.40	0.6-2.0	0.20-0.24	5.6-7.3	<2	Low--------	0.32	5	6	2-4
	32-60	18-35	1.40-1.65	0.6-2.0	0.17-0.22	5.6-7.3	<2	Moderate	0.32			
We---------------- Welda	0-7	12-29	1.25-1.35	0.6-2.0	0.22-0.24	5.1-7.3	<2	Low--------	0.32	5	6	.5-1
	7-35	35-42	1.35-1.40	0.2-0.6	0.14-0.20	5.1-6.5	<2	Moderate	0.32			
	35-60	18-35	1.40-1.45	0.6-2.0	0.18-0.22	5.1-6.5	<2	Moderate	0.32			
Wo---------------- Woodson	0-7	18-30	1.25-1.45	0.2-0.6	0.22-0.24	5.6-6.5	<2	Low--------	0.43	4	6	1-4
	7-40	40-60	1.30-1.45	<0.06	0.12-0.15	5.6-7.3	<2	High-------	0.32			
	40-60	30-50	1.35-1.45	0.06-0.2	0.10-0.15	5.6-7.8	<2	High-------	0.32			

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "rare," "brief," and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In			
Bb, Bc: Bates	B	None	---	---	>6.0	---	---	20-40	Soft	Low	Moderate.
Cb: Catoosa	B	None	---	---	>6.0	---	---	20-40	Hard	Moderate	Moderate.
Cm*:											
Clareson	C	None	---	---	>6.0	---	---	20-40	Hard	High	Moderate.
Rock outcrop.											
De, Df: Dennis	C	None	---	---	2.0-3.0	Perched	Dec-Apr	>60	---	High	Moderate.
Ec, Ed: Eram	C	None	---	---	2.0-3.0	Perched	Dec-Apr	20-40	Soft	High	Moderate.
Ef*:											
Eram	C	None	---	---	2.0-3.0	Perched	Dec-Apr	20-40	Soft	High	Moderate.
Lebo	B	None	---	---	>6.0	---	---	20-40	Soft	Moderate	Low.
Gc: Grundy	C	None	---	---	1.0-3.0	Perched	Mar-May	>60	---	High	Moderate.
Hp: Hepler	C	Occasional	Brief	Mar-Jul	1.0-3.0	Apparent	Nov-Mar	>60	---	High	Moderate.
Ke: Kenoma	D	None	---	---	>6.0	---	---	>60	---	High	Moderate.
La: Lanton	D	Common	Very brief	Jan-May	1.0-2.0	Apparent	Dec-May	>60	---	High	Low.
Lb: Lebo	B	None	---	---	>6.0	---	---	20-40	Soft	Moderate	Low.
Mb: Mason	B	Rare	---	---	>6.0	---	---	>60	---	Moderate	Moderate.
Nf, Ng, Nh: Newtonia	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate.
Oh: Okemah	C	None	---	---	2.0-3.0	Perched	Mar-Jun	>60	---	High	Moderate.
Om*, Op*. Orthents											
Ot, Ov: Osage	D	Occasional	Brief to long.	Nov-May	0-1.0	Perched	Nov-May	>60	---	High	Moderate.
Pc: Parsons	D	None	---	---	0.5-1.5	Perched	Dec-Apr	>60	---	High	Moderate.
Po*. Pits											
Sn, So: Summit	C	None	---	---	2.0-3.0	Perched	Dec-Apr	>60	---	High	Low.
Vb: Verdigris	B	Occasional	Very brief	Dec-Jun	>6.0	---	---	>60	---	Low	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Uncoated steel	Concrete
					Ft			In			
Vc----------------- Verdigris	B	Frequent----	Very brief	Dec-Jun	>6.0	---	---	>60	---	Low------	Low.
We----------------- Welda	C	None---------	---	---	>6.0	---	---	>60	---	Moderate	Moderate.
Wo----------------- Woodson	D	None---------	---	---	0.5-2.0	Perched	Dec-Apr	>60	---	High-----	Moderate.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 18.--ENGINEERING INDEX TEST DATA

[Dashes indicate data were not available]

Soil name, horizon, and depth in inches	Classification		Grain-size distribution*							Liquid limit	Plasticity index	Moisture density**	
			Percentage passing sieve--				Percentage smaller than--						
	AASHTO	Unified	No. 4	No. 10	No. 40	No. 200	.02 mm	.005 mm	.002 mm			Max. dry density	Optimum moisture
										Pct		Lb/ft3	Pct
Catoosa silt loam:													
Ap--------0 to 8	A-4 (10)	ML	100	100	99	97	73	35	22	34	9	--	19
B21t-----18 to 25	A-7-6(20)	ML	100	100	99	98	85	55	43	46	17	250	23
Dennis silt loam:													
Ap--------0 to 7	A-4 (09)	CL-ML	100	100	99	87	53	24	17	20	7	562	15
B22t-----25 to 36	A-7-6(21)	ML	100	100	100	92	73	55	47	48	19	250	25
B3-------48 to 60	A-7-6(19)	CL	100	100	100	89	68	46	35	44	20	187	21
Eram silty clay loam:													
Ap--------0 to 8	A-7-5(20)	ML-MH	100	100	95	89	69	44	31	50	19	250	23
B2t------11 to 22	A-7-5(21)	MH	100	100	95	86	73	53	39	52	21	437	23
Grundy silt loam:													
Ap--------0 to 7	A-4 (09)	ML	100	100	99	96	61	22	9	33	9	125	18
B22t-----24 to 33	A-7-5(27)	MH	100	100	99	96	80	55	46	54	23	62	27
B23t-----33 to 46	A-7-6(34)	CH	100	100	99	98	85	53	44	58	29	187	26
B3-------46 to 60	A-7-6(20)	CL	100	100	99	96	74	44	34	41	19	62	20
Parsons silt loam:													
Ap--------0 to 9	A-4 (08)	CL	100	100	98	91	55	24	14	30	9	312	16
B21t-----12 to 28	A-7-6(23)	ML	100	100	99	95	76	54	44	49	20	187	25
B3-------37 to 60	A-7-6(20)	CL	100	100	99	94	71	47	36	44	19	562	21

* Grain-size distribution according to AASHTO Designation T88-72 with the following variations: (1) all material is crushed in a laboratory steel jawed crusher; (2) the sample is not soaked prior to dispersion; (3) dispersing time is 5 minutes at 7 p.s.i. using an Iowa air tube; and (4) AASHTO Designation T-133-74 is followed except for sample size to obtain SpG for the hydrometer analysis. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

** Based on AASHTO Designation T99-74, Method A, with the following variations: (1) all material is crushed in a laboratory steel jawed crusher after drying; and (2) no time is allowed for dispersion of moisture after mixing with the soil material.

TABLE 19.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Bates	Fine-loamy, siliceous, thermic Typic Argiudolls
Catoosa	Fine-silty, mixed, thermic Typic Argiudolls
Clareson	Clayey-skeletal, mixed, thermic Typic Argiudolls
Dennis	Fine, mixed, thermic Aquic Paleudolls
Eram	Fine, mixed, thermic Aquic Argiudolls
Grundy	Fine, montmorillonitic, mesic Aquic Argiudolls
Hepler	Fine-silty, mixed, thermic Udollic Ochraqualfs
Kenoma	Fine, montmorillonitic, thermic Vertic Argiudolls
*Lanton	Fine-silty, mixed, thermic Cumulic Haplaquolls
Lebo	Loamy-skeletal, mixed, thermic Typic Hapludolls
Mason	Fine-silty, mixed, thermic Typic Argiudolls
Newtonia	Fine-silty, mixed, thermic Typic Paleudolls
Okemah	Fine, mixed, thermic Aquic Paleudolls
Orthents	Mixed, thermic Typic Udorthents
Osage	Fine, montmorillonitic, thermic Vertic Haplaquolls
Parsons	Fine, mixed, thermic Mollic Albaqualfs
Summit	Fine, montmorillonitic, thermic Vertic Argiudolls
Verdigris	Fine-silty, mixed, thermic Cumulic Hapludolls
Welda	Fine, montmorillonitic, mesic Typic Hapludalfs
Woodson	Fine, montmorillonitic, thermic Abruptic Argiaquolls

* The soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series.

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