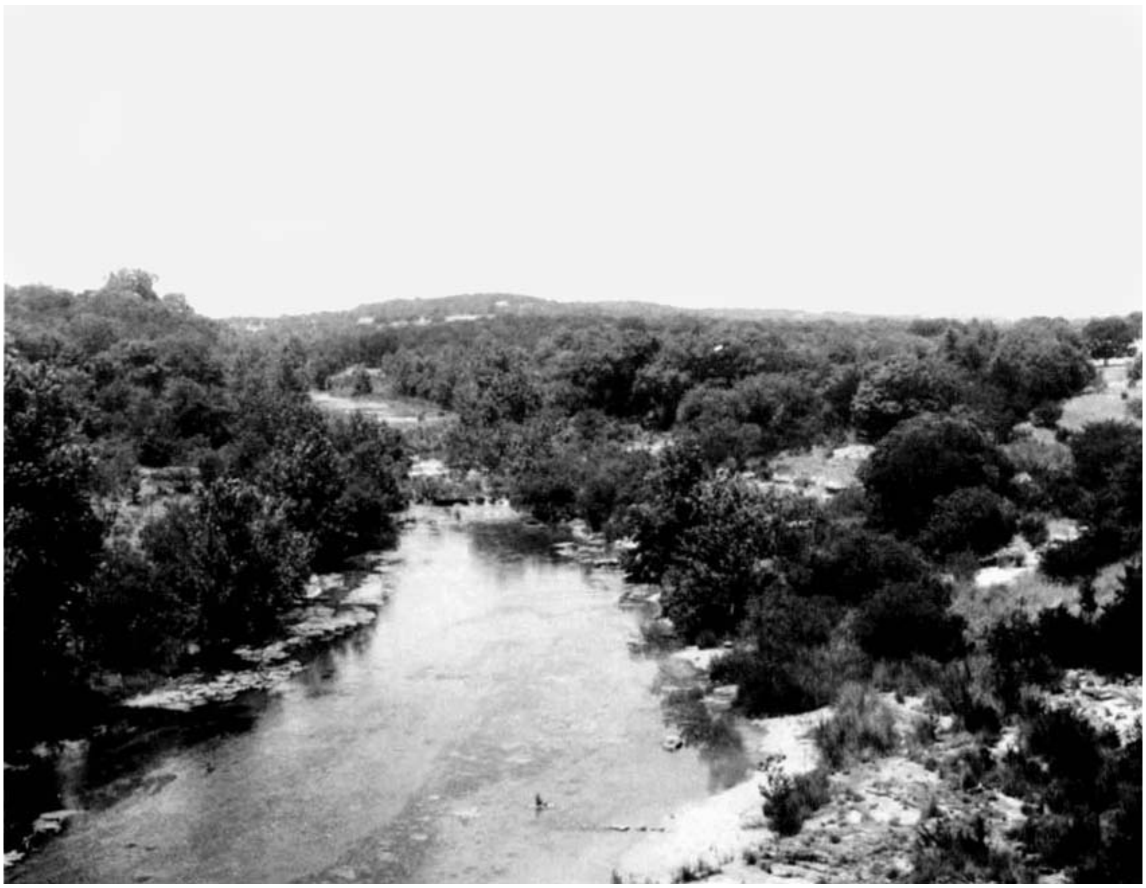
SOIL SURVEY OF

KERR COUNTY, TEXAS

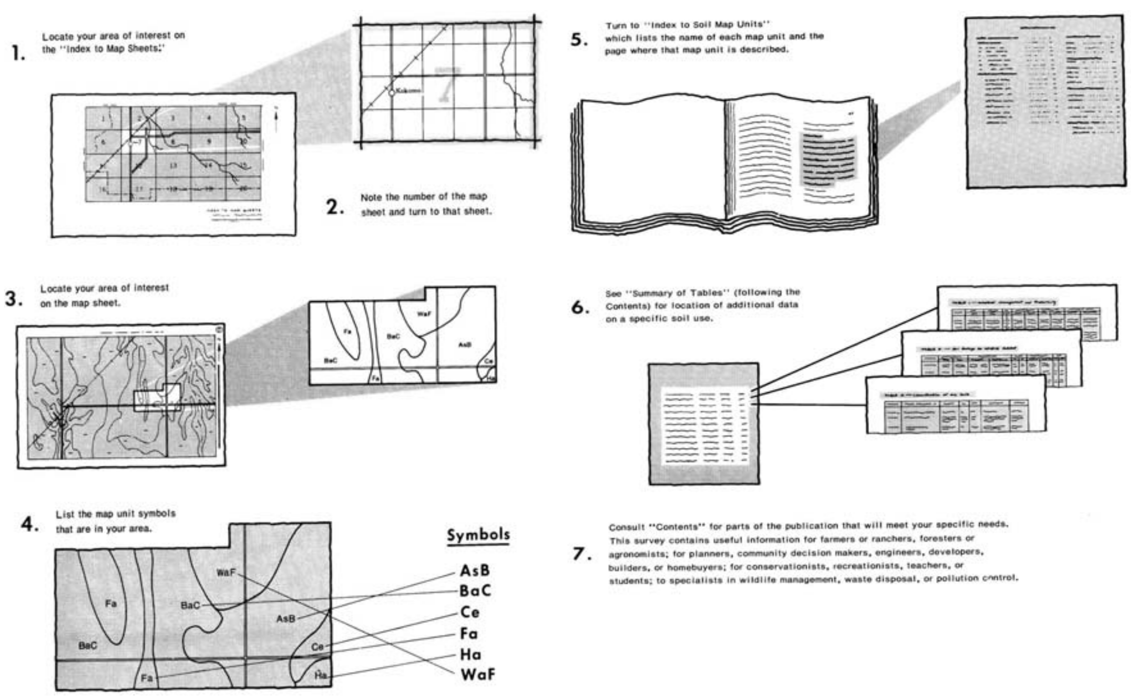


ELECTRONIC VERSION

This soil survey is an electronic version of the original printed copy, dated March 1986. It has been formatted for electronic delivery. Additional and updated information may be available from the Web Soil Survey. In Web Soil Survey, identify an Area of Interest (AOI) and navigate through the AOI Properties panel to learn what soil data is available.

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

HOW TO USE THIS SOIL SURVEY



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.

Major fieldwork for this soil survey was completed in 1982. Soil names and descriptions were approved in 1982. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1982. This survey was made cooperatively by the Soil Conservation Service and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Kerr County Soil and Water Conservation District.

This soil survey is dedicated to the memory of William H. Dittemore, Jr., party leader, who died before this soil survey was completed.

Cover: The North Fork of the Guadalupe River. The Orif-Boerne association, frequently flooded, is on the flood plain along the river, and the Tarrant-Eckrant association, gently undulating, is adjacent to the flood plain.

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Soil Series

Issued March 1986

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Summary of Tables

Foreword

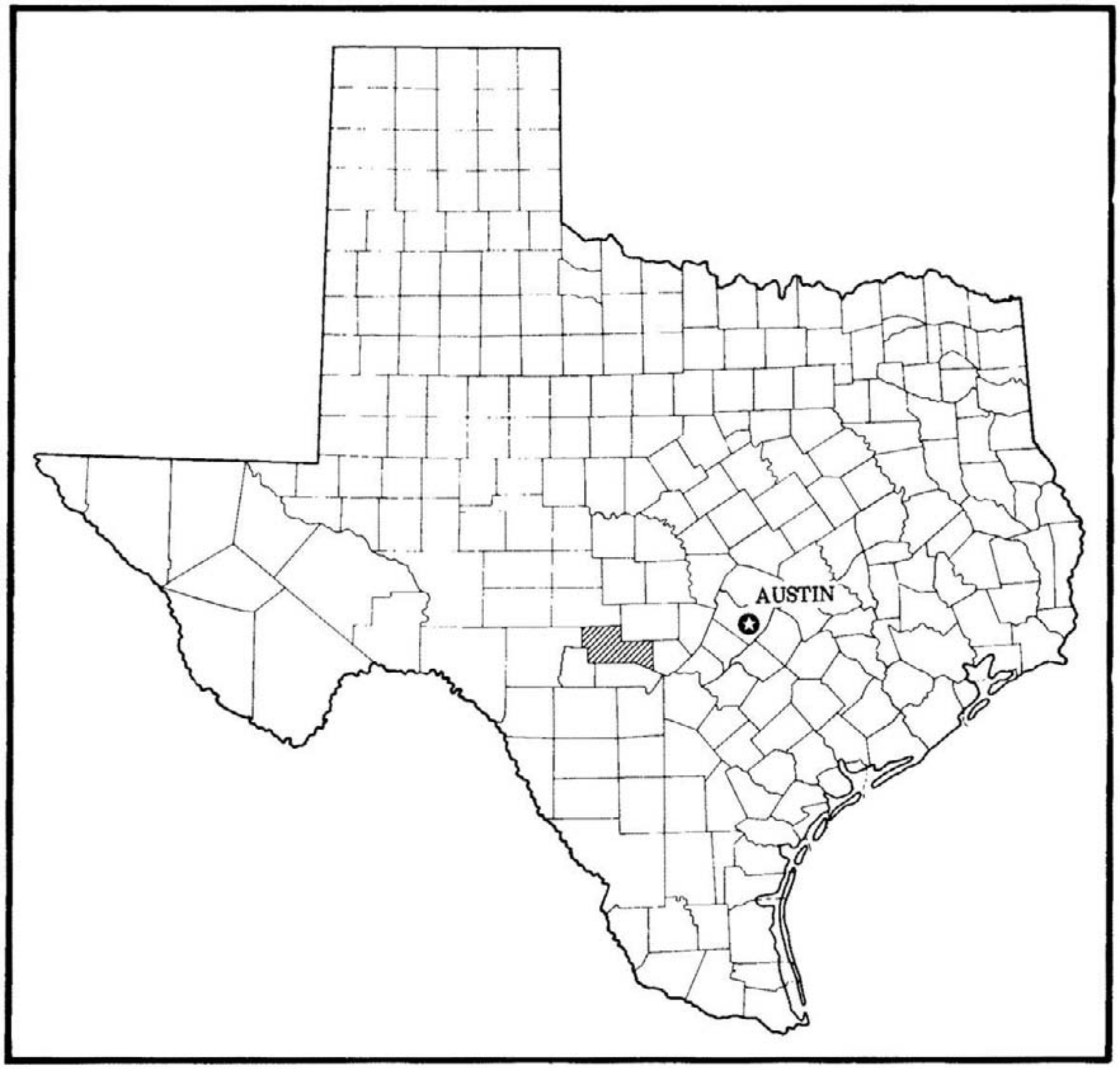
This soil survey contains information that can be used in land-planning programs in Kerr County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of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

This soil survey is designed for many different users. Farmers, ranchers, 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 subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey soils are poorly suited to use as septic tank absorption fields.

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.

Billy C. Griffin
State Conservationist
Soil Conservation Service



Location of Kerr County in Texas.

Soil Survey of
Kerr County, Texas

By William H. Dittemore, Jr., and Winfred C. Coburn
Fieldwork by James L. Hensell, William H. Dittemore, Jr., and Winfred C. Coburn,
Soil Conservation Service

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

Kerr County is in the south-central part of Texas on the southern edge of the Edwards Plateau. It has a total area of 708,506 acres, or about 1,107 square miles. The landscape consists of gently undulating, clayey and stony soils in the western part of the county; gently sloping, loamy soils on hilltops; steep side slopes; narrow valleys in the central to eastern part; and nearly level to gently sloping, loamy and clayey soils along the Guadalupe River and other major streams. The county is drained by numerous streams, the largest of which are the Guadalupe River, Cypress Creek, Johnson Creek, Town Creek, Turtle Creek, and Verde Creek. Many of these water areas are perennial spring fed streams.

Kerrville, which had a population of 15,276 in 1980, is the county seat. Other towns in the survey area are Center Point, Hunt, Ingram, and Mountain Home. In 1970, according to the Bureau of Census, the population of the county was about 19,454. In 1980, the population was 28,780. Land in the county is rapidly being developed as homesites.

In 1982, according to records in the Kerrville field office of the Soil Conservation Service, approximately 630,000 acres in Kerr County was used as rangeland, 21,000 acres as cropland, 7,000 acres as pastureland, and 50,000 acres as urban and built-up land.

Descriptions, names, and delineations of soils in this soil survey do not fully agree with those of adjacent counties. Differences are the result of better knowledge of the 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 general information concerning Kerr County. It discusses settlement and agriculture, transportation, and climate.

Settlement and Agriculture

Kerr County was formally organized in 1856 from Bexar County. It was named for Major James Kerr, a soldier and statesman and an early settler on the Guadalupe River.

Early settlers in the area, led by Joshua David Brown, established a shingle-making camp, using the huge cypress trees along the Guadalupe River. Within a few years, however, hand-hewn shingles became obsolete, and sawmills replaced this industry. The first mill was also a gristmill. It was on Verde Creek, not far from Center Point *(7).*

As pioneers and immigrants from Germany began to settle the area, the fertile, tillable land along the river and creeks was cleared and planted to corn, grain, and cotton. The raising of livestock, which began in the hills, eventually became the county's chief economic resource. The cattle drives began early in 1870. By the latter part of 1870 sheep and goats were also being raised.

In the early 1840's the area was open country with scattered trees. Grass was waist high, and there was an abundance of turf and bunchgrass. As a result of the livestock industry, however, overstocking depleted the rangeland. Undesirable forbs, grasses, and brush, especially cedar, overran the rangeland. The shortage of desirable vegetation caused farmers to plow soil that was too steep, too shallow, or too close to streambanks. Runoff increased on the overused rangeland, and the undesirable cropland became eroded.

On May 8, 1944, the Kerr County Soil and Water Conservation District was organized. Through this conservation district the Soil Conservation Service, U.S. Department of Agriculture, provides technical assistance to farmers and ranchers in managing, using, and conserving the soils on their farms and ranches.

Transportation

Interstate Highway 10 crosses Kerr County from east to northwest. Texas Highway 27 takes the same direction as the Interstate; Texas Highway 16 runs from the northeastern part of the county to the south-central part; and Texas Highway 41 runs from Interstate Highway 10 to the west-central part. Texas Highway 39 runs from Ingram to the southwestern corner of the county, and Texas Highway 173 connects Kerrville and the southern part. Several ranch roads and paved county roads provide other means for excellent vehicular travel throughout Kerr County.

Climate

Prepared by the National Climatic Center, Asheville, North Carolina

Table 1 gives data on temperature and precipitation for the survey area as recorded at Kerrville, Texas, in the period 1951 to 1978. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 47 degrees F, and the average daily minimum temperature is 33 degrees. The lowest temperature on record, which occurred at Kerrville on February 2, 1951, is -2 degrees. In summer the average temperature is 80 degrees, and the average daily maximum temperature is 92 degrees. The highest recorded temperature, which occurred at Kerrville on July 27, 1954, is 110 degrees.

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

The total annual precipitation is 29.57 inches. Of this, 17 inches, or 60 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 12 inches. The heaviest 1-day rainfall during the period of record was 8.25 inches at Kerrville on June 23, 1965. Thunderstorms occur on about 40 days each year, and most occur in summer.

Snowfall is rare. In 75 percent of the winters, there is no measurable snowfall. In 20 percent, the snowfall, usually of short duration, is more than 2 inches. The heaviest 1-day snowfall on record was more than 6 inches.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in summer and 50 percent in winter. The prevailing wind is from the southeast. Average windspeed is highest, 11 miles per hour, in spring.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management were assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed, and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soils on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

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 on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map 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 map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The soils in the survey area vary widely in their potential for major land uses. Soil potential ratings are based on the practices commonly used in the survey area to overcome soil limitations. These ratings reflect the ease of overcoming the limitations. They also reflect the problems that will persist even if such practices are used.

Each map unit is rated for *cultivated crops, pasture, rangeland, urban uses*, and *recreation areas*. Cultivated crops are those grown extensively in the survey area. Pasture refers to land used for growing pasture plants, such as improved bermudagrass, kleingrass, and lovegrass. Rangeland refers to land in native or introduced range plants. Urban uses include residential, commercial, and industrial sites. Recreation areas included are campsites, picnic areas, playgrounds, paths and trails, and other areas that are subject to heavy foot traffic.

1. Tarrant-Eckrant-Purves

Very shallow and shallow, gently undulating and undulating, clayey, stony, and cobbly sods; on uplands

The landscape consists of gently undulating Tarrant soils on low, irregularly shaped ridges, gently undulating Eckrant soils on slightly lower slopes, and undulating Purves soils in positions similar to those of the Eckrant and Tarrant soils. These soils are on a broad plateau that is locally called "the divide." Stones and rock outcrop are at the surface. Slopes range from 1 to 8 percent.

This map unit makes up about 41 percent of the county. It is about 42 percent Tarrant soils, 18 percent Eckrant soils, 17 percent Purves soils, and 23 percent soils of minor extent (fig. 1).

Typically, the surface layer of the Tarrant soils is calcareous, dark grayish brown stony clay about 5 inches thick. The next layer to a depth of 9 inches is calcareous, dark grayish brown very stony clay. Below that is a thick bed of hard limestone bedrock.

Typically, the surface layer of the Eckrant soils is mildly alkaline, very dark gray cobbly clay about 4 inches thick. The next layer to a depth of 7 inches is moderately alkaline, dark grayish brown very cobbly clay. Below that is a thick bed of hard limestone bedrock.

Typically, the surface layer of the Purves soils is calcareous, dark grayish brown stony clay about 7 inches thick. The next layer to a depth of 15 inches is calcareous, dark brown gravelly clay. Below that is hard, fractured limestone bedrock.

Of minor extent in this map unit are the Denton, Kerrville, Krum, Oakalla, Roughcreek, Spires, and Tarpley soils and areas of outcrop. The moderately deep, gently sloping to hilly, loamy Kerrville soils are on low, rounded hills and steep side slopes. The deep, gently sloping, clayey Denton and Krum soils are on uplands at the head of stream drainageways and in valleys. The deep, nearly level, loamy Oakalla soils are on flood plains of larger streams. The shallow to moderately deep, gently undulating, clayey to loamy Roughcreek, Spires, and Tarpley soils are on broad uplands. Rock outcrop mainly occurs along shoulders of slopes.

The soils in this map unit are used mainly as rangeland and as wildlife habitat. The major soils are not suited to pasture or crops because of surface stones and the very shallow to shallow depth to bedrock. Some of the minor soils can be used as pastureland and cropland.

Deer, turkeys, doves, and quail and squirrels and other furbearing animals are the most common wildlife. Deer and turkeys are plentiful. Most areas are managed by ranchers for hunting. There are many nesting areas for doves and songbirds.

The main limitations for dwellings, lawns, and roads are depth to rock, large stones, slope, and corrosivity to uncoated steel. Foundations for buildings, roads, and other structures can be easily placed on solid bedrock; however, excavating the bedrock is difficult. Steel utility lines corrode rapidly unless they are protected.

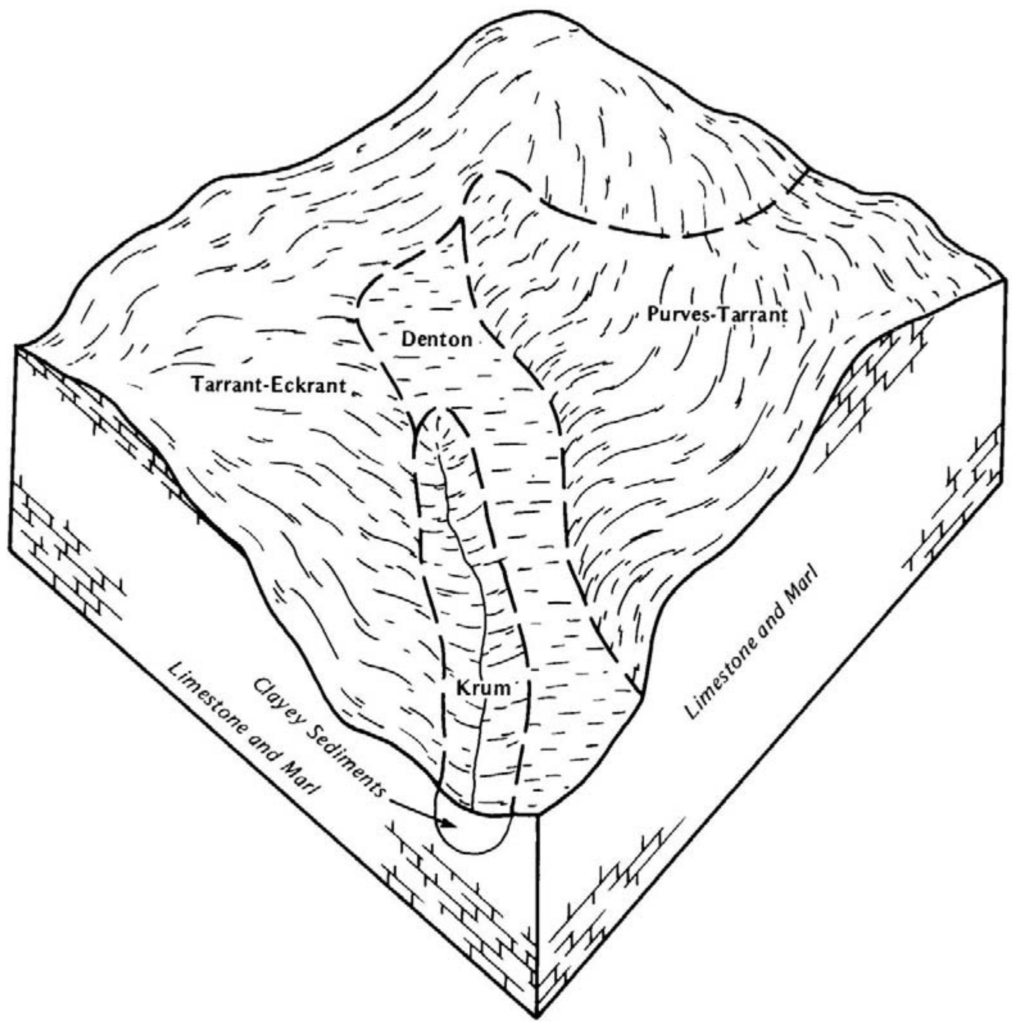


Figure 1.—Pattern of soils and underlying material in the Tarrant-Eckrant-Purves map unit.

Special design is needed for septic systems to function properly, and care must be taken to prevent pollutants from passing through the bedrock and into the underground water supplies. Maintaining a grass cover, landscaping, and gardening are difficult. These soils are sticky and slippery when wet.

2. Eckrant-Kerrville-Rock outcrop

Very shallow to moderately deep, gently undulating to hilly and steep, clayey and loamy, cobbly and gravelly soils and Rock outcrop; on uplands

The landscape consists of gently undulating to steep Eckrant soils mainly on northeast-facing side slopes and hilltops, gently sloping to hilly Kerrville soils on ridges, foot slopes, and side slopes, and areas of Rock outcrop. Slopes range from 1 to 30 percent.

This map unit makes up about 36 percent of the county. It is about 31 percent Eckrant soils, 23 percent Kerrville soils, 13 percent Rock outcrop, and 33 percent soils of minor extent (fig. 2).

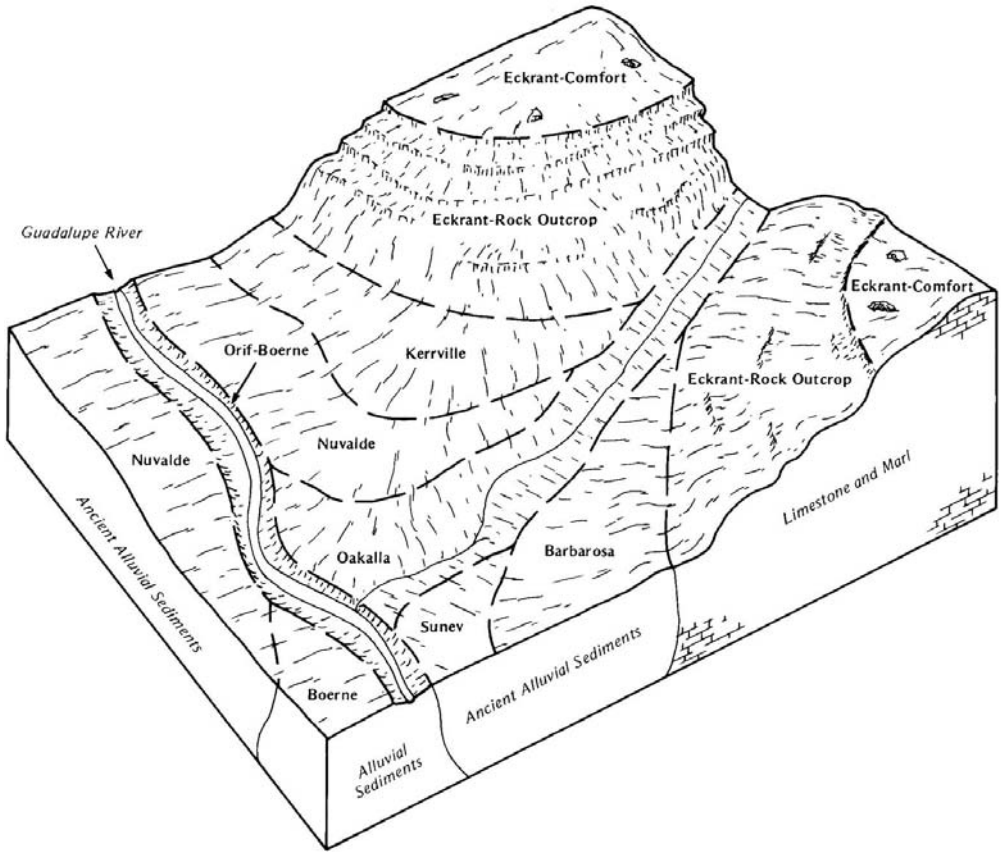


Figure 2.—Pattern of soils and underlying material in the Eckrant-Kerrville-Rock outcrop map unit on the right and at the back and the Nuvalde-Oakalla-Boerne map unit on the left.

Typically, the surface layer of the Eckrant soils is moderately alkaline, dark grayish brown cobbly clay that is about 45 percent, by volume, limestone cobbles and is 7 inches thick. The next layer to a depth of 12 inches is moderately alkaline, dark grayish brown very cobbly clay that is about 60 percent, by volume, limestone cobbles. Below that is hard limestone bedrock.

Typically, the surface layer of the Kerrville soils is calcareous, pale brown gravelly clay loam about 8 inches thick. The next layer to a depth of 15 inches is calcareous, very pale brown clay loam that is 10 percent limestone gravel. The next layer to a depth of 24 inches is calcareous, extremely gravelly clay loam that is 75 percent limestone gravel and flagstones. Below that is coarsely fractured indurated limestone.

The Rock outcrop consists of exposures of limestone bedrock that follow the contour of the slope. The outcrops range from 10 to 20 feet in width. In gently undulating areas, the outcrops are mainly less than 1 foot above the surface of the surrounding soils, but in hilly and steep areas they are ledges, cliffs, or bluffs.

Of minor extent in this map unit are the Comfort, Denton, Depalt, Doss, Krum, Oakalla, Real, Roughcreek, and Tarpley soils. The shallow, gently undulating, loamy and clayey Comfort, Roughcreek, and Tarpley soils are on broad hilltops and ridges on uplands. The moderately deep to deep, gently sloping and clayey Denton, Depalt, and Krum soils are on foot slopes, at the heads of stream drainageways, and in upland valleys. The shallow, gently sloping to hilly, clayey and loamy Doss and Real soils are on dominantly northeast facing ridges and side slopes. The deep, nearly level, loamy Oakalla soils are on flood plains of larger streams.

The soils in this map unit are mainly used as rangeland and as wildlife habitat. The rough, rocky terrain is more easily accessible to goals and sheep than to cattle. Most ranchers, however, raise some cattle. The major soils are not suited to crops or pasture because of the slope, surface stones, and depth to bedrock. Some of the minor soils can be used as cropland and pastureland.

Deer, turkeys, and squirrels and other furbearing animals are the most common wildlife. Deer and turkeys are plentiful. Most areas are managed by ranchers for hunting. There are many nesting areas for songbirds.

Depth to rock, slope, large stones, high lime content, and corrosivity to uncoated steel are the main limitations for dwellings, lawns, and roads. Because of the outstanding views in the canyons, however, many vacation and weekend homes, ranchettes, and dude ranches are in this area. Special precautions are needed in constructing buildings and roads. Excavating the hard rock is difficult. Rapid surface runoff and seepage through the limestone following rains are major concerns. Special construction of septic systems in raised beds or large fields is necessary, but even with this precaution effluent may surface downslope or percolate through the bedrock into the underground water. Underground steel is subject to rapid corrosion unless it is protected. The high lime content causes iron chlorosis of many plants. Because lawns are difficult to maintain, it is usually advisable to retain the rustic, natural landscape. In places limestone is quarried for roadbuilding material.

3. Spires-Tarpley-Tarrant

Moderately deep to very shallow, gently undulating, loamy and clayey, cobbly and stony soils, on uplands

The landscape consists of gently undulating Spires soils in concave areas below ridges, Tarpley soils on convex ridges, and Tarrant soils in long, narrow, crescent shaped, convex areas between the Spires and Tarpley soils. Slopes range from 1 to 8 percent.

This map unit makes up about 8 percent of the county. It is about 38 percent Spires soils, 25 percent Tarpley soils, 9 percent Tarrant soils, and 28 percent soils of minor extent (fig. 3).

Typically, the surface layer of the Spires soil is neutral, dark reddish gray, cobbly clay loam about 5 inches thick. The next layer to a depth of 23 inches is neutral, red clay. Below that is a thick bed of hard crystalline limestone.

Typically, the surface layer of the Tarpley soils is neutral, dark reddish brown stony clay about 7 inches thick. The next layer to a depth of 16 inches is neutral, dark reddish brown clay. Below that is a thick bed of hard crystalline limestone.

Typically, the surface layer of the Tarrant soils is calcareous, dark grayish brown stony clay about 7 inches thick. The next layer to a depth of 15 inches is calcareous, very dark grayish brown very stony clay. Below that is a bed of hard, fractured limestone bedrock.

Of minor extent in this map unit are the Comfort, Denton, Eckrant, Purves, and Roughcreek soils. The shallow, gently undulating, loamy Comfort and Roughcreek soils are on broad hilltops on uplands. The deep, gently sloping, clayey Denton soils are at the head of drainageways and in slightly lower areas on uplands. The very shallow to shallow, gently undulating, clayey Eckrant and Purves soils are on broad uplands.

The soils in this map unit are used mainly as rangeland and as wildlife habitat. Some areas of Spires soils and some of the minor soils are used as cropland and pastureland. In many areas, uses are restricted because of bedrock, stones, and available water capacity.

Deer, turkeys, doves, and quail are the most common wildlife. Most areas are managed by ranchers for hunting.

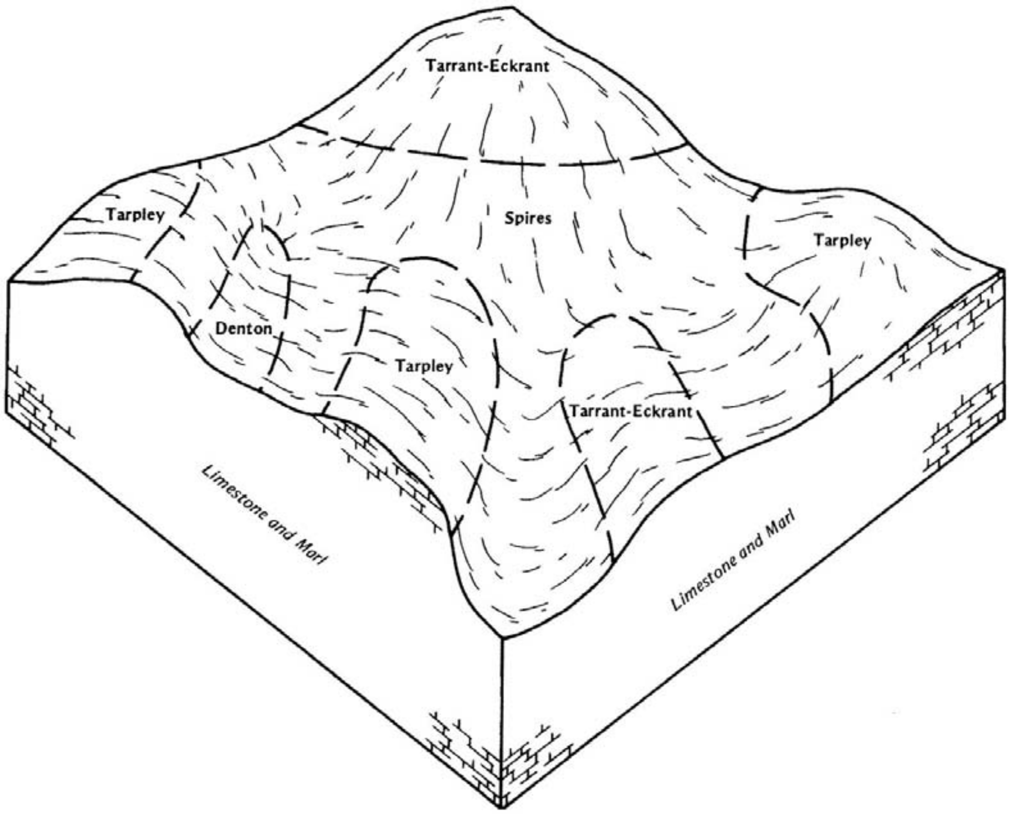


Figure 3.—Pattern of soils and underlying material in the Spires-Tarpley-Tarrant map unit.

Depth to rock, shrinking and swelling with changes in moisture, large stones, and corrosivity to uncoated steel are the main limitations for dwellings, roads, and other structures. Bases or foundations for roads and buildings should be placed on bedrock because shrinking and swelling of the soil can cause rupturing. Excavating the hard rock is difficult. Steel utility lines are subject to rapid corrosion unless they are protected. Septic systems need to be specially designed to function in these clayey soils, and care must be taken to prevent pollutants from passing through the bedrock and into the underground water supplies.

4. Tarpley-Eckrant-Roughcreek

Shallow and very shallow, gently undulating, clayey and loamy, stony and cobbly soils; on uplands

The landscape consists of gently undulating Eckrant soils on broad hilltops and slightly raised ridges on uplands, gently undulating Tarpley soils on broad upland plateaus that are slightly lower than the surrounding Eckrant and Roughcreek soils, and Roughcreek soils on broad plateaus on uplands. Slopes range from 1 to 5 percent.

This map unit makes up about 6 percent of the county. It is about 51 percent Tarpley soils, 17 percent Eckrant soils, 13 percent Roughcreek soils, and 19 percent other soils.

Typically, the surface layer of the Tarpley soils is neutral, dark reddish brown stony clay loam about 7 inches thick. The next layer to a depth of 18 inches is neutral, reddish brown clay. Below that is a bed of fractured limestone bedrock.

Typically, the surface layer of the Eckrant soils is mildly alkaline, very dark gray cobbly clay about 5 inches thick. The next layer to a depth of 9 inches is calcareous, dark grayish brown very cobbly clay. Below that is a bed of coarsely fractured limestone bedrock.

Typically, the surface layer of the Roughcreek soils is neutral, dark reddish brown stony clay loam about 8 inches thick. The next layer, to a depth of 17 inches, is neutral, reddish brown very stony clay. Below that is a bed of fractured limestone bedrock.

Of minor extent in this map unit are the Kerrville, Comfort, Denton, Krum, and Oakalla soils. The moderately deep, hilly, loamy Kerrville soils are on side slopes on uplands. The shallow, gently undulating, loamy Comfort soils are on hilltops on uplands. The deep, gently sloping, clayey Denton soils are on uplands that are slightly lower than the surrounding stony soils. The deep, gently sloping, clayey Krum soils are in narrow valleys. The deep, nearly level, loamy Oakalla soils are on flood plains of the larger streams.

The soils in this map unit are mainly used as rangeland and as wildlife habitat. The major soils are not suited to crops or pasture because of the stony surface and the shallow depth to bedrock. Some of the minor soils can be used as cropland and pastureland.

Deer, turkeys, quail, and furbearing animals are the most common wildlife. Most areas are managed by ranchers for hunting. Nesting areas are plentiful for doves and songbirds.

Depth to rock, large stones, and corrosivity to uncoated steel are the main limitations for dwellings, roads, and other structures. Foundations for buildings and roads can be easily placed on solid bedrock; however, excavating the rock is difficult. Steel utility lines are subject to rapid corrosion unless they are protected. Septic systems need to be specially designed in order to function properly, and care must be taken to prevent pollutants from passing through the bedrock and into the underground water supplies. Landscaping and gardening are difficult because of stones and bedrock.

5. Nuvalde-Oakalla-Boerne

Deep, nearly level to gently sloping, clayey and loamy soils; on terraces and bottom lands

The landscape consists of nearly level to gently sloping Nuvalde soils on terraces and foot slopes near flood plains of streams, nearly level Oakalla soils on flood plains of larger streams, and gently sloping Boerne soils on flood plains and alluvial fans. Slopes range from 0 to 5 percent

This map unit makes up about 5 percent of the county. It is about 31 percent Nuvalde soils, 26 percent Oakalla soils, 12 percent Boerne soils, and 31 percent soils of minor extent (fig. 2).

Typically, the surface layer of the Nuvalde soils is calcareous, dark grayish brown silty clay 12 inches thick. The next layer to a depth of 31 inches is calcareous, brown silty clay. Below that to a depth of 40 inches is calcareous, light brown silty clay that has films, threads, soft masses, and concretions of calcium carbonate. The underlying material to a depth of 63 inches is calcareous, light brown silty clay that has films, threads, and concretions of calcium carbonate.

Typically, the surface layer of the Oakalla soils is calcareous silty clay loam that is very dark gray in the upper 22 inches and dark grayish brown in the lower 8 inches. The next layer to a depth of 63 inches in calcareous, brown silty clay loam that has films, threads, and soft masses of calcium carbonate and a few thin strata of darker material.

Typically, the surface layer of the Boerne soils is calcareous, brown fine sandy loam about 8 inches thick. The next layer to a depth of 41 inches is calcareous, light yellowish brown fine sandy loam. Below that to a depth of 63 inches is calcareous, brownish yellow fine sandy loam that has many threads and soft masses of calcium carbonate.

Of minor extent in this map unit are the Barbarosa, Depalt, Krum, Orif, and Sunev soils. The deep, nearly level to gently sloping, loamy Barbarosa and Sunev soils are on stream terraces near major streams. The deep, gently sloping, loamy and clayey Depalt and Krum soils are on uplands and valley fills. The deep, gently sloping, loamy Orif soils are on the flood plains of major streams.

The soils in this map unit are used mainly as cropland, rangeland, pastureland, and urban land and for recreation. The Okalla and Boerne soils, however, are subject to flooding 1 to 2 times every 1 to 4 years and remain under water 24 to 48 hours. The current is swift during periods of flooding. Crops are mainly oats and wheat. Some forage sorghum and grain sorghum are also grown. Improved pasture grasses are mainly bermudagrass and kleingrass.

Deer, turkeys, quail, doves, and squirrels are the most common wildlife. In many areas, lack of cover is a restriction for deer during the day, but at night they graze the fields planted to oat and wheat. The Oakalla soils provide nesting areas for doves and songbirds.

The Guadalupe River and adjacent scenic areas provide opportunities for fishing, swimming, boating, hiking, and related sports. The hazard of flooding on the Oakalla and Boerne soils needs to be considered in the design and construction of dwellings and roads and playgrounds and camping areas. Buildings and roads can be easily built on Nuvalde soils, but special design and construction are needed because of the high shrink-swell potential of the soils. Unprotected areas become muddy following rains, making foot traffic and vehicle traffic difficult.

6. Doss-Kerrville

Shallow and moderately deep, gently sloping to undulating, clayey and loamy soils; on uplands

The landscape consists of gently sloping to undulating Doss soils on foot slopes on uplands and undulating Kerrville soils on foot slopes that have a stairstep appearance and on oval knolls. Slopes range from 1 to 8 percent.

This map unit makes up about 4 percent of the county. It is about 50 percent Doss soils, 40 percent Kerrville soils, and 10 percent soils of minor extent.

Typically, the surface layer of the Doss soils is calcareous, dark grayish brown silty clay about 7 inches thick. The next layer to a depth of 13 inches is calcareous, brown silty clay that has soft masses of calcium carbonate. Below that to a depth of 40 inches is calcareous, very pale brown marl interbedded with soft limestone.

Typically, the surface layer of the Kerrville soils is calcareous, pale brown clay loam about 7 inches thick. The next layer to a depth of 18 inches is calcareous, very pale brown clay loam that has many concretions and soft masses of calcium carbonate. The underlying material to a depth of 24 inches is very pale brown loam and marl that is 70 percent, by volume, limestone gravel and flagstones. Below that is cemented limestone.

Of minor extent in this map unit are the Comfort, Eckrant, Krum, Roughcreek, and Tarpley soils. The shallow, gently undulating, loamy and clayey Comfort and Eckrant soils are on hilltops on uplands. The deep, gently sloping, clayey Krum soils are in narrow valleys. The shallow, gently undulating, loamy and clayey Roughcreek and Tarpley soils are on broad ridgetops.

The soils in this map unit are used mainly as rangeland and as wildlife habitat. A few areas of Doss soils are used as cropland.

Deer, turkeys, and furbearing animals are the most common wildlife. Most areas are managed by ranches for hunting. Nesting areas for doves and songbirds are plentiful.

The main limitations for dwellings, lawns, and roads are depth to rock, corrosivity to uncoated steel, and high lime content. Excavating for structures and utility lines is difficult. The high lime content of this soil causes iron chlorosis of many plants. Lawns and gardens need to be watered frequently.

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 uses. 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 soils series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Krum silty clay, 1 to 3 percent slopes, is one of several phases in the Krum series.

Some map units are made up of two or more major soils. These map units are called soil complexes or soil associations.

A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Doss-Urban land complex, 1 to 8 percent slopes, is an example.

A *soil association* is made up of two or more geographically associated soils that are shown as one unit on the maps. Because of present or anticipated soil uses in the survey area, it was not considered practical or necessary to map the soils separately. The pattern and relative proportion of the soils are somewhat similar. Doss-Kerrville association, undulating, 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. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils 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.

BaA—Barbarosa silty clay loam, 0 to 1 percent slopes. This deep, nearly level soil is on terraces near the flood plain of the Guadalupe River and its tributaries. Slopes are smooth and plane. Areas are long and oval and range from 20 to 250 acres.

Typically, the surface layer is dark brown, mildly alkaline silty clay loam 12 inches thick. The upper part of the subsoil to a depth of 32 inches is reddish brown clay. The lower part to a depth of 65 inches is yellowish red clay that has soft bodies and concretions of calcium carbonate. This soil is moderately alkaline and calcareous below a depth of 12 inches.

This Barbarosa soil is well drained. Surface runoff is slow. Permeability is slow, and available water capacity is high. The hazard of water erosion is slight.

Included with this soil in mapping are small, long, narrow areas of Boerne soils, and small, roughly circular areas of slightly concave Oakalla soils. The included soils make up about 10 percent of a mapped area.

This soil is used mainly for oats and wheat. Improved bermudagrass is used for pasture and hay in some places.

This soil should be tilled when the moisture content is low for best results. At that time the structure is broken but not destroyed, and aeration is improved. Crop residue should be kept on the surface to improve tilth and water intake. The rooting zone is deep, and air, water, and roots move through the soil easily. This soil receives additional water from nearby higher lying areas. Crops respond well to nitrogen and phosphate fertilizers.

Foundations for buildings, roads, and other structures need to be specially constructed to withstand the high shrink-swell potential of the soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields should be enlarged or the design modified to function properly in this slowly permeable soil. Lawns and gardens can be easily prepared and maintained. Farm ponds, also, can be built and maintained easily.

This soil is suitable for most recreational uses. It is, however, wet, sticky, and muddy in unprotected areas following rains, and passage can become difficult for vehicles.

This soil provides good habitat for doves, quail, and rabbits. Lack of cover is a restriction for deer during the day, but at night they graze the fields planted to oats and wheat.

This Barbarosa soil is in capability subclass IIs and Clay Loam range site.

Be—Boerne fine sandy loam, occasionally flooded. This deep, gently sloping soil is on flood plains or terraces near streams. Slopes are mostly convex. They range from 1 to 3 percent but average 1.5 percent. Areas are long and narrow and range from 20 to 60 acres.

Typically, the surface layer is brown fine sandy loam about 8 inches thick. The subsoil to a depth of 41 inches is light yellowish brown fine sandy loam. Below this to a depth of 63 inches is light yellowish brown fine sandy loam that has threads and soft bodies of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

This Boerne soil is well drained. Surface runoff is slow. Permeability is moderately rapid, and available water capacity is moderate. The rooting zone is deep. Air, water, and roots move through the soil easily. The hazard of water erosion is moderate. Flooding occurs 1 or 2 times every 1 to 4 years.

Included with this soil in mapping are small, long, oval areas of Oakalla soils; long, narrow areas of Nuvalde soils; a stream channel, which is as much as 100 feet wide in places; and long, narrow areas of Boerne soils that are frequently flooded. The included soils make up as much as 10 percent of a mapped area.

This soil is used as cropland and rangeland. Oats and wheat are the main crops.

Moderate available water capacity is the most limiting feature for cropland and pasture. Keeping crop residue on the surface helps to control water erosion and conserve moisture and also helps to improve soil tilth and water intake by preventing sealing of the surface layer.

The high lime content of this soil causes yellowing of the leaves, or iron chlorosis and results in a reduction of yields. Foliar application of solutions containing iron temporarily helps to reduce chlorosis. In places, crusting of the surface layer prevents the emergence of small seedlings.

Flooding is the most restrictive limitation for urban uses. In addition, seepage is a limitation for sanitary landfills and sewage lagoons. The corrosivity of uncoated steel pipes is moderate.

The hazard of flooding needs to be considered if this soil is used for camping areas and playgrounds. The soil is suitable for picnic areas and for paths and trails.

This soil provides fair habitat for deer, turkeys, and squirrels, and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

This Boerne soil is in capability subclass IIe and Loamy Bottomland range site.

DnB—Denton silty clay, 1 to 3 percent slopes. This deep, gently sloping soil is on uplands. Slopes are concave or convex. Areas are irregular in shape or long and oval. They range from 30 to 75 acres.

Typically, the surface layer is dark grayish brown silty clay 12 inches thick. The subsoil to a depth of 35 inches is brown silty clay loam that has small, rounded bodies of soft calcium carbonate. Below that to a depth of 50 inches is light brown gravelly silty clay loam that is marly. Cemented limestone is below a depth of 50 inches. This soil is moderately alkaline and calcareous throughout.

This Denton soil is well drained. Surface runoff is medium. Permeability is slow. The rooting zone is deep; however, the high clay content tends to impede the movement of air, water, and roots. Available water capacity is moderate. The hazard of water erosion is moderate.

Included with this soil in mapping are small, long, oval areas of Doss soils; small, long, narrow areas of Krum soils; and long, narrow areas of Nuvalde soils. The included soils make up 8 to 15 percent of a mapped area.

This soil is used as cropland, rangeland, and improved pastureland.

Oats and wheat are the principal crops. The moderate available water capacity is the most limiting feature. Crops respond well to fertilizers. Nitrogen and phosphorus are needed to obtain optimum yields. This soil has good tilth if cultivated at a low moisture content. Terraces and contour farming help to control water erosion and conserve moisture. Crop residue left on the surface helps to maintain tilth and control erosion.

Foundations for buildings, roads, and other structures need to be constructed to withstand the high shrink-swell potential of the soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields should be enlarged or the design modified to function properly in this slowly permeable soil. Limestone bedrock is a problem if the soil is excavated to a depth of more than 40 inches. Some fruit trees and vegetables develop iron chlorosis because of the high lime content of this soil.

This soil is suitable for most recreational uses. It is, however, wet, sticky, and muddy in unprotected areas following rains, and foot traffic and vehicle traffic can become difficult. In some areas slope is a limitation for playgrounds.

This soil provides good habitat for doves, quail, and rabbits. Lack of cover is a restriction during the day for deer, but at night they graze the fields planted to oats and wheat.

This Denton soil is in capability subclass IIe and Clay Loam range site.

DpB—Depalt silty clay loam, 0 to 3 percent slopes. This deep, nearly level to gently sloping soil is on uplands. Slopes are slightly concave and average 2 percent. Areas are irregular in shape and range from 40 to 200 acres. In rangeland areas the surface is characterized by gilgai microrelief consisting of microknolls and microdepressions. The microknolls are 2 to 6 inches higher than the microdepressions. They range from 2 to 8 feet across and are 3 to 15 feet apart. The gilgai microrelief smooths out after a few years of cultivation.

In the center of a microknoll, the surface layer is neutral, very dark gray silty clay loam about 6 inches thick. The upper part of the subsoil is neutral or mildly alkaline, reddish brown clay and gravelly clay about 24 inches thick. The lower part to a depth of 35 inches is moderately alkaline and calcareous, reddish brown gravelly clay and to a depth of 63 inches is moderately alkaline and calcareous, yellowish red gravelly clay that is 35 percent, by volume, pebbles of limestone.

This Depalt soil is well drained. Surface runoff is slow to medium. When dry, this soil has wide deep cracks that extend from the surface to a depth of 24 inches. Water enters the soil rapidly when it is dry and cracked, but very slowly when it is wet and the cracks are closed. Permeability is very slow, and available water capacity is high. The hazard of water erosion is moderate.

Included with this soil in mapping are small, circular areas of Tarpley soils. Also included are soils on knolls that are similar to Depalt soils except that the surface layer is about 20 percent, by volume, pebble and cobble size chert fragments. The included soils make up as much as 15 percent of a mapped area.

This soil is used for cultivated crops, improved pasture, and rangeland. Oats, forage sorghum for hay, and wheat are the principal crops. This soil is well suited to bermudagrass and kleingrass for pasture and hay (fig. 4).

Figure 4.—Large round bales of kleingrass hay on Depalt silty clay loam, 0 to 3 percent slopes.

If this soil is tilled continuously to the same depth, a plowpan can form. Good tilth is difficult to maintain when the soil is cultivated because of the high clay content, which causes the soil to be sticky when wet and very hard and cloddy when dry. Tilling when moisture conditions are low improves aeration and maintains tilth. The rooting zone is deep, but the clay content tends to impede the movement of air, water, and roots.

Foundations for buildings, roads, and other structures need to be specially constructed to withstand the high shrink swell potential of this soil, or they will shift, buckle, and break. Underground steel pipes corrode rapidly unless they are protected. Septic systems do not function well and generally malfunction during extended rainy periods. The banks of excavated areas cave easily. Most garden and landscaping plants grow well, but the clayey soil is difficult to work with handtools. Farm ponds are easily built and maintained.

This soil can be used for recreational uses. The clayey surface layer and very slow permeability are the most restrictive features. When wet, this soil is muddy and sticky, and foot traffic and vehicle traffic can become difficult. During dry periods, cracks in the soil limit some playground activities.

This soil provides fair habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

This Depalt soil is in capability subclass IIIe and Deep Redland range site.

DrB—Depalt-Urban land complex, 0 to 3 percent slopes. This map unit consists of nearly level to gently sloping areas in the western part of the city of Kerrville. Areas are roughly circular and range from 35 to 100 acres. The boundaries of these areas commonly coincide with the outer limits of developed subdivisions, built-up areas, and extra territorial jurisdictions of Kerrville. Slopes range from 0 to 3 percent but average 1.5 percent.

Depalt soil makes up about 47 percent of this map unit and Urban land, 37 percent. Tarpley soil makes up 13 percent, and a soil that has limestone within 40 inches of the surface but otherwise is similar to the upper part of the Depalt soil, makes up 3 percent. The areas of the map unit are so intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Typically, in an undisturbed area of Depalt soil, the surface layer is dark reddish gray clay that has a few chert pebbles. It is 11 inches thick. The upper part of the subsoil to a depth of 31 inches is reddish brown clay that has a few chert pebbles. The lower part to a depth of 63 inches is yellowish red clay. This soil is neutral to a depth of 31 inches and moderately alkaline and calcareous between depths of 31 and 63 inches. Local areas have been disturbed by excavating and grading.

This Depalt soil is well drained. Surface runoff is medium. When dry, this soil has wide deep cracks that extend from the surface to a depth of 24 inches or more. Water enters rapidly when the soil is dry and cracked but very slowly when it is wet and the cracks are closed. Permeability is very slow, and available water capacity is high. The hazard of water erosion is moderate.

Urban land consists of soils that have been altered or covered by single family dwellings, patios, driveways, streets, sidewalks, shopping centers, parking areas, and apartment buildings and other buildings. The land has been cut and shaped for urban development. Shallow excavations as much as 1 foot to 3 feet in depth are made to accommodate utility lines and foundation footings. Construction changes, however, have not altered the shrink-swell characteristics, the permeability rate, or the available water capacity of the soils.

This map unit provides an excellent location for home site development, but the heavy clay texture of the soils has several unfavorable characteristics. The high shrink-swell properties can cause foundations to shift and buckle. Paved roads, which become bumpy and broken, need frequent patching. Uncoated steel pipes will corrode and rupture if used for underground utilities. Septic systems function poorly in the heavy clay subsoil and may fail to function during periods of high rainfall when the soils are saturated. Native elm and post oak grow well, but fruit trees grow poorly. Although soil reaction is favorable for vegetables, gardening with handtools is difficult. Organic matter should be added to improve the tilth of these soils.

In areas used for intensive foot traffic, such as playgrounds, grass is difficult to maintain, and surfaces become wet and muddy. The muddy surfaces, in addition to possessing low bearing strength, hinder the use of the soil for concentrated vehicular traffic, such as is needed for campgrounds.

This Depalt-Urban land complex is not assigned to a capability subclass or range site.

DsC—Doss silty clay, 1 to 5 percent slopes. This shallow, gently sloping soil is on uplands (fig. 5). It is underlain by cemented limestone and marl. Slopes are smooth and average 3.5 percent. Areas are oblong and range from 20 to 140 acres.

Figure 5.—An area of Doss silty clay, 1 to 5 percent slopes, in the foreground and Kerrville-Real association, hilly, in the background.

Typically, the surface layer is dark grayish brown silty clay about 9 inches thick. The subsoil to a depth of 17 inches is reddish brown silty clay that contains common soft bodies, concretions, and threads of calcium carbonate. Below that is a bed of cemented limestone that becomes softer as depth increases. This soil is moderately alkaline and calcareous throughout.

This Doss soil is well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is moderate.

Included with this soil in mapping are small, roughly circular areas that have a clay loam surface layer averaging less than 35 percent clay and a few small, long, oval areas of Kerrville soils and Denton soils. The included soils make up from 5 to 15 percent of a mapped area.

This soil is used as cropland and rangeland. Oats and wheat are the main crops, and improved bermudagrass is the main pasture grass.

Shallow rooting depth and very low available water capacity are the most limiting features of this soil. Crops respond to fertilizers. Nitrogen and phosphorus are needed to maintain yields. The hazard of erosion restricts the amount of cultivation. Crop residue kept on the surface helps to maintain good tilth, conserves moisture, and controls erosion. Contour farming and terracing are needed to control water erosion. If cuts or excavations for terraces or waterways exceed about 12 inches, there is a hazard of exposing the bedrock.

The clayey texture, shallowness, low strength, shrinking and swelling with changes in moisture content, corrosivity of uncoated steel pipes, and moderately slow permeability are main limitations for urban uses. Because of the shallowness to rock, the construction of foundations and underground utility lines is difficult. Underground water contamination from sewage systems is possible. Septic systems will function properly if they are correctly installed. Many garden and landscaping plants are affected by iron chlorosis because of the high lime content of this soil. Gardens and lawns need to be watered regularly because of the very low available water capacity of the soil.

Shallowness to rock is the main limitation for recreational uses. The clayey texture limits some uses, especially when the soil becomes wet and muddy.

This soil provides fair habitat for deer, turkeys, and furbearing animals. Nesting areas for doves and songbirds are plentiful.

This Doss soil is in capability subclass IIIe and Shallow range site.

DsD—Doss-Urban land complex, 1 to 8 percent slopes. This map unit consists of gently sloping to sloping areas throughout the city of Kerrville. Areas are roughly oval and range from 20 to 60 acres. Boundaries of the areas commonly coincide with the outer limits of developed subdivisions, built-up areas, and extra territorial jurisdictions of Kerrville. Slopes range from 1 to 8 percent but average 3 percent.

Doss soil makes up about 53 percent of this map unit, and Urban Land makes up 30 percent. Denton and Kerrville soils and a soil that is similar to Doss soil but has a clay loam surface layer make up 17 percent. The areas of this map unit are so intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Typically, in an undisturbed area of Doss soil, the surface layer is dark grayish brown silty clay 8 inches thick. The subsoil is brown silty clay that has many soft bodies of calcium carbonate. It is 9 inches thick. Below that is interbedded limestone and marl. This soil is moderately alkaline and calcareous throughout. Local areas have been disturbed by excavating and grading.

This Doss soil is well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is very low. Excess lime may cause yellowing of the leaves in some plants, and where this occurs, the vigor of the plant is reduced. The rooting zone is shallow. The hazard of water erosion is moderate.

Urban land consists of soils that have been altered or covered by single family dwellings, patios, driveways, streets, sidewalks, and small buildings. The land has been altered by cutting, grading, and filling. Shallow excavations as much as 1 foot to 3 feet in depth have been made to accommodate utility lines and foundation footings; however, these construction changes have not altered the shrink-swell characteristics, the permeability rate, or the available water capacity of the soil.

The clayey texture, shallowness, low strength, shrinking and swelling with changes in moisture content, corrosivity to uncoated steel pipes, and moderately slow permeability are the main limitations for most uses. Moderately slow permeability limits the use of these soils for septic tank absorption fields.

This map unit provides good locations for homesite development. Rock is within 20 inches of the surface, but the rock can be excavated if proper excavation techniques are used. The moderate shrink-swell characteristics of the soil can cause cracking and buckling of foundations, driveways, and sidewalks if they are not properly reinforced. A good base is needed to prevent cracking and buckling of the paved surface of roads and streets. Uncoated steel pipes will corrode if they are used for underground utilities. Septic systems will function properly if the perforated pipe is packed in gravel and the system is large enough for the needs of the household; however, during trenching operations, rock will be encountered at a depth of less than 20 inches. Native live oak trees grow well in this soil, but fruit trees do not produce well and survive only a short time. Successful gardens can be grown; however, leaves turn yellow because of the high lime content of the soil, and where this occurs, the vigor and quality of the blooms and vegetables are reduced.

In areas used for intensive foot traffic, such as playgrounds, grass is difficult to maintain, and surfaces become wet and muddy. The muddy surface, in addition to having low bearing strength, hinders use of the soil for concentrated vehicular traffic, such as is needed for campgrounds.

This Doss-Urban land complex is not assigned to a capability subclass or range site.

DTD—Doss-Kerrville association, undulating. This map unit consists of shallow to moderately deep, undulating, loamy and clayey soils on uplands. Slopes are convex and range from 1 to 8 percent. Areas are irregular in shape to oval and range from 30 to 400 acres.

Doss and Kerrville soils are in all mapped areas. Doss soil makes up 60 percent of the map unit, and Kerrville soil makes up 37 percent. Eckrant, Krum, and Tarpley soils make up about 3 percent. These percentages are based on transect data using an 80 percent confidence level. Seven transects, comprising 70 observations, served as the data base. Eckrant and Tarpley soils are in areas of hard limestone. Krum soil is on the lower part of the landscape. The composition of this map unit is variable; however, use and management are similar and mapping has been controlled well enough for the anticipated uses of the soils.

The Doss soil is on the less sloping parts of this association. It is in long, narrow, concentric bands that follow the contour of the slope. Typically, the surface layer is dark grayish brown silty clay 7 inches thick. The next layer to a depth of 13 inches is brown silty clay. The underlying material is white, weakly cemented limestone and very pale brown, soft, chalky earth. This soil is moderately alkaline and calcareous throughout.

The Kerrville soil is on crescent or oval knolls. Typically, the surface layer is pale brown clay loam 7 inches thick. The subsoil to a depth of 18 inches is very pale brown clay loam that is about 25 percent, by volume, soft and weakly cemented bodies of calcium carbonate. The underlying material to a depth of 24 inches is very pale brown loam and marl that is 70 percent gravelly and flaggy limestone fragments. Below that is cemented limestone. This soil is moderately alkaline and calcareous throughout.

These Doss and Kerrville soils are well drained. Surface runoff is medium to rapid. Permeability is moderate or moderately slow, and available water capacity is very low. Seeps are common after periods of high rainfall. The rooting zone is shallow. The hazard of water erosion is severe.

All of the acreage is used as rangeland. It is not suited to crops.

Shallow depth, slope, high lime content, very low available water capacity, and rock ledges are the main limitations for urban uses. Excavating for foundations and utility lines is difficult. The high lime content of the soils causes chlorosis of yard and garden plants. Lawns and gardens need to be watered frequently.

Depth to rock and small stones hinder recreational uses. Slope is an additional restriction for use as playgrounds.

These soils provide fair habitat for deer, turkeys, and furbearing animals. Nesting areas for doves and songbirds are plentiful.

The Doss soil is in capability subclass VIe and Shallow range site, and the Kerrville soil is in capability subclass VIs and Adobe range site.

ECC—Eckrant-Comfort association, gently undulating. This map unit consists of shallow, cobbly and stony soils on hilltops on uplands (fig. 6). The Eckrant soil generally is near the edge of the hilltops and on the narrower parts of the hilltops.

The Comfort soil is in the middle of the broader hilltops. Slopes are plane to convex and range from 1 to 5 percent. Areas are irregular in shape and range from 40 to more than 1,000 acres. Many pebbles, cobbles, and stones are on the surface of these soils.

Figure 6.—An area of Eckrant-Comfort association, gently undulating, in good range condition. The grass cover hides the many stones and cobbles.

The Eckrant soil is a part of all the mapped areas. It makes up about 51 percent of each area, but the range is 40 to 80 percent. The Comfort soil makes up about 34 percent of each mapped area. These percentages are based on transect data using an 80 percent confidence level. Seven transects, comprising 160 observations, served as the data base. The rest of the map unit is rock outcrop; small areas of Real, Kerrville, Tarpley, and Purves soils; and a soil that is of redder hue but otherwise is similar to Eckrant soil. Areas of this map unit are large, and the composition is variable; however, mapping has been controlled well enough for the anticipated uses of the soils.

Typically, the Eckrant soil has a surface layer of very dark gray, mildly alkaline cobbly clay. It is 5 inches thick. The next layer to a depth of 9 inches is dark grayish brown, moderately alkaline and calcareous very cobbly clay. Below that is fractured limestone bedrock.

Typically, the Comfort soil has a surface layer of dark reddish brown stony clay. It is 8 inches thick. The subsoil to a depth of 14 inches is reddish brown stony clay.

Below that is indurated crystalline limestone bedrock. This soil is mildly alkaline throughout.

These Eckrant and Comfort soils are well drained. Surface runoff is slow or medium. Permeability is slow or moderately slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is moderate.

All of the acreage is used as rangeland. It is not suited to crops.

The cobbly and stony clay surface, depth to bedrock, and very low available water capacity are main limitations for most uses. Foundations for buildings, roads, and other structures can easily be placed on solid bedrock; however, excavating the rock is difficult. Steel utility lines corrode rapidly unless they are protected. Septic systems should be specially designed to function properly, and care needs to be taken to prevent pollutants from passing through the bedrock and into the underground water supply. Landscaping and gardening are difficult because of stones and bedrock.

Stones and cobbles on the surface and depth to bedrock are the main limitations to use of these soils for recreational purposes. Maintaining a grass cover is difficult. The soil is sticky and slippery when wet.

These soils provide fair habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

The Eckrant soil is in capability subclass VIIs, and the Comfort soil is in capability subclass VIs. Both soils are in Low Stony Hills range site.

ERG—Eckrant-Rock outcrop association, steep. This map unit consists of very shallow, cobbly and stony, clayey soils on sides of long, narrow limestone hills that are the side slopes of some of the secondary drainageways in the county. Slopes are convex and range from 8 to 30 percent. Areas are long and narrow and generally follow the contour of the hillsides. They range from 40 to 1,000 acres or more. Many pebbles, cobbles, and stones are on the surface.

Eckrant soil makes up about 60 percent of the map unit but ranges from 40 to 90 percent. Rock outcrop makes up 37 percent but ranges from 10 to 60 percent. These percentages are based on transect data using an 80 percent confidence level. Seven transects, comprising 70 observations, served as the data base. Rock outcrop occurs as ledges that follow the contour of the slope. These ledges are 10 to 20 feet wide. The rest of the map unit is small areas of Kerrville, Krum, and Real soils. Areas of this map unit are large, and the composition is variable; however, mapping has been controlled well enough for the anticipated uses of the areas.

Typically, the Eckrant soil has a surface layer of dark grayish brown cobbly clay that is 45 percent, by volume, limestone fragments of cobble and pebble size. It is 7 inches thick. The next layer to a depth of 12 inches is dark grayish brown very cobbly clay that is 60 percent, by volume, limestone fragments of cobble and pebble size. Below that is indurated limestone bedrock that is fractured. Cobbles and stones cover as much as 70 percent of the surface of this soil. The soil is moderately alkaline throughout and is calcareous in the lower 5 inches.

This Eckrant soil is well drained. Surface runoff is rapid. Permeability is moderately slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is severe.

The Rock outcrop is as much as 8 inches high and ranges from 10 to 20 feet wide. Some outcrops are partially covered with as much as 3 inches of soil and range from 10 to 20 feet wide. The layered bedrock is as much as 50 feet thick. Fractured fragments of bedrock are 6 inches to more than 20 feet thick.

All of the acreage is used as rangeland. This area is not suited to crops.

The stony clay surface, large stones, rock outcrops, shallowness, slope, and very low available water capacity are the most limiting features for most uses. Because they offer scenic views, some areas are used as sites for houses. Special precautions are necessary, however, in constructing houses and other buildings. Excavating the hard rock is difficult. Allowances should be made for rapid surface runoff and seepage of water through the limestone following rains. Septic systems need to be specially constructed in raised beds or large fields, but even then, seepage may surface downslope or penetrate through the bedrock into the underground water supply. Underground steel pipes corrode rapidly unless they are protected. Because lawns are difficult to maintain, retention of the rustic, natural landscape is usually advisable.

Steep slopes, depth to rock, and large stones are the main limitations for recreational uses.

These soils provide fair habitat for a variety of wildlife, including deer, doves, and quail. Turkeys and squirrels from adjacent bottom lands also frequent the area to feed on acorns and other mast. Songbirds and small mammals are plentiful. Because of the slopes and rocky soil, habitat for wildlife is sometimes the primary use of this soil.

The Eckrant soil is in capability subclass VIIs and Steep Rocky range site. Rock outcrop was not assigned to a capability subclass or range site.

KeD—Kerrville clay foam, 1 to 8 percent slopes. This moderately deep, loamy soil is on ridges and foot slopes. Slopes average about 4 percent. Areas are long and oval or irregular in shape and range from 120 to 600 acres. Bands or ledges of limestone that are perpendicular to the slopes are exposed on the low, rounded hills. In places angular and rounded limestone pebbles are on the surface.

Typically, the surface layer is grayish brown clay loam about 6 inches thick. The subsoil to a depth of 14 inches is light yellowish brown clay loam that has many concretions and soft masses of calcium carbonate. The underlying material to a depth of 30 inches is very pale brown very gravelly clay loam interbedded with marl and weakly cemented limestone. Cemented limestone is at a depth of 30 inches. This soil is moderately alkaline and calcareous throughout.

This Kerrville soil is well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Seepage is common after periods of high rainfall. The rooting zone is moderately deep. The hazard of water erosion is severe.

Included with this soil in mapping are areas where the surface layer is gravelly loam, gravelly clay loam, or loam. Also included are small areas of Denton, Doss, Eckrant, and Krum soils. Denton and Krum soils are on the lower parts of the landscape. Eckrant soils are underlain by hard limestone. Doss soils and the Kerrville soil are in similar positions on the landscape. The included soils make up less than 20 percent of any mapped area.

This soil is used primarily as rangeland. It is not suited to crops.

Depth to rock, slope, high lime content, and very low available water capacity are the most limiting features for urban uses. Excavating for structures and underground lines is difficult. The high content of lime causes chlorosis of lawn and garden plants. Lawns and gardens need to be watered regularly.

Depth to rock and small stones affect the use of this soil for recreational purposes. Slope is a restriction for use of the soil as playgrounds.

This soil provides fair habitat for deer, doves, and quail. Several woody plants, forbs, and grasses provide good cover, browse, fruits, and seeds for wildlife.

This Kerrville soil is in capability subclass VIe and Adobe range site.

KfF—Kerrville-Urban land complex, 8 to 20 percent slopes. This map unit consists of areas on hills. Areas are irregular in shape and range from 60 to 140 acres. Boundaries of the areas commonly coincide with the outer limits of developed subdivisions, built-up areas, and extra territorial jurisdictions of the city of Kerrville. Slopes average 16 percent but range from 8 to 20 percent.

Kerrville soil makes up an average of 45 percent of this map unit and Urban land 40 percent. Doss, Eckrant, and Krum soils make up 15 percent. The areas of this map unit are so intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Typically, in an undisturbed area of Kerrville soil, the surface layer is grayish brown gravelly clay loam that has a few soft bodies of calcium carbonate and is about 25 percent limestone gravel. It is 5 inches thick. The subsoil to a depth of 13 inches is light yellowish brown clay loam that has soft bodies of calcium carbonate. The underlying material to a depth of 32 inches is light yellowish brown extremely gravelly clay loam that is about 75 percent gravelly and flaggy fragments of limestone. Below that is cemented limestone. This soil is moderately alkaline and calcareous throughout. Local areas have been disturbed by excavating or by adding a thin layer of soil material to the surface.

This Kerrville soil is well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Seeps are common after periods of high rainfall. Excess lime may cause a yellowing of the leaves of some plants, and where this occurs, the vigor of the plant is reduced. The hazard of water erosion is severe. Increased runoff is a problem on some areas of this map unit.

Urban land consists of soils that have been altered or covered by single family dwellings, patios, driveways, sidewalks, and streets. About 25 percent of the area has been excavated to a depth of as much as 16 feet to accommodate construction. Walls have been constructed to prevent soil slippage.

Many housing subdivisions are located in areas of this map. Homesites range from 1 acre to 10 acres. They provide good foundations for homes and scenic views. Steep slopes, runoff, seepage from septic systems, and difficulty in trenching or grading for streets and foundations are the main limitations. Unpaved roads are subject to damage from erosion. Seepage under the paved roads causes the pavement to crumble, and resurfacing of the road is frequently necessary. Plastic perforated pipe drains packed in gravel and placed under the road near seep areas are needed to control seepage. Because the steep banks crumble and slide downward during wet weather, retaining walls are needed to prevent soil slippage. Excavating is needed to level house sites. Private drives are difficult and expensive to construct and maintain. The establishment of lawns is also difficult because of the steep slopes and low soil fertility, high content of lime, and shallow rooting depth. Grasses native to the site are recommended for lawn establishment. The addition of fertile topsoil is needed for the successful growing of ornamentals. The high lime content in the soil causes iron chlorosis or yellowing of ornamental plants and fruit trees, and where this occurs, the vigor and quality of the blooms and fruit are reduced. Homesites should be spaced far enough apart to insure the efficient operation of septic tank absorption fields. Efficiency can be improved by packing the perforated pipe in gravel and increasing the area of the field.

Depth to rock, small stones, and slope are restrictions for recreational uses.

This Kerrville-Urban land complex is not assigned to a capability subclass or range site.

KNG—Kerrville-Real association, hilly. This map unit consists of moderately deep and shallow, gravelly and loamy soils. Slopes are convex and range from 8 to 30 percent. Areas are oblong or irregular in shape and range from 50 to 1,500 acres. Horizontal outcrops of limestone give the slopes a stairstepped or benched appearance (fig. 7). Angular limestone pebbles and cobbles are on the surface of some areas.

Kerrville soil makes up 67 percent of the map unit but ranges from 60 to 80 percent of each mapped area. Real soil makes up 30 percent but ranges from 10 to as much as 40 percent of each mapped area. These percentages are based on transect data using an 80 percent confidence level. Seven transects, comprising 70 observations, served as the data base. The rest of the map unit is small areas of Doss, Eckrant, Krum, and Tarpley soils. Doss soil is on smoother slopes than Kerrville soil. Eckrant and Tarpley soils are in areas of hard limestone. Krum soil is on lower slopes. Kerrville soil is in areas between bands of Real soil. Kerrville is in long, narrow, continuous bands that lie perpendicular to the slope. These bands range

Figure 7.—An area of Kerrville-Real association, hilly, showing the benched topography.

from 25 feet to 150 feet in width. These soils were not mapped separately because their use and management are similar. Areas of this map unit are large, and the composition is variable; however, mapping has been controlled well enough for the anticipated uses of the soils.

Typically, the Kerrville soil has a surface layer of pale brown gravelly clay loam that has a few bodies of calcium carbonate and is about 20 percent limestone gravel. It is 8 inches thick. The subsoil is very pale brown clay loam that has soft bodies and concretions of calcium carbonate. The underlying material to a depth of 24 inches is very pale brown extremely gravelly clay loam that is about 75 percent gravelly and flaggy limestone fragments. Below that is cemented limestone. This soil is moderately alkaline and calcareous throughout.

Typically, the Real soil has a surface layer of very dark gray very gravelly clay loam. It is 4 inches thick. The next layer to a depth of 16 inches is very dark grayish brown extremely gravelly clay loam that is about 80 percent angular limestone pebbles and a few limestone cobbles and stones. Below that is weakly cemented limestone and marl. This soil is moderately alkaline and calcareous throughout.

The Kerrville and Real soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Seeps are common after periods of high rainfall. The hazard of water erosion is severe.

All of the acreage is used as rangeland. The soils are not suited to crops.

Depth to bedrock, slopes, high lime content, and very low available water capacity are the most limiting features for most uses. Because they offer scenic views, some areas are used as sites for houses. Special precautions are necessary, however, in constructing houses and other buildings. Rapid runoff and soil slippage are common. Excavating is difficult. Seepage from septic systems may surface downslope or penetrate through the bedrock into the underground water supply. Uncoated steel pipes corrode rapidly, unless they are protected. Lawns are difficult to maintain. The high lime content of these soils causes chlorosis of many plants.

Steep slopes and depth to rock are the main limitations for recreational uses.

These soils provide fair habitat for deer, turkeys, and furbearing animals. Nesting areas for doves and songbirds are plentiful. Because livestock grazing is somewhat limited due to the steep and rough terrain, this site sometimes has greater value as habitat for wildlife than for livestock production.

Both of these soils are in capability subclass VIIs and Steep Abode range site.

KrB—Krum silty clay, 1 to 3 percent slopes. This deep, gently sloping soil is in valleys below limestone hills. Slopes are smooth to concave. The areas are long and narrow and range from 20 to 80 acres. Most areas are dissected by a U-shaped, intermittent, spring-fed drainage channel that is 2 to 8 feet deep and 4 to 12 feet wide.

Typically, the surface layer is dark gray silty clay 15 inches thick. The subsoil to a depth of 47 inches is grayish brown silty clay that contains darker vertical streaks of soil in closed cracks. The next layer to a depth of 87 inches is pale brown silty clay that has many concretions and soft bodies of calcium carbonate and small limestone fragments. This soil is moderately alkaline and calcareous throughout.

This Krum soil is well drained. Surface runoff is slow. Permeability is moderately slow, and available water capacity is high. The rooting zone is deep; however, the high clay content impedes the movement of air, water, and roots. The hazard of water erosion is moderate.

Included with this soil in mapping are small, long, oval areas of Denton and Doss soils and small, long, oval areas of soils that are wet most of the year. The included soils make up as much as 15 percent of a mapped area.

This soil is used as cropland, pastureland, and rangeland. Oats, wheat, and forage sorghum are the main crops. Improved bermudagrass and kleingrass are the main grasses.

Keeping crop residue on the surface helps to control water erosion, conserve moisture, and improve soil tilth and water intake. This soil should be tilled when the moisture content is low. This practice helps maintain good soil structure and aeration. Contour farming and terracing are needed in most areas to control water erosion. Grassed waterways provide good outlets for terrace systems in areas where excess water is a problem. Crops respond well to fertilizers. Nitrogen and phosphorus are needed to maintain good yields.

Foundations for buildings, roads, and other structures need to be constructed to withstand the high shrink-swell potential of this soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields need to be increased in size or modified in design to function properly in this soil because of the moderately slow permeability. Most garden and landscaping plants grow well, but the clayey soil is difficult to work with handtools. Farm ponds are easily built and maintained.

This soil can be used for recreational purposes. The clayey surface layer causes the soil to be muddy and sticky when wet, however, and foot traffic and vehicle traffic become difficult. In some areas slope is a limitation for playgrounds.

This soil provides good habitat for rabbits, doves, and quail. Lack of cover is a restriction for deer during the day, but at night they graze the fields planted to oats and wheat.

This Krum soil is in capability subclass IIe and Clay Loam range site.

KrC—Krum silty clay, 3 to 5 percent slopes. This deep, gently sloping soil is on foot slopes of limestone hills. Slopes are concave. Areas are long and narrow and range from 40 to 120 acres. Most of the areas have U-shaped, intermittent spring-fed drainage channels that range from 2 to 12 feet deep and from 10 to 60 feet wide.

Typically, the surface layer of this soil is dark gray silty clay 21 inches thick. The subsoil to a depth of 43 inches is grayish brown silty clay that has common calcium carbonate concretions. The underlying material to a depth of 63 inches is pale brown silty clay that has soft bodies and concretions of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

This Krum soil is well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but the clay content impedes the movement of air, water, and roots. The hazard of water erosion is moderate.

Included with this soil in mapping are small, long, oval areas of Denton and Doss soils; small, circular knolls of Kerrville soils; and small, long, narrow areas that are wet most of the year. The included areas make up as much as 15 percent of a mapped area.

This soil is used as cropland and rangeland. Oats. wheat, and forage sorghum are the main crops.

Keeping crop residue on the surface helps to control water erosion, conserve moisture, and improve soil tilth and water intake. This soil should be tilled when the moisture content is low to maintain good soil structure and aeration. Contour farming and terracing are needed in most areas to control water erosion. Grassed waterways provide good outlets for terrace systems in areas where excess water is a problem. Crops respond well to fertilization. Nitrogen and phosphorus are needed to maintain good yields.

Foundations for buildings, roads, and other structures need to be constructed to withstand the high shrink-swell potential of this soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields need to be increased in size or the design modified to function properly in this soil because of the moderately slow permeability. Most garden and landscaping plants grow well, but the clayey soil is difficult to work with handtools. Farm ponds are easily built and maintained.

This soil can be used for recreational purposes. The clayey surface layer causes the soil to be muddy and sticky when wet, and foot traffic and vehicle traffic become difficult. Slope is a limitation for some playgrounds.

The soil provides fair habitat for deer, doves, quail, and rabbits. Lack of cover is a restriction for deer during the day, but at night they graze the fields planted to oats and wheat.

This Krum soil is in capability subclass IIIe and Clay Loam range site.

KuB—Krum-Urban land complex, 1 to 3 percent slopes. This map unit consists of gently sloping areas in drainageways in the city of Kerrville. Areas are long and narrow and range from 30 to 70 acres. Boundaries of the areas commonly coincide with the outer limits of developed subdivisions and built-up areas. Slopes range from 1 to 3 percent but average 2 percent.

Krum soil makes up an average of 63 percent of this map unit and Urban Land, 30 percent. Denton, Doss, and Depalt soils make up 7 percent. The areas of this map unit are so intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Typically, the Krum soil has a surface layer of dark grayish brown silty clay. It is 16 inches thick. The next layer to a depth of 41 inches is brown silty clay that has darker vertical streaks of soil from the upper horizon in closed cracks. Below that to a depth of 50 inches is light yellowish brown silty clay that has 2 percent soft bodies of calcium carbonate and a few small limestone fragments. The underlying material to a depth of 63 inches is light yellowish brown silty clay that has a few soft bodies of calcium carbonate and about 5 percent small, angular limestone fragments. This soil is moderately alkaline and calcareous throughout.

This Krum soil is well drained. Surface runoff is slow. Permeability is moderately slow, and the available water capacity is high. The hazard of water erosion is moderate. The rooting zone is deep, but the clay content impedes the movement of air, water, and roots.

Urban land consists of soils that have been altered or covered by single family dwellings, patios, driveways, streets, sidewalks, schools, and a golf course. The land has been cut and shaped for urban development. Shallow excavations as much as 1 foot to 3 feet in depth have been made to accommodate utility lines and foundation footings. In some places the surface layer has been buried. These construction changes, however, have not altered the shrink-swell characteristics of the soil. Where the soil is packed and the structure has been destroyed, the permeability rate and the available water capacity have been altered.

Shrinking and swelling with changes in moisture, low strength, cutbanks caving, and high corrosivity to uncoated steel pipes are the most limiting features. Most of these limitations can be overcome by good design and careful installation procedures. The clay content in the lower layer of this soil restricts permeability, which is a limitation for use of the soil as septic tank absorption fields. Septic systems will function properly if the perforated pipe is packed in gravel and the system is large enough for the needs of the household; however, they may fail to function during periods of high rainfall when the soil is saturated.

This soil is moderately suited to recreational uses. The clayey surface layer and slow permeability are the most limiting features. Grass cover is difficult to maintain in areas of extensive foot traffic, such as playgrounds, because the surface layer becomes wet and muddy. The muddy surface, in addition to having low bearing strength, hinders the use of the soil for concentrated vehicular traffic, such as is needed for camp areas. Roads and streets should have a good base to prevent cracking and buckling of the paved surface.

This soil offers possibilities for homesite development if proper precautions are taken to prevent cracking and buckling of foundations, driveways, and sidewalks caused by the shrink-swell characteristics of the soil. If uncoated steel pipes are used for underground utility lines, they will corrode. Native live oak trees grow well, but fruit trees do not produce well. Successful gardens can be grown on this soil, but the silty clay soil is difficult to till. Organic matter should be added to the soil to improve the soil tilth.

This Krum-Urban land complex was not assigned to a capability subclass or range site.

NuA—Nuvalde silty clay, 0 to 1 percent slopes. This deep, nearly level soil is on terraces near flood plains of streams. Slopes are smooth or slightly concave. Areas are long and oval or long and narrow and range from 25 to 50 acres.

Typically, the surface layer is dark grayish brown silty clay about 10 inches thick. The upper part of the subsoil to a depth of 35 inches is grayish brown silty clay. The lower part to a depth of 49 inches is grayish brown silty clay that has common soft bodies, concretions, and threads of calcium carbonate. Below that to a depth of 63 inches is pink silty clay loam that has many soft bodies, concretions, threads, and films of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

This Nuvalde soil is well drained. Surface runoff is slow. Permeability is moderate, and available water capacity is high. The hazard water erosion is slight. The rooting zone is deep, and air, water, and roots move through the soil easily. This soil receives additional water from surrounding higher lying areas.

Included with this soil in mapping are small areas of Boerne, Oakalla, and doss soils. The included areas make up as much as 10 percent of a mapped area.

This soil is used for cropland, pastureland, and rangeland. Oats, wheat, and forage sorghum are the main crops. Improved bermudagrass and kleingrass are the main pasture grasses (fig. 8).

Figure 8.—Improved bermudagrass is a main pasture grass on Nuvalde silty clay, 0 to 1 percent slopes.

The use of crop residue on this soil helps to control water erosion, conserve moisture, and improve soil tilth and water intake. Crops respond to nitrogen and phosphate fertilizers. Tilling when the moisture content is low improves aeration of the soil and prevents the formation of large clods.

Foundations for buildings, roads, and other structures can be easily designed and constructed to withstand the high shrink-swell potential of the soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields need to be constructed to accommodate the moderately permeable soil. Some garden and landscaping plants develop iron chlorosis because of the high lime content of the soil. Although farm ponds can be easily built, seepage is a major problem.

This soil can be used for recreational uses. The silty clay surface layer is the most limiting feature. Unprotected areas become muddy following rains, and vehicle traffic becomes difficult.

This soil provides good habitat for rabbits, doves, and quail. Lack of cover is a restriction during the day for deer, but at night they graze the fields planted to oats and wheat.

This Nuvalde soil is in capability subclass IIc and the Clay Loam range site.

NuB—Nuvalde silty clay, 1 to 3 percent slopes. This deep, gently sloping soil is on terraces and foot slopes near the flood plains of streams. Slopes are slightly concave. Areas are long and range from 25 to 80 acres.

Typically, the surface layer is dark grayish brown silty clay about 12 inches thick. The subsoil to a depth of 31 inches is brown silty clay that has threads of calcium carbonate. Below that to a depth of 40 inches is light brown silty clay that has threads, films, and soft and cemented bodies of calcium carbonate. The underlying material to a depth of 63 inches is light brown silty clay.

This soil is moderately alkaline and calcareous throughout.

This Nuvalde soil is well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is high. The hazard of water erosion is moderate. The rooting zone is deep, and air, water, and roots move through the soil easily. This soil receives additional water from surrounding higher lying areas.

Included with this soil in mapping are small, oblong areas that have a light colored surface layer but otherwise are similar to Nuvalde soil. Also included are roughly circular areas of Doss and Denton soils. The included areas make up as much as 10 to 15 percent of a mapped area.

This soil is used as cropland, pastureland, and rangeland. Oats, wheat, and forage sorghum are the main crops. Improved bermudagrass and kleingrass are the main pasture grasses.

Keeping crop residue on the surface helps to control water erosion, conserve moisture, and improve soil tilth and water intake. Crops respond to nitrogen and phosphate fertilizers. Tilling the soil when the moisture content is low improves aeration of the soil and prevents the formation of large clods.

Foundations for buildings, roads, and other structures can be easily designed and constructed to withstand the high shrink-swell potential of the soil. Underground steel pipes corrode rapidly unless they are protected. Septic tank absorption fields can be constructed to function properly in this moderately permeable soil. Some garden and landscaping plants develop iron chlorosis because of the high lime content of this soil. Although farm ponds can be easily built, seepage is a major problem.

This soil can be used for recreational purposes. The silty clay surface layer is the most limiting feature. Unprotected areas become muddy following rains, and vehicular traffic becomes difficult. In some areas slope is a limitation for playgrounds.

This soil provides a good habitat for rabbits, doves, and quail. Lack of cover is a restriction during the day for deer, but at night they graze the fields planted to oats and wheat.

This Nuvalde soil is in capability subclass IIe and Clay Loam range site.

Oa—Oakalla silty clay loam, occasionally flooded. This deep, nearly level to gently sloping soil is on flood plains of major streams. Slopes are smooth to slightly concave and range from 0 to 2 percent. Areas are long and oval or long and narrow and range from 15 to 100 acres.

Typically, the surface layer is very dark gray silty clay loam about 22 inches thick. The next layer to a depth of 30 inches is dark grayish brown silty clay loam. Below that to a depth of 63 inches is brown silty clay loam that contains films, threads, concretions, and soft bodies of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

This Oakalla soil is well drained. Runoff is slow. Permeability is moderate, and available water capacity is high. The rooting zone is deep, and air, water, and roots move through the soil easily. The hazard of water erosion is slight. This soil receives additional water and floods about once every 1 to 4 years for periods of 12 to 36 hours.

Included with this soil in mapping are small, long, oval areas of Nuvalde, Boerne, and Orif soils. The included soils make up from 5 to 15 percent of a mapped area.

This soil is used as cropland, pastureland, and rangeland (fig. 9). Oats, wheat, and forage sorghum for hay are the principal crops. Improved bermudagrass and kleingrass are the main grasses.

Figure 9.—Oakalla silty clay loam, occasionally flooded, suitable for pasture.

Keeping crop residue on the soil surface helps to improve fertility, reduce crusting, control water erosion, increase water infiltration, and conserve moisture. It also helps to improve soil tilth and water intake. This soil should be tilled at a low moisture content. Crops respond well to fertilizers. Nitrogen and phosphorus help to improve yields. Because of the high lime content of this soil, plants develop yellowing of the leaves, or iron chlorosis.

This soil is limited for urban uses because of the hazard of flooding, low strength for roads and streets, and corrosivity to uncoated steel underground pipes.

The silty clay loam surface layer and flooding are the main restrictions for recreational uses.

This soil provides good habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

This Oakalla soil is in capability subclass IIw and the Loamy Bottomland range site.

OB—Orif-Boerne association, frequently flooded. This map unit consists of loamy and gravelly soils on flood plains adjacent to and from 3 to 6 feet above stream channels (fig. 10). The Orif soil is mostly adjacent to the stream channel, and the Boerne soil is on the outer edges of the flood plain at a higher elevation. Areas are long and narrow and are parallel to the major perennial streams in the county. The areas from 30 to 160 acres. Slopes range from 1 to 5 percent.

Orif and Boerne soils are in all mapped areas. The Orif soil makes up 30 to 75 percent of the map unit and averages 52 percent. The Boerne soil makes up 20 to 30 percent and averages 27 percent. Long, narrow beds of gravel and cobbles 6 to 10 feet thick and 100 to 200 yards wide make up an average of 14 percent of this map unit, and perennial stream channels 75 to 200 feet wide make up 7 percent. These percentages are based on transect data using an 80 percent confidence level. Seven transects, comprising 77 observations, served as the data base. Areas of this map unit are large, and the composition is variable; however, mapping has been controlled well enough for the foreseeable uses of the soils.

Figure 10.—An area of Orif-Boerne association, frequently flooded. The gravel was deposited by high velocity flood water.

Typically, the Orif soil has a surface layer of grayish brown gravelly sandy loam. It is 9 inches thick. The next layer to a depth of 21 inches is grayish brown very gravelly loamy sand. Below that to a depth of 60 inches are layers of light brownish gray extremely gravelly loamy sand that is 60 to 90 percent rounded waterworn limestone pebbles and cobbles. This soil is moderately alkaline and calcareous throughout.

Typically, the Boerne soil has a surface layer of brown fine sandy loam. It is 11 inches thick. Below that, to a depth of 63 inches, there is light yellowish brown loam that has a few threads of calcium carbonate in the upper 39 inches and an estimated 25 percent calcium carbonate in the form of threads and soft bodies and rounded limestone pebbles in the lower 13 inches. This soil is moderately alkaline and calcareous throughout. The texture of the surface layer ranges to loam.

These Orif and Boerne soils are well drained. Surface runoff is slow to medium. Permeability is moderately rapid or rapid, and available water capacity is low to moderate. The hazard of water erosion is severe. These soils are subject to flooding one or two times every 1 to 4 years for periods of 24 to 48 hours. Recent flooding is apparent from the debris lodged in tree limbs as much as 20 feet above ground. In some places the gravelly substratum of the Orif soil is exposed after the topsoil is washed away by flood waters. In other places flood waters have deposited layers of gravel, stones, and boulders on the surface of the soil.

All of the acreage is used as rangeland. It is not suited to crops. Areas along the streams provide scenic enjoyment.

Flooding, gravel content, and the available water capacity are the most limiting features for most uses.

These soils are severely limited for urban and recreational uses because of flooding and the content of gravel. In spite of the flood hazard, however, these soils are used as picnic and camping areas because they are adjacent to beautiful streams and nearby scenic hills.

These soils provide fair habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

The Orif soil is in capability subclass VIs, and the Boerne soil is in capability subclass Vw. Both soils are in the Loamy Bottomland range site.

PTD—Purves-Tarrant association, undulating. This map unit consists of very shallow and shallow, stony soils that are underlain by hard limestone. Slopes are convex and range from 1 to 8 percent. Areas are irregular in shape and range from 60 to 1,000 acres or more.

Purves soil makes up 50 to 90 percent of the map unit and averages 65 percent. Tarrant soil makes up 10 to 30 percent of the map unit and averages 15 percent. Doss soil makes up about 13 percent. Purves soil is in long, irregularly shaped bands below the higher lying Tarrant soil. The Tarrant soil is on low ridges in long, narrow, and, in places, oval areas. The percentages are based on transect data using an 80 percent confidence level. Six transects, comprising 60 observations, served as the data base. The rest of the map unit is small areas of Denton and Kerrville soils, narrow outcropping bands of limestone and marl, and noncalcareous, black clay that is 16 to 24 inches deep over limestone. Many pebbles, cobbles, and stones are on the surface.

Typically, the Purves soil has a surface layer of dark grayish brown stony clay. It is 7 inches thick. The subsoil to a depth of 15 inches is brown gravelly clay. Below that is indurated, fractured limestone bedrock. This soil is moderately alkaline and calcareous throughout.

Typically, the Tarrant soil has a surface layer of dark grayish brown stony clay that is 40 percent, by volume, limestone cobbles and stones. It is 7 inches thick. The next layer to a depth of 15 inches is very dark grayish brown very stony clay that is 70 percent, by volume, limestone cobbles and stones. Below that is indurated limestone bedrock. This soil is moderately alkaline and calcareous throughout.

These Purves and Tarrant soils are well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is severe.

All of the acreage is used as rangeland. These soils are not suited to crops. The stony surface, shallow and very shallow depth to bedrock, and very low available water capacity are limitations for most uses.

Foundations for buildings, roads, and other structures should be placed on the bedrock to withstand the shrinking and swelling of these soils. Excavating the hard rock is difficult. Extreme care needs to be taken in the construction of septic tank filter fields to prevent pollutants from passing unfiltered through the fractured bedrock and into the underground water supply.

Uncoated steel pipes corrode rapidly unless they are protected. Lawns are difficult to establish and maintain because of the large stones and very low available water capacity.

Recreational uses are restricted on these soils because of depth to rock and large stones. Slope and the clayey texture are additional limitations to some uses.

These soils provide fair habitat for deer, turkeys, doves, quail, and other birds. In favorable years several kinds of plants supply good cover, browse, fruits, and seeds for game birds and animals.

The Purves soil is in capability subclass VIs and Shallow range site, and the Tarrant soil is in capability subclass VIIs and Low Stony Hills range site.

STC—Spires-Tarpley association, gently undulating. This map unit consists of moderately deep to shallow, clayey and loamy soils on broad uplands (fig. 11). Slopes are convex and range from 1 to 5 percent. Areas are irregular in shape and range from 150 to 1,000 acres or more.

Figure 11.—An area of Spires-Tarpley association, gently undulating. Cobbles and stones are limitations for most uses.

Spires soil makes up 61 percent of the map unit, but the range is 50 to 80 percent. Tarpley soil averages 28 percent but ranges from 20 to 39 percent. Comfort and Eckrant soils and rock outcrops make up 11 percent on the average, but the range is 0 to 20 percent. The Tarpley soil is on the top of low rounded ridges in long, oval or long, narrow areas. Spires soil is on the less sloping areas below the low ridges. Chert pebbles, cobbles, and stones are on the surface. In most areas stones are exposed on 0.1 percent of the surface.

Typically, the Spires soil has a surface layer of dark reddish gray cobbly clay loam. It is 5 inches thick. The subsoil to a depth of 23 inches is red clay. Below that, to a depth of 25 inches, there is a bed of fractured, indurated limestone. This soil is neutral throughout.

Typically, the Tarpley soil has a surface layer of dark reddish brown stony clay. It is 7 inches thick. The subsoil to a depth of 16 inches is dark reddish brown clay that has vertical streaks of darker soil from the upper horizon in closed cracks. Below that is a bed of indurated, fractured limestone. This soil is neutral throughout.

These Spires and Tarpley soils are well drained. Surface runoff is medium. Permeability is slow, and available water capacity is low to very low. The root zone is shallow to moderately deep. The hazard of water erosion is moderate.

These soils are mainly used as rangeland. The Spires soil could be used for crops, but yields would be marginal. The Tarpley soil is not suited to crops.

Shallowness, stones, shrinking and swelling, and very low available water capacity are limitations for most uses.

Foundations for buildings, roads, and other structures should be placed on the bedrock to withstand the shrinking and swelling of the soils. Excavating the hard rock is difficult. Uncoated steel pipes corrode rapidly. Septic systems need to be specially designed to function in these clayey soils, and care should be taken to prevent pollutants from passing unfiltered through the bedrock and into the underground water supply. Garden and lawn plants grow well but require frequent watering. These soils are difficult to work with handtools because of cobbles, stones, and the clayey texture of the soils.

Recreational uses are restricted because of stones and shallowness.

These soils provide fair habitat for deer, turkeys, squirrels, and furbearing animals. Nesting areas for doves and songbirds are plentiful.

The Spires soil is in capability subclass IVe and the Tarpley soil is in capability subclass VIs. Both soils are in Redland range site.

SuA—Sunev silty clay loam, 0 to 2 percent slopes. This deep, nearly level to gently sloping soil is on terraces of major streams. Slopes are smooth to slightly concave. Areas are long and oval and range from 20 to 150 acres.

Typically, the surface layer is dark grayish brown silty clay loam about 14 inches thick. The next layer to a depth of 23 inches is light yellowish brown silty clay loam that has many threads of calcium carbonate. Below that to a depth of 63 inches is light brown loam that has common soft bodies and threads of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

The Sunev soil is well drained. Surface runoff is slow. Permeability is moderate, and available water capacity is moderate. The rooting zone is deep, and air, water, and roots move through the soil easily. The hazard of water erosion is moderate.

Included with this soil in mapping are small, long, oval areas of Boerne, Nuvalde, and Oakalla soils. They range from 1 to 3 acres. The included soils make up as much as 10 percent of a mapped area.

This soil is used as cropland and pastureland. Forage sorghum, oats, and wheat are the main crops (fig. 12). Improved bermudagrass and kleingrass are the main pasture grasses.

Moderate available water capacity is the main limitation of this soil. Keeping crop residue on the surface helps to control water erosion, conserve moisture, and improve soil tilth and water intake by preventing sealing of the surface layer. The high lime content causes a yellowing of leaves, or chlorosis of plants, and results in a reduction of yields. Foliar applications of solutions containing iron temporarily help to reduce chlorosis. In places, crusting of the surface layer prevents the emergence of small seedlings. Crops respond to nitrogen and phosphate fertilizers.

Buildings, roads, and other structures can be easily constructed on this soil. Septic tank absorption fields function properly. Underground steel pipes should be protected from corrosion. Many garden and landscaping plants develop iron chlorosis because of the high lime content of the soil. Although farm ponds can be easily built, seepage may be a problem.

Figure 12.—Oats ready for harvest in an area of Sunev silty clay loam, 0 to 2 percent slopes.

This soil can be easily used for most recreational uses.

This soil provides good habitat for deer, doves, quail, and rabbits. Lack of cover in the open fields is a restriction during the day for deer, but at night they graze the fields planted to oats and wheat.

This Sunev soil is in capability subclass IIe and Clay Loam range site.

TpB—Tarpley clay, 1 to 3 percent slopes. This gently sloping, shallow soil is on uplands. Slopes are convex. Areas are roughly circular and range from 20 to 160 acres.

Typically, the surface layer is dark reddish gray clay about 8 inches thick. The subsoil to a depth of 19 inches is reddish brown clay. Below that is indurated limestone bedrock. This soil is neutral throughout.

This Tarpley soil is well drained. Surface runoff is medium. Permeability is slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is moderate. Most areas have less than 10 percent chert fragments on the surface and in the soil, but some small areas have as much as 20 percent.

Included with this soil in mapping are small, irregularly shaped areas of Depalt soil, circular areas of Doss soil, and an occasional small outcrop of rock that is level with the surface. The included areas make up as much as 10 percent of a mapped area.

This soil is used as cropland and rangeland. Forage sorghum and oats are the main cultivated crops.

Shallow rooting depth and very low available water capacity are the most limiting features. Keeping residue on the surface helps to control water erosion, conserve moisture, and improve soil tilth and water intake. Farming on the contour is necessary in most areas to control water erosion. If cuts or excavations exceed about 12 inches, there is a hazard of cutting into limestone bedrock.

Depth to rock, corrosivity to uncoated steel pipes, and shrinking and swelling with changes in moisture content are the most limiting features for urban uses. Foundations for buildings, roads, and other structures should be placed on the bedrock to withstand the shrinking and swelling of the soil. Excavating the hard rock is difficult. Uncoated steel pipes corrode rapidly. Septic systems need to be specially designed to function in these clayey soils, and care must be taken to prevent pollutants from passing unfiltered through the bedrock and into the underground water supply. Lawn and garden plants grow well but require frequent watering. The clayey soil is difficult to work with handtools.

Recreational uses are restricted by the depth to rock and clayey texture of the soil. These restrictions are difficult to overcome.

This soil provides a fair habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

This Tarpley soil is in capability subclass IIIe and Redland range site.

TRC—Tarpley-Roughcreek association, gently undulating. This map unit consists of shallow, gently undulating, stony and clayey soils on uplands. These soils are on ridgetops, and they are underlain by limestone (fig. 13). Slopes are convex and range from 1 to 5 percent. Areas are irregular in shape and range from 40 to 1,000 acres or more.

Figure 13.—An area of Tarpley-Roughcreek association, gently undulating. The good grass cover hides the stony surface.

Tarpley soil averages about 67 percent but ranges from 60 to as much as 80 percent of the mapped areas. Roughcreek soil averages about 22 percent, but ranges from 10 to 40 percent of the mapped areas. The rest of the map unit is limestone outcrops and small areas of Depalt, Eckrant, and Spires soils. These percentages are based on transect data using an 80 percent confidence level. Six transects, comprising 60 observations, served as the data base. The limestone outcrops are in areas ranging from 3 to 10 feet across or are irregularly shaped ledges ranging from 12 to 60 feet wide and from 50 to 600 feet long in a continuous band. The rock outcrops range from level with the surface to as much as 30 inches above the surface. Some outcrops are smooth limestone, and some are solution pitted or “honeycombed." The outcrops, and the areas of Depalt, Eckrant, and Spires soils make up as much as 5 to 20 percent of the landscape and average about 11 percent. Areas of this map unit are large, and the composition is variable; however, mapping has been controlled well enough for the foreseeable uses of the soils.

Typically, the Tarpley soil has a surface layer of dark reddish brown stony clay loam. It is about 7 inches thick. The next layer to a depth of 18 inches is reddish brown clay. Below that is fractured limestone bedrock. This soil is neutral throughout.

Typically, the Roughcreek soil has a surface layer of dark reddish brown stony clay. It is about 8 inches thick. The next layer to a depth of 17 inches is reddish brown very stony clay. Below that is crystalline limestone bedrock. This soil is neutral throughout.

These Tarpley and Roughcreek soils are well drained. Surface runoff is medium. Permeability is slow, and available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is moderate.

All of the acreage is used as rangeland. These soils are not suited to crops.

Stoniness, shallowness, shrinking and swelling, and very low available water capacity are the most limiting features for most uses.

Foundations for buildings, roads, and other structures should be placed on the bedrock to withstand the shrinking and swelling of the soil. Excavating the hard rock is difficult. Uncoated steel pipes corrode rapidly. Septic systems need to be specially designed to function in these clayey soils, and care should be taken to prevent pollutants from passing unfiltered through the bedrock and into the underground water supply. Garden and lawn plants grow well but require frequent watering. This soil is difficult to work with handtools because of stones and the clayey texture.

Recreational uses are restricted. Depth to rock, stoniness, and the clayey texture are the most limiting features. These limitations are difficult to overcome.

These soils provide fair habitat for deer, turkeys, and squirrels and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

Both of these Tarpley and Roughcreek soils are in capability subclass VIs and Redland range site.

TTC—Tarrant-Eckrant association, gently undulating. This map unit is made up of shallow to very shallow, cobbly and stony soils on broad uplands (fig. 14). Slopes are plane and range from 1 to 5 percent. Areas are irregular in shape and range from 400 to more than 2,500 acres. Many pebbles, cobbles, and stones are on the surface of these soils.

Tarrant soil is in all mapped areas in an irregular pattern. It ranges from 50 to 60 percent and averages 59 percent. This soil is on the higher ridges and steeper side slopes. Eckrant soil ranges from 20 to 30 percent and averages 27 percent of the mapped areas. It is in crescent-shaped, less sloping areas that range from 200 to 2,600 feet long and from 100 to 300 feet wide. The rest of the map unit is small areas of Purves, Comfort, Spires, and Tarpley soils; rock outcrop; and a soil that is of redder hue but otherwise is similar to Eckrant soil. Rock outcrop makes up less than 2 percent of the mapped area. The outcrops are 1 to 2 inches above the surface of

Figure 14.—An area of Tarrant-Eckrant association, gently undulating. Stones and cobbles are limitations for most uses.

the surrounding soil and range from 6 to 18 feet across. These percentages are based on transect data using an 80 percent confidence level. Nine transects, comprising 100 observations, served as the data base. Fractured, angular limestone as much as 1 foot above the surface is an additional feature of the landscape. Areas of this map unit are much larger and the composition is more variable than that of other map units in the county; however, mapping has been controlled well enough for the anticipated uses of the soils.

Typically, the Tarrant soil has a surface layer of dark grayish brown stony clay. It is about 5 inches thick. The next layer is dark grayish brown very stony clay 4 inches thick. Below that is indurated, fractured limestone bedrock. This soil is moderately alkaline and calcareous throughout.

Typically, the Eckrant soil has a surface layer of very dark gray cobbly clay that has an estimated 50 percent, by volume, limestone cobbles. It is 4 inches thick. The next layer is dark grayish brown very cobbly clay that has an estimated 70 percent, by volume, limestone cobbles. It is 3 inches thick. Below that is a thick bed of hard limestone. This soil is moderately alkaline throughout and is calcareous in the lower 3 inches.These Tarrant and Eckrant soils are well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is very low. The rooting zone is very shallow to shallow. The hazard of water erosion is moderate.

All of the acreage is used as rangeland. These soils are not suited to crops.

The cobbly and stony clay surface, depth to bedrock, and very low available water capacity are the most limiting features for most uses.

Foundations for buildings, roads, and other structures can easily be placed on solid bedrock. Excavating the rock, however, is difficult. Steel utility lines corrode rapidly unless they are protected. Septic systems need to be specially designed to function properly, and care should be taken to prevent pollutants from passing through the bedrock and into the underground water supply. Landscaping and gardening are difficult because of the stones and bedrock.

The main limitations to the use of these soils as recreation areas are stones and cobbles on the surface and shallowness. Maintaining a grass cover is difficult. These soils are sticky and slippery when wet.

These soils provide fair habitat for deer, turkeys, and squirrels, and other furbearing animals. Nesting areas for doves and songbirds are plentiful.

Both of these Tarrant and Eckrant soils are in capability subclass VIIs and Low Stony Hills range site.

UdB—Urban land-Nuvalde complex, 0 to 3 percent slopes. This map unit consists of nearly level to gently sloping areas in the southern part of the city of Kerrville. Areas are long and narrow and range from 40 to 90 acres. Boundaries of the areas commonly coincide with built-up areas of downtown Kerrville and the Guadalupe River. Slopes range from 0 to 3 percent but average 0.9 percent.

Urban land makes up an average of 50 percent of this map unit but ranges from 30 to 70 percent, and Nuvalde soil makes up an average of 48 percent but ranges from 30 to 70 percent. Krum soil makes up 2 percent. Five transects, comprising 50 observations, served as the data base. The areas of this map unit are intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Urban land consists of soils that have been altered or covered by multistoried buildings, hospitals, small businesses, single family dwellings, patios, parking areas ranging from 2 to 5 acres, sidewalks, residential streets, highways, schools, and churches. The surface has been altered by cuts, fills, and excavations to accommodate construction. Excavations range from 18 to 24 inches in depth, and in some places the surface layer has been buried. These construction changes have not altered the shrink-swell characteristics of the soil. Where the soil has been packed and the structure destroyed, the permeability rate and available water capacity have been altered.

Typically, in an undisturbed area of Nuvalde soil the surface layer is dark grayish brown silty clay about 14 inches thick. The subsoil to a depth of 26 inches is brown silty clay. The next layer to a depth of 40 inches is light brown silty clay that has many soft bodies, concretions, and threads of calcium carbonate. The underlying material to a depth of 63 inches is pink clay loam that has soft bodies, threads, and films of calcium carbonate. This soil is moderately alkaline and calcareous throughout.

The Nuvalde soil is well drained. Surface runoff is slow. Permeability is moderate, and available water capacity is high. The hazard of water erosion is none to slight.

Slow permeability, seepage, the clayey texture, shrinking and swelling with changes in moisture content, and low strength are the main limiting features for most uses. Most of these limitations can be overcome by good design and careful installation procedures.

This map unit has possibilities for homesite development if proper precautions are taken to overcome the soil problems. The silty clay texture of this soil has several unfavorable characteristics. Strong shrink-swell properties with changes in moisture content cause foundations and driveways to buckle and shift. Paved roads become bumpy and broken and frequently need patching to fill potholes. Roads and streets should have a good base to prevent cracking and buckling of the paved surface. Uncoated steel pipes will corrode and rupture if used for underground utility lines. Septic systems function poorly unless the perforated pipe is packed in gravel, and the system is large enough for the needs of the household. These systems may fail during periods of high rainfall when the soil is saturated. Native live oak trees grow well, but fruit trees do not grow well. The silty clay soil is difficult to till; however, gardens can be grown successfully on this soil. Some plants develop iron chlorosis because of the high lime content of the soil. The addition of organic matter improves the soil tilth.

In areas used for intensive foot traffic, such as playgrounds, grass cover is difficult to maintain; the surface becomes wet and muddy. The muddy surface, in addition to possessing low bearing strength, hinders the use of the soil for concentrated vehicular traffic, such as is needed in campgrounds.

This Urban land-Nuvalde complex is not assigned to a capability subclass or range site.

Uk—Urban land-Oakalla complex, rarely flooded. This map unit consists of nearly level areas in the southern part of the city of Kerrville adjacent to the Guadalupe River. Areas are long and narrow and range from 155 to 300 acres. Boundaries of the areas commonly coincide with the Guadalupe River, the outer limits of built-up areas, and the extraterritorial jurisdictions of Kerrville. Slopes range from 0 to 1 percent but average 0.5 percent.

Urban land makes up an average of 65 percent of the map unit but ranges from 60 to 70 percent, and Oakalla soil makes up an average of 35 percent but ranges from 30 to 40 percent. Two transects, comprising 20 observations, served as the data base. The areas of this map unit are so intricately mixed that it was not practical to map them separately at the scale of mapping used for this survey.

Urban land consists of soils that have been altered or covered by multistoried buildings, small businesses, single family dwellings, patios, small parking areas, sidewalks, residential streets, and highways. Surfaces have been excavated to accommodate construction. Excavations range from a few inches for foundations to 36 inches for utility lines. These construction changes have not altered the physical characteristics of the soil.

Typically, in an undisturbed area the surface layer of the Oakalla soil is dark grayish brown silty clay loam 24 inches thick. The underlying material is brown loam to a depth of 63 inches. This soil is moderately alkaline and calcareous throughout.

This Oakalla soil is well drained. Surface runoff is slow. Permeability is moderate, and available water capacity is high. The rooting zone is deep, and air, water, and roots move through the soil easily. Excess lime causes a yellowing of the leaves, or iron chlorosis, of some plants, and where this occurs, the vigor of the plant is reduced. The hazard of water erosion is none to slight. This soil receives additional water and floods about one time every 3 to 5 years for periods of 12 to 18 hours after periods of above normal rainfall.

Flooding, seepage, low strength, and corrosivity to uncoated steel are the main limiting features for most uses.

Areas of this map unit provide poor possibilities for homesite development because of flooding. If the areas are protected from flooding, however, they make desirable homesites. Large pecan trees grow on this soil. Low strength and moderate shrink-swell potential can cause cracking of foundations, driveways, and streets. The topsoil is fertile. The high lime content in the soil causes iron chlorosis or yellowing of leaves of grass, vegetables, and ornamentals, and where this occurs, the vigor and quality of blooms and vegetables are reduced. Septic systems should be properly installed to prevent pollution of nearby streams. Increasing the size of the system to more than the needs of the household will insure an efficient system.

This soil is dusty when dry, and muddy when wet. These dusty and muddy conditions cause problems when the soil is used for camp areas, picnic areas, playgrounds, or vehicle traffic.

This Urban land-Oakalla complex is not assigned to a capability subclass or range site.

Prime Farmland

This section provides information about prime farmland soils in Kerr County. It defines, discusses requirements for, and lists the prime farmland soils in the county.

Each year thousands of acres of land throughout the United States are converted from agricultural to industrial, urban, and other uses. Some of the land converted includes prime farmland soils.

Prime farmland soils are one of several groups of important farmland soils defined by the U.S. Department of Agriculture. They are 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 the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, must encourage and facilitate the use of our nation's prime farmland soils with wisdom and foresight.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, feed, forage, fiber, and oilseed crops. They have the quality, growing season, and moisture supply needed to economically produce a sustained high yield of crops if treated and managed using acceptable farming methods. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources, and farming these soils results in the least damage to the environment.

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

Prime farmland soils usually have an adequate and dependable supply of moisture from precipitation or irrigation. They have favorable temperature and growing season and acceptable acidity or alkalinity. These soils have few or no rocks and are permeable to water and air. Prime farmland soils are not excessively erodible or saturated with water for long periods and are not flooded during the growing season. Slope ranges mainly from 0 to 5 percent. More detailed information on the criteria for prime farmland soils can be obtained from the local office of the Soil Conservation Service.

About 68,780 acres, or nearly 10 percent of the soils, in Kerr County meets the requirements for prime farmland soils. These areas are scattered throughout the county. Map unit 5 of the general soil map has the largest area of prime farmland soils, map unit 2 has moderate-sized areas, and map units 1, 3, 4, and 6 have only small scattered areas. Approximately 21,000 acres of these prime farmland soils are used for cultivated crops. Crops grown on these soils, mainly forage sorghum, wheat, and oats, account for a moderate amount of the county's total agricultural income each year.

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

The following map units, or soils, make up the prime farmland in Kerr County.

BaA	Barbarosa silty clay loam, 0 to 1 percent slopes
DnB	Denton silty clay, 1 to 3 percent slopes
DpB	Depalt silty clay loam, 0 to 3 percent slopes
KrB	Krum silty clay, 1 to 3 percent slopes
KrC	Krum silty clay, 3 to 5 percent slopes
NuA	Nuvalde silty clay, 0 to 1 percent slopes
NuB	Nuvalde silty clay, 1 to 3 percent slopes
Oa	Oakalla silty clay loam, occasionally flooded
SuA	Sunev silty clay loam, 0 to 2 percent slopes

This list does not constitute a recommendation for a particular land use. The extent of each listed map unit is shown in table 4. The location of each map unit is shown on the detailed soil maps in the back of this publication. 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; 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 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.

According to the local field office of the Soil Conservation Service, about 21,000 acres of the survey area is used for cultivated crops, and 7,000 acres is used for pasture. Wheat, oats, and forage sorghum are the main crops. Some acreage that was formerly cropped has been returned to open land.

The soils in Kerr County are well suited to increased production of food. Of about 105,000 acres of arable land in the survey area, only about 21,000 acres are cultivated. In addition to the reserve production capacity of these soils, food production also could be increased considerably by extending the latest crop production technology to all cropland in the survey area. This soil survey can help facilitate the application of such technology.

The acreage used for crops and pasture has been gradually decreasing as more and more land is used for urban development. In 1982, about 50,000 acres was urban or built-up land in the survey area. This acreage is rapidly increasing. The use of this soil survey to help make land use decisions that will influence the future role of farming in the county is discussed in the section "General Soil Map Units."

Soil erosion is the major concern on the cropland in Kerr County. If the slope is more than 1 percent, erosion is a hazard. Denton, Doss, Krum, and Tarpley soils, for example, have slopes of more than 1 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 on soils that have a clayey subsoil, such as Barbarosa soils. In addition, loss of the surface layer is damaging to soils that have a restricted rooting depth because of the shallow depth to bedrock. Doss and Tarpley soils, for example, are underlain by limestone at a shallow depth. Second, soil erosion results in sedimentation of streams, ponds, and reservoirs. This adversely affects domestic water supplies as well as fish and wildlife resources.

Effective erosion control practices increase the rate of water infiltration, reduce the amount of runoff, and hold soil losses to amounts that can be tolerated without reducing productive capacity.

A conservation tillage system that keeps plant cover on the surface for extended periods is a very effective method of soil protection. Minimizing tillage and leaving crop residue on the soil surface helps to increase infiltration and reduce the hazards of runoff and erosion. These practices can be used on most soils in the survey area.

On livestock farms, which require pasture and hay, forage crops of legumes and grasses in the cropping system reduce erosion, provide nitrogen, and improve soil tilth for the crops following.

Contour farming, terraces, and diversions are erosion control practices used in the survey area. Terraces and diversions reduce the length of slope and help to slow runoff and control erosion. They are more practical on deep, moderately well drained and well drained soils that have regular slopes. Denton, Krum, and Nuvalde soils are examples of soils that are suitable for terraces. Other soils in the survey area are less suitable for terraces and diversions because of steep slopes, bedrock at a depth of less than 20 inches, or flooding.

Information on erosion control practices for each kind of soil can be obtained at the local office of the Soil Conservation Service.

Soil fertility is naturally low in most of the soils on uplands in the survey area and naturally high in most of the soils on flood plains. Oakalla soil is an example of a fertile soil on the flood plain. The dark, more clayey, alkaline soils on uplands, such as Barbarosa, Denton, Krum, Nuvalde, and Sunev soils, are also high in natural fertility. In places, however, these alkaline soils hold the nutrients in forms unavailable for plant use. On all of the soils, the amount and type of fertilizer should be based on the results of soil tests, on the need of the crop, on the expected level of yields, on the previous land use or cropping sequence, and on the amount of available soil moisture. The local office of the Cooperative Extension Service can help in determining the kinds and amounts of fertilizer to apply.

Field crops suited to the soils and climate of the survey area include many that are not now commonly grown. Oats, wheat, and forage sorghum are the common crops.

Special crops are grown commercially on a small scale. Pecan trees are grown in a few orchards. Some beans, tomatoes, corn, peppers, and other vegetables are also grown. Latest information and suggestions for growing special crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

Improved pasture grasses suited to the soils in the survey area include several varieties of bermudagrass, weeping lovegrass, and kleingrass (fig. 15). Legumes, such as vetch, singletary peas, sweet clover, and arrowleaf clover, could be grown in pure stands or interseeded in sod forming grasses, such as bermudagrass. However, these plantings would be dependent on good moisture conditions to germinate, and during periods of drought deer would graze the young plants before they had a chance to mature.

Suitability of the grasses to the soils is the most important consideration in developing pastureland and hayland. Careful consideration should also be given to the possibility of developing a yearlong forage program by using a combination of forage plants. This program could include grazing of both warm-season and cool-season grasses during their respective growing seasons, or feeding the field-cured, warm-season plants to the animals in winter. One combination would provide improved bermudagrass forage from May to November and kleingrass forage from November to May. If pastureland were used with rangeland, improved bermudagrass could be used for warm-season grazing and field-cured native grasses and protein supplement could be fed to the livestock in winter.

Figure 15.—Kleingrass growing on Oakalla silty clay loam, occasionally flooded.

If fertilizer is applied in several increments throughout the growing season, yields of high quality forage can be increased on all soils. Sustained high production can be achieved only through proper management of both grasses and soil. Proper management should include fertilization, weed control, and regulation of grazing.

The need for fertilizer varies among different kinds of soil. The need mainly depends on past use of the soil, the amount of erosion that has taken place, and the kind of soil. Generally, improved grasses on all soils benefit from applications of nitrogen and phosphorus. Most soils contain enough potassium. The kind and amount of fertilizer needed in relation to the selected plants and the desired yield is best determined by a chemical soil test. Fertilizers should be applied and incorporated into the surface by disking 2 or 3 weeks before grasses are sprigged or seeded.

Controlling weeds reduces the competition for moisture and plant nutrients and provides growing space for desirable grasses. Weeds are controlled by mowing or by herbicides. Weeds are less likely to be a problem on well managed pastures than on overgrazed, poorly managed pastures.

Grazing should be regulated. Proper distribution of water for livestock and cross-fencing help prevent overgrazing. Such procedures allow for rotation of pastures and let one pasture rest while others are being grazed. Generally, pasture of a single grass species is easier to manage than one of mixed grass species.

Supplementary grazing crops, for example, sudangrass and small grain, are frequently grown on soils used for crops to provide seasonal forage and to avoid overgrazing the permanent pasture.

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 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 for those crops.

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 criteria used in grouping do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they 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 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 few limitations that restrict their use. There are no Class I soils in Kerr County.

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. There are no class VIII soils in Kerr County.

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

The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Rangeland

William W. Reeder, range conservationist, Soil Conservation Service, assisted with the preparation of this section.

Rangeland is land covered with native vegetation consisting mainly of grasses and some grasslike plants, forbs, shrubs, and trees. Vegetative species are generally suitable for grazing, and growth is sufficient for the plants to be used for grazing. Rangeland, or native grassland, receives no regular or frequent cultural treatment. The composition and production of the plant community is determined by the soil, climate, topography, overstory canopy, and grazing management.

According to field office records of the Soil Conservation Service in Kerrville, about 630,000 acres, or about 90 percent of the agricultural land, in Kerr County is in rangeland. The rangeland mainly consists of native vegetation that is used for the production of domestic livestock and by deer and other wildlife.

The vegetative community of Kerr County rangelands has changed drastically over the last 75 years. Continuous grazing by cattle, sheep, and goats has resulted in the removal of much of the higher quality vegetation. In its place is now a mixture of short- to mid-grasses, poor quality forbs, and Ashe juniper. Remnants of original plant species still remain in protected areas and on well managed ranches, however, and in most cases, these high quality plants can reestablish themselves on the rangeland if good grazing management is practiced.

Rangeland is the main renewable natural resource in the county, and raising livestock is the main enterprise. Cattle, sheep, and Angora goats graze throughout the survey area. Some horses are raised and used for ranch work and pleasure riding. Use of areas for recreational purposes and sale of hunting rights for deer and wild turkeys that use the rangeland for food and cover are additional profitable enterprises in many parts of Kerr County.

The soils on the limestone hills produce live oak, Texas oak, and other browse plants, as well as grasses and forbs. This area is well suited to grazing by sheep, goats, and cattle. The deeper soils in the valleys and lower lying plains produce native mid- and tall grass prairie intermixed with some forbs and woody plants.

On all of the soils in the county, it is necessary to keep livestock numbers in balance with forage yields. Yields will fluctuate according to the seasonal rainfall pattern. Dry years result in decreased forage yields and in reduction of the plant cover. Seasonal rainfall has varying effects, depending on the time of precipitation. Rainfall generally occurs in spring and early in the summer, and 60 to 70 percent of the total annual forage is produced during this period. Another period of forage growth follows the rains in August, September, and October. The deeper, more fertile soils produce a number of grasses and forbs that grow late in winter and early in the spring if rainfall is favorable.

Some livestock operations supplement grazing on the native grassland with grazing on improved pastureland and grazing of crops on cropland. These practices take place especially in the eastern part of the county. Kleingrass and coastal bermudagrass are commonly used as improved pasture. Small grain and hybrid sudangrass are commonly used for grazing on cropland. Protein supplement, and sometimes hay, is used to supplement grazing throughout the winter.

The main concern in management of most of the rangeland is control of grazing so that the kinds and amounts of plants that make up the potential plant community are reestablished. This can be done by proper stocking and by a deferred grazing system. Controlling brush is also a concern. This can be accomplished by mechanical, chemical, or biological means (fig. 16). Seeding adapted grasses, such as little bluestem, indiangrass, sideoats grama, and King Ranch bluestem, in areas of inadequate vegetative cover prevents excessive runoff and erosion and furnishes desirable forage. If sound range management based on soil survey information and rangeland inventories is applied, the potential is good for increasing the productivity of rangeland in Kerr County.

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 and the total annual production of vegetation in favorable, normal, and unfavorable years. Only those soils that are used as rangeland or are suited to use as 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 established 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 and seepage following above average rainfall are also important.

Figure 16.—An area of Tarrant-Eckrant association, gently undulating, in the second year following prescribed burning to control invading brush. The live oak has not been damaged.

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 of air-dry vegetation. Yields are adjusted to a common percent of air-dry moisture content. The relationship of green weight to air-dry weight varies according to such factors as exposure, amount of shade, recent rains, and unseasonable dry periods.

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 erosion. Sometimes, however, a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

In Kerr County nine different range sites have been identified. They are Adobe, Clay Loam, Deep Redland, Loamy Bottomland, Low Stony Hills, Redland, Shallow, Steep Adobe, and Steep Rocky range sites.

Adobe range site. The Kerrville soil (map units DTD and KeD) (fig. 17) is the main soil in this range site.

Figure 17.—An area in the Adobe range site. The soil is Kerrville clay loam, 1 to 8 percent slopes.

The potential plant community on the Adobe range site is a tall grass, live oak, Texas oak savannah. Typically, the dominant plants are little bluestem, 50 percent; sideoats grama, 10 percent; indiangrass, 5 percent; and other midgrasses, such as seep and canyon muhly, pinhole and cane bluestem, tall dropseed, hairy grama, purple and Wright threeawn, 25 percent. Woody plants, such as Texas oak, agarito, evergreen and flameleaf sumac, live oak, and greenbrier, and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, make up the rest.

Little bluestem, indiangrass, and Engelmann-daisy are grazed out of the community if heavily grazed by domestic livestock. These plants are replaced by sideoats grama, tall grama, seep muhly, and live oak. If heavy grazing continues for many years, Ashe juniper will invade and form a dense stand with an understory of plants, such as Texas grama, red grama, puffsheath dropseed, Lindheimer muhly, and Texas persimmon.

Clay Loam range site. The Barbarosa, Denton, Krum, Nuvalde, and Sunev soils (map units BaA, DnB, KrB, KrC, NuA, NuB, and SuA) are in the Clay Loam range site.

The potential plant community on the Clay Loam range site is a tall grass prairie. Typically, the dominant plants are little bluestem, 50 percent; indiangrass, 10 percent; big bluestem, 10 percent; and midgrasses, such as sideoats grama, cane bluestem, vine-mesquite, Texas cupgrass, tall dropseed, and plains lovegrass, 20 percent. Woody plants, such as elm, live oak, hackberry, bumelia, and elbowbrush; and forbs, such as Maximilian sunflower, Engelmann-daisy, and bushsunflower, make up the rest.

Little bluestem, indiangrass, and big bluestem are grazed out of the community if continuously grazed by livestock. These plants are replaced by sideoats grama, Texas wintergrass, cane bluestem, and buffalograss. Continued heavy use causes further deterioration and plants such as tumblegrass, hairy tridens, Texas grama, red threeawn, western ragweed, broomweed, prairie coneflower, and Ashe juniper will dominate the site.

Deep Redland range site. The Depalt soil (map unit DpB) is in the Deep Redland range site.

The potential plant community on the Deep Redland range site is a tall grass, post oak savannah. Typically, the dominant plants are big bluestem, 10 percent; little bluestem, 30 percent; indiangrass, 15 percent; sideoats grama, 10 percent; and other midgrasses, such as Texas cupgrass, pinhole bluestem, meadow dropseed, vine-mesquite, curlymesquite, and buffalograss, 25 percent; woody plants such as post oak, blackjack oak, live oak and greenbrier, 5 percent; and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, 5 percent.

Big bluestem, little bluestem, indiangrass, and Engelmann-daisy are grazed out of the community if heavily grazed by livestock. These plants are replaced by sideoats grama, pinhole bluestem, buffalograss, and post oak. If heavy grazing continues for many years, oaks will form a dense stand with an understory of plants, such as threeawn, Texas wintergrass, Ashe juniper, Texas persimmon, pricklypear, and mesquite.

Loamy Bottomland range site. The Boerne, Oakalla, and Orif soils (map units Be, Oa, and OB) are in the Loamy Bottomland range site.

The potential plant community on the Loamy Bottomland range site is a grassed bottom land with scattered trees. Typically, the dominant plants are little bluestem, indiangrass, big bluestem, switchgrass, and eastern gamagrass, 35 percent; sideoats grama and cane bluestem, 10 percent; other midgrasses, such as Texas cupgrass, pinhole bluestem, meadow dropseed, vine-mesquite, tall dropseed, southwestern bristlegrass, Canada wildrye, purple tridens, broadleaf uniola, and buffalograss, 35 percent; woody plants, such as baldcypress, live oak, pecan, sycamore, elm, wild grape, and greenbrier, 15 percent; and forbs, such as Engelmann-daisy, bushsunflower, and Maximilian sunflower, 5 percent.

Little bluestem, big bluestem, eastern gamagrass, indiangrass, and Engelmann-daisy are grazed out of the community if heavily grazed by livestock. These plants are replaced by sideoats grama, pinhole bluestem, and buffalograss. If heavy grazing continues for many years, oaks, elm, and mesquite will form a dense stand with an understory of plants, such as Texas wintergrass, common bermudagrass, and Ashe juniper.

Low Stony Hills range site. The Comfort, Eckrant, and Tarrant soils (map units ECC, PTD, and TTC) are in the Low Stony Hills range site (fig. 18).

The potential plant community on the Low Stony Hills range site is an open grassland with scattered oak motts. Typically, the dominant plants are little bluestem, 25 percent; sideoats grama, 30 percent; other midgrasses, such as Texas cupgrass, pinhole bluestem, Texas wintergrass, vine-mesquite, curlymesquite, and buffalograss, 35 percent; woody plants, such as shin oak, live oak, and hackberry, 5 percent; and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, 5 percent.

Little bluestem and Engelmann-daisy are grazed out of the community if heavily grazed. These plants are replaced by sideoats grama, pinhole bluestem, buffalograss, and post oak. If heavy grazing continues for many years, oaks and juniper will form a dense stand with an understory of plants, such as threeawn, hairy tridens, Texas grama, red grama, and pricklypear.

Figure 18.—An area of Eckrant-Comfort association, gently undulating, in the Low Stony Hills range site.

Redland range site. The Spires, Tarpley, and Roughcreek soils (map units STC, TpB, and TRC) are in the Redland range site.

The potential plant community on Redland range site is a tall grass, post oak, and live oak savannah (fig. 19). Typically, the dominant plants are little bluestem, 50 percent; indiangrass, 15 percent; other midgrasses, such as sideoats grama, Texas cupgrass, cane bluestem, tall dropseed, vine-mesquite, curlymesquite, and buffalograss, 25 percent; woody plants, such as post oak, blackjack oak, live oak, and greenbrier, 5 percent; and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, 5 percent.

Little bluestem, indiangrass, and Engelmann-daisy are grazed out of the community if heavily grazed by livestock. These plants are replaced by plants, such as sideoats grama, cane bluestem, buffalograss, and post oak. If heavy grazing continues for many years, plants, such as threeawn, Texas wintergrass, Ashe juniper, Texas persimmon, and pricklypear, will dominate the site.

Shallow range site. The Doss and Purves soils (map units DsC, DTD, and PTD) are in the Shallow range site.

The potential plant community on the Shallow range site is an open grassland with scattered oak motts. Typically, the dominant plants are little bluestem, 25 percent; sideoats grama, 30 percent; other midgrasses, such as Texas cupgrass, pinhole bluestem, Texas wintergrass, vine-mesquite, curlymesquite, and buffalograss, 35 percent; woody plants, such as shinnery oak, live oak, and hackberry, 5 percent; and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, 5 percent.

Figure 19.—An area in the Redland range site. The tall grass and deciduous oaks are typical. The soil is Tarpley-Roughcreek association, gently undulating.

Little bluestem and Engelmann-daisy are grazed out of the community if heavily grazed. These plants are replaced by sideoats grama, pinhole bluestem, buffalograss, and post oak. If heavy grazing continues for many years, oaks and juniper will form a dense stand with an understory of plants, such as threeawn, hairy tridens, Texas grama, red grama, pricklypear, and mesquite.

Steep Adobe range site. Kerrville and Real soils (map unit KNG) are in the Steep Adobe range site.

The potential plant community on the Steep Adobe range site is a Texas oak, live oak savannah. Typically, the dominant plants are little bluestem, 40 percent; sideoats grama, 10 percent; midgrasses, such as tall grama, pinhole bluestem, tall dropseed, slim and rough tridens, Wright threeawn, and seep muhly, 25 percent; woody plants, such as Texas oak, evergreen and flameleaf sumac, live oak, and Ashe juniper, 15 percent; and forbs, such as Engelmann-daisy, bushsunflower, and sensitivebrier, 10 percent.

Little bluestem and Engelmann-daisy are grazed out of the community if heavily grazed. These plants are replaced by Wright threeawn, pinhole bluestem, canyon and seep muhly, and Ashe juniper. If heavy grazing continues for many years, Ashe juniper will increase to a dense stand and suppress most of the other vegetation.

Steep Rocky range site. The Eckrant soil (map unit ERG) is in the Steep Rocky range site.

The potential plant community on the Steep Rocky range site is a live oak, Texas oak savannah. Typically, the dominant plants are little bluestem, 35 percent; sideoats grama, 15 percent; indiangrass, 5 percent; and other midgrasses, such as Texas cupgrass, cane and pinhole bluestem, tall grama, purple threeawn, plains lovegrass, and green sprangletop, 35 percent. Woody plants, such as Texas oak, shin oak, lacey oak, live oak, and greenbrier, and forbs, such as Engelmann-daisy, bushsunflower, and bundleflower, make up the rest.

Little bluestem, indiangrass, and Engelmann-daisy are grazed out of the community if heavily grazed by livestock. These plants are replaced by sideoats grama, pinhole bluestem, and live oak. If heavy grazing continues for many years, oaks will form a dense stand with an understory of plants, such as threeawn, Texas wintergrass, slim tridens, Ashe juniper, and Texas persimmon.

Recreation

Commercial and noncommercial recreation has had a large economic impact on Kerr County, and the potential for further recreational development is high. Areas adjacent to the Guadalupe River (fig. 20), Johnson Creek, and Turtle Creek afford good sites for camping, picnicking, vacation cabins, cottages, and homes as well as opportunities for fishing and other water-related activities.

Figure 20.—Homesites and recreational facilities along the Guadalupe River. The soils are Orif-Boerne association, frequently flooded, in the foreground and Kerrville-Real association, hilly, in the background.

Publicly owned, water-based recreational areas include Flat Rock Dam at Kerrville State Park, Louise Hays Park in the city of Kerrville, Ingram Lake at Ingram, Center Point Dam at Center Point, and the Upper Guadalupe River Authority in Kerrville. These areas offer opportunities for picnicking, camping, swimming, fishing, hiking, canoeing, and water skiing.

Hunting for deer by a drawing and fee system is permitted in the Kerr Wildlife Management Area. Other hunting permits for deer, turkey, and exotic game are provided by individual ranchers who sell leases or charge a fee.

The Guadalupe River and its tributaries are the areas most often used for fishing. Most of the stream frontage is privately owned. Stock ponds in the county, which range from one-fourth acre to 40 surface acres, are also used for recreational fishing. The potential for increased income from fishing and water-oriented sports is high.

There are approximately 37 commercial camps in Kerr County, in addition to Boy Scout camps, YMCA and YWCA camps, church camps, and an H.E.B. camp. These camps have a major impact on the economy of the area.

The soils in the survey area are rated in table 7 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 7, 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 7 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 10 and interpretations for dwellings without basements and for local roads and streets in table 9.

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 and horseback riding 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.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

James Henson, biologist, Soil Conservation Service, prepared this section.

The soils of Kerr County support a wide variety of plant communities that provide habitat for many kinds of wildlife. In addition to native species, many exotic species of wildlife have been introduced into the area.

The native wildlife commonly found in the county are white-tailed deer, javelina, fox squirrels, cottontail rabbits, and jack rabbits. Raccoons, foxes, ringtail cats, skunk, and opossums are also common. Coyotes and bobcats are the main predators.

Kerr County may have a greater variety and larger number of exotic animals than any area in Texas (fig. 21). Among the most common are axis deer, blackbuck antelope, aoudad sheep, sika deer, fallow deer, mouflon sheep, European wild boar, nilgai antelope, and red deer. Most of the exotic animals are confined by high fences; however, free-ranging herds of axis deer are in some parts of the county.

Figure 21.—A pair of oryx and a gnu grazing on Oakalla silty clay loam, occasionally flooded. These animals are among the exotics in Kerr County.

Many bird species inhabit Kerr County. Other birds that winter in the tropics pass through the county on their migrations. The rare golden-cheeked warbler is a summer resident. It lives in the cedar-clad hills of the county during the months of March through August.

The ponds, lakes, and streams, and their immediate shorelines are considered wetlands. Each site is classed into one of three major wetland systems; Lacustrine, Palustrine, and Riverine *(3).* Most ponds, lakes, and streams support warm-water fish, such as channel catfish, black bass, crappie, carp, and various species of sunfish and minnows. These water areas also attract migratory waterfowl. They use the areas as resting and feeding places during fall and spring migrations. The fish and wildlife resources are of great economic importance to the county.

Successful management of wildlife on any tract of land requires that food, cover, and water be available in a suitable combination. Lack of any one of these necessities, an unfavorable balance among them, or poor distribution of them may prevent the use of the soil by wildlife. Information about the soils helps to create, improve, or maintain suitable habitat.

Wildlife habitat is commonly managed by planting suitable vegetation, by manipulating existing vegetation, or by combining these measures. In addition, new water areas can be created or existing ones improved as habitat for wildlife. Soil interpretations for wildlife habitat aid in selecting the most suitable sites for management. They indicate the intensity of management needed to achieve satisfactory results and show why it may not be feasible to manage a specific area for a particular kind of wildlife. Such interpretations may also be used in broad-scale planning of wildlife management areas, parks, and nature areas, or for acquiring additional land for the preservation of wildlife.

The soil areas shown on the soil survey maps in the back of this publication are rated by the kind of soil. The influence of adjoining areas is not considered. Some influences on habitat, such as elevation, must be appraised onsite.

In table 8 the soils of Kerr County are rated for producing four elements of wildlife habitat and two categories of wildlife. 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. Each soil is rated in table 8 according to its suitability for producing various kinds of plants and other elements that make up wildlife habitats. The ratings take into account primarily the characteristics of the soils and closely related natural factors of the environment. They do not take into account climate, present use of soils, or present distribution of wildlife and population. For this reason, selection of a site for development as a wildlife habitat requires onsite inspection.

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, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are grain sorghums, wheat, oats, 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, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, kleingrass, lovegrass, bromegrass, clover, alfalfa, and wintergreen hardinggrass.

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, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestems, johnsongrass, plains bristlegrass, croton, western ragweed, wildbuckwheat, Maximilian sunflower, common sunflower, and wildrye.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, and soil moisture. Examples of shrubs are mountain mahogany, flameleaf and skunkbush sumac, plum, algerita, elbowbush, condalia, and Texas persimmon.

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, doves, meadowlarks, field sparrows, various kinds of songbirds, and small mammals.

Habitat for rangeland wildlife consists of areas of shrubs and wild herbaceous plants. Wildlife attracted to rangeland include antelope, deer, turkeys, grey foxes, and many species of small mammals and songbirds.

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 must 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, slope, likelihood of flooding, natural soil structure aggregation, and soil density. 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 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 9 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. 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 susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture (fig. 22).

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. Flooding and shrink swell potential can cause the movement of footings. 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, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil) and shrink-swell potential affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, depth to bedrock, and the available water capacity in the upper 40 inches affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Figure 22.—An unstable cutbank has caved, destroying the fence and exposing the yard to further damage. The soil is Doss silty clay, 1 to 5 percent slopes.

Sanitary Facilities

Table 10 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 10 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 that 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, 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, or if slope is excessive. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. 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 10 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, depth to bedrock, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. 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 10 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock, slope, and flooding affect both types of landfill. Texture, stones and boulders, and soil reaction, 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, 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 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 11 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 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. 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 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 11, 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 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 such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, rock fragments, and bedrock.

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 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 or stones, 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 or stones or have slopes of more than 15 percent.

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 12 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 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.

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 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 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, 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, slope, and depth to bedrock affect the construction of grassed waterways. Low available water capacity, restricted rooting depth, 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.

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 13 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 the content of particles coarser than sand is as much as 15 percent, 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.

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 ovendry 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.

The estimates of grain-size distribution, liquid limit, and plasticity index are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 14 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 earthmoving 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.

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.

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

In table 14, the estimated content of organic matter 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 15 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 is not considered flooding, nor is water in swamps and marshes.

Table 15 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 the average, no more than once in 2 years; and *frequent* that it occurs, on the average, 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 are 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.

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 can be made with trenching machines, back hoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

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.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(6).* 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. Table 16 shows the classification of the soils in the survey area. 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 Ustoll (*Ust*, meaning dry or burnt, 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 Calciustoll (*Calc*, meaning a calcic horizon, plus *ustoll*, the suborder of the Mollisols that have an ustic 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 Calciustolls.

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 Calciustolls.

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. An example is the Nuvalde series, which is a member of the fine-silty, mixed, thermic Typic Calciustolls.

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. 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 *(5).* Many of the technical terms used in the descriptions are defined in Soil Taxonomy *(6).* Unless otherwise stated, colors in the descriptions are for dry 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."

Barbarosa Series

The Barbarosa series consists of nearly level, deep, well drained, loamy soils that formed in calcareous, clayey sediments. These soils are on nearly level, ancient stream terraces near the Guadalupe River and its tributaries. Slopes are dominantly less than 1 percent.

Typical pedon of Barbarosa silty clay loam, 0 to 1 percent slopes; from the intersection of Farm Road 480 and Texas Highway 27 in Center Point, 0.2 mile west on Texas Highway 27 and 530 feet north, in cultivated field:

Ap—0 to 12 inches; dark brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate fine subangular blocky structure parting to moderate fine granular; hard, friable; cracks 1/4 inch to 1/2 inch wide; common fine roots; noncalcareous; mildly alkaline; abrupt smooth boundary.

Bt—12 to 32 inches; reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate medium angular blocky structure; very hard, very firm; darker soil material in vertical filled cracks; few thin discontinuous clays films and pressure faces on peds; calcareous; moderately alkaline; gradual wavy boundary.

Btk—32 to 65 inches; yellowish red (5YR 5/6) clay, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; hard, firm; few thin discontinuous clay films on faces of peds; estimated 25 percent, by volume, soft bodies and concretions of calcium carbonate; calcareous; moderately alkaline.

The thickness of the solum ranges from 60 to more than 72 inches. The dry soil has cracks as much as 1 inch wide to a depth of more than 20 inches. COLE ranges from 0.07 to 0.15. Depth to visible secondary calcium carbonate is 28 to 40 inches in more than half of the pedon.

The A horizon is reddish brown, dark brown, or dark grayish brown. It is mildly alkaline or moderately alkaline and is calcareous in some pedons. The A horizon ranges from 10 to 20 inches in thickness.

The Bt horizon is red, reddish brown, or brown silty clay or clay. It ranges from 10 to 28 inches in thickness. The clay content ranges from 40 to 60 percent.

The Btk horizon is reddish yellow or yellowish red. It is silty clay or clay and is 5 to 30 percent, by volume, concretions and soft bodies of calcium carbonate. Below a depth of 6 feet, some pedons are underlain by thick beds of gravel and sand.

Boerne Series

The Boerne series consists of gently sloping and gently undulating, deep, well drained, loamy soils that formed in loamy alluvial sediments derived from soft limestone and marl. These soils are on stream terraces and flood plains. Slopes range from 1 to 5 percent.

Typical pedon of Boerne fine sandy loam, occasionally flooded; from the intersection of Texas Highways 16 and 173 in Kerrville, 4.1 miles south on Texas Highway 173 and 100 feet east, in cultivated field:

Ap—0 to 8 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, very friable; common fine roots; common fine pores; few fine cemented bodies of calcium carbonate; about 59 percent calcium carbonate equivalent; calcareous; moderately alkaline; abrupt smooth boundary.

Bk—8 to 41 inches; light yellowish brown (10YR 6/4) fine sandy loam, dark yellowish brown (10YR 4/4) moist; moderate fine subangular blocky structure parting to moderate fine granular; slightly hard, very friable; common fine and few medium roots; common fine pores; common insect burrows and casts; few horizontal discontinuous lenses of round calcareous pebbles 1/2 inch to 1 inch in diameter: few films and threads of calcium carbonate; about 66 percent calcium carbonate equivalent; calcareous; moderately alkaline; gradual wavy boundary.

Ck—41 to 63 inches; light yellowish brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) moist; massive; slightly hard, very friable common fine threads and soft bodies of calcium carbonate; thin strata of calcareous pebbles 1/2 inch to 1 inch in diameter and loamy fine sand; about 75 percent calcium carbonate equivalent; calcareous; moderately alkaline.

The thickness of the solum ranges from 36 to 80 inches. The calcium carbonate equivalent ranges from 55 to 75 percent. The soil is loam or fine sandy loam and has 12 to 18 percent silicate clay. Pebble-size, rounded, waterworn limestone fragments 3 to 15 millimeters in size range from 1 to 5 percent, by volume. These fragments are in discontinuous, horizontal, wavy layers 1 inch to 3 inches thick.

The A horizon is grayish brown, brown, light brownish gray, or yellowish brown. It is 4 to 12 inches thick.

The Bk horizon is pale brown, light yellowish brown, or pinkish gray. It is 24 to 40 inches thick.

The Ck horizon has color and texture similar to those of the Bk horizon. It has thin discontinuous strata of other textures ranging from clay to sand.

Comfort Series

The Comfort series consists of gently undulating, shallow, well drained, clayey and stony soils that formed in clayey sediments over indurated limestone of the Lower Cretaceous age. These soils are on plateaus on uplands. Slopes range from 1 to 5 percent.

Typical pedon of Comfort stony clay, in an area of Eckrant-Comfort association, gently undulating; from the intersection of Texas Highway 27 and Ranch Road 480 in Center Point; 1 mile south to Elm Pass Road, 3.5 miles south on Elm Pass Road, 1.2 miles east into Pecan Valley subdivision, 0.3 mile south on an improved road, and 50 feet west on top of a ridge, in rangeland:

A—0 to 8 inches; dark reddish brown (5YR 3/2) stony clay, dark reddish brown (5YR 2/2) moist; moderate medium subangular blocky structure; very hard, very firm; common fine and few medium roots; common fine tubular pores; estimated 15 percent, by volume angular limestone pebbles; 45 percent, by volume, cobbles and stones partially on the surface and in the soil; mildly alkaline; clear wavy boundary.

Bt—8 to 14 inches; reddish brown (5YR 4/3) stony clay, dark reddish brown (5YR 3/3) moist; strong medium angular blocky structure; extremely hard, very firm; few fine and medium grass roots; distinct discontinuous clay films on ped faces; estimated 50 percent, by volume, cobble and stone size and 10 percent pebble size angular limestone fragments; many roots at soil rock interfaces; mildly alkaline; abrupt wavy boundary.

R—14 to 20 inches; coarsely fractured indurated crystalline limestone that has irregular cracks filled with soil, which makes up about 3 percent of the volume.

The thickness of the solum ranges from 9 to 20 inches and corresponds to the depth to limestone bedrock. Reaction ranges from neutral to moderately alkaline. Coarse fragments of stone, cobbles, and pebbles range from 35 to 60 percent on the surface and in the soil. Cobbles and stones are crystalline limestone, and pebbles are dominantly chert.

The A horizon is dark grayish brown, very dark grayish brown, dark brown, dark reddish gray, or dark reddish brown. The fine earth fraction is clay or clay loam. The A horizon ranges from 3 to 10 inches in thickness.

The Bt horizon is red, reddish brown, dark reddish brown, dark reddish gray, or dark brown. The fine earth fraction is clay, with clay content ranging from 55 to about 75 percent. The Bt horizon ranges from 6 to 14 inches in thickness.

Denton Series

The Denton series consists of gently sloping, deep, well drained, clayey soils that formed in clayey sediments over fractured limestone and marl. These soils are on uplands. Slopes range from 1 to 3 percent.

Typical pedon of Denton silty clay, 1 to 3 percent slopes; from the intersection of Texas Highway 27 and Farm Road 1338 in Kerrville, 0.9 mile northwest on Farm Road 1338, and 150 feet north, in rangeland:

A—0 to 12 inches; dark grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; hard, firm; common fine grass roots; few fine pores; calcium carbonate equivalent is 35 percent; calcareous; moderately alkaline; clear smooth boundary.

Bk—12 to 35 inches; brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; hard, firm; few fine roots; few soft bodies of calcium carbonate; calcium carbonate equivalent is 38 percent; calcareous; moderately alkaline; gradual smooth boundary.

Ck—35 to 50 inches; light brown (7.5YR 6/4) marly soil material of gravelly silty clay loam texture, brown (7.5YR 5/4) moist; massive; hard, firm; estimated 35 percent, by volume, visible threads, soft bodies, and weakly cemented fragments of calcium carbonate; calcium carbonate equivalent is 59 percent; calcareous; moderately alkaline; abrupt smooth boundary.

R—50 to 60 inches; cemented limestone.

The thickness of the solum ranges from 22 to 40 inches, and the depth to limestone ranges from 40 to 60 inches. The upper part of the control section is clayey, and the lower part is loamy. The average silicate clay content in the control section ranges from 25 to 35 percent, and the average calcium carbonate equivalent ranges from 40 to 65 percent. COLE ranges from 0.07 to 0.10 in the upper part of the soil and from 0.02 to 0.06 in the lower part. The soil does not have a layer 20 inches or thicker with COLE of 0.07 or more. When dry this soil may have cracks 2 inches wide at the surface but less than 0.4 inch wide at a depth of 20 inches.

The A horizon is dark grayish brown, very dark grayish brown, or brown. Thickness is 7 to 20 inches.

The Bk horizon is brown, yellowish brown, or light brown. It is mainly silty clay loam, but thin layers of loam are in the lower part of some pedons. Thickness ranges from 15 to 30 inches.

Depalt Series

The Depalt series consists of nearly level to gently sloping, deep, well drained, loamy soils that formed in residuum from the weathering of limestone. Slopes range from 0 to 3 percent.

Typical pedon of Depalt silty clay loam, 0 to 3 percent slopes, at the center of a microknoll; from the intersection of Texas Highways 16 and 173 in Kerrville, 5.7 miles southeast on Texas Highway 173 to entrance of "The Woods" subdivision, southwest 1.4 miles on an improved road, and 50 feet south of the center of the road between a large blackjack oak and a large post oak, in rangeland:

A—0 to 6 inches; very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; strong medium angular blocky structure; extremely hard, extremely firm, very plastic; common fine roots; common fine pores; few angular chert pebbles; neutral; gradual wavy boundary.

Bw1—6 to 26 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; coarse strong blocky structure; extremely hard, extremely firm, very plastic; common fine roots; common fine pores; distinct intersecting slickensides; shiny ped surfaces; discontinuous vertical streaks of darker soil in closed cracks; few chert pebbles; neutral; gradual wavy boundary.

Bw2—26 to 30 inches; reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate medium angular blocky structure; extremely hard, extremely firm, very plastic; few fine roots; common fine pores; distinct intersecting slickensides; shiny ped surfaces; few fine limestone pebbles; mildly alkaline; gradual wavy boundary.

Bk1—30 to 35 inches; reddish brown (5YR 5/4) gravelly clay, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; hard, firm, plastic; few fine roots and pores; about 15 percent, by volume, calcium carbonate concretions; calcareous; moderately alkaline; gradual wavy boundary.

Bk2—35 to 63 inches; yellowish red (5YR 5/6) gravelly clay, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; hard, firm, plastic; estimated 35 percent, by volume, limestone pebbles; calcareous; moderately alkaline.

The solum ranges from 40 to more than 80 inches in thickness. Reaction ranges from slightly acid to moderately alkaline. Coarse fragments (chert and limestone pebbles) range from a few to 15 percent in the Bw horizon and from 10 to 40 percent in the Bk horizon.

The A horizon is dark gray, very dark gray, dark reddish gray, dark reddish brown, dark brown, dark gray, dark grayish brown, or very dark grayish brown. The A horizon ranges from 4 to 11 inches in thickness.

The Bw and Bk1 horizons are dark reddish gray or reddish brown. The Bk2 horizon is red, reddish brown, reddish yellow, or yellowish red. Clay content in the 10- to 40-inch section is 40 to 60 percent. The B horizon is mostly clay, gravelly clay, or silty clay. In some pedons below a depth of 30 inches it is silty clay loam, clay loam, or the gravelly counterparts. Reaction is neutral through moderately alkaline.

Weakly consolidated to cemented and weathered limestone occurs in parts of some pedons below a depth of 40 inches. The limestone is cemented or indurated below a depth of 60 inches in some pedons.

Doss Series

The Doss series consists of gently sloping, sloping, and undulating, shallow, well drained, clayey soils. These soils formed in calcareous marl and cemented limestone. Slopes range from 1 to 8 percent.

Typical pedon of Doss silty clay, 1 to 5 percent slopes; from the intersection of Texas Highway 27 and Ranch Road 1338 in Kerrville, 0.6 mile northwest on Ranch Road 1338, and 160 feet southwest, in rangeland:

A—0 to 9 inches; dark grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate fine subangular blocky structure; hard, firm; common fine roots; few line irregular pores; few very fine calcium carbonate fragments; 42 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear smooth boundary.

Bk—9 to 17 inches; reddish brown (5YR 4/3) silty clay, dark reddish brown (5YR 3/3) moist; moderate medium subangular blocky structure; hard, firm; common fine roots; many fine pores; common fine concretions, threads, and soft bodies of calcium carbonate: 52 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear smooth boundary.

Crk—17 to 40 inches; pink (5YR 7/4) marl with weakly cemented limestone in ½-inch discontinuous strata.

The solum ranges from 11 to 20 inches in thickness and is underlain by weakly cemented limestone or marl. It has 3 to 10 percent coarse fragments. In some areas, 5 to 15 percent of the surface is covered by pebble-size coarse fragments. Below the A horizon the calcium carbonate equivalent ranges from 41 to 54 percent, and the soil material is silty clay, silty clay loam, or clay loam that has clay content of about 32 to 48 percent. Silicate clay ranges from 25 to 35 percent.

The A horizon is dark grayish brown, very dark grayish brown, or dark brown. It ranges from 5 to 12 inches in thickness.

The Bk horizon, which is absent in places, is brown or reddish brown. It ranges from 4 to 13 inches in thickness.

The Crk horizon is pink, very pale brown, or light yellowish brown. It is marl or limy earth of clayey and loamy texture and is interbedded with weakly cemented limestone.

Eckrant Series

The Eckrant series consists of gently undulating to steep, shallow and very shallow, well drained, stony and clayey soils on uplands (fig. 23). These soils formed in limestone. Slopes are convex and range from 0 to 30 percent.

Typical pedon of Eckrant cobbly clay, in an area of Eckrant-Rock outcrop association, steep; from the intersection of Interstate Highway 10 and Ranch Road 783 north of Kerrville, 2.2 miles north on Ranch Road 783, 0.6 mile east on private road, and 260 feet south, in rangeland:

A1—0 to 7 inches; dark grayish brown (10YR 4/2) cobbly clay, very dark grayish brown (10YR 3/2) moist; moderate fine subangular blocky structure parting to moderate fine granular; very hard, very firm; common fine and few medium roots; common irregular pores; estimated 45 percent, by volume, angular cobble and pebble size limestone fragments; noncalcareous; moderately alkaline; clear wavy boundary.

A2—7 to 12 inches; dark grayish brown (10YR 4/2) very cobbly clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure parting to moderate fine granular; very hard, very firm; common fine and few medium roots; estimated 60 percent, by volume, angular cobble and pebble size limestone fragments; calcareous; moderately alkaline; abrupt wavy boundary.

R—12 to 20 inches; coarsely fractured indurated limestone with soil material in interstices.

The thickness of the solum ranges from 4 to 20 inches. Angular limestone and chert pebbles, cobbles, and stones make up 40 to 65 percent of the volume. Reaction ranges from neutral through moderately alkaline. Some pedons are calcareous.

The A horizon is very dark gray, black, dark grayish brown, very dark grayish brown, or dark brown. It is cobbly clay, very cobbly clay, or stony clay. Clay content ranges from 40 to 60 percent.

Figure 23.—A profile of Eckrant cobbly clay. Cobble- and pebble-size limestone fragments are prominent in the upper part, and coarse fractured limestone is in the lower part.

Kerrville Series

The Kerrville series consists of undulating and hilly, moderately deep, well drained, loamy soils that formed in material weathered from interbedded limestone and marly earth (fig. 24). The sequence of more resistant layers of limestone and softer strata of marl results in a stairstepped or benched appearance. Kerrville soils are on uplands. Slopes range from 1 to 30 percent.

Figure 24.—A profile of Kerrville gravelly clay loam. The indurated limestone layer is at a depth of about 36 inches.

Typical pedon of Kerrville gravelly clay loam, in an area of Kerrville-Real association, hilly; from the intersection of Texas Highway 16 and Loop 534 in Kerrville, 2.8 miles south on Loop 534, 0.4 mile east on paved road, 0.3 mile northeast on sanitary landfill road, 0.3 mile northeast on private road and across north end of pit to northeast corner of city property, and 120 feet north of road; in rangeland:

A—0 to 8 inches; pale brown (10YR 6/3) gravelly clay loam, brown (10YR 5/3) moist; weak fine subangular blocky structure parting to moderate fine granular; hard, firm; many fine roots; many worm casts; estimated 20 percent, by volume, angular limestone pebbles; 47 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear wavy boundary.

Bk—8 to 15 inches; very pale brown (10YR 7/4) clay loam, light yellowish brown (10YR 6/4) moist; weak fine subangular blocky structure; hard, firm; few fine roots; many worm casts; many soft bodies and concretions of calcium carbonate; about 10 percent, by volume, pebble fragments of limestone; 54 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear wavy boundary.

C/B—15 to 24 inches; light yellowish brown (10YR 6/4) extremely gravelly clay loam; weak fine subangular blocky structure; hard, firm; about 75 percent white (10YR 8/2) weakly and strongly cemented gravelly and flaggy fragments of limestone; few fine roots; common worm casts; calcareous; moderately alkaline; abrupt smooth boundary.

R—24 to 30 inches; coarsely fractured indurated limestone.

Thickness of the solum ranges from 20 to 40 inches. The calcium carbonate equivalent in the control section ranges from 50 to 80 percent. Clay content ranges from 20 to 34 percent.

The A horizon is very pale brown, pale brown, brown, light yellowish brown, grayish brown, or light brownish gray. It is clay loam, loam, or their gravelly counterparts. The A horizon is 3 to 12 inches thick.

The Bk horizon is light yellowish brown, very pale brown, pale brown, yellowish brown, or light brownish gray. It is loam or clay loam or their gravelly counterparts. The Bk horizon ranges from 4 to 16 inches in thickness.

The C/B horizon is very pale brown, light yellowish brown, pale brown, pale yellow, yellowish brown, or white. It is 50 to 90 percent gravelly or flaggy limestone fragments. The fine earth fraction is loam or clay loam. The C/B horizon ranges from 4 to 20 inches in thickness.

The R layer is strongly cemented or indurated limestone that is interbedded with softer strata of marl.

Krum Series

The Krum series consists of gently sloping, deep, well drained, clayey soils that formed in thick beds of calcareous, clayey sediments in valleys on uplands. Slopes range from 1 to 5 percent.

Typical pedon of Krum silty clay, 3 to 5 percent slopes; from the intersection of Ranch Road 480 and Elm Pass Road at the south edge of Center Point, 2.9 miles south on Elm Pass Road and 520 feet east, in rangeland:

A—0 to 21 inches; dark gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; moderate fine subangular blocky structure parting to moderate fine granular; hard, firm; common fine and few medium grass roots; few fine 1/4- to 1/2-inch angular limestone fragments; calcareous; moderately alkaline; gradual smooth boundary.

Bk—21 to 43 inches; grayish brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; moderate medium angular blocky structure; hard, very firm; few fine roots; common very fine calcium carbonate concretions; calcareous; moderately alkaline; gradual smooth boundary.

Ck—43 to 63 inches; pale brown (10YR 6/3) silty clay, brown (10YR 5/3) moist; massive; hard, firm; estimated 15 percent by volume soft bodies and concretions of calcium carbonate; calcareous; moderately alkaline.

The solum thickness ranges from 38 to 70 inches. COLE ranges from 0.07 to about 0.2 in the upper 40 inches. When dry the soil has cracks 0.4 inch to 1.2 inches wide that extend from the surface to depths of 24 to 40 inches.

The A horizon is dark gray, dark grayish brown, very dark grayish brown, brown, or dark brown. It ranges from 14 to 30 inches in thickness.

The Bk horizon is grayish brown, brown, or yellowish brown silty clay or clay. It ranges from 18 to 50 inches in thickness.

The Ck horizon is pale brown, light brown, or light yellowish brown clay, silty clay, or silty clay loam. Segregated calcium carbonate ranges from 5 to 20 percent, by volume.

Nuvalde Series

The Nuvalde series consists of nearly level to gently sloping, deep, well drained, clayey soils that formed in ancient alluvium on stream terraces. Slopes range from 0 to 3 percent.

Typical pedon of Nuvalde silty clay, 1 to 3 percent slopes; from the intersection of Texas Highway 27 and Ranch Road 1338 at the west edge of Kerrville, 0.5 mile northwest on Ranch Road 1338 and 530 feet south, in idle field:

A—0 to 12 inches; dark grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; hard, firm; common fine grass roots; few very fine calcium carbonate fragments; calcareous; moderately alkaline; clear smooth boundary.

Bk1—12 to 31 inches; brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; moderate fine subangular blocky structure; hard, firm; few fine grass roots; few fine threads of calcium carbonate; calcareous; moderately alkaline; gradual smooth boundary.

Bk2—31 to 40 inches; light brown (7.5YR 6/4) silty clay, brown (7.5YR 5/4) moist; weak fine subangular blocky structure; hard, firm; estimated 35 percent by volume small concretions, soft bodies, and threads of calcium carbonate; calcareous; moderately alkaline; gradual smooth boundary.

Ck—40 to 63 inches; light brown (7.5YR 6/4) silty clay, brown (7.5YR 5/4) moist; massive; hard, firm; estimated 25 percent by volume threads and concretions of calcium carbonate; calcareous; moderately alkaline.

The thickness of the solum ranges from 20 to 50 inches. The calcium carbonate content of the 10- to 40-inch control section ranges from 23 to 38 percent. Silicate clay in the control section ranges from 25 to 35 percent, and the total clay ranges to as much as 50 percent.

The A horizon is brown, grayish brown, or dark grayish brown. It ranges from 10 to 20 inches in thickness.

The Bk horizon is grayish brown, brown, light brown, light yellowish brown, or yellowish brown clay or silty clay. It ranges from 10 to 30 inches in thickness.

The Ck horizon ranges from brownish to pink to white clay, silty clay, or silty clay loam. Some pedons have 15 to 35 percent, by volume, gravel below a depth of 3 feet. The Ck horizon has an estimated 5 to 25 percent visible carbonates, and total carbonates range to as much as 80 percent in some pedons.

Oakalla Series

The Oakalla series consists of nearly level to gently sloping, deep, well drained, loamy soils that formed in alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Oakalla silty clay loam, occasionally flooded; from Texas Highway 16 in Kerrville, 21.2 miles east on Interstate 10 to Cypress Creek exit, 2.0 miles north on Farm Road 1341, 0.2 mile southeast on access road, 0.6 mile south on private road, and 590 feet south, in cropland:

A1—0 to 22 inches; very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate fine subangular blocky structure; hard, firm; common fine and few medium roots; common fine tubular pores; few insect casts and burrows; sand fraction consists of white limestone and crushed snail shells; 43 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear smooth boundary.

A2—22 to 30 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate fine subangular blocky structure; hard, firm; common fine and few coarse roots; common fine tubular pores; few insect casts and burrows; sand fraction consists of white angular limestone and partially weathered crushed snail shells; thin strata of brown organic matter; 52 percent calcium carbonate equivalent; calcareous; moderately alkaline; gradual smooth boundary.

Ck—30 to 63 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; massive; hard, firm; many films and threads, soft bodies, and concretions of calcium carbonate; few strata of dark soil; 55 percent calcium carbonate equivalent; calcareous; moderately alkaline.

The calcium carbonate equivalent in the 10- to 40-inch control section ranges from 40 to 55 percent. The mollic epipedon is 20 to 40 inches thick. Limestone pebbles make up as much as 10 percent of any horizon to a depth of 72 inches.

The A horizon is very dark gray, dark gray, very dark grayish brown, dark grayish brown, dark brown, or brown. It is silty clay loam, clay loam, or loam and contains 25 to 40 percent silicate clay. An estimated 5 to 12 percent of the total clay is carbonate clay.

The Ck horizon is grayish brown, brown, yellowish brown, or light yellowish brown. It is silty clay loam, loam, or clay loam. In some pedons gravel or contrasting textured sediment is at a depth of 6 to 10 feet.

Orif Series

The Orif series consists of gently sloping, deep, well drained, gravelly and loamy soils on flood plains of streams that have high gradients which drain limestone areas. Periodic catastrophic floods deposit most of the coarse fragments, which are mainly limestone, and smaller floods deposit a large part of the soil material (fig. 25). Slopes range from 1 to 3 percent.

Typical pedon of Orif gravelly sandy loam, in an area of Orif-Boerne association, frequently flooded; 0.3 mile southwest of the eastern county line on Texas Highway 27, 0.6 mile south on county road to south bank of the Guadalupe River, and east 150 feet:

A—0 to 9 inches; grayish brown (10YR 5/2) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure; hard, friable; common fine grass roots; few fine tubes and pores; estimated 15 percent, by volume, rounded waterworn limestone pebbles; 48 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear wavy boundary.

C—9 to 21 inches; grayish brown (10YR 5/2) very gravelly loamy sand, dark grayish brown (10YR 4/2) moist; weak fine subangular blocky structure; hard, friable; few fine grass roots; few fine tubes and pores; estimated 35 percent, by volume, rounded waterworn limestone pebbles; 41 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear wavy boundary.

Figure 25.—A profile of Orif gravelly sandy loam. An extremely gravelly layer is at a depth of about 28 inches.

2C—21 to 40 inches; light brownish gray (10YR 6/2) extremely gravelly loamy sand, grayish brown (10YR 5/2) moist; single grained; slightly hard, very friable; estimated 60 percent, by volume, rounded waterworn limestone pebbles; calcareous; moderately alkaline; diffuse wavy boundary.

3C—40 to 60 inches; light brownish gray (10YR 6/2) extremely gravelly loamy sand, grayish brown (10YR 5/2) moist; single grained; slightly hard, very friable; estimated 70 percent, by volume, rounded waterworn limestone pebbles and estimated 20 percent, by volume, rounded waterworn cobbles; calcareous; moderately alkaline.

The thickness of the soil ranges from 50 to 100 inches. The 10- to 40-inch control section is 35 to 90 percent, by volume, limestone. Carbonates in the soil smaller than 20 millimeters are 40 to 80 percent, by volume.

The A horizon is light brownish gray, pale brown, brown, or grayish brown. The fine earth fraction is fine sandy loam, loam, or loamy fine sand. The A horizon ranges from 6 to 18 inches in thickness. It is 15 to 35 percent, by volume, rounded, waterworn limestone fragments 1/4 to 3/4 inch in diameter.

The C horizons are light brownish gray, grayish brown, light gray, very pale brown, or pale brown. The fine earth fraction averages loamy fine sand or sand, but individual strata range from sandy clay loam to sand. The C horizons (rounded, waterworn limestone pebbles that are 1/2 inch to 6 inches in diameter, with a few fragments as much as 10 inches in diameter) range from 35 to 90 percent, by volume.

Purves Series

The Purves series consists of undulating, shallow, well drained, clayey soils that formed in interbedded limestone and marl on uplands (fig. 26). Slopes range from 1 to 8 percent.

Typical pedon of Purves stony clay, in an area of Purves-Tarrant association, undulating; from the intersection of Texas Highways 27 and 41 northwest of Mountain Home, 5 miles west on Texas Highway 41, 0.4 mile north on private ranch road, and east 100 feet; in rangeland:

A—0 to 7 inches; dark grayish brown (10YR 4/2) stony clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure parting to moderate fine subangular blocky; hard, firm; many fine roots; few fine calcium carbonate concretions; few stone size and pebble size limestone fragments; calcareous; moderately alkaline; clear smooth boundary.

Ak—7 to 15 inches; dark brown (10YR 4/3) gravelly clay, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, firm; few fine roots; estimated 20 percent, by volume, pebble size limestone fragments that have secondary calcium carbonate coatings on the upper surface; calcareous; moderately alkaline; abrupt smooth boundary.

R—15 to 17 inches; strongly cemented limestone; fractures at 1 foot to 3 feet intervals.

The solum thickness ranges from 8 to 20 inches. Fragments of limestone ranging from 3/4 inch to 20 inches across the long axis make up 0 to 35 percent, by volume, of the material above bedrock. The soil is brown, dark grayish brown, very dark grayish brown, or dark brown. The fine earth fraction is 40 to 55 percent clay.

Figure 26.—A profile of Purves stony clay. Indurated limestone is at a depth of about 12 inches.

Real Series

The Real series consists of hilly, shallow, well drained, gravelly and loamy soils on uplands. These soils formed in interbedded limestone and marl. Slopes range from 8 to 30 percent.

Typical pedon of Real very gravelly clay loam, in an area of Kerrville-Real association, hilly; from the intersection of Interstate Highway 10 and Texas Highway 16 at the north edge of Kerrville, approximately 3 miles northeast on Canyon View Road, in rangeland:

A—0 to 4 inches; very dark gray (10YR 3/1) very gravelly clay loam, black (10YR 2/1) moist; moderate fine subangular blocky structure parting to moderate fine granular; slightly hard, firm; many fine and common medium grass roots; contains an estimated 40 percent, by volume, weakly to strongly cemented angular limestone fragments 1/8 inch to 1 1/2 inches in diameter; 42 percent calcium carbonate equivalent; calcareous; moderately alkaline; clear wavy boundary.

Ak—4 to 16 inches; very dark grayish brown (10YR 3/2) extremely gravelly clay loam, very dark brown (10YR 2/2) moist; moderate fine granular structure; slightly hard, firm; many fine and common medium roots; estimated 80 percent, by volume, weakly cemented angular limestone fragments 1/2 inch to 4 inches in diameter with 1/16- to 1/4-inch discontinuous coatings of secondary calcium carbonate; few cobble and stone size fragments; 47 percent calcium carbonate equivalent; calcareous; moderately alkaline; abrupt wavy boundary.

Crk—16 to 40 inches; white (2.5Y 8/2) cemented limestone in upper 3 inches, weakly cemented marl below; few medium tree roots in seams.

The thickness of the solum ranges from 8 to 20 inches. Coarse fragments make up 35 to 85 percent, by volume, of the soil and consist of limestone fragments ranging from 1/8 inch to 10 inches in diameter. The calcium carbonate equivalent content in the fraction smaller than 2 centimeters is 40 to 70 percent. The texture is very gravelly or extremely gravelly loam and clay loam. Clay content ranges from 22 to 35 percent in the fine earth fraction.

The A and Ak horizons are very dark gray, dark grayish brown, dark brown, or very dark grayish brown.

The Crk horizon is pale yellow, light yellowish brown, light gray, or white interbedded limestone and marl.

Roughcreek Series

The Roughcreek series consists of gently undulating, shallow, well drained, stony and loamy soils on uplands. These soils formed in indurated limestone. Slopes range from 1 to 5 percent.

Typical pedon of Roughcreek stony clay loam, in an area of Tarpley-Roughcreek association, gently undulating; from the intersection of Texas Highway 16 and Ranch Road 1341 in Kerrville, 5 miles east on Ranch Road 1341, 1.5 miles south on private road, and 100 feet east, in rangeland:

A—0 to 8 inches; dark reddish brown (5YR 3/2) stony clay loam, dark reddish brown (5YR 2/2) moist; moderate medium angular blocky structure parting to moderate fine granular; very hard, very firm; many fine and few medium roots; few fine pores; estimated 25 percent, by volume, angular chert pebbles and 20 percent, by volume, chert cobbles and limestone stones; neutral; clear wavy boundary.

Bt—8 to 17 inches; reddish brown (2.5YR 4/4) very stony clay, dark reddish brown (2.5YR 3/4) moist; strong medium blocky structure; extremely hard, very firm; common fine and few medium roots; few fine irregular pores; few faint discontinuous clay films on ped faces; estimated 65 percent, by volume, chert cobbles and limestone cobbles and stones; neutral; abrupt smooth boundary.

R—17 to 20 inches; fractured indurated crystalline limestone.

The solum thickness ranges from 10 to 20 inches and corresponds to the depth to limestone bedrock. The solum is 35 to 80 percent, by volume, rock fragments, which range from 30 to 60 percent in the A horizon and from 40 to 80 percent in the Bt horizon. These rock fragments are as much as 4 feet thick and 6 feet across. Rock fragments are dominantly limestone, but chert gravel and cobbles are in some pedons. Reaction is slightly acid through mildly alkaline.

The A horizon is 4 to 10 inches thick. It is dark reddish brown, dark reddish gray, reddish brown, dark brown, and very dark grayish brown. Colors that have moist values and chromas of 3 or less extend to a depth of 7 inches or more. In some pedons these values and chromas extend into the Bt horizon. Texture of the fine earth fraction is clay loam or clay.

Clay content of the fine earth fraction ranges from 40 to 60 percent. The Bt horizon is 6 to 15 inches thick. It is reddish brown, red, or dark reddish gray.

The R layer is indurated limestone that has a hardness of 3 or more on the Mohs scale.

Spires Series

The Spires series consists of gently undulating, moderately deep, well drained, loamy soils on uplands. These soils formed in limestone (fig. 27). Slopes range from 1 to 5 percent.

Typical pedon of Spires cobbly clay loam, in an area of Spires-Tapley association, gently undulating; from the intersection of Ranch Road 187 and Texas Highway 39 in the southwestern part of the county, 1.25 miles east on Texas Highway 39, 1.1 miles south on a range road, and 30 feet east of road, in rangeland:

A—0 to 5 inches; dark reddish gray (5YR 4/2) cobbly clay loam, dark reddish brown (5YR 3/2) moist; moderate fine subangular blocky structure; very hard, friable; many fine grass roots; estimated 10 percent, by volume, chert pebbles and 15 percent chert cobbles; neutral; gradual wavy boundary.

Bt—5 to 23 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; moderate medium angular blocky structure; very hard, very firm; few fine grass roots; common thin clay films on ped faces; estimated 10 percent, by volume, calcium carbonate concretions in lower 3 inches; neutral; abrupt wavy boundary.

R—23 to 25 inches; bed of indurated fractured limestone fragments.

The thickness of the solum over limestone ranges from 20 to 40 inches. Coarse fragments of chert 1/2 inch to 6 inches across the long axis range from 2 to 25 percent. In some pedons fragments of chert and limestone range from 6 to 24 inches in diameter. Reaction ranges from slightly acid through mildly alkaline.

The A horizon is reddish gray, reddish brown, dark reddish gray, dark reddish brown, dark brown, dark gray, or very dark gray. It has colors within the range of a mollic epipedon but does not have the required thickness. The A horizon is loam or clay loam or their gravelly or cobbly counterparts. It is 4 to 7 inches thick.

The Bt horizon is dark red, red, reddish brown, or dark reddish brown. Clay content ranges from 42 to 57 percent. The Bt horizon is 16 to 26 inches thick.

The R layer is crystalline limestone that has a hardness of 3 or more on the Mohs scale.

Figure 27.—A profile of Spires cobbly clay loam. Indurated fractured limestone is at a depth of about 24 inches.

Sunev Series

The Sunev series consists of nearly level to gently sloping, deep, well drained, loamy soils that formed in ancient alluvium on stream terraces (fig. 28). Slopes range from 0 to 2 percent.

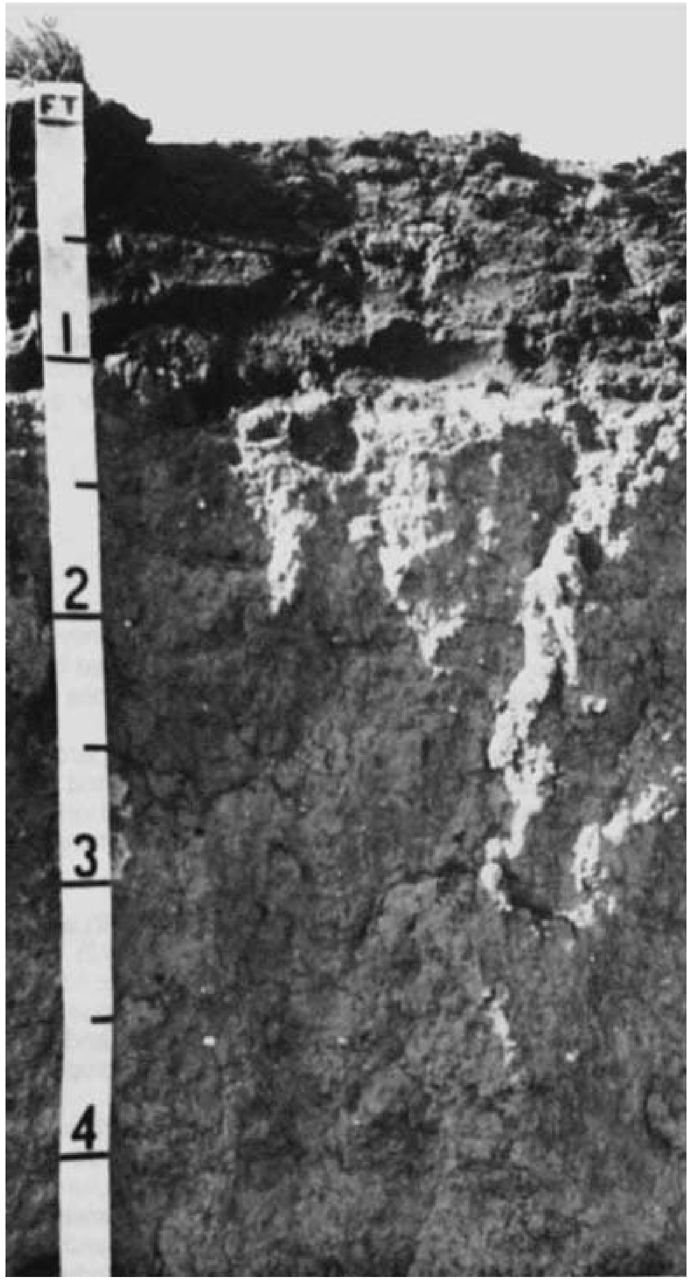


Figure 28.—A profile of Sunev silty clay loam, 0 to 2 percent slopes. The topsoil extends to a depth of about 13 inches.

Typical pedon of Sunev silty clay loam, 0 to 2 percent slopes; from the intersection of Farm Road 480 and Texas Highway 27 in Center Point, 2.1 miles east on Texas Highway 27, 100 feet southeast of the highway centerline, in cropland:

Ap—0 to 5 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; hard, friable; common fine roots; few weathered snail fragments; common insect and worm casts and burrows; calcareous; moderately alkaline; abrupt smooth boundary.

A—5 to 14 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; hard, friable; few fine roots; few weathered snail fragments; common insect and worm casts and burrows; calcareous; moderately alkaline; gradual smooth boundary.

Bk1—14 to 23 inches; light yellowish brown (10YR 6/4) silty clay loam, yellowish brown (10YR 5/4) moist; weak medium subangular blocky structure parting to weak fine granular; hard, friable; many fine pores; many insect and worm casts and burrows; many threads of calcium carbonate; calcareous; moderately alkaline; gradual smooth boundary.

Bk2—23 to 63 inches; light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist: weak medium subangular blocky structure; hard, friable; common soft bodies and threads of calcium carbonate; calcareous; moderately alkaline.

The solum thickness ranges from 40 to 70 inches. The calcium carbonate equivalent in the 10- to 40-inch control section ranges from 40 to 70 percent. Silicate clay in the control section ranges from 18 to 35 percent, and the total clay ranges to 40 percent.

The A horizon is dark grayish brown, grayish brown, dark brown or brown. It is 10 to 20 inches thick.

The Bk horizons are light yellowish brown, brown, pale brown, grayish brown, yellowish brown, or light brown. They are silty clay loam, clay loam, or loam. In some pedons the lower part of the horizons are as much as 50 percent, by volume, limestone pebbles and calcium carbonate concretions.

Tarpley Series

The Tarpley series consists of gently undulating, shallow, well drained, clayey soils on uplands. These soils formed in clays and material weathered from limestone (fig. 29). Slopes range from 1 to 5 percent.

Typical pedon of Tarpley stony clay loam, in an area of Tarpley-Roughcreek association, gently undulating; from the intersection of Texas Highway 16 and Ranch Road 1341 in Kerrville, 5 miles east on Ranch Road 1341, 1.5 miles south on private ranch road, and 150 feet east, in rangeland:

A—0 to 7 inches; dark reddish brown (5YR 3/2) stony clay loam, dark reddish brown (5YR 2/2) moist; moderate medium angular blocky structure parting to moderate fine granular; hard, firm; many fine and few medium roots; common fine irregular pores; about 10 percent of surface covered with 10- to 20-inch limestone fragments; estimated 2 percent by volume fine limestone particles; few cracks 1/8 inch wide; neutral; clear wavy boundary.

Bt—7 to 18 inches: reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate medium angular blocky structure; extremely hard, very firm; common fine and few medium roots; few fine irregular pores; thin discontinuous clay films on ped faces; estimated 5 percent by volume angular chert pebbles; neutral; abrupt smooth boundary.

R—18 to 19 inches; fractured indurated limestone.

The solum thickness ranges from 13 to 20 inches and corresponds to the depth to limestone bedrock. Reaction ranges from slightly acid through mildly alkaline. Coarse fragments of limestone or chert cobbles and stones range from a few to about 30 percent on the surface and in the soil. The mollic epipedon may include part or all of the argillic horizon.

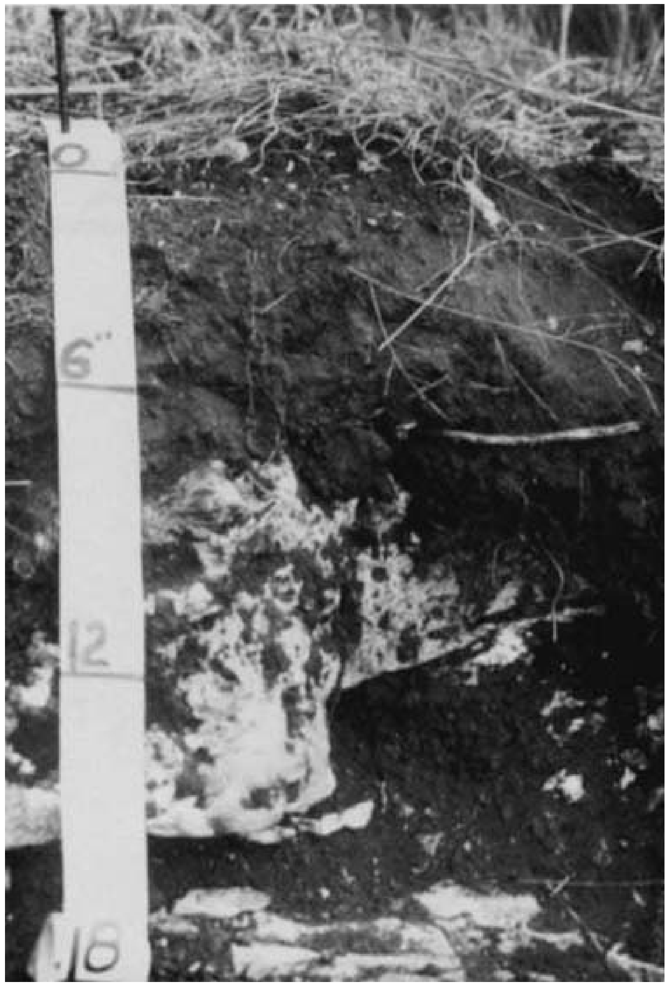


Figure 29.—A profile of Tarpley stony clay loam. The reddish subsoil is at a depth of about 5 inches and extends to indurated limestone.

The A horizon is very dark brown, very dark grayish brown, dark grayish brown, dark brown, dark reddish gray, reddish brown, or dark reddish brown. It is clay loam or clay, excluding the coarse fragments. The A horizon is 3 to 8 inches thick.

The Bt horizon is dark brown, reddish brown, dark reddish brown, or dark reddish gray clay or cobbly clay. The clay content ranges from 60 to 80 percent. The Bt horizon is 10 to 15 inches thick.

The R layer is coarse grained limestone bedrock.

Tarrant Series

The Tarrant series consists of gently undulating to undulating, very shallow and shallow, well drained, stony and clayey soils on uplands. These soils formed in residuum weathered from limestone (fig. 30). Slopes range from 1 to 8 percent.

Typical pedon of Tarrant stony clay, in an area of Tarrant-Eckrant association, gently undulating; from the intersection of Texas Highway 41 and U.S. Highway 83 in the western part of Kerr County, 3.5 miles north on U.S. Highway 83, 0.35 mile east on private road, and 50 feet north near live oak mott, in rangeland:

Figure 30.—A profile of Tarrant stony clay. Limestone fragments and fractured indurated limestone are at a depth of about 14 inches.

A—0 to 5 inches; dark grayish brown (10YR 4/2) stony clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky and moderate medium granular structure; hard, firm; common fine roots; common fine tubular pores; many fine limestone fragments 1/4 to 3/8 inch in size; estimated 35 percent, by volume, irregularly shaped porous limestone cobbles and stones that have coatings of calcium carbonate on faces; calcareous; moderately alkaline; clear wavy boundary.

Ak—5 to 9 inches; dark grayish brown (10YR 4/2) very stony clay, very dark grayish brown (10YR 3/2) moist; moderate fine subangular blocky structure and moderate fine granular; hard, firm; common fine roots; common fine calcium carbonate concretions; estimated 70 percent by volume irregularly shaped porous limestone stones and cobbles that have veins of powdery calcium carbonate oriented horizontally; calcareous; moderately alkaline; abrupt wavy boundary.

R—9 to 10 inches; coarsely fractured indurated limestone.

The thickness of the solum ranges from 6 to 20 inches and corresponds to the depth to indurated limestone. The solum is 35 to 85 percent coarse fragments. These fragments range from 10 to 60 percent in the A horizon and from 70 to 90 percent in the Ak horizon. Secondary coating of calcium carbonate on the fragments is absent in the upper 4 inches of some pedons but is 1 centimeter or more thick on some fragments immediately above the R layer. The carbonates appear as coatings or as powdery to cemented pendants.

The A horizon is dark grayish brown, very dark grayish brown, very dark gray, and dark brown stony clay, very stony clay, or very stony silty clay. Clay content of the fine earth fraction is 40 to 60 percent.

The strata of the underlying fractured bedrock range from 2 to 24 inches in thickness. In some pedons, massive pulverulent lime is interbedded with bedrock.

Formation of the Soils

This section describes the factors of soil formation and relates them to the formation of the soils in Kerr County. It also describes the topography and geology of the survey area.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of a soil at any given point are determined by (1) the physical and mineral composition of the parent material; (2) the climate under which the soil material accumulated and has existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material. All five factors have influenced the present characteristics of every soil, but the significance of each factor varies from one place to another. A factor that dominates the formation of a soil in one area may be replaced by a different factor in another area.

The interrelationship among these five factors is complex, and the effects of any one factor cannot be isolated and completely evaluated. It is convenient to discuss each factor separately, however, and to indicate the probable effects of each.

Parent Material

Parent material is the unconsolidated mass from which a soil forms. It determines the chemical and mineral composition of the soil. Unconsolidated or soft materials weather faster and form soil more rapidly than consolidated or hard materials. In Kerr County the parent material consists of sediment of the Cretaceous and Quaternary geological periods.

Most of the soils in Kerr County formed from parent material deposited during the Cretaceous Period. This parent material included beds of limestone from which Comfort, Eckrant, Purves, Roughcreek, Spires, Tarpley, and Tarrant soils developed and marl and limestone from which Kerrville, Doss, and Real soils developed.

Other soils formed from parent material deposited during the Quaternary Period. The Pleistocene and Holocene (Recent) Epochs are subdivisions of the Quaternary Period. Parent material deposited during the Pleistocene Epoch is on ancient stream terraces. This parent material includes clayey sediment from which Barbarosa, Krum, and Nuvalde soils developed and loamy sediment from which Sunev soils developed. Parent material from the Holocene Epoch is on flood plains of streams. The loamy Boerne, Oakalla, and Orif soils developed in this material. They have little horizon development.

Climate

The climate contributes to the formation of soils in several ways. Rainfall, evaporation, and temperature are the main climatic influences. Kerr County has a dry, subhumid climate with periods of heavy, high intensity rainfall alternating with periods of major and minor drought.

The wet climate of past ages and the recession of Cretaceous waters influenced the deposition of parent material in the valleys together with the leaching of carbonates and the illuviation of clays in mature soils. Precipitation, however, was limited in later years and did not leach the carbonates of the younger Kerrville, Doss, Purves, and Tarrant soils; therefore, these soils are calcareous to the surface.

Some soils, such as Barbarosa, Depalt, Comfort, Roughcreek, Spires, and Tarpley soils, have clayey subsoils. Water moving through the soil detaches clay particles from the surface layer and deposits these particles in lower layers as the water movement slows. As clay accumulates, the water moves more slowly and the deposition of clay accelerates. As the accumulative process speeds up, the lower layers become more clayey.

Plant and Animal Life

Vegetation, animals, earthworms, micro-organisms and other organisms, and, more recently, man contribute to the development of these soils. Gains in organic matter and nitrogen in the soil, gains or losses in plant nutrients, and changes in structure and porosity are caused by living organisms. In the nearly treeless prairies of Kerr County, tall grasses had more influence on soil development than other plants. These grasses provided litter that protected the surface and added organic matter to dark soils, such as those of the Denton, Krum, Nuvalde, and Sunev series. The grass roots reached deep into the soil and utilized minerals at a lower depth. Lime, other minerals, and organic matter were distributed throughout the soil profile as these plants died and decomposed. The decomposed plant roots left channels that increase the intake of water and aeration of the soil. Earthworms and other soil organisms fed on the decomposed roots. The borings of earthworms also helped channel water and air through the soil.

In parts of the county where the native vegetation is mostly oak savannah, organic matter has mainly accumulated in the upper few inches of the soil. A soil such as the Spires soil has a light colored surface layer and is slightly acid to mildly alkaline in the upper part of the subsoil. Burrowing animals, such as crayfish, gophers, and moles, help mix the soil and parent material.

Man, in his methods of tillage and grazing of animals, has also influenced soil formation. Cultivation has encouraged runoff and erosion and reduced the content of organic matter. Tillage and continuous grazing have compacted the clayey soils and reduced aeration, infiltration, and permeability. All of these changes are reflected in the present productivity of the soil and will affect the rate and kinds of future development of the soils.

Relief

Relief affects soil formation through its influence on drainage, erosion, plant cover, and soil temperature.

The relief in Kerr County ranges from nearly level to steep. On nearly level to gently sloping soils, such as Barbarosa, Depalt, Krum, and Nuvalde soils, most of the rainfall enters the soil and permits deep development. Some of the stronger sloping soils, for example, Kerrville soil, formed in similar parent material, but less moisture, natural erosion, and rapid runoff have kept the surface layer thin and light colored. The solum of this soil is not so thick as that of the soils that formed in less sloping topography.

Some soils, such as Boerne, Oakalla, and Orif soils, are affected by relief in another way. Sediment from the surrounding watersheds is deposited on these soils by floodwater.

The strongly sloping to steep Eckrant and Real soils that are on north- and northwest-facing slopes have a thicker and darker surface layer than those soils on slopes that face toward the south and west. Where slopes are less exposed to sunlight, the soil temperature is lower, less moisture is lost, and more organic matter accumulates.

Time

Time, usually a long time, is required for formation of soils that have distinct horizons. However, the effects of time are modified by the other four factors of soil development. The differences in the length of time that parent material has been in place are generally reflected in the degree of development of the soil profile.

The soils in Kerr County range from young to old. The young soils have very little horizon development, but the older soils have well expressed soil horizons.

Orif soils, which are young soils, show little development. The soil horizons still show the evidence of stratification, and there has been little change from the original stream deposited alluvium. Barbarosa soils, which are older soils, have well developed soil horizons. Because the parent material of these soils has been in place for a long time, there has been a downward movement and accumulation of soil particles, resulting in a distinct Bt horizon.

Topography and Geology

Weldon W. Hammond, Jr., College of Sciences and Mathematics, University of Texas at San Antonio, prepared this section.

Topography

Kerr County is in the Edwards Plateau section of the Great Plains physiographic province. The predominantly rough and rolling topography is typical of the carbonate units of the Edwards Plateau, which have been deeply to moderately dissected by stream erosion. The land surface in the western part of the county has moderate relief. The rolling uplands and eroded areas caused by streams of the resistant carbonate units have formed steep-walled canyons with narrow valleys. The eastern part of the county has undergone extensive fluvial erosion and subsequent removal of carbonate material. As a result broad valleys have formed which are separated by high hills along the interstream divides.

The topography consists of four primary geomorphic components: (1) the steep-sided narrow canyons eroded into Cretaceous carbonate rock formations, (2) the gently sloping interstream divides and uplands, (3) broad valleys of the major streams, and (4) the stream courses. The altitude of the land surface ranges from 1,400 feet in the southeastern part of the county to 2,405 feet in the northern part.

The major stream in Kerr County is the Guadalupe River, which rises in the western part of the county and drains the majority of the county. In the western part of the county the Guadalupe River has eroded headward to form narrow valleys with steep walls of carbonate strata. In the southeastern part of the county the Guadalupe River has developed a wide valley, which may have been the result of both dissolution of carbonate material and lateral cutting processes. The valley may have been formed during the Pleistocene Epoch, which was a period of more precipitation. Tributaries of the Llano and Pedernales Rivers drain a small area in the northern part of the county, and tributaries of the Medina River drain a small area in the southern part.

Geology

The relatively flat surface of the Edwards Plateau is an elevated tableland composed of resistant limestone and dolomite. This level surface reflects the very gentle dip to the south 10 to 15 feet per mile of the underlying rock formations. Several small discontinuous northeast trending faults occur in Kerr County; however, these faults are small displacements and do not have a major effect on the geology of the county.

The principal geologic units at the surface are the Glen Rose Formation and the Edwards Formation of Cretaceous age and alluvial deposits of Pleistocene age and Holocene Age *(4).*

The lower member of the Glen Rose Formation is the oldest geologic unit exposed in the county. It crops out in a narrow band along the Guadalupe River in the extreme eastern part of the county. This lower member consists mostly of medium to thick bedded fossiliferous limestone that has interbedded layers of sand and shale.

The upper member of the Glen Rose Formation crops out in the eastern part of the county where the overlying Edwards Formation has been removed by fluvial erosion. The upper member is formed of thin beds of impure limestone alternating with shale and marly limestone. In addition, the upper member contains evaporite deposits of yellow marl, dolomite, and anhydrite interbedded with chalky limestone.

Differential erosion of the carbonate sequence in the Glen Rose Formation has produced the characteristic "stair step" topography of the hill country. In this area the resistant limestones and dolomites formed steep slopes, and the less resistant marly limestones developed gentle slopes. The Glen Rose Formation maintains a uniform thickness of 590 feet along the southern border of the county. In the northeastern and north-central part of the county, the lower member thins rapidly to the north. Soils of the Doss-Kerrville general soil map unit and the Kerrville part of the Eckrant-Kerrville-Rock outcrop general soil map unit formed in the Glen Rose Formation.

The Edwards Formation rests on the Glen Rose Formation. The Edwards Formation caps the higher topographic divides in the eastern part of the county and forms an extensive surface over the entire central and western parts of the county (fig. 31). The lower part of the Edwards Formation, the Fort Terret Member, is a permeable unit resting on the relatively impermeable Glen Rose Formation. The Fort Terret Member is the parent material of the reddish soils that make up the Comfort soils in the Eckrant-Kerrville-Rock outcrop general soil map unit, the Spires and Tarpley soils in the Spires-Tarpley-Tarrant general soil map unit, and the Tarpley and Roughcreek soils in the Tarpley-Eckrant-Roughcreek general soil map unit. The upper part of the Edwards Formation, the Segovia Member, is the parent material of the dark brownish soils in the Tarrant-Eckrant-Purves general soil map unit, the Eckrant soils in the Eckrant-Kerrville-Rock outcrop and the Tarpley-Eckrant-Roughcreek general soil map units, and the Tarrant soils in the Spires-Tarpley-Tarrant general soil map unit.

Numerous springs and seeps issue from the base of the Edwards Formation in steep walled canyons that have eroded into the upland surface. These springs and seeps support a rich vegetation of ferns and cypress, pecan, and oak trees that contrast to the juniper-covered, semiarid slopes and uplands. The Edwards Formation consists of approximately 500 feet of massive limestone with beds of dolomite and chert.

Small outcrops of the Buda Limestone Formation and the Del Rio Clay Formation are along the western edge of Kerr County. These outcrops consist of nodular and manly limestone about 50 feet thick. Soils in the Tarrant-Eckrant-Purves general soil map unit developed in these formations.

The alluvium deposits of gravel, sand, silt, and clay of the Pleistocene and Holocene Epochs occur as flood plain deposits, terrace deposits, and alluvial fan deposits. The flood plain deposits are narrow, linear, gently sloping areas adjacent to underfit incised streams and are subject to high frequency flooding. Stream terraces are at two or three levels also adjacent to the streams but not subject to high frequency flooding because of their higher elevation. The alluvial fan deposits are at the base of slopes and can be recognized by their distinctive fan shape. The alluvium is generally thin and has a maximum thickness of approximately 40 feet in the Guadalupe River Valley in the eastern part of the county. The soils in the Nuvalde-Oakalle-Boerne general soil map unit formed in these terrace and alluvial deposits.

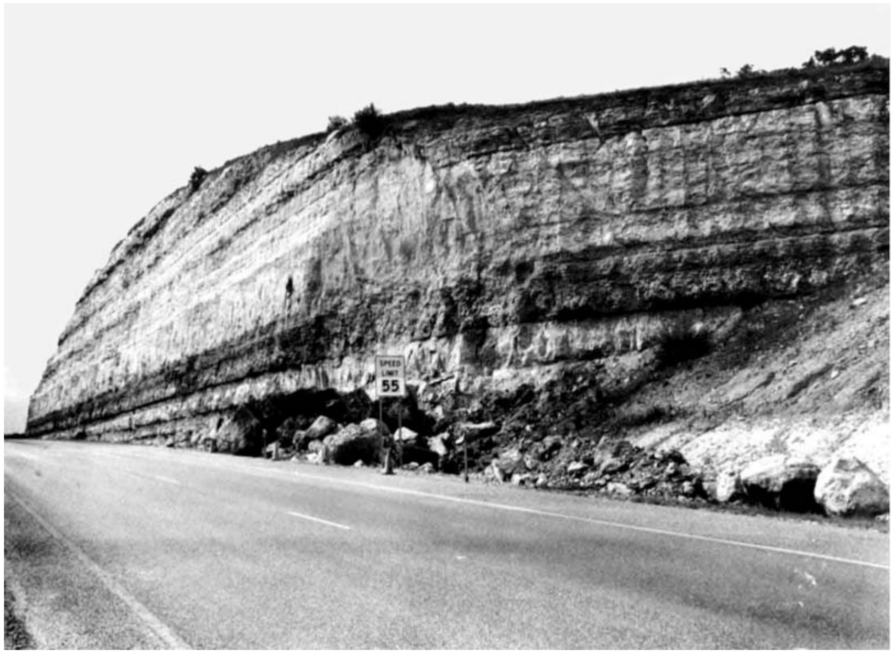


Figure 31.—This roadcut along Interstate Highway 10 has exposed the Edwards Formation.

The geologic history of the rocks exposed at the surface in Kerr County began with a transgression or invasion by the sea from the southwest, approximately 135 million years ago. The Cretaceous sea spread across an ancient landmass composed of weathered and metamorphosed sediment and igneous rocks of the Paleozoic Era. Cretaceous carbonate strata were deposited in vast, warm, shallow seas. As the extensive, thick deposits of carbonate rock accumulated, the older formations at the base of the sequence were overlapped by progressively younger formations. These carbonate sequences generally are thicker to the southwest or toward the transgressing sea and thin out northward in the direction of the advance of the sea. At the close of the Cretaceous Period approximately 60 to 70 million years ago, the sea retreated toward the Gulf of Mexico, and the area changed from a carbonate accumulation area on a broad marine continental shelf to an emergent landmass. Since the close of the Cretaceous Period, the surface of this landmass has been extensively eroded and stripped by fluvial erosion, and as a result, the land has been shaped into steep canyons, hills, uplands, and wide valleys.

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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.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

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

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

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

Bottom land. The normal flood plain of a stream, subject to flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas. Caliche occurs as soft, thin layers in the soil or as hard, thick beds just beneath the solum, or it is exposed at the surface by erosion.

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.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

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.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The wails of excavations tend to cave in or slough.

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 grazingland for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

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 is not a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Fast intake (in tables). The rapid movement of water into the soil.

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. 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.

Gilgai. Commonly a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of Vertisols—clayey soils having a high coefficient of expansion and contraction with changes in moisture content.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

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.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon 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 Arabic numeral 2 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.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

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.

Large stones (in tables). Rock fragments 3 inches (7.5 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

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

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

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.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

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.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

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.

Peres 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 0.2 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.

Plastic limit. The moisture content at which a soil changes from semisolid to 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.

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

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.

Rippable. Bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar horsepower rating.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

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.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

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.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

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 surface runoff.

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.

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.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

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.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of 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 millimeters 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, E. 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.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind and water erosion.

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).

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

Substratum. The part of the soil below the solum.

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."

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.

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.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial melt water. In nonglaciated regions, alluvium deposited by heavily loaded 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

The tables in this soil survey contain information that affects land use planning in this survey area. More current data tables may be available from the Web Soil Survey at the Tabular Data tab.

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