United States Department of Agriculture

Natural Resources Conservation Service

In cooperation with the Missouri Agricultural Experiment Station

Soil Survey of Audrain County, Missouri

How To Use This Soil Survey

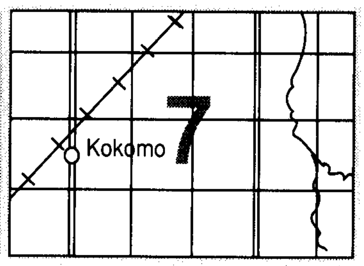
General Soil Map

The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

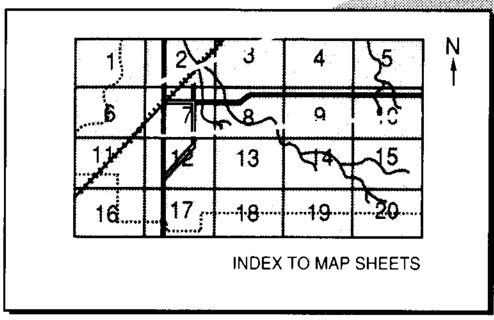
Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps can be useful in planning the use and management of small areas.



MAP SHEET

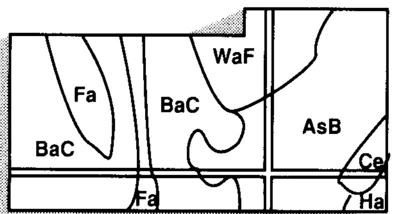
To find information about your area of interest, locate that area on the **Index to Map Sheets**, which precedes the soil maps. Note the number of the map sheet, and turn to that sheet.



INDEX TO MAP SHEETS

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Index to Map Units** (see Contents), which lists the map units by symbol and name and shows the page where each map unit is described.

MAP SHEET



AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

The **Summary of Tables** shows which table has data on a specific land use for each detailed soil map unit. See **Contents** for sections of this publication that may address your specific needs.

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 Natural Resources Conservation Service (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1990. Soil names and descriptions were approved in 1991. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1990. This survey was made cooperatively by the Natural Resources Conservation Service and the Missouri Agricultural Experiment Station. The Missouri Department of Natural Resources provided a soil scientist to assist with the field mapping. Funding for a district soil scientist was provided by the Missouri Department of Natural Resources and administered through the Audrain County Soil and Water Conservation District. This survey is part of the technical assistance furnished to the Audrain County Soil and Water Conservation District.

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

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Cover: Typical landscape in the Mexico-Leonard-Armstrong association.

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Issued June 1995

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Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in Audrain 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, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

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

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the Cooperative Extension Service.

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Soil Survey of Audrain County, Missouri

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Fieldwork by Frederick E. Horn, Ron Taylor, Bobby Ward, and Fred J. Young, Natural Resources Conservation Service, and George H. Davis, Alice W. Geller, and Wyn Kelly, Missouri Department of Natural Resources

United States Department of Agriculture, Natural Resources Conservation Service,
in cooperation with
the Missouri Agricultural Experiment Station

AUDRAIN COUNTY is in east-central Missouri, north of the Missouri River (fig. 1). It has an area of 446,285 acres, or about 697 square miles.

Audrain County is bordered on the north by Monroe and Ralls Counties, on the east by Pike County, on the south by Montgomery and Callaway Counties, and on the west by Boone and Randolph Counties. The town of Mexico is the county seat. It is located near the center of the county. In 1980, the population of Mexico was 12,276. The town of Vandalia, in the northeastern part of the county, had a population of just over 3,000. Other smaller towns in the county include Laddonia, Farber, and Martinsburg. In 1982, the population of Audrain County was 25,779.

Audrain County is entirely within the Central Claypan Areas major land resource area *(20)*. It is primarily an agricultural county.

This survey updates the soil survey of Audrain County published in 1911 *(5)*. It provides additional interpretive information and larger maps, which show the soils in greater detail.

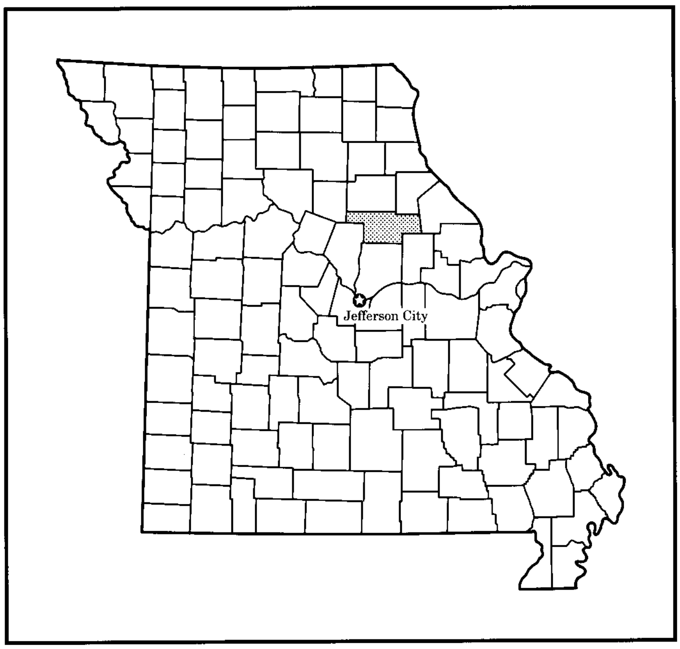

Figure 1.—Location of Audrain County in Missouri.

General Nature of the County

This section gives general information about the county. It describes climate; physiography, relief, and drainage; and history and development.

Climate

The consistent pattern of climate in Audrain County is one of cold winters and long, hot summers. Heavy rains occur mainly in spring and early in summer, when moist air from the Gulf of Mexico interacts with drier continental air. The annual rainfall is normally adequate for corn, soybeans, and all grain crops.

Tornadoes and severe thunderstorms occur occasionally in the county but are local and of short duration. Hailstorms occur at times during the warmer part of the year but in an irregular pattern and in only small areas.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Mexico, Missouri, in the period 1951 to 1987. 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 29 degrees F and the average daily minimum temperature is 19 degrees. The lowest temperature on record, which occurred at Mexico on January 11, 1982, is -20 degrees. In summer, the average temperature is 75 degrees and the average daily maximum temperature is 87 degrees. The highest recorded temperature, which occurred on July 15, 1954, is 116 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 about 40 inches. Of this, about 25 inches, or 65 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 18 inches. The heaviest 1-day rainfall during the period of record was 5.18 inches at Mexico on September 16, 1965. Thunderstorms occur on about 53 days each year.

The average seasonal snowfall is about 23 inches. The greatest snow depth at any one time during the period of record was 18 inches. On the average, 16 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 85 percent. The sun shines 65 percent of the time possible in summer and 45 percent in winter. The prevailing wind is from the south-southeast. Average windspeed is highest, 12 miles per hour, in spring.

Physiography, Relief, and Drainage

About 88 percent of Audrain County is on a glacial till plain. The level to gently sloping surface of this till plain is at an elevation of about 760 feet near Vandalia to about 900 feet near the Boone County border. Slopes are generally long and smooth. This relatively undissected portion of the till plain is covered with a layer of loess.

The till plain is dissected primarily by the Salt River and its tributaries. The Salt River flows north in Audrain County and drains most of the central and western areas. The Cuivre River system drains much of the eastern portion of the county, and the Loutre River drains a relatively small area in the south. A portion of the Grand Divide between the Missouri and Mississippi River systems is in Audrain County. It is the part of the undissected till plain between the Salt and Cuivre River systems, which drain to the Mississippi River, and the Loutre River system, which drains into the Missouri River.

The glacial till is more dissected adjacent to these drainages. Local relief is greater in these areas of moderately sloping to steep glacial till soils. Geologic erosion has removed most of the overlying loess in these areas, and in a few places the underlying shale or cherty limestone is exposed. A few limestone bluffs are adjacent to the northernmost reaches of the Salt River and major tributaries, where dissection of the glacial till plain has been most effective.

Alluvial landforms consist of flood plains and stream terraces that are directly adjacent to most of the rivers, streams, and major creeks. The elevation ranges from about 650 feet on the terraces of the Salt River along the Monroe County border in the north, to nearly 850 feet along the Boone County line near Centralia. As many as three distinct surfaces are within these areas, separated by generally indistinct scarps or short slopes that are usually less than a foot to as much as 15 feet high. Most areas are nearly level, although many areas of the highest terrace are dissected and gently sloping.

History and Development

Audrain County was home to the Osage and Missouri Indians prior to Anglo settlement. These people primarily hunted in the area and camped along the major streams *(4)*.

Robert Littleby was the first settler. He homesteaded along a creek, which is named after him, in north-central Audrain County. Early settlers selected the wooded draws in the county as homesites. These draws provided wood for fuel, timber for building material, and habitat for game. During the early 1800's, at least 75 percent of the county was tall grass prairie, which appeared foreign and barren to people accustomed to the forests of Kentucky and Tennessee *(15)*.

Audrain County was organized in 1836 and named for Colonel James H. Audrain, a Missouri statesman. Settlement continued slowly, and by 1865, only 6,500 people had settled in the county. About one-tenth of the land was cultivated *(15)*. Over the next 50 years, immigration and cultivation greatly increased. In 1910, about 97 percent of the county was farmed and 48 percent of the land was cultivated and planted to corn, wheat, rye, oats, or sorghum. Cattle were the major livestock raised. Horses, mules, sheep, and hogs also were raised.

Crop production has continued as the primary land use. The only decrease in cropland occurred during World War II when several thousand acres was converted to pasture. Since then the amount of land area planted to crops has increased to its current level of approximately 89 percent of the county. Soybeans were first grown around 1945 and are now the most widely planted crop in the county. Winter wheat, corn, and grain sorghum also are major crops *(23)*.

The amount of pasture and hayland acreage was highest in 1950, when it included 36 percent of the county. Currently, about 11 percent of the county is pasture or hayland. Cattle and hogs are the primary livestock raised, and many farmers raise sheep *(23)*.

The acreage of woodland ranged from a high of 25.0 percent before settlement to the current level of 6.4 percent. The acreage of woodland has remained essentially constant since 1929. Slightly over one-half of the woodland is used as pasture *(23)*.

Concurrent with the development of farming in Audrain County was the mining of fireclay and the production of refractory brick. The clay was deposited in sinkholes over a large area in and around the county during the Pennsylvanian period *(8)*. These sinkholes were subsequently covered by rock strata and glacial till. Several active and abandoned mines are in scattered areas throughout the county. The first firebrick plant began operation in 1883 near Vandalia. The industry grew, and plants operated in Mexico, Vandalia, and Farber by 1943. Today, plants are in Mexico and Vandalia. Although production is diminishing in intensity, Audrain County remains a world leader in refractory brick production.

To a lesser extent coal and limestone also have been mined in Audrain County. Currently, there is no active mining of these resources. Several abandoned mines are in the north-central portion of the county. The amount of reclamation in these mined areas is slight or none.

The first soil survey of Audrain County was conducted and published in 1911 *(5)*. The authors noted that "erosion is doing considerable damage to some of the rougher areas along larger streams" and in some areas the surface layer was entirely washed away. The Audrain County Soil and Water Conservation District was formed in 1967 to assist farmers in reducing the hazard of erosion.

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 biological activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and 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 a considerable degree of 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, reaction, 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 interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are 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 are 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 predict with a fairly high degree of accuracy 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.

Some of the boundaries on the soil maps of Audrain County do not match those on the soil map of adjacent counties, and some of the soil names and descriptions do not fully agree. The differences are a result of improvements in the classification of soils, particularly modifications or refinements in soil series concepts. Also, there may be differences in the intensity of mapping or in the extent of the soils within the survey area.

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 two or three 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 soil 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 the soil associations in this survey area. Each association has a distinctive pattern of soils, relief, and drainage. Each is a unique natural landscape. Typically, an association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in another but in a different pattern.

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

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

1. Mexico-Putnam Association

Nearly level and very gently sloping, loamy over clayey, somewhat poorly drained and poorly drained soils; on uplands

This association is on a broad, loess-covered glacial till plain that has not been dissected by drainageways. The highest elevation in the county is in this association. Slopes range from 0 to 3 percent. They are very long and smooth. Few natural drainageways are in this association, although grassed waterways have been established in some areas.

This association makes up about 41 percent of the county. It is about 65 percent Mexico soils, 31 percent Putnam soils, and 4 percent soils of minor extent (fig. 2).

The Mexico soils are very gently sloping and somewhat poorly drained. They are on broad, convex interfluves and divides. Typically, the surface layer is very dark grayish brown, friable silt loam about 7 inches thick. In sequence downward, the subsoil is mixed dark grayish brown and red silty clay loam and grayish brown silt loam; mottled dark grayish brown, red, and yellowish brown silty clay; grayish brown, mottled silty clay; and multicolored silty clay loam. The substratum is light brownish gray, mottled clay loam.

The Putnam soils are nearly level and poorly drained. They are on the broad divides that are in the highest landscape positions. Typically, the surface layer is very dark grayish brown, friable silt loam about 8 inches thick. The subsurface layer is light brownish gray, mottled silt loam about 8 inches thick. The subsoil is dark gray, mottled silty clay in the upper part and grayish brown and gray, mottled silty clay loam in the lower part.

Of minor extent in this association are the Leonard and Lenzburg soils. Leonard soils have more sand in the lower part of the subsoil than the major soils and are on gently sloping side slopes. Lenzburg soils consist of material that has been excavated during surface mining activities. They are very gently sloping to very steep.

Nearly all of this association is used for cultivated crops, mainly corn and soybeans. Winter wheat, grain sorghum, and some alfalfa also are grown. A small acreage is pastured.

This association is suited to cultivated crops and to most grasses and legumes. The main management concern in areas of the Mexico soils is the hazard of erosion. Wetness is a limitation in areas of the Putnam soils.

The wetness, a shrink-swell potential, and restricted permeability are limitations affecting building site development and septic tank absorption fields.

Very little cover is available for wildlife in this association. Some habitat is provided along brushy fence rows and the edge of fields. Wildlife habitat can be improved by maintaining the quality and increasing the extent of permanent vegetative cover in uncultivated areas.

2. Mexico-Leonard-Armstrong Association

Very gently sloping to moderately sloping, loamy over clayey, poorly drained to moderately well drained soils; on uplands

This association is on the part of the glacial till plain that has been weakly dissected by drainageways. The

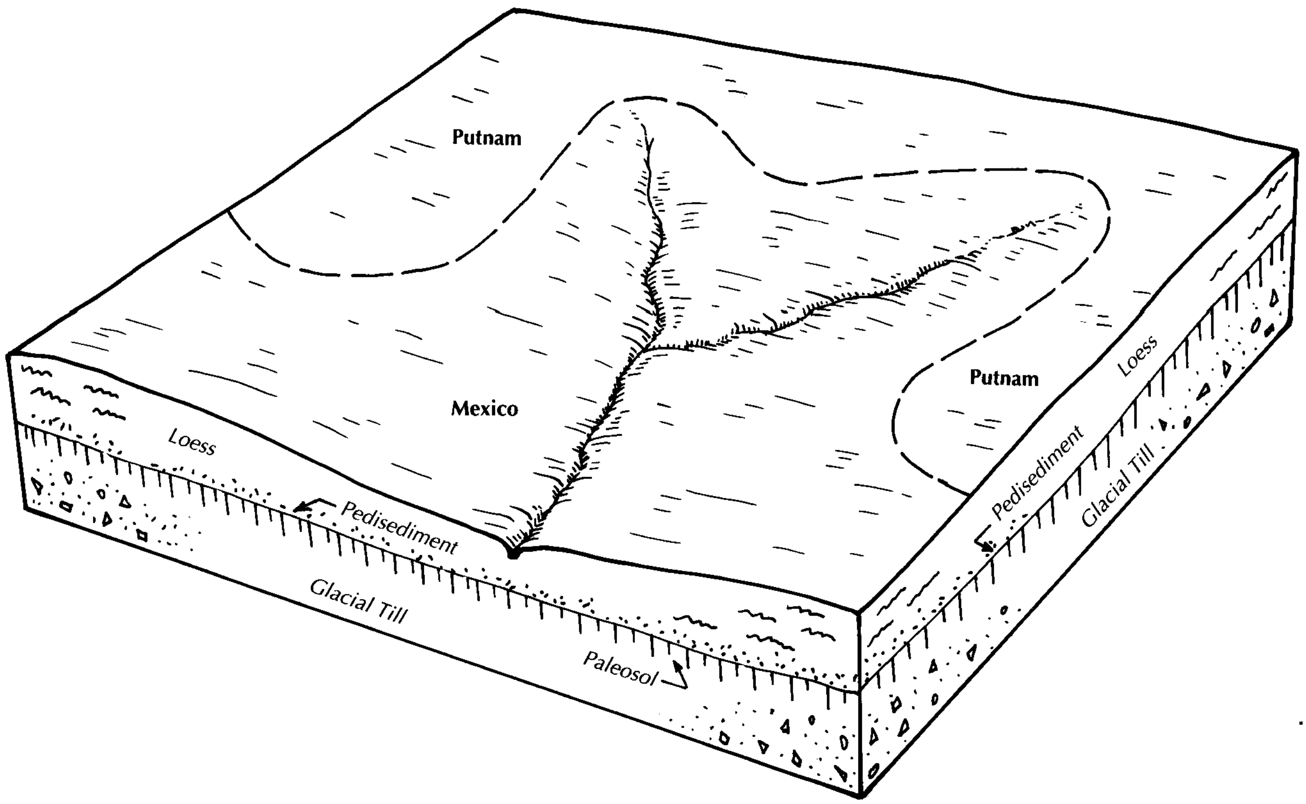

Figure 2.—Typical pattern of soils and parent material in the Mexico-Putnam association.

landscape consists mainly of narrow, convex, elongated interfluves and long side slopes. Drainageways are small and narrow. Slopes range from 1 to 9 percent. Many grassed waterways have been established on concave slopes. Much of the original surface layer of the soils in this association has been removed by erosion.

This association makes up about 42 percent of the county. It is about 32 percent Mexico soils, 32 percent Leonard soils, 30 percent Armstrong and similar soils, and 6 percent soils of minor extent (fig. 3).

The Mexico soils are very gently sloping and somewhat poorly drained. They are on interfluves. Typically, the surface layer is very dark grayish brown, friable silty clay loam about 5 inches thick. The upper part of the subsoil is dark gray and dark grayish brown, mottled silty clay. The next part is grayish brown, mottled silty clay loam. The lower part is grayish brown, mottled clay loam.

The Leonard soils are gently sloping and poorly drained. They are on upland side slopes and at the head of drainageways. Typically, the surface layer is very dark grayish brown, firm silty clay loam about 6 inches thick. The upper part of the subsoil is dark gray, mottled silty clay. The next part is dark grayish brown and gray, mottled silty clay loam. The lower part is gray and grayish brown, mottled clay loam.

The Armstrong soils are moderately sloping and moderately well drained. They are on upland side slopes. Typically, the surface layer is very dark grayish brown, very friable loam about 4 inches thick. In sequence downward, the subsoil is dark brown clay loam; dark brown, mottled clay loam; yellowish brown and dark brown, mottled clay; and grayish brown, yellowish brown, and light brownish gray, mottled clay loam.

Of minor extent in this association are the Twomile, Belknap, and Lenzburg soils. Twomile soils have a thick subsurface layer of silt loam and are in nearly level high flood plains. Belknap soils are silt loam throughout and are on narrow flood plains. Lenzburg soils are clay loam throughout. They consist of material that has been excavated during surface mining activities.

The very gently sloping and gently sloping areas of this association are used mainly for cultivated crops, and the moderately sloping areas are used mainly for pasture. Corn and soybeans are the main crops. Grain sorghum, winter wheat, and alfalfa also are grown.

Many areas have a permanent grass cover. Trees and brush grow in narrow areas along drainageways and on some moderately sloping side slopes.

This association is suited to cultivated crops, grasses, and legumes. The hazard of erosion is the main management concern.

Wetness, a high shrink-swell potential, and restricted permeability are limitations affecting building site development and septic tank absorption fields.

The areas of trees and brush provide important wildlife habitat in this association. Additional habitat is provided along brushy fence rows and the edge of fields and in pastures of warm-season grasses that have not been overgrazed. Wildlife habitat can be improved by maintaining the quality and increasing the extent of permanent vegetative cover in uncultivated areas.

3. Keswick-Marion Association

Very gently sloping to strongly sloping, loamy over clayey, moderately well drained and somewhat poorly drained soils; on uplands

This association is on the part of the glacial till plain that has been strongly dissected by drainageways. The landscape consists mainly of short side slopes and narrow, convex, elongated interfluves. Slopes range from 1 to 14 percent. The drainageways are small and narrow, and many are deeply incised.

This association makes up about 8 percent of the county. It is about 75 percent Keswick and similar soils, 11 percent Marion soils, and 14 percent soils of minor extent (fig. 4).

The Keswick soils are moderately sloping and strongly sloping and are moderately well drained. They are on side slopes. Typically, the surface layer is dark brown, friable silt loam about 2 inches thick. The subsurface layer is dark brown, mottled silt loam about 5 inches thick. The subsoil is mottled clay loam. It is dark yellowish brown, yellowish brown, and strong brown in the upper part and grayish brown in the lower part.

The Marion soils are very gently sloping and gently sloping and are somewhat poorly drained. They are on narrow ridgetops. Typically, the surface layer is dark grayish brown, very friable silt loam about 2 inches thick. The subsurface layer is light brownish gray, mottled silt loam about 7 inches thick. The upper part of the subsoil is brown, mottled silty clay, and the lower

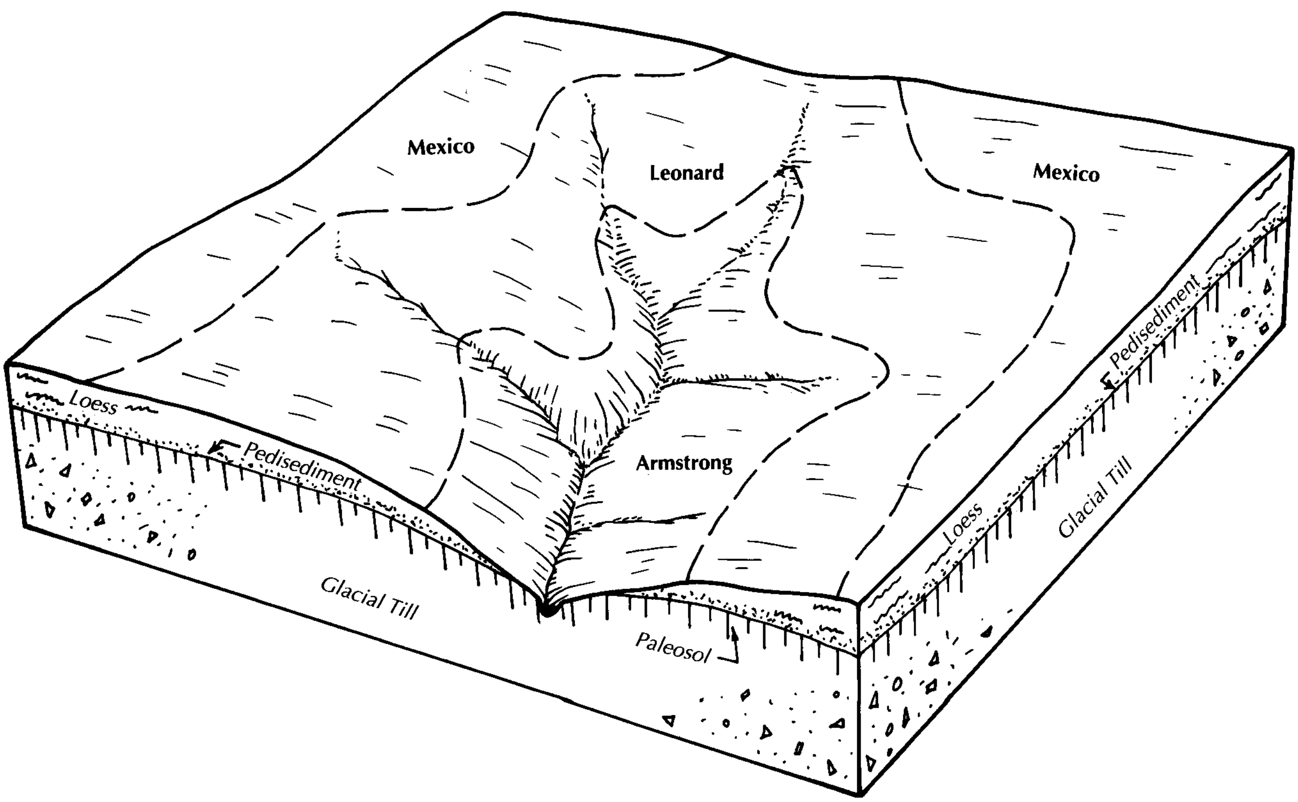

Figure 3.—Typical pattern of soils and parent material in the Mexico-Leonard-Armstrong association.

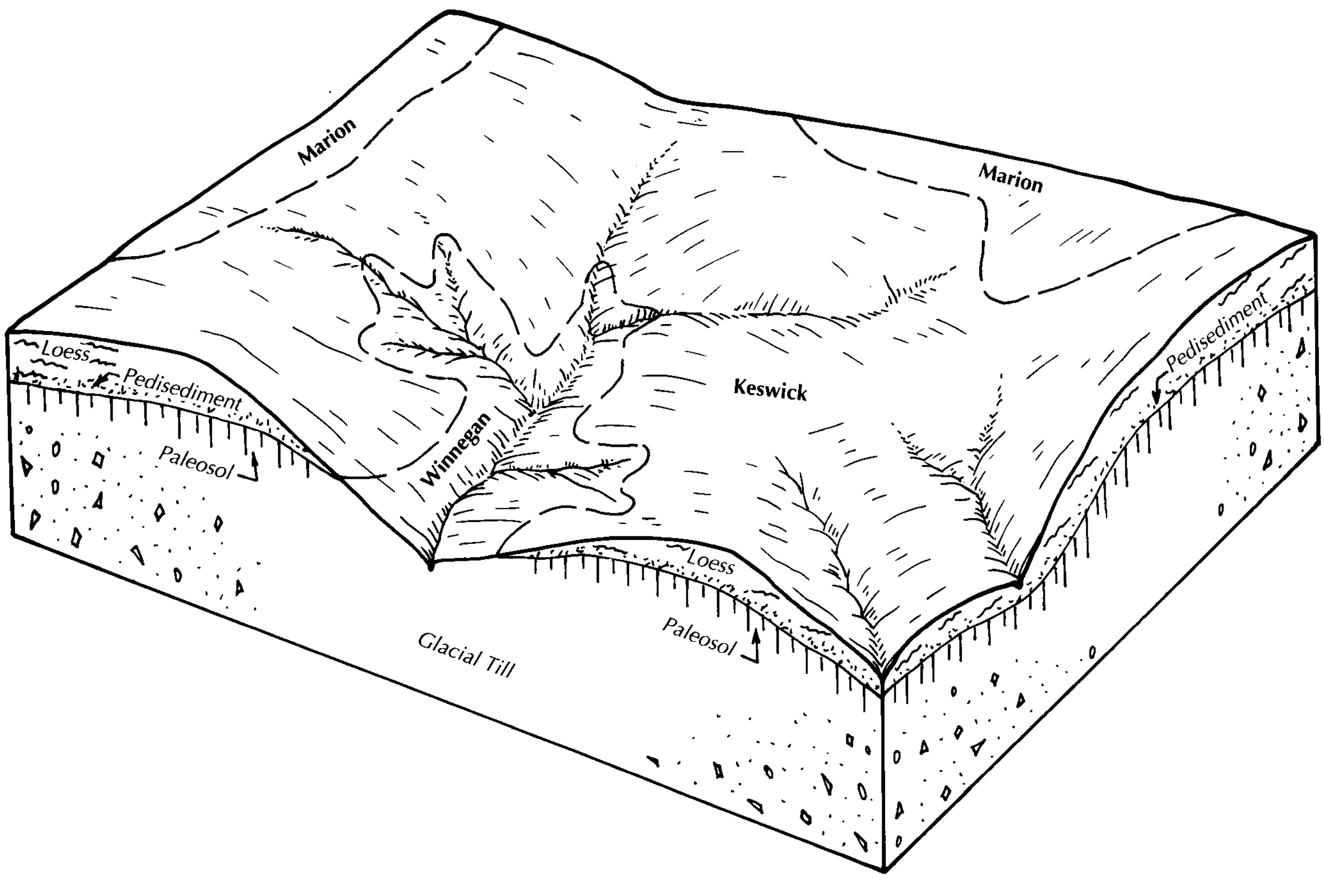

Figure 4.—Typical pattern of soils and parent material in the Keswick-Marion association.

part is light brownish gray, mottled silty clay loam.

Of minor extent in this association are the Winnegan, Goss, Twomile, Belknap, and Lenzburg soils. Winnegan soils do not have mottles in the upper part of the subsoil. Goss soils are cobbly or very cobbly throughout. Winnegan and Goss soils are on steep side slopes below the Keswick soils. Twomile soils are poorly drained. Belknap soils are silt loam throughout. Twomile and Belknap soils are on nearly level flood plains. Lenzburg soils are clay loam throughout. They consist of material that has been excavated during surface mining activities.

Most areas of the Marion soils and the moderately sloping areas of the Keswick soils are used as pasture. Other areas of the Keswick soils, particularly the strongly sloping areas, are used as woodland. A few gently sloping or moderately sloping areas are used for cultivated crops. Timber is harvested in some forested areas, but commercial logging is minimal.

Most areas of this association are suited to cultivated crops, grasses, and legumes. The hazard of erosion is the main management concern. It is very severe in strongly sloping areas.

Wetness, a shrink-swell potential, and restricted permeability are limitations affecting building site development and septic tank absorption fields. The slope is an additional limitation in the steeper areas.

The forested areas in this association include valuable timber species, such as white oak, and can be managed for timber production. The seedling mortality rate and the hazard of windthrow are the main management concerns in these areas.

This association provides most of the forest cover necessary for wildlife in the county. Additional habitat is provided along brushy fence rows and the edge of fields and in pastures of warm-season grasses that have not been overgrazed.

4. Belknap-Twomile-Gifford Association

Nearly level and gently sloping, loamy and loamy over clayey, somewhat poorly drained and poorly drained soils; on flood plains and stream terraces

This association is on the flood plains and high stream terraces of major drainageways. Individual areas of this association are narrow and elongated and include a perennial stream. Flooding occurs frequently in areas of the Belknap soils and occasionally in areas of the Twomile soils.

This association makes up about 9 percent of the county. It is about 38 percent Belknap soils, 34 percent Twomile soils, 14 percent Gifford soils, and 14 percent soils of minor extent, mostly Chariton soils (fig. 5).

The Belknap soils are nearly level and somewhat poorly drained. They are on low flood plains. Typically, the surface layer is dark grayish brown, friable silt loam about 11 inches thick. The substratum is mottled silt loam. It is dark grayish brown and grayish brown in the upper part and light brownish gray and gray in the lower part.

The Twomile soils are nearly level and poorly drained. They are on high flood plains. Typically, the surface layer is dark grayish brown, friable silt loam about 9 inches thick. The subsurface layer is mottled silt loam. It is grayish brown in the upper part and light brownish gray in the lower part. The subsoil is mottled silty clay loam. It is grayish brown and dark grayish brown in the upper part and dark grayish brown in the lower part.

The Gifford soils are gently sloping and poorly drained. They are on the high stream terraces. Typically, the surface layer is very dark grayish brown, friable silt loam about 7 inches thick. The upper part of the subsoil is dark grayish brown, mottled silty clay loam. The next part is dark grayish brown and grayish brown, mottled silty clay. The lower part is grayish brown and dark gray, mottled silty clay loam and dark gray, mottled silt loam.

Of minor extent in this association are the Jemerson and Chariton soils. Jemerson soils are on the high flood plains and are well drained. Chariton soils are on the high terraces and are nearly level.

Most areas of the Twomile and Gifford soils are used for cultivated crops, mainly corn and soybeans. Winter wheat and grain sorghum also are grown. Some areas are used for pasture. Most areas of the Belknap soils are used as woodland. Some areas are used for cultivated crops or as pasture.

The soils in this association are suited to cultivated crops and to the grasses and legumes that can tolerate the wetness. The main management concerns are the wetness and the flooding.

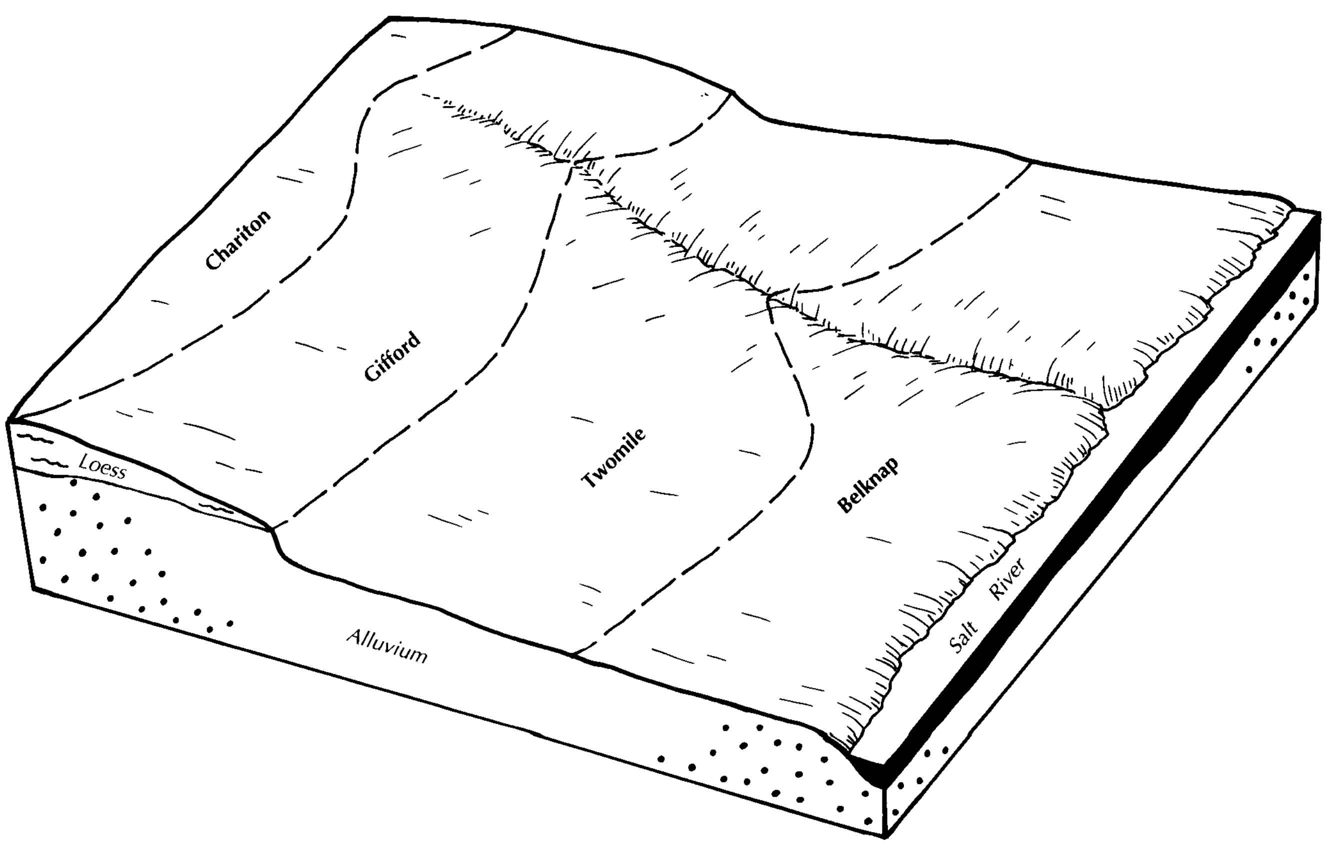

Figure 5.—Typical pattern of soils and parent material in the Belknap-Twomile-Gifford association.

The Belknap and Twomile soils are not suited to building site development because of the flooding. The Gifford soils are limited mainly by the wetness, a shrink-swell potential, and restricted permeability.

The forested areas of the Belknap soils provide important wildlife habitat. The forest vegetation also stabilizes streambanks. Maintaining or increasing the extent of the forest vegetation is necessary to stabilize streambanks. Wildlife habitat can be improved by maintaining the quality and increasing the extent of permanent vegetative cover in uncultivated areas.

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 the heading "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 substratum, 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 substratum. They also can differ in the slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Armstrong loam, 4 to 9 percent slopes, eroded, is a phase of the Armstrong series.

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.

Soil Descriptions

10C2—Armstrong loam, 4 to 9 percent slopes, eroded. This very deep, moderately sloping, moderately well drained soil is on upland side slopes that were originally covered by a mixture of trees and grasses. It formed in a thin layer of pedisediments and in the underlying paleosol, which weathered from glacial till. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 800 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:

0 to 4 inches, very dark grayish brown, very friable loam

Subsoil:

4 to 7 inches, dark brown clay loam
7 to 11 inches, dark brown, mottled clay loam
11 to 28 inches, yellowish brown and dark brown, mottled clay
28 to 46 inches, grayish brown and yellowish brown, mottled clay loam
46 to 60 inches, light brownish gray and yellowish brown, mottled clay loam

In some places the surface layer is silt loam. In other places, the surface layer is dark and thicker and the soil is somewhat poorly drained or well drained. In some areas the slopes are 3 percent or less. In a few areas the slopes are short and are more than 9 percent.

Included with this soil in mapping are areas of Belknap, Gifford, Leonard, and Twomile soils and severely eroded areas of Armstrong soils. Belknap soils are silt loam throughout. They are on narrow flood plains and are subject to flooding. Gifford soils are poorly drained and are on high stream terraces along the downslope margins of the unit. Leonard soils have a surface layer of silty clay loam. They are poorly drained and are in gently sloping areas along the upslope margins of the unit. Twomile soils are poorly drained and are on narrow, high flood plains. The severely eroded Armstrong soils have a surface layer of dark brown clay loam and are in convex areas. Included soils make up less than 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderate
Shrink-swell potential: High
Depth to a seasonal high water table: 1 to 3 feet (perched)

In most areas this soil is used for hay and pasture. In a few areas it is used for cultivated crops.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by a severe hazard of erosion. The hazard of erosion can be reduced by farming on the contour and by terracing. A conservation tillage system that leaves a protective cover of crop residue on the surface is needed. If the soil is not terraced, very large amounts of residue should be left on the surface in order to minimize excessive erosion. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to prevent excessive erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland; however, equipment should not be operated when the soil is saturated. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

10C3—Armstrong clay loam, 5 to 9 percent slopes, severely eroded. This very deep, moderately sloping, moderately well drained soil generally is on upland side slopes that were originally covered by a mixture of trees and grasses. It formed in a thin layer of pedisediments and in the underlying paleosol, which weathered from glacial till. Nearly all of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 3 inches, brown, friable clay loam

Subsoil:
3 to 10 inches, brown, mottled clay loam
10 to 25 inches, gray, mottled clay
25 to 42 inches, gray, mottled clay loam

Substratum:
42 to 60 inches, grayish brown, mottled clay loam

In places the slope is less than 5 percent.

Included with this soil in mapping are concave areas of soils that are moderately eroded. These soils have a surface layer of dark brown loam. Also included are small areas where gullies are as deep as 2 feet and some poorly drained, depositional areas at the base of slopes. Inclusions make up less than 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Medium

Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 1 to 3 feet (perched)

In most areas this soil is used for cultivated crops. It is suited to cultivated crops grown on a limited basis with crop rotations that include close-growing pasture and hay crops. It is limited by a severe hazard of erosion. Seedbed preparation may be limited by the poor physical characteristics of the surface layer. The hazard of erosion can be reduced by farming on the contour and by terracing. A conservation tillage system that leaves a protective cover of crop residue on the surface is needed. If the soil is not terraced, very large amounts of residue should be left on the surface in order to minimize excessive erosion. Grassed waterways help to control erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland; however, equipment should not be operated when the soil is saturated. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade helps to prevent the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IVe.

18F—Goss cobbly silt loam, 14 to 30 percent slopes. This very deep, moderately steep and steep, well drained soil is on upland side slopes. It formed in material weathered from cherty limestone or cherty dolomite and some interbedded shale. Individual areas are irregular in shape and range from 5 to 50 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 5 inches, very dark grayish brown, friable cobbly silt loam
5 to 11 inches, dark brown very cobbly silt loam

Subsoil:
11 to 20 inches, dark brown very cobbly silt loam
20 to 44 inches, yellowish red very cobbly clay
44 to 60 inches, strong brown very cobbly clay

In places the dark surface layer is more than 6 inches thick. In a few areas the soil is less than 60 inches deep over bedrock. Some areas are very steep.

Included with this soil in mapping are areas of rock outcrop, soils that are shallow over bedrock, Keswick soils, and alluvial soils in narrow drainageways. The rock outcrop is on shoulder slopes or on bluffs along streambanks. The shallow soils commonly are closely associated with the rock outcrop. Keswick soils are not cobbly and are near the upslope margins of the unit. The alluvial soils are subject to flooding. Inclusions make up about 10 percent of this unit.

Important soil properties—

Permeability: Moderate
Surface runoff: Very rapid
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: Moderate

In most areas this soil is used as woodland. It is unsuited to cultivated crops and generally unsuited to pasture. It is limited by the slope, the cobbly surface layer, and a very severe hazard of erosion. Extreme management measures are needed if the soil is used for cultivated crops.

The main limitations on sites for dwellings are the slope, the shrink-swell potential, and the large stones.

Dwellings should be designed so that they conform to the natural slope of the land, or the soil should be graded to an acceptable slope. Installing tile drains around footings and foundations minimizes the damage caused by wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is limited as a site for septic tank absorption fields because of the slope, the moderate permeability, and the large stones. Land shaping and installing the distribution lines across the slope help to ensure the proper operation of the absorption fields. The absorption fields should be increased in size and properly constructed because of the restricted permeability. Sewage generally can be piped to a nearby area where the soils are better suited to onsite waste disposal systems.

The slope, the shrink-swell potential, and frost action are the main limitations affecting local roads and streets. Cutting and filling generally is necessary to reduce the slope to an acceptable grade for roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling. Grading the roads so that they shed water and installing a gravel moisture barrier in the subgrade minimize the damage caused by frost action.

The land capability classification is VIIe.

19B—Marion silt loam, 1 to 5 percent slopes. This very deep, very gently sloping and gently sloping, somewhat poorly drained soil generally is on narrow ridgetops that were originally forested. It is also in a few areas on high stream terraces in the northern part of the county. It formed in loess and in the underlying pedisediments. Individual areas are irregular in shape and range from 5 to 90 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 2 inches, dark grayish brown, very friable silt loam

Subsurface layer:
2 to 9 inches, light brownish gray, mottled silt loam

Subsoil:
9 to 29 inches, brown, mottled silty clay
29 to 60 inches, light brownish gray, mottled silty clay loam

In places the surface layer is thicker and darker. In some areas the soil is poorly drained. In a few small areas it is moderately well drained.

Included with this soil in mapping are areas of Keswick soils. These soils have a higher sand content than the Marion soil. They are on shoulder slopes along margins of the unit. They make up less than 3 percent of this unit.

Important soil properties—

Permeability: Very slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 1 to 2 feet (perched)

In most areas this soil is used for hay and pasture. In a few areas it is used for cultivated crops.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is moderate. The wetness is a limitation in the very gently sloping areas during some spring and fall months; however, fieldwork generally is only slightly affected. The hazard of erosion can be reduced by farming on the contour and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. It can be further reduced by terracing, stripcropping, or including high-residue crops, such as pasture grasses, in crop rotations. Grassed waterways help to control runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as birdsfoot trefoil, red clover, timothy, tall fescue, and switchgrass. No serious limitations affect pasture and hayland, although the wetness and the hazard of erosion are management concerns. Equipment should not be operated when the soil is saturated. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Installing tile drains around footings and foundations also minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile or a sump pump is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the very slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately on this soil.

The high shrink-swell potential, low strength, the wetness, and frost action are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

22C2—Keswick silt loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, moderately well drained soil is on upland side slopes that were originally forested. It formed in a thin layer of loess and pedisediments and in the underlying paleosol, which weathered from glacial till. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 400 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:

0 to 2 inches, dark brown, friable silt loam

Subsurface layer:

2 to 7 inches, dark brown, mottled silt loam

Subsoil:

7 to 15 inches, dark yellowish brown, mottled clay loam

15 to 51 inches, yellowish brown and strong brown, mottled clay loam

51 to 60 inches, grayish brown, mottled clay loam

In places the dark surface layer is more than 6 inches thick. In a few areas the soil is well drained. In some areas the slope is less than 5 percent, and in a few small areas it is more than 9 percent.

Included with this soil in mapping are areas of Leonard, Belknap, and Winnegan soils. Leonard soils are poorly drained and are in the concave upslope margins of the unit. Belknap soils are nearly level and are on narrow flood plains. They are silt loam throughout. Winnegan soils are 40 to 60 inches deep over bedrock. They are on the lower side slopes. Included soils make up about 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 1 to 3 feet (perched)

In most areas this soil is used for hay and pasture. In a few areas it is used as woodland.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by a severe hazard of erosion. The hazard of erosion can be reduced by farming on the contour and by terracing. A conservation tillage system that leaves a protective cover of crop residue on the surface is needed. If the soil is not terraced, very large amounts of residue should be left on the surface in order to minimize excessive erosion. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to minimize excessive erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland; however, equipment should not be operated when the soil is saturated. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

22D2—Keswick loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, moderately well drained soil is on upland side slopes that were originally forested. It formed in a thin layer of loess and pedisediments and in the underlying paleosol, which weathered from glacial till. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 2 inches, very dark grayish brown, friable loam

Subsurface layer:
2 to 5 inches, brown loam

Subsoil:
5 to 8 inches, strong brown clay loam
8 to 16 inches, strong brown, mottled clay
16 to 23 inches, yellowish brown, mottled clay loam
23 to 36 inches, light brownish gray, mottled clay loam
36 to 60 inches, dark yellowish brown, mottled clay loam

In places the surface layer is thicker. In a few areas the soil is well drained. In some areas the slope is less than 9 percent, and in a few small areas it is more than 14 percent.

Included with this soil in mapping are areas of Belknap and Winnegan soils. Belknap soils are nearly level and are on narrow flood plains. They are silt loam throughout. Winnegan soils are 40 to 60 inches deep over bedrock and are on the lower side slopes. Included soils make up about 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Rapid
Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 1 to 3 feet (perched)

In most areas this soil is used as woodland. In a few areas it is used for hay and pasture.

This soil is suited to cultivated crops grown on a limited basis with crop rotations that include close-growing pasture and hay crops. It is limited by a very severe hazard of erosion. The hazard of erosion can be reduced by farming on the contour and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. Because of the slope and the clayey subsoil, the soil is not suited to terraces. Establishing grassed waterways in small drainageways helps to control erosion.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. The main limitation affecting pasture and hayland is the hazard of erosion when establishing new seedings. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Livestock trails and overgrazed areas are subject to erosion. A rotation grazing system and the proper location of livestock water and supplements reduce this hazard. Equipment should not be operated when the soil is saturated.

The main limitations on sites for dwellings are the wetness, the shrink-swell potential, and the slope. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability, the wetness, and the slope. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Land shaping and installing the distribution lines across the slope help to ensure the proper operation of the absorption fields. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, the slope, and the wetness are the main limitations affecting local roads and streets.

Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the structural damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Some cutting and filling is necessary to reduce the slope to an acceptable grade for roads and streets, or the roads should be designed so that they conform to the natural slope of the land. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IVe.

23B2—Leonard silty clay loam, 2 to 4 percent slopes, eroded. This very deep, gently sloping, poorly drained soil is on upland side slopes and at the head of drainageways. It formed in loess and in the underlying pedisediments or paleosol, which weathered from glacial till. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 600 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
- 0 to 6 inches, very dark grayish brown, firm silty clay loam

Subsoil:
- 6 to 13 inches, dark gray, mottled silty clay
- 13 to 19 inches, dark grayish brown, mottled silty clay loam
- 19 to 25 inches, gray, mottled silty clay loam
- 25 to 56 inches, gray, mottled clay loam
- 56 to 60 inches, grayish brown, mottled clay loam

In places the surface layer is silt loam and is thicker. In a few places, the subsurface layer is silt loam and the subsoil is at a depth of more than 12 inches. In some areas the slope is more than 4 percent.

Included with this soil in mapping are areas of Armstrong, Belknap, Chariton, and Twomile soils and severely eroded areas of Leonard soils. Armstrong soils are somewhat poorly drained and are on the steeper slopes. Belknap soils are nearly level and are on narrow flood plains. They are silt loam throughout. Chariton and Twomile soils are nearly level. The surface layer and subsurface layer of Chariton and Twomile soils are thick and are silt loam. Chariton soils are on high stream terraces. Twomile soils are on flood plains. The severely eroded Leonard soils have a very thin surface layer that has a higher content of clay than the surface layer of the Leonard soils that are not so eroded. They generally are in convex areas that have slopes of 4 percent. Included soils make up about 5 to 10 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 0.5 foot to 2.0 feet (perched)

In most areas this soil is used for cultivated crops. In some areas it is used as pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is moderate. The wetness delays fieldwork in spring and fall in some years, particularly in concave areas. The hazard of erosion can be reduced by farming on the contour and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. It can be further reduced by terracing, stripcropping, or including high-residue crops, such as pasture grasses, in crop rotations. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to control erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to the grasses and legumes that can tolerate the wetness. Examples are ladino clover, birdsfoot trefoil, tall fescue, and switchgrass. The soil is poorly suited to alfalfa. The main limitation affecting pasture and hayland is the perched seasonal high water table during the period November to May. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system. Erosion is a management concern when establishing new seedings. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Installing tile drains around footings and foundations also minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

24F—Winnegan silt loam, 14 to 30 percent slopes. This very deep, moderately steep and steep, moderately well drained soil is on upland side slopes. It formed in glacial till. Individual areas are irregular in shape and range from 5 to 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 2 inches, very dark gray, friable silt loam

Subsurface layer:
2 to 7 inches, yellowish brown silt loam

Subsoil:
7 to 14 inches, strong brown clay
14 to 29 inches, strong brown and yellowish brown, mottled clay
29 to 39 inches, yellowish brown, mottled clay loam
39 to 60 inches, yellowish brown, mottled, calcareous clay loam

In places the surface layer is loam. In a few small areas the slope is more than 30 percent, and in other areas it is less than 14 percent.

Included with this soil in mapping are areas of Belknap and Goss soils. Belknap soils are nearly level and are silt loam throughout. They are on narrow flood plains. Goss soils are cobbly and are lower on the side slopes than the Winnegan soil. Included soils make up about 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Very rapid
Available water capacity: Moderate
Organic matter content: Low
Shrink-swell potential: High
Depth to a seasonal high water table: 2.0 to 3.5 feet (perched)

In most areas this soil is used as woodland. In a few areas it is used as pasture.

This soil generally is unsuited to cultivated crops. It is limited by the slope and a very severe hazard of erosion.

This soil is suited to trees. Most areas support native hardwoods. Erosion and the equipment limitation are the main concerns in timber management. Because of the slope, haul roads and skid trails should be located across the slope in the steeper areas. Installing water-breaks helps to control erosion. Disturbed areas may need to be reseeded after logging has been completed.

This soil is suited to most of the commonly grown grasses and legumes, such as birdsfoot trefoil, red clover, tall fescue, and switchgrass. The main limitation affecting pasture and hayland is the severe hazard of erosion when establishing new seedings. The hazard of erosion can be reduced by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Livestock trails and overgrazed areas are subject to erosion. A rotation grazing system and the proper location of livestock water and supplements reduce this hazard. The wetness also is a management concern. Equipment should not be operated when the soil is saturated.

The main limitations on sites for dwellings are the slope, the wetness, and the shrink-swell potential. Dwellings should be designed so that they conform to the natural slope of the land, or the soil should be graded to an acceptable slope. Adequately reinforcing concrete in the footings and foundations and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability, the wetness, and the slope. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Land shaping and installing the distribution lines across the slope help to ensure the proper operation of the absorption fields. Holding tanks are an effective alternative to septic tank absorption fields.

Sewage generally can be piped to a nearby area where soils are better suited to an onsite waste disposal system.

The high shrink-swell potential, low strength, the slope, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. Cutting and filling generally is necessary to reduce the slope to an acceptable grade for roads and streets. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is VIe.

27B—Mexico silt loam, 1 to 3 percent slopes. This very deep, very gently sloping, somewhat poorly drained soil is on broad upland interfluves and divides. It formed in loess and in the underlying pedisediments. Individual areas are irregular in shape and range from 5 to 1,500 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
- 0 to 7 inches, very dark grayish brown, friable silt loam

Subsoil:
- 7 to 11 inches, dark grayish brown and red silty clay loam and grayish brown silt loam
- 11 to 17 inches, mottled dark grayish brown, red, and yellowish brown silty clay
- 17 to 36 inches, grayish brown, mottled silty clay
- 36 to 48 inches, mottled grayish brown, dark yellowish brown, and yellowish brown silty clay loam

Substratum:
- 48 to 60 inches, light brownish gray, mottled clay loam

In places, the soil is eroded and the surface layer is silty clay loam.

Included with this soil in mapping are areas of Putnam and Leonard soils. Putnam soils are poorly drained and are in nearly level areas. Leonard soils also are poorly drained. They are on the lower side slopes. Included soils make up less than 5 percent of this unit.

Important soil properties—

Permeability: Very slow
Surface runoff: Slow
Available water capacity: Moderate
Organic matter content: Moderate
Shrink-swell potential: High
Depth to a seasonal high water table: 1.0 to 2.5 feet (perched)

In most areas this soil is used for cultivated crops. In a few areas it is used for hay and pasture (fig. 6).

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is moderate. The wetness delays fieldwork in some years, but yields generally are only slightly affected. The hazard of erosion can be reduced by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Grassed waterways serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, birdsfoot trefoil, red clover, tall fescue, and switchgrass. The wetness may affect the selection of plants. Generally, the species that can tolerate the wetness grow best. Equipment should not be operated when the soil is saturated. Erosion is a management concern when establishing new seedings. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the very slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential and low strength are the main limitations affecting local roads and streets. The wetness and frost action also are limitations. Strengthening the subgrade by adding crushed rock or

Figure 6.—An area of Mexico silt loam, 1 to 3 percent slopes, used for row crops and hay.

other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIe.

27B2—Mexico silty clay loam, 1 to 3 percent slopes, eroded. This very deep, very gently sloping, somewhat poorly drained soil generally is on broad upland interfluves and divides. It formed in loess and in the underlying pedisediments. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 1,000 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:

0 to 5 inches, very dark grayish brown, friable silty clay loam

Subsoil:

5 to 10 inches, dark gray, mottled silty clay
10 to 16 inches, dark grayish brown, mottled silty clay
16 to 47 inches, grayish brown, mottled silty clay loam
47 to 60 inches, dark grayish brown, mottled clay loam

In places, the soil is not eroded and the surface layer is silt loam. In a few areas the slope is 4 percent.

Included with this soil in mapping are areas of

Putnam and Leonard soils. Putnam soils are nearly level and poorly drained and are on the higher broad divides. Leonard soils also are poorly drained. They are on side slopes below the Mexico soils. Included soils make up less than 5 percent of this unit.

Important soil properties—

Permeability: Very slow
Surface runoff: Slow
Available water capacity: Moderate
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 1.0 to 2.5 feet (perched)

In most areas this soil is used for cultivated crops. In a few areas it is used for hay and pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is moderate. The wetness affects fieldwork in some years, but yields generally are only slightly affected. The hazard of erosion can be minimized by farming on the contour and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. It can be further reduced by terracing, stripcropping, or including high-residue crops, such as pasture grasses, in crop rotations. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to control erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. The wetness may affect the selection of plants. Generally, the species that can tolerate the wetness grow best. Equipment should not be operated when the soil is saturated. Erosion is a management concern when establishing new seedings. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is severely limited by the very slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, the wetness, and frost action are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

28—Twomile silt loam. This very deep, nearly level, poorly drained soil is on high flood plains. It formed in alluvium. It is occasionally flooded during the period November to May. Individual areas are irregular in shape and range from 5 to 160 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 9 inches, dark grayish brown, friable silt loam

Subsurface layer:
9 to 17 inches, grayish brown, mottled silt loam
17 to 23 inches, light brownish gray, mottled silt loam

Subsoil:
23 to 33 inches, grayish brown, mottled silty clay loam
33 to 60 inches, dark grayish brown, mottled silty clay loam

In places, the surface layer or subsurface layer is thicker and the depth to the subsoil generally is more than 30 inches.

Included with this soil in mapping are areas of Armstrong and Belknap soils. Armstrong soils are somewhat poorly drained and strongly sloping. They are on the upslope margins of the unit. Belknap soils are silt loam throughout. They are on low flood plains and are frequently flooded. Included soils make up about 5 to 10 percent of this unit.

Important soil properties—

Permeability: Moderate in the upper part of the profile and slow in the lower part
Surface runoff: Slow
Available water capacity: Moderate

Organic matter content: Moderately low
Shrink-swell potential: Moderate
Depth to a seasonal high water table: 1 to 2 feet (perched)

In most areas this soil is used for cultivated crops. In a few areas it is used for hay and pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by a slight hazard of erosion, the wetness in spring and fall, and an insufficient amount of soil moisture in summer for growing crops. Erosion can be minimized by farming on the contour and by applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The wetness delays fieldwork in spring and fall in some years. Installing shallow drainage ditches helps to remove excess surface water if suitable outlets are available. Diversion ditches installed along the upslope margins of the unit help to intercept runoff from the higher elevations.

This soil is suited to the grasses and legumes that can tolerate the wetness. Examples are ladino clover, red clover, tall fescue, and switchgrass. The soil is poorly suited to alfalfa. The main limitation affecting pasture and hayland is the perched seasonal high water table. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system.

This soil is unsuited to building site development. It is limited by the flooding and the wetness. Very intensive measures are needed to overcome these limitations. Dwellings should be built in areas of better suited soils.

The moderate shrink-swell potential, low strength, the wetness, frost action, and the flooding are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness. Roads should be constructed on raised, well compacted fill material. Culverts minimize flood damage by providing drainage outlets for floodwaters.

The land capability classification is IIIw.

33—Belknap silt loam. This very deep, nearly level, somewhat poorly drained soil is on narrow flood plains. It formed in alluvium. It is frequently flooded during the period November to May. Individual areas are long and narrow and range from 5 to 230 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 5 inches, dark grayish brown, friable silt loam

Subsurface layer:
5 to 11 inches, dark grayish brown, mottled, friable silt loam

Substratum:
11 to 24 inches, dark grayish brown and grayish brown, mottled silt loam
24 to 60 inches, light brownish gray and gray, mottled silt loam

In places the soil is somewhat poorly drained or well drained. In a few areas the surface layer is thick and is darker, and in some places it is silty clay loam. In a few places the soil is only occasionally flooded.

Included with this soil in mapping are areas of Gifford and Twomile soils, soils that have thick sandy strata, and soils that are clayey. Also included are small depressional areas that are ponded in the early spring. Gifford soils have a silty clay subsoil and are in sloping areas along upslope margins of the unit. Twomile soils have a silty clay loam subsoil and are on high flood plains that are slightly higher than those of the Belknap soil. The soils that have thick sandy strata are in areas throughout the unit. The clayey soils are in areas adjacent to uplands that are underlain by shale bedrock. Inclusions make up about 15 percent of this unit.

Important soil properties—

Permeability: Moderate
Surface runoff: Very slow
Available water capacity: High
Organic matter content: Moderately low
Shrink-swell potential: Low
Depth to a seasonal high water table: 1 to 3 feet (apparent)

In most areas this soil is used as woodland. In a few areas it is used for cultivated crops or for hay and pasture.

This soil is suited to trees. Many areas support native hardwoods. No limitations affect timber management; however, flooding may affect the use of equipment.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat; however, many areas are highly dissected by meandering streambeds. As a result, farming may be impractical. Spring flooding can cause crop damage. Wetness can delay fieldwork in spring and fall in some years. Installing shallow drainage ditches helps to remove excess surface water if suitable outlets are available. Diversion ditches installed along the upslope margins of the unit help to intercept runoff from the higher elevations. Streambank erosion is a management concern. Forested buffer strips should be maintained adjacent to the stream channel.

This soil is suited to the grasses and legumes that can tolerate wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The soil is poorly suited to alfalfa. The main limitations affecting pasture and hayland are the wetness and the flooding. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system. The flooding may damage new plantings.

This soil is unsuited to building site development. It is limited by the flooding and the wetness. Very intensive measures are needed to overcome these limitations. Dwellings should be built in areas of better suited soils.

Frost action, the flooding, and the wetness are the main limitations affecting local roads and streets. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness. Roads should be constructed on raised, well compacted fill material. Culverts minimize flood damage by providing drainage outlets for floodwaters.

The land capability classification is IIIw.

34—Putnam silt loam. This very deep, nearly level, poorly drained soil is on broad upland divides. It formed in loess. Individual areas are irregular in shape and range from 20 to 2,000 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
- 0 to 8 inches, very dark grayish brown, friable silt loam

Subsurface layer:
- 8 to 16 inches, light brownish gray, mottled silt loam

Subsoil:
- 16 to 30 inches, dark gray, mottled silty clay
- 30 to 48 inches, grayish brown, mottled silty clay loam
- 48 to 60 inches, gray, mottled silty clay loam

In places the soil is somewhat poorly drained. In some areas the subsurface layer is very thin.

Included with this soil in mapping are areas that are ponded for extended periods in the spring and following heavy rains. These areas make up about 2 percent of this unit.

Important soil properties—

Permeability: Very slow
Surface runoff: Slow
Available water capacity: Moderate
Organic matter content: Moderate
Shrink-swell potential: High
Depth to a seasonal high water table: 0.5 foot to 1.5 feet (perched)

In most areas this soil is used for cultivated crops. It is suited to corn, soybeans, grain sorghum, and winter wheat. The wetness is a limitation during most winter and spring months. It delays fieldwork in some years (fig. 7). Installing shallow drainage ditches helps to remove excess surface water if suitable outlets are available.

This soil is suited to the grasses and legumes that can tolerate the wetness. Examples are ladino clover, red clover, tall fescue, and switchgrass. The soil is poorly suited to alfalfa. The wetness during winter and spring is a major management concern. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system.

The main limitations for dwellings are the wetness and the shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Installing tile drains around footings and foundations also minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile or a sump pump is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the very slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Properly constructed lagoons function adequately on this soil. Holding tanks are an effective alternative to septic tank absorption fields.

The high shrink-swell potential, low strength, the wetness, and frost action are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable

Figure 7.—Wetness in an area of Putnam silt loam.

material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIw.

45B—Gifford silt loam, 1 to 4 percent slopes. This very deep, very gently sloping and gently sloping, poorly drained soil is on high stream terraces. It formed in loess and in the underlying alluvium. Individual areas are irregular in shape and range from 5 to 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 7 inches, very dark grayish brown, friable silt loam

Subsoil:
7 to 10 inches, dark grayish brown, mottled silty clay loam
10 to 27 inches, dark grayish brown and grayish brown, mottled silty clay
27 to 45 inches, grayish brown and dark gray, mottled silty clay loam
45 to 60 inches, dark gray, mottled silt loam

In some places, the soil is eroded and the surface layer is silty clay loam. In other places the dark surface layer is thicker. In a few places the subsoil is browner.

Included with this soil in mapping are areas of Chariton soils, areas having short, steep escarpments, and some areas that are subject to rare flooding. Chariton soils are nearly level and have a subsurface layer of silt loam. They are higher on the landscape than the Gifford soil. Inclusions make up about 5 percent of this unit.

Important soil properties—

Permeability: Very slow
Surface runoff: Medium
Available water capacity: High
Organic matter content: Moderately low
Shrink-swell potential: High
Depth to a seasonal high water table: 0.5 foot to 2.0 feet (perched)

In most areas this soil is used for cultivated crops. In a few areas it is used for hay and pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is moderate. The wetness affects fieldwork for short periods in some years. The hazard of erosion can be reduced by farming on the contour and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. It can be further reduced by terracing, stripcropping, or including high-residue crops, such as pasture grasses, in crop rotations. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to control erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to the grasses and legumes that can tolerate the wetness. Examples are ladino clover, birdsfoot trefoil, tall fescue, and switchgrass. The soil is poorly suited to alfalfa. The wetness during most winter and spring months is a major limitation. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system. Erosion is a management concern when establishing new seedings. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the very slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIe.

47—Chariton silt loam. This very deep, nearly level, poorly drained soil is on high stream terraces. It formed in loess and in the underlying alluvium. Individual areas are irregular in shape and range from 5 to 180 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 9 inches, very dark grayish brown, friable silt loam

Subsurface layer:
9 to 16 inches, dark grayish brown, mottled silt loam

Subsoil:
16 to 30 inches, dark grayish brown, mottled silty clay
30 to 46 inches, gray, mottled silty clay
46 to 60 inches, mottled dark gray and gray silty clay loam

In some places the soil is somewhat poorly drained, and in other places it is moderately well drained.

Included with this soil in mapping are areas of Gifford and Belknap soils; a few short, steep slopes; a few depressional areas that are ponded in the early spring; and some areas that are subject to rare flooding. Gifford soils do not have a subsurface layer. They are in gently sloping areas. Belknap soils are silt loam throughout and are on narrow flood plains. Inclusions make up about 10 to 15 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Slow
Available water capacity: High
Organic matter content: Moderate
Shrink-swell potential: High
Depth to a seasonal high water table: 0 to 1.5 feet (perched)

In most areas this soil is used for cultivated crops. In a few areas it is used for hay and pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness and a slight hazard of erosion. The hazard of erosion can be reduced by farming on the contour and by applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The wetness delays fieldwork in spring and fall in some years. Installing shallow drainage ditches helps to remove excess surface water if suitable outlets are available. Diversion ditches installed along the upslope margins of the unit help to intercept runoff from the higher elevations.

This soil is suited to the grasses and legumes that can tolerate wetness. Examples are ladino clover, birdsfoot trefoil, tall fescue, and switchgrass. The soil is poorly suited to alfalfa. The main limitation affecting pasture and hayland is the perched seasonal high water table. Equipment should not be operated when the soil is saturated. Grazing when the soil is wet results in damage to the pasture. This damage can be minimized by applying a properly designed rotation grazing system.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Installing tile drains around footings and foundations also minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile or a sump pump is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability and the wetness. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIw.

56B—Jemerson silt loam, 1 to 3 percent slopes. This very deep, very gently sloping, well drained soil generally is on high flood plains. It formed in silty alluvium. It is subject to rare flooding. Individual areas are irregular in shape and range from 5 to 50 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 6 inches, dark brown, friable silt loam

Subsurface layer:
6 to 14 inches, dark brown silt loam

Subsoil:
14 to 40 inches, dark brown silty clay loam
40 to 60 inches, dark brown, mottled silt loam

In places the surface layer is fine sandy loam. In some areas the soil is moderately well drained.

Included with this soil in mapping are areas of Twomile, Gifford, and Belknap soils. Twomile soils are poorly drained and are in depressions. Gifford soils are poorly drained and have a silty clay subsoil. They are along upslope margins of the unit. Belknap soils are silt loam throughout. They are in sloughs or are adjacent to stream channels. Included soils make up about 5 percent of this unit.

Important soil properties—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: High
Organic matter content: Moderately low
Shrink-swell potential: Low
Depth to a seasonal high water table: 3.5 to 5.0 feet (apparent)

In most areas this soil is used for cultivated crops. In many areas it is used for hay and pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. The hazard of erosion is slight. It can be reduced by farming on the contour and by applying a conservation tillage system that leaves a protective cover of crop residue on the surface and by stripcropping. Grassed waterways serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland.

This soil generally is not used as a building site because of the flooding. Extreme measures are needed to overcome this hazard. Dwellings should be built in areas of better suited soils.

Low strength and potential frost action are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the structural damage caused by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Roads should be constructed on raised, well compacted fill material. Roadside ditches and culverts minimize damage caused by wetness and flooding.

The land capability classification is IIe.

74C2—Winnegan clay loam, bedrock substratum, 5 to 9 percent slopes, eroded. This deep, moderately sloping, moderately well drained soil is on upland side slopes. It formed in a layer of glacial till and in the underlying shale residuum. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 60 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 4 inches, dark brown, firm clay loam

Subsoil:
4 to 10 inches, dark brown, mottled clay
10 to 35 inches, dark grayish brown and grayish brown, mottled clay
35 to 47 inches, light gray, mottled silty clay loam

Bedrock:
47 to 60 inches, weathered shale

In places the surface layer is darker and thicker and is silt loam. In many areas the depth to bedrock is more than 60 inches. In a few places the soil is well drained.

Included with this soil in mapping are areas of Belknap soils, soils that are shallow over bedrock, and soils that have a cobbly surface layer. Belknap soils are silt loam throughout and are on nearly level flood plains. The soils that are shallow over bedrock are interspersed throughout the unit. The soils that have a cobbly surface layer generally are on the lower side slopes. Included soils make up about 5 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Low
Shrink-swell potential: High
Depth to a seasonal high water table: 2.0 to 3.5 feet (perched)

In most areas this soil is used for hay and pasture. In a few areas it is used as woodland.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat on a limited basis with crop rotations that include close-growing pasture and hay crops. It is limited by a severe hazard of erosion. The hazard of erosion can be reduced by farming on the contour and by terracing. A conservation tillage system that leaves a protective cover of crop residue on the surface is needed. If the soil is not terraced, very large amounts of residue should be left on the surface in order to control erosion. During terrace construction, the soil from the surface layer can be stockpiled and later spread across the finished terraces. Grassed waterways help to prevent excessive erosion in small drainageways and serve as outlets for runoff from terraces.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness, the shrink-swell potential, and the depth to bedrock. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling. The depth to bedrock limits the depth of excavation and the extent to which the site can be leveled. Special equipment and techniques may be needed.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability, the wetness, and the depth to bedrock. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Holding tanks are an effective alternative to septic tank absorption fields. Properly constructed lagoons function adequately if the site is leveled and the lagoon is sealed with slowly permeable soil material.

The high shrink-swell potential, low strength, frost action, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IIIe.

74D2—Winnegan loam, bedrock substratum, 9 to 14 percent slopes, eroded. This deep, strongly sloping, moderately well drained soil is on upland side slopes. It formed in a layer of glacial till and in the underlying shale residuum. Much of the original dark surface soil has been removed by erosion in most areas. Individual areas are irregular in shape and range from 5 to 150 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 5 inches, dark brown, friable loam

Subsoil:
5 to 9 inches, dark brown, mottled clay loam
9 to 13 inches, brown, mottled clay loam
13 to 20 inches, gray, mottled clay
20 to 27 inches, grayish brown, mottled silty clay

Substratum:
27 to 40 inches, grayish brown, mottled silty clay

Bedrock:
40 to 60 inches, weathered shale

In places the surface layer is darker and thicker and is silt loam. In many areas the depth to bedrock is more than 60 inches.

Included with this soil in mapping are areas of Belknap, Goss, and Twomile soils, rock outcrop, soils that are shallow over bedrock, and areas having short, steep slopes. Belknap soils are nearly level and are on flood plains. They are silt loam throughout. Goss soils are cobbly and are on the lower slopes. Twomile soils are nearly level and poorly drained. They are on high flood plains. The rock outcrop and the soils that are shallow over bedrock are intermingled with areas of the Winnegan soil throughout the unit. The short, steep slopes are adjacent to narrow flood plains. Inclusions make up about 10 to 15 percent of this unit.

Important soil properties—

Permeability: Slow
Surface runoff: Rapid
Available water capacity: Moderate
Organic matter content: Low
Shrink-swell potential: High
Depth to a seasonal high water table: 2.0 to 3.5 feet (perched)

In most areas this soil is used for hay and pasture. In some areas it is wooded.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat grown on a limited basis with crop rotations that include close-growing pasture and hay crops. It is limited by a severe hazard of erosion. Applying a conservation tillage system that leaves a protective cover of crop residue on the surface and farming on the contour reduce the hazard of erosion.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. The main limitation affecting pasture and hayland is the hazard of erosion when establishing new seedings. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Livestock trails and overgrazed areas are subject to erosion. A rotation grazing system and the proper location of livestock water and supplements reduce this hazard. Equipment should not be operated when the soil is saturated.

The main limitations on sites for dwellings are the wetness, the shrink-swell potential, the slope, and the depth to bedrock. Installing tile drains around footings and foundations minimizes the damage caused by excessive wetness. A suitable outlet for the drainage tile is needed. Adequately reinforcing footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling. Dwellings should be designed so that they conform to the natural slope of the land. The depth to bedrock limits the depth of excavation and the extent to which the site is leveled. Special equipment and construction practices may be needed.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the slow permeability, the wetness, the depth to bedrock, and the slope. The absorption fields can function adequately if they are properly constructed in a mound of moderately rapidly permeable fill material so that they are raised a sufficient distance above the perched seasonal high water table. Land shaping and installing the distribution lines across the slope help to ensure the proper operation of the absorption fields. Holding tanks are an effective alternative to septic tank absorption fields. Sewage generally can be piped to a nearby area where the soils are better suited to onsite waste disposal systems.

The high shrink-swell potential, low strength, frost action, the slope, and the wetness are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by shrinking and swelling and by low strength. A gravel moisture barrier in the subgrade minimizes the damage caused by frost action. Some cutting and filling is necessary to reduce the slope to an acceptable grade for roads and streets, or the roads should be designed so that they conform to the natural slope of the land. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts minimize the damage caused by wetness.

The land capability classification is IVe.

90B—Lenzburg silty clay loam, 1 to 5 percent slopes. This very deep, very gently sloping and gently sloping, well drained soil is on uplands that have been reconstructed. It consists of material that has been excavated and smoothed during surface mining activities. Individual areas are irregular in shape and range from 5 to 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 1 inch, dark gray, firm silty clay loam

Substratum:
1 to 60 inches, variegated light gray to dark yellowish brown clay loam

In places the surface layer is clay loam or is gravelly.

Included with this soil in mapping are barren, gullied, nonvegetated areas, steep escarpments as much as 100 feet high, excavated pits that are commonly filled with water, and a few areas of soils having a very gravelly or extremely gravelly surface layer. In many areas root penetration is limited by surface or subsurface compaction. Inclusions make up about 15 percent of this unit.

Important soil properties—

Permeability: Moderately slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Low
Shrink-swell potential: Moderate

In most areas this soil is used for wildlife habitat. In a few areas it is used as pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by a moderate hazard of erosion and low soil fertility. Fields should be designed so that they do not include escarpments and the steeper areas. The hazard of erosion can be reduced by farming on the contour and by terracing. A conservation tillage system that leaves a protective cover of crop residue on the surface is needed. Because little or no topsoil is in the surface layer of this soil, proper fertilization based on soil test results is particularly important for establishing the stand.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, tall fescue, and switchgrass. No serious limitations affect pasture and hayland, although low soil fertility is a management concern.

The main limitation on sites for dwellings is the shrink-swell potential. Adequately reinforcing the footings and foundations with concrete and backfilling with coarse textured material help to prevent the structural damage caused by shrinking and swelling.

This soil is unsuitable as a site for conventional septic tank absorption fields. It is limited by the moderately slow permeability. The absorption fields can function adequately if they are properly designed and constructed and are increased in size. Properly constructed lagoons function adequately if the site is leveled.

Low strength and frost action are the main limitations affecting local roads and streets. Strengthening the subgrade by adding crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a gravel moisture barrier in the subgrade minimize the damage caused by frost action.

The land capability classification is IIe.

90F—Lenzburg clay loam, 5 to 50 percent slopes. This very deep, moderately sloping to very steep, well drained soil is on uplands that have been reconstructed. It consists of material that has been excavated during surface mining activities. Individual areas are irregular in shape and range from 5 to 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 5 inches, olive yellow, firm clay loam

Substratum:
5 to 60 inches, variegated dark grayish brown to brownish yellow silty clay loam

In places the surface layer is silty clay loam or silty clay or is gravelly.

Included with this soil in mapping are barren, nonvegetated areas, small nearly level areas, excavated pits that are commonly filled with water, a few areas of Armstrong soils, and a few nearly vertical highwalls. Armstrong soils are not reconstructed soil material. They are in landscape positions similar to or higher than those of the Lenzburg soil. Inclusions make up about 15 percent of this unit.

Important soil properties—

Permeability: Moderately slow
Surface runoff: Medium to very rapid
Available water capacity: Moderate
Organic matter content: Low
Shrink-swell potential: Moderate

In most areas this soil is used as wildlife habitat. It is unsuited to cultivated crops. It is limited by an erratic pattern of very steep slopes, low fertility, and the poor physical properties of the soil material in the surface layer. Although this soil is suited to most of the commonly grown grasses and legumes, extreme management practices are needed if the soil is used for grasses and legumes.

This soil generally is not used for building site development because of the slope. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is VIIe.

100—Udorthents, nearly level to strongly sloping. This map unit consists of landfill in the town of Mexico. The single unit of these soils is on uplands and is 90 acres in size.

Udorthents consist of a mixture of clay loam, silty clay loam, and silty clay soil material several feet thick. In most places they contain small pieces of brick, wood, plastic, glass, or concrete.

Active areas of the landfill contain cutbanks, trenches, and piles of soil material. Completed areas have been smoothed and seeded to grass.

This unit is not assigned a land capability classification.

Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cultivated land, pasture, woodland, or other land, but it is not urban or built-up land or water areas. It either is used for food or fiber crops or is available for those crops. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to produce a sustained high yield of crops in an economic manner. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment.

Prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

About 4,539 acres in the survey area, or about 1 percent of the total acreage, meets the soil requirements for prime farmland without additional measures being applied. Most of this acreage is in detailed soil map unit 19B, Marion silt loam, 1 to 5 percent slopes. An additional 331,195 acres, or about 75 percent of the total acreage, is classified as prime farmland in areas where the soil has been drained. Much of this acreage has been drained to some extent by applying such drainage measures as surface ditches, land smoothing, and diversions. This acreage includes areas of Putnam, Mexico, Leonard, Chariton, Gifford, and Twomile soils. Nearly all of the cultivated crops in the county are on this land. Detailed soil map unit 33, Belknap silt loam, is prime farmland in areas protected from flooding and in areas not frequently flooded during the growing season. Most of the 18,595 acres of Belknap silt loam are not protected from flooding, but the unit generally is not flooded during the growing season.

The map units in the survey area that are considered prime farmland are listed in table 5. 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 is shown on the detailed soil maps at the back of this publication. The soil qualities that affect use and management are described under the heading "Detailed Soil Map Units."

Some soils that have a seasonal high water table and a soil that is frequently flooded during the growing season qualify as prime farmland only in areas where these limitations have been overcome by drainage measures or flood control. The need for these measures is indicated after the map unit name in table 5. Onsite evaluation is needed to determine whether or not these limitations have been overcome by corrective measures.

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 to prevent 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 behavioral 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 woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

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

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

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

Crops and Pasture

Terry Hill, district conservationist, Natural Resources Conservation Service, helped prepare this section.

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 Natural Resources 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 the heading "Detailed Soil Map Units." Specific information can be obtained from the local office of the Natural Resources Conservation Service or the Cooperative Extension Service.

Approximately 344,979 acres, or 77.3 percent of the total acreage in the county, is cropland. Another 50,876 acres, or 11.4 percent of the total acreage, is pasture and hayland. Thus, 88.7 percent of the acreage in Audrain County is used for agricultural production *(3)*.

The major crops in the county are soybeans, grain sorghum, winter wheat, and corn. The minor crops include barley and oats. In 1988, soybeans were grown on 147,000 acres, resulting in the fourth highest production rate in the state. Corn was grown on 43,200 acres, sorghum on 36,100 acres, and wheat on 22,000 acres *(9)*. Double cropping of soybeans and wheat is a common practice. Double cropping of barley after soybeans or sorghum after wheat also is practiced. Sorghum is more drought tolerant than the other commonly grown crops and can grow on eroded soils, which commonly have a lower available water capacity because of the higher content of clay in the surface layer. Occasionally, canola or sunflowers are grown.

The potential of the soils in Audrain County for sustained agricultural production is excellent. About 354,329 acres, or 79 percent of the county, is classified as prime farmland, depending on if the soils have been drained or are protected from flooding. Most of the wet soils have been adequately drained by some sort of farming practice, and most of the frequently flooded soils are not flooded during the growing season. About 68 percent of the acreage in the county is made up of highly erodible soils that need conservation practices to control erosion if they are farmed.

Water erosion is the main management concern on much of the sloping cropland and overgrazed pasture in the county. All soils with slopes of more than 2 percent are subject to erosion. When soils are eroded, productivity is reduced because of the loss of all or part of the surface layer and subsequent incorporation of the subsoil into the tillage layer. Loss of the surface layer is especially damaging on soils that have a clayey subsoil, such as Mexico, Leonard, Armstrong, Marion, and Keswick soils. Mixing of the surface layer and the clayey subsoil degrades tilth, reduces productivity, and decreases the amount of water available to plants.

Erosion on most of the cropland can be reduced to within tolerable limits by applying conservation practices designed for specific sites, situations, and soils. These measures help to protect the surface of the soils, reduce the rate of water runoff, and increase the rate of water infiltration.

Conservation tillage helps to control erosion without involving any mechanical construction. A cover of crop residue on the ground for extended periods of time minimizes the impact of raindrops and reduces the rate of runoff, thus reducing the rate of erosion, improving or maintaining productivity, and increasing the rate of water infiltration. Tillage across a slope also minimizes erosion by reducing the speed of water flowing downhill.

Crop rotation also is an effective method of erosion control. It involves alternating pasture and hayland plantings with field crops. Including legumes, such as clover or alfalfa, in the rotation system helps to provide nitrogen for the subsequent crop.

Several mechanical methods of erosion control reduce the rate of water erosion. Each is applied as the situation warrants and is designed for specific sites, fields, and soils.

Terraces reduce the rate of water runoff by shortening the length of slopes. They are often used on slopes of 3 to 5 percent. During terrace construction the surface layer can be stockpiled and spread across the finished terraces. This procedure is particularly important on gently sloping or moderately sloping, erodible soils. To ensure continued effectiveness, the condition of the terraces must be maintained.

Grassed waterways reduce the concentrated flow of water, thus reducing the formation of gullies. They are often used as an outlet for terraces. Underground tile outlets are used for this purpose at sites where waterways are not appropriate, such as on overly steep slopes.

Diversions also can be effective in controlling erosion. They redirect excess water runoff from sloping areas that are higher on the landscape away from cropped fields. Excessive runoff from upslope areas can cause siltation problems in diversions and render them useless. For this reason, diversions are used in areas below pasture and hayland.

Sediment retention basins are used in areas where gully erosion is a problem. Rolling, dissected areas of the moderately sloping Armstrong and Keswick soils may need these basins to help control gully erosion.

Currently, nearly 25,000 acres in Audrain County is irrigated (fig. 8). Records kept by the Extension Service for a period of 16 years indicate an average increase of 13 bushels per acre in yields for irrigated soybeans over dryland soybeans and an increase of more than 50 bushels per acre for irrigated corn over dryland corn. The irrigation water is primarily obtained from reservoirs. A small amount is from deep wells. Irrigation provides supplemental water during critical periods of crop growth. Most of the irrigation systems, which were installed in the early 1970's, are center-pivot sprinkler systems. The expansion of current systems is more common than new construction. Irrigation is most commonly applied in areas where corn is grown and in areas double cropped with soybeans and wheat.

Soil drainage is a management concern on several of the soils in the county. Belknap, Putnam, Chariton, and Twomile soils have a seasonal high water table that may interfere with plant growth or cultivation. These soils are in nearly level areas. When they receive excess water, they tend to remain wet for long periods. Also, flooding occurs frequently in areas of the Belknap soils and occasionally in areas of the Twomile soils. It generally occurs during the period November to May.

Soil fertility is lower in most of the eroded soils in the county than in other soils. The addition of plant nutrients is necessary for the sustained productivity of all commercially cropped soils in the county. Most of the soils in the county are naturally acid in the upper part of the root zone. Applications of ground limestone are needed to raise the pH and calcium levels sufficiently for optimum plant growth. On all soils, additions of lime and fertilizer should be based on the results of soil tests, on the needs of the crop, and on the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to be applied.

Soil tilth is an important factor affecting the germination of seeds and the infiltration of water into the soil. Soils with good tilth are granular and porous. Most of the uneroded upland soils that are used for crops have a surface layer of silt loam or silty clay loam. All of the eroded soils a higher content of clay in the surface layer than the uneroded soils. Tillage and compaction generally weaken the structure of the soil. During periods of heavy rainfall, a crust forms on the surface. The crust is hard when dry. As a result, it reduces the rate of water infiltration and increases the

Figure 8.—Irrigated corn in an area of Mexico silt loam, 1 to 3 percent slopes.

runoff rate. Also, the ease of tillage is reduced. Regular additions of crop residue, manure, or other organic material improve soil structure and tilth.

Fall tillage is common in the county but generally is a poor conservation practice on upland soils. Most of the cropland in the uplands consists of sloping soils that are subject to erosion if they are plowed in the fall.

The pasture plants and hay crops suited to the soils and climate of the county include several legumes, cool-season grasses, and native warm-season grasses. Red clover and alfalfa are common legumes grown for hay. Fescue and orchardgrass are commonly grown for hay and pasture. Brome, timothy, and redtop are grown to a lesser extent. Orchardgrass is used in a mixture of red clover or alfalfa for hay. Big bluestem and indiangrass are the typical warm-season grasses grown in the county. Warm-season grasses are often reestablished naturally along roadsides and in formerly cropped fields. Generally, moderately sloping areas of Armstrong and Keswick soils are used for pasture, whereas other soils that are nearly level to gently sloping are primarily used for field crops.

The major concerns in managing pasture are overgrazing and erosion. A controlled grazing system helps to ensure maximum forage production. Keeping the grasses at a desirable height reduces the runoff rate and helps to control erosion. Alfalfa and other species that are sensitive to wetness are not suited to poorly drained soils, such as Putnam, Leonard, and Chariton soils. Species that can tolerate the wetness should be selected for planting on these soils. Suitable species include ladino clover, alsike clover, birdsfoot trefoil, switchgrass, and reed canarygrass. The seasonal high water table is a management concern on these poorly drained soils. Equipment should not be operated when the soil is wet. Grazing when the soil is wet can damage the plants. A properly designed rotation grazing system helps to overcome this concern.

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 6. 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 land capability classification also is shown in the table.

The yields are based on an agricultural productivity index that has been developed for soils in Missouri *(13)*. This index ranks the potential productivity of the soils in the state based on nutrient-supplying power, depth of root penetration, natural soil drainage, soil texture, flooding and ponding, and slope and erosion. A reference soil, Putnam silt loam, was used to relate the productivity index to average yields in Audrain County. Long-term records of farmers, conservationists, and extension agents were used to estimate the average yields on Putnam silt loam. Yields on other map units were calculated from the ratio of their productivity indexes to that of Putnam silt loam.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures 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 6 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 Natural Resources 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 the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include 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 woodland or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit *(18)*. Only class and subclass are used in this survey.

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

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

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

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

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

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c* to the class numeral, for example, IIe. The letter *e* shows that the main hazard is the 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. There are no class I, V, or class VIII soils in Audrain County.

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, woodland, wildlife habitat, or recreation.

The capability classification of the map units is given in the section "Detailed Soil Map Units" and in the yields table.

Woodland Management and Productivity

Douglas C. Wallace, forester, Natural Resources Conservation Service, helped prepare this section.

The presettlement vegetation in most of Audrain County was tallgrass prairie or a transitional area of prairie and woodland. The native woodland grew along the lower slopes in protected draws along the major creeks and rivers in the county *(16)*. Currently, about 6.4 percent of the county, or 28,251 acres, is wooded *(6)*. Much of this acreage is used as wooded pasture. Some tracts of forest land are used for timber production. Most of the forested areas are capable of timber production if they are properly managed.

Several factors restricted the development of woodland. Wildfires frequently burned the broad prairie expanses. This frequent burning was conducive to the growth of grassland. Also, the county includes a vast acreage of soils that have a clayey subsoil and a seasonal high water table. These characteristics reduce the uptake of air by roots, thus limiting tree growth. The soils are the Putnam, Mexico, and Leonard soils. Trees tended to grow along the lower slopes where the fires were less intense or did not occur.

Some woodland currently exists in what was, at one time, the transitional area between prairie and woodland in the county. In presettlement times, Armstrong soils supported savanna vegetation of widely spaced trees with an understory of grasses and shrubs. After the settlers began controlling wildfires, these sites converted to woodland. White oak, northern red oak, bur oak, pin oak, white ash, black cherry, hawthorn, and eastern redcedar occur in areas of Armstrong soils *(22)*.

Areas of Leonard and Mexico soils, which formed under prairie vegetation, now support small acreages of woodland because the wildfires were controlled by the settlers. These poorly drained and somewhat poorly drained soils support species that can tolerate the wetness. The species include pin oak, hackberry, and green ash *(22)*.

Belknap, Twomile, Keswick, Winnegan, Marion, and Goss soils formed under forest vegetation. Most areas of the Twomile and Marion soils and the moderately sloping areas of the Keswick and Winnegan soils have been cleared for agricultural production, although significant forested tracts still remain in areas of these soils. Most of the timber in the county presently grows in areas of the Belknap, Goss, and Winnegan soils and in the strongly sloping areas of the Keswick soils. White oak, post oak, black oak, white ash, northern red oak, sugar maple, shingle oak, shagbark hickory, and mockernut hickory are the primary overstory species that grow on these soils. Hazel, eastern hophornbeam, American plum, smooth sumac, downy serviceberry, hawthorn, prairie crabapple, dogwood, and slippery elm are the common understory species *(17)*. The oak is marketable as grade lumber and pallet lumber. High-quality white oak is cut for veneer lumber. Some differences in forest composition between sites may be attributed to the soil type. For example, Goss soils have a low available water capacity and woodland sites in areas of these soils may be drier than on other soils, although forest productivity is high.

Belknap and Twomile soils are on nearly level flood plains along the streams in the county. Belknap soils, which are on low flood plains, support black willow, eastern cottonwood, river birch, American elm, slippery elm, American sycamore, and green ash (fig. 9). Twomile soils, which are on high flood plains, support black walnut, pin oak, hackberry, honeylocust, sugar maple, silver maple, Ohio buckeye, and bur oak. The understory species on these two soils include pawpaw, eastern wahoo, buttonbush, elderberry, buckbrush, grapevine, gooseberry, and greenbrier *(17)*. Pin oak, maple, and sycamore are used for grade lumber and pallet lumber. High-quality walnut is milled for grade lumber and veneer lumber.

Intensive woodland management in Audrain County is of minor extent. Nonetheless, all woodland soils in the county can benefit from woodland management. Forest productivity can be improved by applying various management practices, such as thinning young stands, harvesting overly mature trees, and controlling fire and grazing.

Many forested areas are managed as woodland pasture to provide shade and protection for livestock. Pasturing can limit or eliminate desirable species within a wooded area. Tree roots can be damaged or destroyed by grazing. As a result, many trees die, including desirable marketable species. Grazing also results in soil compaction, which in turn increases the rate of water runoff and accelerates the rate of erosion.

Figure 9.—Hardwood forest in an area of Belknap silt loam.

Proper woodland management is needed in the forested areas of the county. Erosion is a moderate hazard during timber harvest in areas of the Winnegan and Goss soils. It can be reduced by locating skid trails across the slope, establishing water-breaks on skid trails and logging roads, and locating log landings so that the distance the logs are skidded is minimized. The operation of equipment is limited in areas of the Winnegan and Goss soils that have slopes of more than 15 percent. It is also limited in areas of the Marion, Belknap, and Twomile soils, which have a high water table from November through May. Heavy machinery should not be operated when the soil is saturated. The species selected for planting may also be limited in areas of the Marion, Belknap, and Twomile soils because of the seasonal high water table. Species that can tolerate the wetness are the most productive.

White oak, black oak, and northern red oak are the primary oak species managed for lumber production. They grow on well drained and moderately well drained, very deep and deep upland soils, such as Keswick, Winnegan, and Goss soils. Black walnut grows best on very deep, moderately well drained or well drained alluvial soils. These soils are along the major creeks and rivers in the county. Onsite investigation is necessary to locate these sites. Currently, four mills in the county process pallet, grade, and veneer lumber.

The woodland in the county can also be managed for additional uses. It can be cut for fuel wood that is used locally. Firewood species, such as low-grade oaks, locust, and hickories, are in areas of woodland and along fence rows. The woodland also provides habitat for wildlife, thus enhancing both game and nongame populations of wildlife. Trees provide streambank stabilization and help to protect areas of Belknap soils from scour during flooding. The woodland in the strongly sloping areas of the Keswick and Winnegan soils helps to prevent the erosion that could occur if these sites were cleared for agricultural use. The steep Winnegan and Goss soils are unsuited to agricultural use and should be maintained as woodland. Trees also are effective as field windbreaks. Historically, Osage-orange was planted extensively for this purpose. Many of these remaining hedges need rehabilitation through both top and root pruning.

The potential exists for Christmas tree plantations and for fruit and nut orchards in Audrain County. When a potential site for planting is evaluated, consideration should be given to the type of soils present; adequacy of surface drainage; accessibility of available water, either through the soil or by irrigation; and the species selected for planting.

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

The first part of the *ordination symbol*, a number, indicates the potential productivity of the soils for an indicator tree species. The number indicates the volume, in cubic meters per hectare per year, which the indicator species can produce. The number 1 indicates low potential productivity; 2 and 3, moderate; 4 and 5, moderately high; 6 to 8, high; 9 to 11, very high; and 12 to 39, extremely high. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *R* indicates steep slopes; *X*, stoniness or rockiness; *W*, excess water in or on the soil; *T*, toxic substances in the soil; *D*, restricted rooting depth; *C*, clay in the upper part of the soil; *S*, sandy texture; *F*, a high content of rock fragments in the soil; and *N*, snow pack. The letter *A* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: R, X, W, T, D, C, S, F, and N.

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

Erosion hazard is the probability that damage will occur as a result of site preparation and cutting where the soil is exposed along roads, skid trails, and fire lanes and in log-handling areas. Forests that have been burned or overgrazed also are subject to erosion. Ratings of the erosion hazard are based on the percent of the slope. A rating of *slight* indicates that no particular prevention measures are needed under ordinary conditions. A rating of *moderate* indicates that erosion-control measures are needed in certain silvicultural activities. A rating of *severe* indicates that special precautions are needed to control erosion in most silvicultural activities.

Equipment limitation reflects the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. The chief characteristics and conditions considered in the ratings are slope, stones on the surface, rock outcrops, soil wetness, and texture of the surface layer. A rating of *slight* indicates that under normal conditions the kind of equipment and season of use are not significantly restricted by soil factors. Soil wetness can restrict equipment use, but the wet period does not exceed 1 month. A rating of *moderate* indicates that equipment use is moderately restricted because of one or more soil factors. If the soil is wet, the wetness restricts equipment use for a period of 1 to 3 months. A rating of *severe* indicates that equipment use is severely restricted either as to the kind of equipment that can be used or the season of use. If the soil is wet, the wetness restricts equipment use for more than 3 months.

Seedling mortality refers to the death of naturally occurring or planted tree seedlings, as influenced by the kinds of soil, soil wetness, or topographic conditions. The factors used in rating the soils for seedling mortality are texture of the surface layer, depth to a seasonal high water table and the length of the period when the water table is high, rock fragments in the surface layer, effective rooting depth, and slope aspect. A rating of *slight* indicates that seedling mortality is not likely to be a problem under normal conditions. Expected mortality is less than 25 percent. A rating of *moderate* indicates that some problems from seedling mortality can be expected. Extra precautions are advisable. Expected mortality is 25 to 50 percent. A rating of *severe* indicates that seedling mortality is a serious problem. Extra precautions are important. Replanting may be necessary. Expected mortality is more than 50 percent.

Windthrow hazard is the likelihood that trees will be uprooted by the wind because the soil is not deep enough for adequate root anchorage. The main restrictions that affect rooting are a seasonal high water table and the depth to bedrock, a fragipan, or other limiting layers. A rating of *slight* indicates that under normal conditions no trees are blown down by the wind. Strong winds may damage trees, but they do not uproot them. A rating of *moderate* indicates that some trees can be blown down during periods when the soil is wet and winds are moderate or strong. A rating of *severe* indicates that many trees can be blown down during these periods.

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

The *volume*, a number, is the yield likely to be produced by the most important trees. This number, expressed as cubic feet per acre per year, indicates the amount of fiber produced in a fully stocked, even-aged, unmanaged stand.

The first species listed under *common trees* for a soil is the indicator species for that soil. It generally is the most common species on the soil and is the one that determines the ordination class.

Trees to plant are those that are suitable for commercial wood production.

Windbreaks and Environmental Plantings

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

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

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

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

Recreation

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

In table 9, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 9 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils are gently sloping 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

Bill White, wildlife services biologist, Missouri Department of Conservation, helped prepare this section.

Audrain County lies in the heart of the old Grand Prairie area. Prior to settlement, about 75 percent of the county was prairie *(16)*. Wetland prairie dominated the Putnam soils, which pooled water during the spring and late fall. The prairie on the ridges and side slopes was dominated by tall grasses, such as big bluestem and indiangrass. The soils in these areas were the Armstrong, Leonard, and Mexico soils. Woodland was along the flood plains in areas of the Belknap and Twomile soils. This intricate pattern of prairie, wetlands, and woodland was a major factor in the abundance of wildlife species during the presettlement period in Audrain County.

Nearly all of the naturally occurring wetland and tall grass prairie in the county has been converted to cropland or pasture that is dominated by introduced grasses. A few small remnants of the wetland and tall grass prairie remain along railroad right-of-ways, field borders, and roadsides. By the 1970's, much of the acreage of the nearly level Putnam soils had been drained when the roadside ditches were deepened. The extent of the woodland increased. Woodland is now along most drainageways. The extent of habitat along brushy fence rows increased until the 1970's but is being reduced at a steady rate.

The most common presettlement wildlife species include buffalo, elk, prairie chicken, passenger pigeon, and upland plover. The destruction of the tall grass prairie habitat eliminated most of these species; however, small flocks of prairie chicken are in the county. Other species that have adapted to the changing land uses include deer, wild turkey, bobwhite quail, and coyotes.

As of 1988, about 295 fish and wildlife species were known to be or likely to be in the county *(11)*. Of these, 15 species were rare or endangered. They included the prairie chicken, northern harrier, western fox snake, sharp-shinned hawk, and American bittern.

Hunting and trapping are important recreational activities in the county. The most important game species are bobwhite quail, white-tailed deer, and turkey. In recent years turkey and deer harvests have been increasing in the county as in the rest of Missouri.

Audrain County is in the Mississippi flyway and was visited by an enormous number of migrating waterfowl and shorebirds prior to cultivation of the Putnam soils in the wetland prairie. At present the county is of minor importance to migrating waterfowl, which use mostly farm ponds and irrigation lakes.

Four public use areas are primarily managed for fish and wildlife habitat. The Robert M. White Wildlife Area, which includes a mix of woodland, cropland, and grassland, provides excellent hunting on more than 1,000 acres. The Vandalia Community Lake is the largest public lake in the county. The C.L. Northcutt Memorial Wildlife Area and the Jacks Tract provide hunting opportunities in the uplands, as well as wildlife viewing.

Sport fishermen visit the Salt and Cuivre Rivers and some secondary streams in pursuit of carp and channel catfish. Game fish, including largemouth bass, bluegill, crappie, catfish, and sunfish, are in area lakes and ponds and in the higher quality streams.

The only recent wildlife restoration efforts in this county have centered on the giant Canada goose. Relocation of young birds to the Vandalia Community Lake occurred in 1988 and 1989. Relocation of young birds in adjacent counties since 1978 has resulted in geese also using private ponds and lakes in Audrain County *(10)*. The release of river otter in portions of the Cuivre and Salt River drainageways outside of Audrain County may ultimately influence the county. River otter are transient and travel great distances. As a result, they may become established in Audrain County. Riparian zones, as well as wetlands, adjacent to these major drainageways provide important habitat for the river otter. The population of prairie chicken in the area cannot be increased successfully without improving habitat conditions. Because of the small amount of public land in the county, this habitat improvement is needed on private land.

Many game species respond favorably to habitat development and management. Quail have adapted to intensive agricultural land use and to conservation cropping systems. In particular, conservation tillage systems, grassed waterways, and field borders provide important winter food and nesting cover. Planting grasses, other than fescue, helps to ensure optimum benefits to wildlife. Maintaining trees and brush along fields and ditches and in idle areas helps to provide winter cover. Many of these wildlife areas also can be used as field windbreaks. Prairie chickens respond to pasture rotations that include warm-season grasses and legumes. Planting legumes or grass-legume mixtures and applying a conservation tillage system in areas that have been set aside will also benefit prairie chickens. Deer and turkey do well in ungrazed woodland that supports mature oak trees. Maintaining forested buffer strips along streams helps to stabilize streambanks and provide valuable cover for wildlife. Beaver, muskrat, and raccoon are harvested from the various drainageways. They benefit from stream corridor improvement practices. Most nongame species will benefit from habitat improvements made for quail, deer, and turkey.

The recently renewed emphasis on reducing the hazard of erosion and preserving wetland may improve wildlife habitat in the county. These improvements will ultimately result in an increase in the population of the wildlife species that have adapted to the present day land uses in this area.

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

In table 10, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

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

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

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

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flooding. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of these plants are oak, cherry, apple, hawthorn, dogwood, hickory, and blackberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

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

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

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

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

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

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

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

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. Ratings are given for 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 should 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 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, the shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

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

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

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

Building Site Development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, 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, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and depth to the water table.

Dwellings and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrinking and swelling, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, slope, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 or 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 or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic-supporting capacity.

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, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials 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.

Sanitary Facilities

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

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

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

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to 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 12 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage resulting from rapid permeability in the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans 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 should be considered.

The ratings in table 12 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench 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 sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

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

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

Construction Materials

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

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

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

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

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

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

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

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

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

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

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

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

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

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

Water Management

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

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

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

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

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

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

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

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

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

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

Soil Properties

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

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

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 to characterize key soils.

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

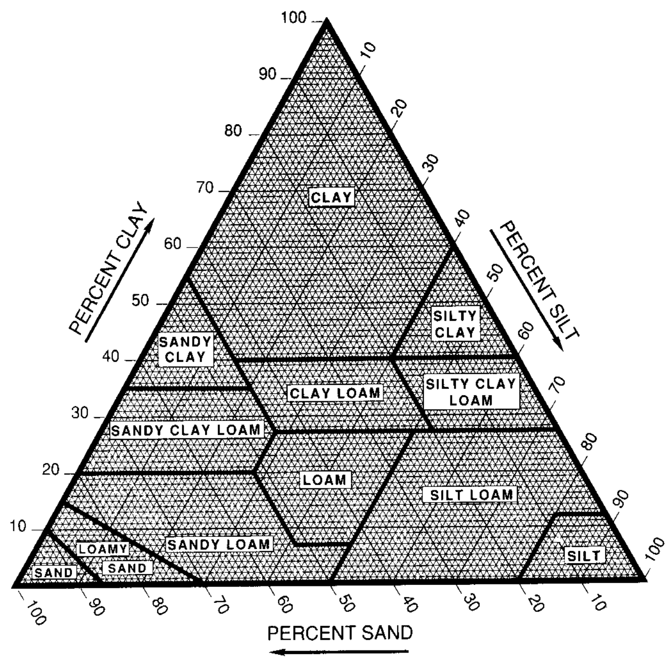

Figure 10.—Percentages of clay, silt, and sand in the basic USDA soil textural classes.

Engineering Index Properties

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

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under the heading "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 (fig. 10). "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 about 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, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

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

Rock fragments greater than 10 inches in diameter and 3 to 10 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 generally 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 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

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

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, 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 ⅓-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 and septic tank absorption fields.

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 classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

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

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

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

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

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

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

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are erodible. Crops can be grown if intensive measures to control soil blowing are used.

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

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control soil blowing are used.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

8. Soils that are not subject to soil blowing because of coarse fragments on the surface or because of surface wetness.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 16, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

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

Soil and Water Features

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

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration 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.

If a soil is assigned to two hydrologic groups in table 17, the first letter is for drained areas and the second is for undrained areas.

Flooding, the temporary inundation of an area, is caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

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

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); and *frequent* that it occurs often under normal weather conditions (the chance of flooding is more than 50 percent in any year). Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 days to 1 month, and *very long* if more than 1 month. Probable dates are expressed in months. About two-thirds to three-fourths of all flooding occurs during the stated period.

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 little or no horizon development.

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.

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

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

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

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

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 results in a severe hazard of corrosion. 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 *(19)*. 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 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Eleven 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 Alfisol.

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 Aqualf (*Aqu*, meaning water, plus *alf*, from Alfisol).

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 Ochraqualfs (*Ochr*, for ochric epipedon, meaning thin surface layer, plus *aqualf*, the suborder of the Alfisols that has an aquic 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 *Udollic* identifies the subgroup that is transitional to better drained soils having a thick, dark surface layer. An example is Udollic Ochraqualfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, 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, montmorillonitic, mesic Udollic Ochraqualfs.

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 Mexico series.

Soil Series and Their Morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. 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" *(21)*. Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" *(19)*. Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

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

Armstrong Series

The Armstrong series consists of very deep, moderately well drained, slowly permeable soils on uplands that were originally covered by a mixture of trees and grasses. These soils formed in a thin layer of pedisediments and in the underlying paleosol, which weathered from glacial till. Slopes range from 4 to 9 percent.

Typical pedon of Armstrong loam, 4 to 9 percent slopes, eroded, 2,400 feet east and 600 feet south of the northwest corner of sec. 31, T. 52 N., R. 8 W.

Ap—0 to 4 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine granular structure; very friable; many fine roots; about 1 percent gravel; moderately acid (pH 5.6); abrupt smooth boundary.

BE—4 to 7 inches; dark brown (10YR 4/3) clay loam; weak very fine subangular blocky structure; friable; many very fine roots; about 1 percent gravel; very strongly acid (pH 5.0); clear smooth boundary.

2Bt1—7 to 11 inches; dark brown (10YR 4/3) clay loam; few fine prominent yellowish red (5YR 5/6) and few fine distinct dark brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; friable; common very fine roots; few faint clay films on faces of peds; about 1 percent gravel; very strongly acid (pH 5.0); clear smooth boundary.

2Bt2—11 to 20 inches; yellowish brown (10YR 5/4) clay; common fine prominent yellowish red (5YR 4/6), few fine prominent grayish brown (2.5Y 5/2), and few fine faint yellowish brown (10YR 5/6) mottles; strong very fine subangular blocky structure; firm; common very fine roots between peds; common distinct clay films on faces of peds; about 1 percent gravel; strongly acid (pH 5.1); clear smooth boundary.

2Bt3—20 to 28 inches; dark brown (10YR 4/3) clay; few fine distinct gray (10YR 5/1) and common fine prominent yellowish brown (10YR 5/8) mottles; common yellowish red (5YR 5/6) mottles near the upper boundary; strong very fine subangular blocky structure; firm; common very fine roots between peds; common distinct clay films on faces of peds; about 3 percent gravel; strongly acid (pH 5.2); clear smooth boundary.

2Bt4—28 to 46 inches; grayish brown (10YR 5/2) and yellowish brown (10YR 5/8) clay loam; common fine prominent brownish yellow (10YR 6/8) mottles; moderate very fine subangular blocky structure; firm; few very fine roots between peds; few faint clay films on faces of peds; few stains of iron and manganese oxide on faces of peds; about 3 percent gravel; moderately acid (pH 6.0); clear smooth boundary.

2Bt5—46 to 60 inches; light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) clay loam; moderate medium subangular blocky structure; firm; few distinct clay films; many stains and fine rounded concretions of iron and manganese oxide; about 3 percent gravel; neutral (pH 7.3).

The A horizon is loam or clay loam. It has chroma of 1 or 2. The Bt horizon dominantly has hue of 10YR, but the hue ranges from 2.5Y to 7.5YR. This horizon has chroma of 2 to 8.

Armstrong clay loam, 5 to 9 percent slopes, severely eroded, does not have the dark surface layer that is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

Belknap Series

The Belknap series consists of very deep, somewhat poorly drained, moderately permeable soils on narrow flood plains. These soils formed in alluvium. Slope is 0 to 1 percent.

Typical pedon of Belknap silt loam, 300 feet west and 2,400 feet south of the northeast corner of sec. 10, T. 52 N., R. 10 W.

Ap—0 to 5 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak fine subangular blocky structure; friable; many fine and very fine roots; moderately acid (pH 6.0); clear smooth boundary.

A—5 to 11 inches; dark grayish brown (10YR 4/2) silt loam; common fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; friable; common very fine roots; strongly acid (pH 5.2); clear smooth boundary.

Cg1—11 to 17 inches; dark grayish brown (10YR 4/2) silt loam; few fine distinct brown (7.5YR 4/4) mottles; massive; friable; common very fine roots; strongly acid (pH 5.4); clear smooth boundary.

Cg2—17 to 24 inches; grayish brown (10YR 5/2) silt loam; common fine faint brown (10YR 5/3), common fine distinct yellowish brown (10YR 5/6), and few fine faint light brownish gray (10YR 6/2) mottles; massive; few very fine roots; strongly acid (pH 5.4); clear smooth boundary.

Cg3—24 to 36 inches; light brownish gray (10YR 6/2) silt loam; many medium faint brown (10YR 5/3) and few fine distinct brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; very strongly acid (pH 4.8); clear smooth boundary.

Cg4—36 to 49 inches; light brownish gray (10YR 6/2) silt loam; common medium faint brown (10YR 5/3) and common fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; very strongly acid (pH 4.8); gradual smooth boundary.

Cg5—49 to 60 inches; gray (10YR 5/1) silt loam; common medium distinct brown (7.5YR 4/4) mottles; massive; friable; very strongly acid (pH 4.8).

The Ap horizon has value of 4 or 5 and chroma of 2 or 3. The C horizon has chroma of 1 to 3. Some pedons have thin strata of loam or silty clay loam below a depth of 40 inches.

Chariton Series

The Chariton series consists of very deep, poorly drained, slowly permeable soils on high stream terraces. These soils formed in loess and in the underlying alluvium. Slope is 0 to 2 percent.

These soils have an A horizon that has higher value when dry than is definitive for the Chariton series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Chariton silt loam, 2,645 feet south and 1,340 feet east of the northwest corner of sec. 36, T. 51 N., R. 5 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; weak very fine granular structure; friable; common fine roots; strongly acid (pH 5.5); abrupt smooth boundary.

E—9 to 16 inches; dark grayish brown (10YR 4/2) silt loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak very fine subangular blocky structure; friable; few fine roots; few concretions of iron and manganese oxide; strongly acid (pH 5.1); clear smooth boundary.

Btg1—16 to 30 inches; dark grayish brown (10YR 4/2) silty clay; few fine prominent dark red (2.5YR 3/6) and common fine distinct yellowish brown (10YR 5/4) mottles; weak very fine subangular blocky structure; firm; few fine roots; few stains and concretions of iron and manganese oxide; common distinct clay films on faces of peds; strongly acid (pH 5.3); clear smooth boundary.

Btg2—30 to 46 inches; gray (10YR 5/1) silty clay; few fine prominent yellowish brown (10YR 5/6) and dark red (2.5YR 3/6) mottles; weak very fine subangular blocky structure; firm; few fine roots; few stains and concretions of iron and manganese oxide; few faint clay films on faces of peds; slightly acid (pH 6.1); clear smooth boundary.

2BCg—46 to 60 inches; dark gray (10YR 4/1) and gray (10YR 5/1) silty clay loam; few fine prominent reddish brown (5YR 4/4) and yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; few very fine roots; few stains and concretions of iron and manganese oxide; common sand grains; neutral (pH 7.1).

The Ap horizon has chroma of 1 or 2. The E horizon has value of 4 or 5 and chroma of 1 or 2. The Btg horizon dominantly has hue of 10YR, but the range includes 2.5Y. This horizon has value of 4 or 5 and chroma of 1 or 2. It is silty clay or silty clay loam. Some pedons are clay loam in the lower part.

Gifford Series

The Gifford series consists of very deep, poorly drained, very slowly permeable soils on high stream terraces. These soils formed in loess and in the underlying alluvium. Slopes range from 1 to 4 percent.

Typical pedon of Gifford silt loam, 1 to 4 percent slopes, 200 feet east and 500 feet south of the northwest corner of sec. 3, T. 50 N., R. 10 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; many very fine roots; neutral (pH 7.3); abrupt smooth boundary.

BE—7 to 10 inches; dark grayish brown (10YR 4/2) silty clay loam; common fine pockets of very dark grayish brown (10YR 3/2) material from the Ap horizon; few fine prominent strong brown (7.5YR 4/6) mottles; weak very fine subangular blocky structure; friable; common very fine roots; few faint clay films on faces of peds; common fine concretions and stains of iron and manganese oxide; slightly acid (pH 6.2); clear smooth boundary.

Btg1—10 to 18 inches; dark grayish brown (10YR 4/2) silty clay; common fine prominent strong brown (7.5YR 4/6) and few fine prominent yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm; few very fine roots; common faint and distinct clay films on faces of peds; common fine concretions and stains of iron and manganese oxide; strongly acid (pH 5.3); clear smooth boundary.

Btg2—18 to 27 inches; grayish brown (2.5Y 5/2) silty clay; common fine prominent yellowish brown (10YR 5/6) and few fine prominent strong brown (7.5YR 4/6) mottles; moderate medium subangular blocky structure; firm; few very fine roots; common faint clay films on faces of peds; few slickensides; many fine concretions and stains of iron and manganese oxide; strongly acid (pH 5.4); clear smooth boundary.

Btg3—27 to 32 inches; grayish brown (2.5Y 5/2) silty clay loam; few fine prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 4/6) mottles; moderate fine subangular blocky structure; friable;

few very fine roots; common faint clay films on faces of peds; common fine stains of iron and manganese oxide; slightly acid (pH 6.1); gradual smooth boundary.

Btg4—32 to 45 inches; dark gray (10YR 4/1) silty clay loam; common medium prominent strong brown (7.5YR 4/6) and few fine prominent strong brown (7.5YR 5/8) and yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; few very fine roots; common faint clay films on faces of peds; common fine concretions and stains of iron and manganese oxide; neutral (pH 6.8); clear smooth boundary.

2Btg5—45 to 60 inches; dark gray (10YR 4/1) silt loam; common fine distinct dark yellowish brown (10YR 4/4) and few fine prominent strong brown (7.5YR 4/6) and yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; friable; few very fine roots; common faint clay films on faces of peds; common fine concretions and stains of iron and manganese oxide; few sand grains; neutral (pH 6.7).

These soils generally have deep, wide cracks during the dry summer months. The Ap horizon has chroma of 1 or 2. The Btg horizon dominantly has hue of 10YR, but the range includes 2.5Y. This horizon has value of 4 or 5 and chroma of 1 or 2. It is silty clay or silty clay loam in the lower part. The 2Btg horizon has value of 4 or 5. It is silt loam, silty clay loam, loam, or clay loam.

Goss Series

The Goss series consists of very deep, well drained, moderately permeable, cobbly soils on uplands. These soils formed in material weathered from cherty limestone, cherty dolomite, and some interbedded shale. Slopes range from 14 to 30 percent.

Typical pedon of Goss cobbly silt loam, 14 to 30 percent slopes, 925 feet east and 275 feet north of the southwest corner of sec. 35, T. 53 N., R. 9 W.

A—0 to 5 inches; very dark grayish brown (10YR 3/2) cobbly silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; many fine and very fine and few very coarse and medium roots; 20 percent chert cobbles and 10 percent chert gravel; slightly acid (pH 6.1); gradual smooth boundary.

E—5 to 11 inches; dark brown (10YR 4/3) very cobbly silt loam; moderate very fine granular structure; friable; many fine and very fine and few medium roots; about 40 percent chert cobbles and 20 percent chert gravel; moderately acid (pH 6.0); abrupt wavy boundary.

BE—11 to 20 inches; dark brown (7.5YR 4/4) very cobbly silt loam; moderate fine subangular blocky structure; friable; many fine and few very coarse roots; many fine silt coatings; about 40 percent chert cobbles and 20 percent chert gravel; moderately acid (pH 6.0); abrupt wavy boundary.

Bt1—20 to 44 inches; yellowish red (5YR 4/6) very cobbly clay; strong fine subangular blocky structure; firm; few fine, medium, and very coarse roots; common prominent clay films on faces of peds; few stains of iron and manganese oxide; about 20 percent chert cobbles and 20 percent chert gravel; very strongly acid (pH 5.0); gradual wavy boundary.

Bt2—44 to 60 inches; strong brown (7.5YR 5/6) very cobbly clay; moderate coarse subangular blocky structure; firm; few very fine roots; common distinct clay films on faces of peds; many concretions of iron and manganese oxide; many stains of iron and manganese oxide on faces of peds and in pores; common brown (10YR 5/3) slickensides; about 30 percent chert cobbles and 20 percent chert gravel; neutral (pH 6.8).

The A horizon has chroma of 1 or 2. The E horizon has value of 4 or 5 and a chroma of 3 or 4. It is cobbly to extremely cobbly. Some pedons have an AE horizon. The Bt horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 4 to 8. It is the very cobbly to extremely cobbly analogs of silty clay loam, silty clay, or clay.

Jemerson Series

The Jemerson series consists of very deep, well drained, moderately permeable soils on low stream terraces. These soils formed in loess and alluvium. Slopes range from 1 to 3 percent.

Typical pedon of Jemerson silt loam, 1 to 3 percent slopes, 750 feet west and 2,000 feet south of the northeast corner of sec. 5, T. 52 N., R. 9 W.

Ap—0 to 6 inches; dark brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak fine subangular blocky structure; common fine roots; neutral (pH 7.3); abrupt smooth boundary.

E—6 to 14 inches; dark brown (10YR 4/3) silt loam; weak fine subangular blocky structure; friable; common fine roots; neutral (pH 6.7); clear smooth boundary.

Bt1—14 to 27 inches; dark brown (7.5YR 4/4) silty clay loam; common fine distinct brown (10YR 5/3) mottles; moderate fine subangular blocky structure; firm; few fine roots; many faint grayish brown (10YR 5/2) silt coatings; common faint clay films on faces of peds; moderately acid (pH 5.8); clear smooth boundary.

Bt2—27 to 40 inches; dark brown (7.5YR 4/4) silty clay loam; common fine distinct pale brown (10YR 6/3) mottles; moderate fine subangular blocky structure; firm; many faint clay films on faces of peds; common fine concretions of iron and manganese oxide; strongly acid (pH 5.2); gradual smooth boundary.

2Bt3—40 to 60 inches; dark brown (7.5YR 4/4) silt loam; common medium prominent gray (10YR 5/1) mottles; moderate fine subangular blocky structure; firm; few very fine roots; few faint clay films on faces of peds; common fine concretions and stains of iron and manganese oxide; common sand grains; strongly acid (pH 5.2); clear smooth boundary.

The Ap horizon has chroma of 2 or 3. The Bt horizon has chroma of 3 to 5. It is silt loam or silty clay loam in the upper part and silt loam, silty clay loam, or loam in the lower part. Some pedons have a C horizon below a depth of 40 inches. The content of gravel ranges from 0 to 3 percent in the lower part of the B horizon and in the C horizon.

Keswick Series

The Keswick series consists of very deep, moderately well drained, slowly permeable soils. These soils are on uplands that were originally forested. They formed in a thin layer of loess and in the underlying paleosol, which weathered from glacial till. Slopes range from 5 to 14 percent.

Typical pedon of Keswick silt loam, 5 to 9 percent slopes, eroded, 1,850 feet south and 50 feet east of the northwest corner of sec. 10, T. 50 N., R. 10 W.

A—0 to 2 inches; dark brown (10YR 3/3) silt loam, pale brown (10YR 6/3) dry; moderate very fine granular structure; friable; few fine and common very fine roots; very strongly acid (pH 5.0); abrupt smooth boundary.

E—2 to 7 inches; dark brown (10YR 4/3) silt loam; common fine prominent strong brown (7.5YR 5/6) and few fine prominent red (2.5YR 4/6) mottles; weak medium platy structure parting to weak very fine subangular blocky; friable; common fine and many very fine roots; strongly acid (pH 5.2); clear smooth boundary.

2Bt1—7 to 15 inches; dark yellowish brown (10YR 4/4) clay loam; many fine prominent red (2.5YR 4/6) mottles; strong fine and very fine subangular blocky structure; firm; common very fine roots; common distinct clay films on faces of peds; common fine concretions of iron and manganese oxide; about 1 percent gravel; very strongly acid (pH 4.8); clear smooth boundary.

2Bt2—15 to 23 inches; yellowish brown (10YR 5/4) clay loam; many fine prominent red (2.5YR 4/6) and common fine faint grayish brown (10YR 5/2) mottles; strong fine and very fine subangular blocky structure; firm; few very fine roots between peds; common distinct clay films on faces of peds; common fine concretions of iron and manganese oxide; about 1 percent gravel; very strongly acid (pH 4.8); clear smooth boundary.

2Bt3—23 to 39 inches; strong brown (7.5YR 5/6) clay loam; common fine distinct grayish brown (10YR 5/2) and common fine prominent red (2.5YR 4/6) mottles; weak medium subangular blocky structure; firm; few very fine roots; few faint clay films on vertical faces of peds; common white weathered sand grains; common fine concretions of iron and manganese oxide; about 2 percent gravel; strongly acid (pH 5.1); gradual smooth boundary.

2Bt4—39 to 51 inches; yellowish brown (10YR 5/6) clay loam; common medium distinct grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; firm; few very fine roots; few faint clay films and iron stains on faces of peds; common fine concretions of iron and manganese oxide; common white weathered sand grains; about 2 percent gravel; moderately acid (pH 5.8); clear smooth boundary.

3Btg5—51 to 60 inches; grayish brown (2.5Y 5/2) clay loam; common medium distinct brownish yellow (10YR 6/8) and yellowish brown (10YR 5/8) mottles; strong coarse subangular blocky structure; firm; common distinct pressure faces; many distinct stains of iron and manganese oxide on faces of peds; common white weathered sand grains; about 3 percent gravel; neutral (pH 6.8).

The A or Ap horizon has value of 3 or 4 and chroma of 2 or 3. The BE horizon, if it occurs, or the E horizon has value of 4 or 5 and chroma of 2 or 3. It is silt loam or loam. The upper part of the Bt horizon has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 4 to 6. It is clay loam or clay. The lower part of the Bt horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 6. It is clay loam or clay. The content of gravel ranges from 1 to 5 percent throughout the B horizon.

Lenzburg Series

The Lenzburg series consists of very deep, moderately slowly permeable, well drained soils on reconstructed uplands. These soils consist of material that has been excavated during surface mining activities. Slopes range from 1 to 50 percent.

These soils are not calcareous as is definitive for the Lenzburg series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Lenzburg silty clay loam, 1 to 5 percent slopes, 500 feet south and 1,200 feet east of the northwest corner of sec. 1, T. 50 N., R. 9 W.

A—0 to 1 inch; dark gray (10YR 4/1) silty clay loam; massive; firm; common very fine roots; about 5 percent chert gravel on surface; neutral (pH 7.0); abrupt irregular boundary.

C—1 to 60 inches; variegated light gray (5Y 7/2) to dark yellowish brown (10YR 4/4) clay loam; massive; very firm; few very fine and fine roots; 10 to 15 percent shale, chert, siltstone, and quartz gravel; few pressure faces along fracture planes; mildly alkaline (pH 7.7).

The A horizon has value of 3 or 4 and chroma of 1 to 3. The content of gravel in this horizon ranges from 1 to 15 percent. The C horizon has hue of 10YR to 5Y, value of 4 to 7, and chroma of 2 to 4. It is clay loam or silty clay loam. The subhorizons of some pedons are gravelly.

Leonard Series

The Leonard series consists of very deep, poorly drained, slowly permeable soils on uplands. These soils formed in loess, pedisediments, and the underlying paleosol, which weathered from glacial till. Slopes range from 2 to 4 percent.

Typical pedon of Leonard silty clay loam, 2 to 4 percent slopes, eroded, 2,200 feet south and 1,700 feet east of the northwest corner of sec. 20, T. 52 N., R. 8 W.

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak very fine subangular blocky structure; firm; many very fine roots; few fine rounded concretions of iron and manganese oxide; some Btg1 material in the lower part; slightly acid (pH 6.1); abrupt smooth boundary.

Btg1—6 to 13 inches; dark gray (10YR 4/1) silty clay; few fine prominent strong brown (7.5YR 5/6) and yellowish red (5YR 4/6) mottles; moderate very fine subangular blocky structure; firm; many very fine roots; common distinct clay films on faces of peds; common slickensides; few fine rounded concretions of iron and manganese oxide; moderately acid (pH 5.7); clear smooth boundary.

Btg2—13 to 19 inches; dark grayish brown (10YR 4/2) silty clay loam; few fine prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 5/8) mottles; weak very fine subangular blocky structure; firm; many very fine roots; common faint clay films on faces of peds; common slickensides; few fine rounded concretions of iron and manganese oxide; strongly acid (pH 5.4); clear smooth boundary.

2Btg3—19 to 25 inches; gray (10YR 5/1) silty clay loam; many fine prominent yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; common very fine roots; very few patchy distinct stains of iron and manganese oxide on vertical faces of peds; common distinct clay films on faces of peds; few slickensides; few fine rounded concretions of iron and manganese oxide; common sand grains; moderately acid (pH 5.8); clear smooth boundary.

2Btg4—25 to 32 inches; gray (10YR 5/1) clay loam; few fine prominent yellowish red (5YR 5/6), many fine distinct yellowish brown (10YR 5/4), and many fine prominent yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; firm; few very fine roots between peds; few distinct stains of iron and manganese oxide on vertical faces of peds; few faint clay films on faces of peds; few fine rounded concretions of iron and manganese oxide; slightly acid (pH 6.1); gradual smooth boundary.

2Btg5—32 to 44 inches; gray (10YR 5/1) clay loam; common fine prominent strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; firm; few very fine roots between peds; very few distinct stains of iron and manganese oxide on vertical faces of peds; few prominent dark reddish brown (5YR 3/3) and strong brown (7.5YR 5/6) clay films on faces of peds; few fine rounded concretions of iron and manganese oxide; neutral (pH 6.6); gradual smooth boundary.

2Btg6—44 to 56 inches; gray (10YR 5/1) clay loam; few fine prominent yellowish red (5YR 4/6) and common fine prominent yellowish brown (10YR 5/6) mottles; strong very fine and fine subangular blocky structure; firm; few very fine roots between peds; few distinct stains of iron and manganese oxide on vertical faces of peds; few prominent reddish brown (2.5YR 4/4) stains; few faint gray (10YR 6/1) silt coatings on faces of peds; few faint clay films on faces of peds; few fine rounded concretions of iron and manganese oxide; neutral (pH 6.7); abrupt smooth boundary.

2Btg7—56 to 60 inches; grayish brown (2.5Y 5/2) clay loam; few fine prominent yellowish red (5YR 5/8) and common fine prominent strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure; firm; common faint clay films on faces of peds; neutral (pH 7.0).

Depth to the 2Bt horizon ranges from 12 to 30 inches. These soils generally have deep, wide cracks during the dry summer months.

The Ap horizon has chroma of 1 or 2. The Bt horizon has value of 4 or 5 and chroma of 1 or 2. The 2Bt horizon dominantly has hue of 10YR or 2.5Y, but the range includes 5Y in the lower part of the horizon. This horizon has value of 5 or 6 and chroma of 1 or 2. The Bt and 2Bt horizons dominantly are clay, silty clay, or silty clay loam, but the range includes clay loam in the lower part of the 2Bt horizon.

Marion Series

The Marion series consists of very deep, somewhat poorly drained, very slowly permeable soils on narrow upland ridgetops that were originally forested. These soils formed in loess and in the underlying pedisediments. Slopes range from 1 to 5 percent.

Typical pedon of Marion silt loam, 1 to 5 percent slopes, 2,650 feet west and 200 feet north of the southeast corner of sec. 6, T. 50 N., R. 8 W.

A—0 to 2 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak fine granular structure; very friable; many fine and very fine roots; slightly acid (pH 6.2); abrupt wavy boundary.

E—2 to 9 inches; light brownish gray (10YR 6/2) silt loam; common medium faint brown (10YR 4/3) mottles; weak thin platy structure parting to moderate fine subangular blocky; friable; few fine and very fine roots; common fine concretions of iron and manganese oxide; slightly acid (pH 6.5); abrupt wavy boundary.

Bt1—9 to 20 inches; brown (10YR 5/3) silty clay; common fine faint yellowish brown (10YR 5/4) and few fine faint light brownish gray (10YR 6/2) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; firm; common very fine roots; common faint clay films on faces of peds; few fine concretions of iron and manganese oxide; very strongly acid (pH 5.0); clear smooth boundary.

Bt2—20 to 29 inches; brown (10YR 5/3) silty clay; common fine faint light brownish gray (10YR 6/2) and few fine faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate fine subangular blocky; firm; common very fine roots; common faint and few distinct clay films on faces of peds; very strongly acid (pH 4.7); clear smooth boundary.

Btg1—29 to 38 inches; light brownish gray (10YR 6/2) silty clay loam; many fine and medium prominent strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; firm; common very fine roots; common faint clay films on faces of peds; strongly acid (pH 5.1); clear smooth boundary.

Btg2—38 to 49 inches; light brownish gray (10YR 6/2) silty clay loam; many medium prominent yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; few very fine roots; common faint clay films on faces of peds; few fine stains of iron and manganese oxide on faces of peds; strongly acid (pH 5.1); clear smooth boundary.

2Btg3—49 to 56 inches; light brownish gray (10YR 6/2) silty clay loam; many coarse prominent brownish yellow (10YR 6/6) mottles; weak medium subangular blocky structure; firm; few very fine roots; common faint clay films on faces of peds; many fine concretions of iron and manganese oxide; many white weathered sand grains; strongly acid (pH 5.3); clear smooth boundary.

2Btg4—56 to 60 inches; light brownish gray (10YR 6/2) silty clay loam; many coarse prominent brownish yellow (10YR 6/6) and few fine prominent yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; firm; few very fine roots; few faint clay films on faces of peds; many white weathered sand grains; moderately acid (pH 6.0).

The A horizon has value of 3 to 5 and chroma of 2 or 3. The E horizon has value of 5 or 6 and chroma of 2 or 3. The upper part of the Bt horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 or 4. The lower part of the Bt horizon and the 2Bt horizon have hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 1 to 3.

Mexico Series

The Mexico series consists of very deep, somewhat poorly drained, very slowly permeable soils on broad interfluves and divides in the uplands. These soils formed in loess and in the underlying pedisediments. Slopes range from 1 to 3 percent.

Typical pedon of Mexico silt loam, 1 to 3 percent slopes, 500 feet east of the northwest corner of sec. 11, T. 50 N., R. 10 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; few fine and many very fine roots; moderately acid (pH 6.0); abrupt smooth boundary.

B/E—7 to 11 inches; dark grayish brown (10YR 4/2) and red (2.5YR 4/6) silty clay loam (Bt); common thin coatings of grayish brown (10YR 5/2) silt loam (E) on faces of peds; weak very fine subangular blocky structure; friable; common very fine roots;

strongly acid (pH 5.1); abrupt smooth boundary.

Bt—11 to 17 inches; mottled dark grayish brown (10YR 4/2), red (2.5YR 4/6), and yellowish brown (10YR 5/6) silty clay; moderate medium subangular blocky structure; very firm; common very fine roots; common distinct clay films on faces of peds; strongly acid (pH 5.1); gradual smooth boundary.

Btg1—17 to 24 inches; grayish brown (10YR 5/2) silty clay; common fine prominent yellowish brown (10YR 5/6) mottles; moderate fine subangular blocky structure; very firm; common very fine roots; common distinct clay films on faces of peds; strongly acid (pH 5.4); clear smooth boundary.

Btg2—24 to 36 inches; grayish brown (10YR 5/2) silty clay; common fine prominent yellowish brown (10YR 5/6) and dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; firm; common very fine roots; few faint clay films on faces of peds; few stains of manganese oxide on faces of peds; few fine rounded concretions of iron and manganese oxide; strongly acid (pH 5.5); clear smooth boundary.

BCg—36 to 48 inches; mottled grayish brown (10YR 5/2), dark yellowish brown (10YR 4/6), and yellowish brown (10YR 5/4) silty clay loam; weak medium prismatic structure; firm; few very fine roots; slightly acid (pH 6.2); abrupt smooth boundary.

2Cg—48 to 60 inches; light brownish gray (10YR 6/2) clay loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive; firm; slightly acid (pH 6.3).

Depth to the 2Cg horizon ranges from 30 to 60 inches. The Ap horizon has value and chroma of 2 or 3. It is silt loam or silty clay loam. The upper part of the Bt horizon has value of 4 or 5 and chroma of 1 or 2. It is silty clay or silty clay loam. The lower part of the Bt horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 or 2. The 2Cg horizon has value of 5 or 6 and chroma of 1 or 2. It is silty clay loam or clay loam.

Putnam Series

The Putnam series consists of very deep, poorly drained, very slowly permeable soils on broad upland divides. These soils formed in loess. Slope is 0 to 1 percent.

Typical pedon of Putnam silt loam, 900 feet south and 300 feet west of the northeast corner of sec. 9, T. 50 N., R. 8 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate very fine granular structure; friable; few very fine roots; moderately acid (pH 5.6); abrupt smooth boundary.

E—8 to 16 inches; light brownish gray (10YR 6/2) silt loam; common fine distinct yellowish brown (10YR 5/4) and common fine faint gray (10YR 5/1) mottles; moderate very fine granular structure; friable; few very fine and fine roots; very strongly acid (pH 4.8); abrupt smooth boundary.

Btg1—16 to 20 inches; dark gray (10YR 4/1) silty clay; few fine prominent strong brown (7.5YR 4/6) and yellowish brown (10YR 5/6) and common fine distinct brown (10YR 4/3) mottles; moderate fine angular blocky structure; firm; few very fine roots; many distinct clay films on faces of peds; very strongly acid (pH 4.6); clear smooth boundary.

Btg2—20 to 30 inches; dark gray (10YR 4/1) silty clay; many fine prominent dark yellowish brown (10YR 4/6) and common fine distinct dark brown (10YR 4/3) mottles; moderate medium subangular blocky structure; very firm; few very fine roots; many distinct clay films on faces of peds; few concretions of iron and manganese oxide in the lower part; very strongly acid (pH 4.7); clear smooth boundary.

Btg3—30 to 36 inches; grayish brown (2.5Y 5/2) silty clay loam; many fine distinct brown (10YR 5/3) and few fine prominent yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; few very fine roots; a large area of yellowish brown material concentrated in the lower part; dark stains along root channels; few faint clay films on faces of peds; very strongly acid (pH 4.8); clear smooth boundary.

Btg4—36 to 48 inches; grayish brown (2.5Y 5/2) silty clay loam; few fine yellowish brown (10YR 5/6 and 5/4) mottles; very weak coarse subangular blocky structure; very firm; common faint clay films on faces of peds; few sand grains in lower part; very strongly acid (pH 5.0); abrupt smooth boundary.

2Ab—48 to 50 inches; black (N 2/0) silty clay loam; massive; firm; strongly acid (pH 5.1); abrupt smooth boundary.

2Btgb—50 to 60 inches; gray (10YR 5/1) silty clay loam; common fine faint grayish brown (10YR 5/2) mottles; weak thin platy structure; very firm; common faint clay films on faces of peds; few bleached sand grains; dark yellowish brown stains along root channels; slightly acid (pH 6.5).

The E horizon has value of 5 or 6 and chroma of 1 or 2. The Bt horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 and 2. The 2B and 2C horizons have hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 1 or 2.

Twomile Series

The Twomile series consists of very deep, poorly drained soils on high flood plains. Permeability is moderate in the upper part of the profile and slow in the lower part. These soils formed in alluvium. Slope is 0 to 2 percent.

Typical pedon of Twomile silt loam, 2,600 feet south and 300 feet west of the northeast corner of sec. 35, T. 50 N., R. 10 W.

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; common fine prominent brown (7.5YR 4/4) mottles; weak fine granular structure; friable; many fine and few very fine roots; very strongly acid (pH 5.0); clear smooth boundary.

E—9 to 17 inches; grayish brown (10YR 5/2) silt loam; few fine prominent strong brown (7.5YR 5/6) mottles; weak medium platy structure parting to weak very fine granular; friable and brittle; common very fine and few fine roots; very strongly acid (pH 4.7); abrupt smooth boundary.

Egx—17 to 23 inches; light brownish gray (10YR 6/2) silt loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak very fine granular structure; friable; compact with variable, weakly expressed brittleness when moist; few very fine roots; few fine concretions of iron and manganese oxide; very strongly acid (pH 4.8); abrupt smooth boundary.

Btg1—23 to 33 inches; grayish brown (10YR 5/2) silty clay loam; common fine distinct dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; firm; few very fine roots; few faint clay films on faces of peds; common fine concretions of iron and manganese oxide; very strongly acid (pH 5.0); gradual smooth boundary.

Btg2—33 to 46 inches; dark grayish brown (10YR 4/2) silty clay loam; few fine distinct dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; firm; few faint clay films on faces of peds; few fine concretions of iron and manganese oxide; strongly acid (pH 5.1); gradual smooth boundary.

Btg3—46 to 60 inches; dark grayish brown (10YR 4/2) silty clay loam; few fine distinct strong brown (7.5YR 4/6) mottles; weak fine subangular blocky structure; firm; few faint clay films on faces of peds; few fine concretions of iron and manganese oxide; strongly acid (pH 5.5).

The A horizon has chroma of 1 or 2. The E horizon has value of 4 to 6 and chroma of 1 or 2. The Bt horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 or 2.

Winnegan Series

The Winnegan series consists of deep and very deep, moderately well drained, slowly permeable soils on uplands. These soils formed in glacial till. Slopes range from 5 to 30 percent.

Typical pedon of Winnegan silt loam, 14 to 30 percent slopes, 250 feet east and 1,600 feet south of the northwest corner of sec. 34, T. 51 N., R. 10 W.

A—0 to 2 inches; very dark grayish brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; moderate fine granular structure; friable; many very fine and fine and few medium roots; many fine interstitial and few medium tubular pores; about 1 percent gravel; strongly acid (pH 5.2); clear wavy boundary.

E—2 to 7 inches; yellowish brown (10YR 5/4) silt loam; weak medium platy structure parting to weak fine subangular blocky; friable; few very fine, common fine and medium, and few coarse roots; common very fine, fine, and medium pores; common distinct grayish brown (10YR 5/2) silt coatings on faces of peds and in pores; few fine concretions of manganese oxide; about 1 percent gravel; very strongly acid (pH 4.7); clear wavy boundary.

Bt1—7 to 14 inches; strong brown (7.5YR 4/6) clay; weak medium prismatic structure parting to strong very fine subangular blocky; firm; few very fine, common fine and medium, and few coarse roots; few medium and coarse pores; many distinct clay films on faces of peds and in pores; about 1 percent gravel; very strongly acid (pH 4.7); gradual smooth boundary.

Bt2—14 to 20 inches; strong brown (7.5YR 5/6) clay; common medium faint strong brown (7.5YR 4/6) and few fine prominent pale brown (10YR 6/3) mottles; weak medium prismatic structure parting to strong medium subangular blocky; firm; few fine, many medium and few coarse roots; many distinct and few prominent clay films on faces of peds and in pores; common fine concretions of manganese oxide; about 1 percent gravel; very strongly acid (pH 4.5); clear smooth boundary.

Bt3—20 to 29 inches; yellowish brown (10YR 5/6) clay; common fine prominent light brownish gray (2.5Y 6/2) mottles; moderate coarse prismatic structure parting to moderate medium subangular blocky; firm; few fine, medium, and coarse roots; many distinct and few prominent clay films on faces of peds and in pores; common fine concretions of manganese oxide; about 1 percent gravel; very strongly acid (pH 4.6); gradual smooth boundary.

Bt4—29 to 39 inches; yellowish brown (10YR 5/6) clay loam; common fine prominent light brownish gray (2.5Y 6/2) mottles; moderate coarse prismatic structure parting to moderate medium and coarse subangular blocky; firm; few fine, medium, and coarse roots; many distinct and few prominent clay films on faces of peds and in pores; common fine and medium stains and concretions of manganese oxide; about 2 percent gravel; few large tilted pressure faces or fine slickensides; very strongly acid (pH 5.0); clear smooth boundary.

Bk—39 to 60 inches; yellowish brown (10YR 5/6) clay loam; many large prominent light olive gray (5Y 6/2) mottles; moderate fine and medium subangular blocky structure; firm; common faint clay films on faces of peds; many stains of manganese oxide on faces of peds; about 10 percent soft limestone fragments; violently effervescent in matrix near saprolitic gravel, strongly effervescent on faces of peds; mildly alkaline (pH 7.8).

Carbonates are at a depth of 24 to 40 inches. The A horizon has value of 2 or 3 and chroma of 1 to 3. The E horizon has value of 4 to 6 and chroma of 2 to 4. Some pedons have a BE horizon. The Bt horizon has hue of 7.5YR or 10YR and chroma of 3 to 8. It is clay loam or clay. Some pedons have a BC or C horizon, which is clay loam. This horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 5.

Formation of the Soils

Soil forms through processes that act on deposited or accumulated geologic material. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material accumulated; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time that the forces of soil formation have acted on the soil material. Human activities also affect soil formation.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material affects the kind of soil profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for the transformation of the parent material into a soil. Generally, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the others.

Parent Material

Parent material is the unconsolidated mass in which a soil forms. The accumulation or deposition of this material is the first step in the development of a soil profile. The characteristics of this material affect the chemical and mineralogical composition of the soil. The parent materials in Audrain County are residuum, or material weathered from bedrock; loess, or silty wind-deposited material; alluvium, or water-deposited material on flood plains; pedisediments, or material deposited by gravity or water on uplands from sources directly upslope; and glacial till, or glacier-deposited material.

Loess probably once mantled all of the uplands and terraces in the survey area. This loess is part of the Wisconsin-aged Peoria loess deposit, dating from the most recent postglacial period. The sources of this material were the flood plains along the Mississippi and Missouri Rivers. As the glaciers receded, silt-laden meltwater left massive deposits on the barren flood plain. Winds redeposited much of this silty material across the landscape. Geologic erosion subsequently removed the loess from sloping areas of the uplands, while continued dissection of the streams and flooding removed the loess from portions of the lowlands.

The loess mantle is thickest in nearly level areas on uplands and high terraces. Putnam and Chariton soils are in these areas. They formed in 4 to 5 feet of loess. The loess is slightly thinner in the very gently sloping or gently sloping areas on uplands and high terraces. Mexico and Marion soils, which are in the uplands, and Gifford soils, which are on high terraces, formed in about 30 to 50 inches of loess. Slightly more loess has been removed from the gently sloping Leonard soils, which formed in about 12 to 30 inches of loess. Moderately sloping and steeper soils, such as Armstrong and Keswick soils, have only a thin surficial layer of loess remaining.

Prior to the deposition of the loess, thick layers of glacial till were deposited over the bedrock. This material is generally yellowish brown and is a heterogeneous mass of calcareous sand, silt, clay, and rock fragments that range in size from small pebbles to boulders. The glacial till in Audrain County is considered to be pre-Illinoian in age *(7)*. After the till was deposited, a long period of soil formation and erosion occurred prior to loess deposition. Soils formed in the glacial till and were subsequently buried by the loess. These buried soils are termed paleosols.

Till underlies nearly all of the upland soils in the county, including Armstrong, Keswick, Leonard, Marion, Mexico, Putnam, and Winnegan soils. Of these soils, Armstrong and Keswick soils have only a thin layer of loess over the glacial till. They formed in a late Sangamon-aged paleosol in the glacial till. Winnegan soils formed entirely in glacial till from which the paleosol has been eroded. Leaching processes have not yet removed the carbonates from the till in the lower part of the Winnegan soils.

Alluvium is the parent material on flood plains and low terraces. It also underlies the loess on the high terraces. Belknap, Jemerson, and Twomile soils formed entirely in alluvium. Chariton and Gifford soils are underlain by alluvium.

Characteristically, the texture of alluvial deposits varies widely because different sizes of particles are deposited at different water velocities. The alluvial deposits in Audrain County, however, are almost entirely silt loam and are remarkably uniform. This is due to the silty texture of the surface layer in the surrounding uplands and to the lack of a large river system in the county. Sandy and clayey areas and strata are not uncommon on the flood plains, where there is more textural variation than on any other landform in the county. Some areas of Belknap soils have slight textural and color stratifications within the soil profile, reflecting the multiple flood deposits that formed the soils.

Pedisediments in Audrain County are derived primarily from erosional products of the glacial till or from a mixture of loess and till. They were probably deposited during the Sangamonian interglacial period and were buried by loess, perhaps with considerable basal mixing. Pedisediments are an important component of Leonard soils. They are overlain by loess and underlain by a paleosol that formed in the underlying glacial till. Pedisediments also occur in the lower part of some Marion and Mexico soils.

Residual soils are near the major streams where dissection has removed the overlying loess and glacial till. Two ages of rock are exposed in Audrain County *(12)*. The upper, younger deposit is Pennsylvanian in age; is composed of limestone, calcareous shale, and mudstone; and has bands of coal. In other areas the older Mississippian rocks are exposed. Goss soils formed in material weathered from this cherty limestone. Over time, the carbonates in the matrix of the limestone have dissolved away and the residual impurities have weathered into the characteristic reddish clays of the Goss soils. The chert fragments are more resistant to the weathering processes and remain in the Goss soils as gravel and cobbles.

Climate

The present climate in Audrain County is subhumid midcontinental with cold winters and hot summers. Rainfall is adequate to thoroughly moisten and leach the soils, especially in the spring and fall, but the soils commonly dry out completely in the late summer. This alternate wetting and drying is conducive to the formation of clay films in soils. Clay is leached out of the surface soil during wet months and is deposited in the subsoil during dry months. With the exception of Lenzburg and Belknap soils, which are young soils, all of the soils in the county have well expressed clay films. This climate-induced process has resulted in the formation of a clayey subsoil and poor drainage in Putnam, Mexico, Leonard, Chariton, and Gifford soils. Warm temperatures and rainfall result in other chemical changes, including the solution and removal of carbonates and bases. Most of the soils in the county are acidic as a result of these chemical changes, and agricultural lime must be added for adequate crop growth on suitable soils.

The past climate has had a profound effect on the soils of the county. Climatic conditions during the Pleistocene epoch caused the massive glaciations that deposited both the glacial till and the source material for the loess. Paleosols that formed in the glacial till did so under the influence of a past climate.

Living Organisms

The living organisms that influence soil formation include plants, burrowing animals, worms and insects in the soil, bacteria, and fungi. Dead vegetation is decomposed in the soil by bacteria and fungi to form organic matter. This organic matter binds soil particles into stable aggregates, improves soil tilth and the rate of infiltration, and slowly releases plant nutrients over a period of time. Insects and burrowing animals mix vegetation and decomposed organic matter into the soil and help to increase soil porosity. Plants also are important in stabilizing soils against the erosive forces of wind and water.

Many of the soils in Audrain County formed mainly under tall grass prairie. These soils have a relatively thick, dark surface layer with moderate amounts of organic matter, derived mainly from the fine, fibrous roots of grasses and forbs. Chariton, Gifford, Leonard, Mexico, and Putnam soils formed under prairie vegetation. Armstrong soils formed under a transitional, oak-savanna vegetation of prairie grass species interspersed with oak trees. The surface layer of the Armstrong soils is similar to that of other soils formed under prairie vegetation.

Soils that formed under forest vegetation have a thin surface layer that generally is moderately low in organic matter. Most of the organic matter in these soils is from deciduous hardwood tree leaves, which have fallen on the surface. Goss, Keswick, Winnegan, Belknap, and Twomile soils formed under forest vegetation.

Human activities have affected soil formation since the time of settlement. Removal of the native vegetation and cultivation of the soils have resulted in accelerated erosion in most areas of the gently sloping and moderately sloping upland soils. Many areas of the Mexico soils and most areas of the Armstrong, Keswick, and Leonard soils have lost significant amounts of surface material because of agricultural practices. Some areas of the Armstrong soils are severely eroded and have lost most of their original dark surface material.

Mining activities have also drastically affected the soils in some small areas. Lenzburg soils formed entirely in soil material excavated during mining activities.

Relief

Relief refers to the general unevenness of the land surface, the variations in elevation, and the nature of the slopes between one elevation and another. It influences soil formation in Audrain County mainly through its effect on drainage, runoff, and erosion.

For some soils in the county, drainage improves as slope increases. The nearly level Chariton, Putnam, and Twomile soils are poorly drained. The very gently sloping Mexico soils are somewhat poorly drained, and the moderately sloping to steep Armstrong, Keswick, and Winnegan soils are moderately well drained. Drainage is influenced by runoff in areas of the Leonard soils, which receive both surface and subsurface runoff from the Mexico soils upslope. As a result, the gently sloping Leonard soils are poorly drained.

Relief influences the potential erosivity of the soil, primarily through slope length and slope steepness. Many of the gently sloping to strongly sloping soils in the county are moderately eroded because the relief of the landscape was not adequately considered when management practices were applied.

Relief also influences soil profile development through its effect on runoff. For example, Winnegan soils are on steep slopes and much of the rainfall received by these soils is lost through surface runoff. There is less effective infiltration and percolation through the soil profile. As a result, Winnegan soils have free carbonates in the lower part of the profile.

Time

Time is necessary for climate, living organisms, and relief to affect the parent material. The degree to which the parent material is altered determines the age of a soil. Young soils show very little profile development or horizon differentiation. Old soils show the effects of the movement of clay and of leaching and have distinct horizons that are readily observable.

The youngest soils in Audrain County are the Lenzburg and Belknap soils. Lenzburg soils formed in mine spoil and show minimal evidence of soil development other than a very thin surface layer. The soils that were excavated and redeposited to form the Lenzburg soils, however, were older and highly weathered. Belknap soils formed in recently deposited alluvium. These soils are on flood plains and probably receive fresh increments of alluvium with every flood. They are stable enough to form a dark surface layer, but no subsoil development has occurred.

Twomile soils also formed in alluvium but are in older deposits in generally higher landscape positions. Time has allowed soil processes to develop a thick subsurface layer, or albic horizon, and a subsoil, or argillic horizon. Gifford and Chariton soils are on the higher, older, loess-covered terraces and have a strong argillic horizon.

Most of the soils in the uplands are strongly developed, reflecting stability over a long period of time. Carbonates and most bases have been leached from the profiles, and strong argillic horizons have formed. This soil development occurred in the Putnam, Marion, Mexico, and Leonard soils in the past 14,000 to 16,000 years since the Peoria loess was deposited *(14)*. Soil development also occurred during this time in the Keswick and Armstrong soils, but the argillic horizon in these soils developed in a paleosol formed during the Sangamonian interglacial period (about 125,000 to 75,000 years ago). The youngest soils in the uplands are the Winnegan soils. Natural erosion has removed both the Peoria loess and the Sangamon paleosol, so these soils formed in unaltered till exposed during the Holocene epoch (about 12,500 years ago to the present). They have a moderately developed argillic horizon and have carbonates in the lower part of the profile.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

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:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Back slope. The steepest inclined surface and principle element of many hillslopes. Back slopes in the profile typically range from gently sloping to very steep and linear and descend to a foot slope. They are erosional forms produced mainly by mass wasting and running water.

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.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

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

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

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 (7.6 to 25 centimeters) in diameter.

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

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.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

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

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

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

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.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by 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 human or animal activities 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.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

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.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, or clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

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.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also, the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial meltwater.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

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

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

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

Ground water (geology). Water filling all the unblocked pores of the 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.

Head slope. The concave surface at the head of a drainageway where the flow of water converges downward toward the center and contour lines form concave curves.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

Highwall. The unexcavated face of exposed overburden and bedrock in a surface mine or the face or bank on the uphill side of a contour strip mining excavation.

Hillslope. The steeper part of a hill between its summit and the drainage line at the base of the hill. In descending order, a simple hillslope may include shoulder, back slope, foot slope, and toe slope.

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 uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

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, any plowed or disturbed surface layer.

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. It has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

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 overlying 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, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

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

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Interfluve. The area between two adjacent streams flowing in the same general direction or any elevated area between two drainageways.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

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.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by the wind.

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

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

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

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

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 three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

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

Nose slope. The projecting end of an interfluve, where contour lines connecting the opposing side slopes form convex curves around the projecting end and lines perpendicular to the contours diverge downward. The overland flow of water is divergent.

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.

Pedisediment. A thin layer of alluvial material that mantles an erosion surface and has been transported to its present position from higher lying areas of the erosion surface.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 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, such as 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.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

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

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

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 degrees of acidity or alkalinity, expressed as pH values, are:

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately 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.

Ridge. A long, narrow elevation of the land surface, usually sharply crested with steep sides forming an extended upland between valleys.

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 drawbar horsepower rating.

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

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

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

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shoulder. The uppermost inclined surface at the top of a hillslope. The area comprises the transitional zone from the back slope to the summit of an upland. The surface is dominantly convex in profile and erosional in origin.

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.

Side slope. The slope bounding a drainageway and lying between the drainageway and the adjacent interfluve. A side slope is generally linear along the slope width, and overland flow is parallel down the slope.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

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.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

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. In this survey the following slope classes are recognized:

Nearly level	0 to 1 percent
Nearly level and very gently sloping	0 to 3 percent
Very gently sloping	1 to 3 percent
Gently sloping	2 to 5 percent
Moderately sloping	5 to 9 percent
Strongly sloping	9 to 14 percent
Moderately steep	14 to 20 percent
Steep	20 to 30 percent
Very steep	more than 30 percent

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Small stones (in tables). Rock fragments less than 3 inches (7.6 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, in millimeters, of separates recognized in the United States are as follows:

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 substratum. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

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 which provide vegetative barriers to soil blowing 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 grain* (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.

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summit. A general term for the top or highest level of an upland feature such as a ridge or hill.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. It includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). A layer of otherwise suitable soil material that is too thin for the specified use.

Till plain. An extensive area of nearly level to undulating soils underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

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

Water-breaks (or water bars). A mound or small dikelike surface drainage structure, properly used only in closing retired roads to traffic and on fire lines and abandoned skid trails.

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.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

(Recorded in the period 1951-87 at Mexico, Missouri)

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days*	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January	35.2	15.1	25.2	65	-12	0	1.54	0.45	2.42	4	5.9
February	40.9	19.7	30.3	71	-8	9	1.73	.85	2.49	4	5.5
March	51.3	28.9	40.1	83	5	42	3.18	1.58	4.56	7	4.7
April	65.0	41.6	53.3	88	22	162	3.91	2.16	5.46	8	.4
May	75.0	51.5	63.3	91	32	421	4.65	2.84	6.27	8	.0
June	84.0	60.9	72.5	96	44	675	4.71	2.43	6.70	7	.0
July	89.2	65.2	77.2	102	50	843	4.48	1.64	6.84	7	.0
August	87.6	62.7	75.2	102	47	781	3.08	1.29	4.59	6	.0
September	80.5	54.5	67.5	98	36	525	3.86	1.48	5.84	6	.0
October	68.4	43.0	55.7	90	25	222	3.41	1.36	5.13	6	.0
November	53.2	31.5	42.4	79	9	22	2.68	1.02	4.05	5	1.6
December	40.0	21.0	30.5	68	-7	12	2.31	1.07	3.36	5	4.5
Yearly:											
Average	64.2	41.3	52.8	---	---	---	---	---	---	---	---
Extreme	---	---	---	103	-15	---	---	---	---	---	---
Total	---	---	---	---	---	3,714	39.54	30.41	47.57	73	22.6

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50 degrees F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

(Recorded in the period 1951-87 at Mexico, Missouri)

Probability	Temperature		
	24 °F or lower	28 °F or lower	32 °F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	Apr. 10	Apr. 20	May 4
2 years in 10 later than--	Apr. 7	Apr. 16	Apr. 29
5 years in 10 later than--	Mar. 31	Apr. 9	Apr. 21
First freezing temperature in fall:			
1 year in 10 earlier than--	Oct. 22	Oct. 13	Oct. 6
2 years in 10 earlier than--	Oct. 26	Oct. 18	Oct. 11
5 years in 10 earlier than--	Nov. 4	Oct. 27	Oct. 20

TABLE 3.--GROWING SEASON

(Recorded in the period 1951-87 at Mexico, Missouri)

Probability	Daily minimum temperature during growing season		
	Higher than 24 °F	Higher than 28 °F	Higher than 32 °F
	Days	Days	Days
9 years in 10	199	183	162
8 years in 10	205	189	169
5 years in 10	217	200	182
2 years in 10	230	210	195
1 year in 10	236	216	201

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

Map symbol	Soil name	Acres	Percent
10C2	Armstrong loam, 4 to 9 percent slopes, eroded	50,275	11.3
10C3	Armstrong clay loam, 5 to 9 percent slopes, severely eroded	1,205	0.3
18F	Goss cobbly silt loam, 14 to 30 percent slopes	1,390	0.3
19B	Marion silt loam, 1 to 5 percent slopes	4,235	0.9
22C2	Keswick silt loam, 5 to 9 percent slopes, eroded	26,250	5.9
22D2	Keswick loam, 9 to 14 percent slopes, eroded	3,345	0.8
23B2	Leonard silty clay loam, 2 to 4 percent slopes, eroded	65,800	14.7
24F	Winnegan silt loam, 14 to 30 percent slopes	1,950	0.4
27B	Mexico silt loam, 1 to 3 percent slopes	111,580	25.0
27B2	Mexico silty clay loam, 1 to 3 percent slopes, eroded	68,680	15.4
28	Twomile silt loam	17,860	4.0
33	Belknap silt loam	18,595	4.2
34	Putnam silt loam	57,045	12.8
45B	Gifford silt loam, 1 to 4 percent slopes	5,450	1.2
47	Chariton silt loam	4,780	1.1
56B	Jemerson silt loam, 1 to 3 percent slopes	304	0.1
74C2	Winnegan clay loam, bedrock substratum, 5 to 9 percent slopes, eroded	655	0.1
74D2	Winnegan loam, bedrock substratum, 9 to 14 percent slopes, eroded	2,055	0.5
90B	Lenzburg silty clay loam, 1 to 5 percent slopes	490	0.1
90F	Lenzburg clay loam, 5 to 50 percent slopes	1,320	0.3
100	Udorthents, nearly level to strongly sloping	90	*
	Water areas less than 40 acres in size	2,765	0.6
	Water areas more than 40 acres in size	166	*
	Total	446,285	100.0

* Less than 0.1 percent.

TABLE 5.--PRIME FARMLAND

(Only the soils considered prime farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime farmland only under certain conditions, the conditions are specified in parentheses after the soil name)

Map symbol	Soil name
19B	Marion silt loam, 1 to 5 percent slopes
23B2	Leonard silty clay loam, 2 to 4 percent slopes, eroded (where drained)
27B	Mexico silt loam, 1 to 3 percent slopes (where drained)
27B2	Mexico silty clay loam, 1 to 3 percent slopes, eroded (where drained)
28	Twomile silt loam (where drained)
33	Belknap silt loam (where protected from flooding or not frequently flooded during the growing season)
34	Putnam silt loam (where drained)
45B	Gifford silt loam, 1 to 4 percent slopes (where drained)
47	Chariton silt loam (where drained)
56B	Jemerson silt loam, 1 to 3 percent slopes

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE

(Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil)

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Orchard-grass-red clover hay	Alfalfa hay	Tall fescue
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
10C2------------ Armstrong	IIIe	77	27	75	43	2.6	3.4	4.3
10C3------------ Armstrong	IVe	72	25	70	40	2.4	3.2	4.0
18F------------- Goss	VIIe	---	---	---	---	---	---	3.0
19B------------- Marion	IIIe	80	28	77	44	2.7	3.6	4.4
22C2------------ Keswick	IIIe	77	27	75	43	2.6	3.4	4.3
22D2------------ Keswick	IVe	67	23	65	37	2.2	3.0	3.7
23B2------------ Leonard	IIIe	75	26	71	42	2.5	---	4.2
24F------------- Winnegan	VIe	---	---	---	---	---	---	---
27B------------- Mexico	IIe	90	30	87	50	3.0	4.0	5.0
27B2------------ Mexico	IIIe	85	28	82	47	2.8	3.5	4.7
28-------------- Twomile	IIIw	75	26	72	42	2.5	---	4.2
33-------------- Belknap	IIIw	85	29	82	47	2.8	---	3.8
34-------------- Putnam	IIw	90	31	87	50	3.0	---	5.0
45B------------- Gifford	IIe	80	28	77	44	2.7	---	4.4
47-------------- Chariton	IIw	90	31	87	50	3.0	---	5.0
56B------------- Jemerson	IIe	100	34	96	55	3.3	4.2	5.6
74C2------------ Winnegan	IIIe	70	24	67	39	2.3	3.4	3.9
74D2------------ Winnegan	IVe	65	22	62	35	2.1	2.9	3.6
90B------------- Lenzburg	IIe	75	26	72	42	2.5	3.3	4.2

See footnote at end of table.

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Orchard-grass-red clover hay	Alfalfa hay	Tall fescue
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
90F------------- Lenzburg	VIIe	---	---	---	---	---	---	---
100. Udorthents								

* Animal unit month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

(Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available)

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Windthrow hazard	Potential productivity: Common trees	Potential productivity: Site index	Potential productivity: Volume*	Trees to plant
10C2, 10C3 Armstrong	3C	Slight	Slight	Moderate	Severe	White oak	55	38	Eastern white pine, sugar maple.
						Northern red oak	55	38	
18F Goss	3R	Moderate	Moderate	Slight	Slight	White oak	54	38	Green ash, black oak, white pine.
						Shortleaf pine	---	---	
						Post oak	---	---	
						Blackjack oak	---	---	
						Black oak	56	39	
19B Marion	2W	Slight	Moderate	Moderate	Severe	White oak	50	34	Swamp white oak, pin oak, green ash.
						Post oak	---	---	
22C2, 22D2 Keswick	3C	Slight	Slight	Moderate	Severe	White oak	57	40	Eastern white pine, black oak.
						Black oak	62	45	
24F Winnegan	3R	Moderate	Moderate	Slight	Slight	White oak	60	43	White oak, black oak, white ash, northern red oak.
						Black oak	---	---	
						Northern red oak	---	---	
28 Twomile	4W	Slight	Moderate	Moderate	Moderate	Pin oak	80	62	Pin oak, eastern cottonwood, silver maple, green ash.
33 Belknap	5A	Slight	Slight	Slight	Slight	Pin oak	90	72	Eastern cottonwood, American sycamore.
						Eastern cottonwood	100	128	
						American sycamore	---	---	
						Sweetgum	---	---	
						Black walnut	75	57	
						Green ash	---	---	
						Hackberry	---	---	
56B Jemerson	3A	Slight	Slight	Slight	Slight	White oak	65	48	Northern red oak, black oak, eastern white pine, green ash.
						Northern red oak	60	43	
						Black oak	65	48	
74C2, 74D2 Winnegan	3A	Slight	Slight	Slight	Slight	White oak	60	43	White oak, black oak, white ash, northern red oak.
						Black oak	---	---	
						Northern red oak	---	---	
90B Lenzburg	7A	Slight	Slight	Slight	Slight	Eastern cottonwood	90	103	Black walnut, eastern cottonwood, white ash.
						Black walnut	73	---	

See footnote at end of table.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Windthrow hazard	Potential productivity: Common trees	Potential productivity: Site index	Potential productivity: Volume*	Trees to plant
90F------------- Lenzburg	7R	Moderate	Moderate	Slight	Slight	Eastern cottonwood-- Black walnut--------	90 73	103 ---	Black walnut, eastern cottonwood, white ash.

* Volume is the yield in cubic feet per acre per year calculated at the age of culmination of mean annual increment for fully stocked natural stands.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

(The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil)

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
10C2, 10C3 Armstrong	---	Eastern redcedar, Washington hawthorn, Amur privet, arrowwood, American cranberrybush, Amur honeysuckle.	Austrian pine, green ash, Osage-orange.	Eastern white pine, pin oak.	---
18F Goss	Siberian peashrub	Lilac, Amur honeysuckle, eastern redcedar, Washington hawthorn, radiant crabapple.	Austrian pine, eastern white pine, red pine.	---	---
19B Marion	---	Amur honeysuckle, American cranberrybush, Amur privet, eastern redcedar, Washington hawthorn, arrowwood.	Austrian pine, green ash.	Eastern white pine, pin oak.	---
22C2, 22D2 Keswick	---	Eastern redcedar, American cranberrybush, Washington hawthorn, arrowwood, Amur privet, Amur honeysuckle.	Austrian pine, green ash.	Eastern white pine, pin oak.	---
23B2 Leonard	---	Amur honeysuckle, Amur privet, eastern redcedar, American cranberrybush, Washington hawthorn, arrowwood.	Austrian pine, green ash.	Eastern white pine, pin oak.	---
24F Winnegan	---	American cranberrybush, Amur honeysuckle, Amur privet, arrowwood, Washington hawthorn, eastern redcedar.	Austrian pine, green ash.	Pin oak, eastern white pine.	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
27B, 27B2. Mexico	---	Amur honeysuckle, American cranberrybush, arrowwood, eastern redcedar, Amur privet, Washington hawthorn.	Austrian pine, green ash.	Eastern white pine, pin oak.	---
28. Twomile	---	Silky dogwood, Amur honeysuckle, American cranberrybush, Amur privet.	Washington hawthorn, white fir, blue spruce, northern whitecedar, Norway spruce, Austrian pine.	Eastern white pine	Pin oak.
33. Belknap	---	Silky dogwood, Amur privet, Amur honeysuckle, American cranberrybush.	Austrian pine, white fir, blue spruce, northern whitecedar, Washington hawthorn.	Norway spruce	Pin oak, eastern white pine.
34. Putnam	---	American cranberrybush, Amur honeysuckle, Amur privet, silky dogwood.	Norway spruce, Austrian pine, northern whitecedar, blue spruce, white fir, Washington hawthorn.	Eastern white pine	Pin oak.
45B. Gifford	---	Amur honeysuckle, Amur privet, eastern redcedar, arrowwood, Washington hawthorn, American cranberrybush.	Green ash, Austrian pine.	Pin oak, eastern white pine.	---
47. Chariton	---	Amur privet, Amur honeysuckle, American cranberrybush, silky dogwood.	Norway spruce, Austrian pine, northern whitecedar, blue spruce, white fir, Washington hawthorn.	Eastern white pine	Pin oak.
56B. Jemerson	---	American cranberrybush, Amur honeysuckle, Amur privet, silky dogwood.	Washington hawthorn, blue spruce, white fir.	Austrian pine, eastern white pine, Norway spruce.	Pin oak.
74C2, 74D2. Winnegan	---	American cranberrybush, Amur honeysuckle, Amur privet, arrowwood, Washington hawthorn, eastern redcedar.	Austrian pine, green ash.	Pin oak, eastern white pine.	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
90B, 90F---------- Lenzburg	Siberian peashrub	Eastern redcedar, Washington hawthorn.	Honeylocust, northern catalpa.	---	---
100. Udorthents					

TABLE 9.--RECREATIONAL DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
10C2------------------ Armstrong	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: wetness.
10C3------------------ Armstrong	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: slope, wetness.	Severe: erodes easily.	Moderate: wetness.
18F------------------- Goss	Severe: slope.	Severe: slope.	Severe: large stones, slope, small stones.	Moderate: slope.	Severe: droughty.
19B------------------- Marion	Severe: wetness, percs slowly.	Severe: percs slowly.	Severe: wetness, percs slowly.	Moderate: wetness.	Moderate: wetness.
22C2------------------ Keswick	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: slope, wetness.	Severe: erodes easily.	Moderate: wetness.
22D2------------------ Keswick	Severe: wetness.	Moderate: slope, wetness, percs slowly.	Severe: slope, wetness.	Severe: erodes easily.	Moderate: wetness, slope.
23B2------------------ Leonard	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
24F------------------- Winnegan	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
27B, 27B2------------- Mexico	Severe: wetness, percs slowly.	Severe: percs slowly.	Severe: wetness, percs slowly.	Moderate: wetness.	Moderate: wetness.
28-------------------- Twomile	Severe: flooding, wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
33-------------------- Belknap	Severe: flooding, wetness.	Moderate: flooding, wetness, percs slowly.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
34-------------------- Putnam	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.
45B------------------- Gifford	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, erodes easily.	Severe: wetness.
47-------------------- Chariton	Severe: flooding, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
56B------------------- Jemerson	Severe: flooding.	Slight----------	Moderate: slope.	Slight----------	Slight.
74C2------------------ Winnegan	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Severe: slope.	Slight----------	Moderate: droughty.
74D2------------------ Winnegan	Moderate: slope, wetness, percs slowly.	Moderate: slope, wetness, percs slowly.	Severe: slope.	Slight----------	Moderate: slope.
90B------------------- Lenzburg	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, small stones, percs slowly.	Severe: erodes easily.	Moderate: large stones.
90F------------------- Lenzburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, erodes easily.	Severe: slope.
100. Udorthents					

TABLE 10.--WILDLIFE HABITAT

(See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
10C2, 10C3: Armstrong	Fair	Good	Fair	Good	Fair	Very poor.	Very poor.	Fair	Good	Very poor.
18F: Goss	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
19B: Marion	Fair	Fair	Fair	Fair	Fair	Poor	Very poor.	Fair	Fair	Very poor.
22C2, 22D2: Keswick	Fair	Good	Fair	Good	Fair	Very poor.	Poor	Fair	Good	Very poor.
23B2: Leonard	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
24F: Winnegan	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
27B, 27B2: Mexico	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
28: Twomile	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
33: Belknap	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
34: Putnam	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair.
45B: Gifford	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
47: Chariton	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair.
56B: Jemerson	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
74C2, 74D2: Winnegan	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
90B: Lenzburg	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
90F: Lenzburg	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
100. Udorthents										

TABLE 11.--BUILDING SITE DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
10C2, 10C3 Armstrong	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength.	Moderate: wetness.
18F Goss	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: droughty.
19B Marion	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: low strength, shrink-swell.	Moderate: wetness.
22C2 Keswick	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength.	Moderate: wetness.
22D2 Keswick	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell, slope.	Severe: shrink-swell, low strength.	Moderate: wetness, slope.
23B2 Leonard	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.
24F Winnegan	Severe: wetness, slope.	Severe: shrink-swell, slope.	Severe: wetness, slope.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength, slope.	Severe: slope.
27B, 27B2 Mexico	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength.	Moderate: wetness.
28 Twomile	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, frost action.	Moderate: wetness, flooding.
33 Belknap	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, frost action.	Severe: flooding.
34 Putnam	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.
45B Gifford	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.
47 Chariton	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, wetness, frost action.	Severe: wetness.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
56B---------------- Jemerson	Moderate: wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, frost action.	Slight.
74C2--------------- Winnegan	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Moderate: droughty.
74D2--------------- Winnegan	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength.	Moderate: slope.
90B---------------- Lenzburg	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Moderate: large stones.
90F---------------- Lenzburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
100. Udorthents						

TABLE 12.--SANITARY FACILITIES

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "poor," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
10C2 Armstrong	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
10C3 Armstrong	Severe: wetness, percs slowly.	Severe: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
18F Goss	Severe: slope.	Severe: seepage, slope.	Severe: slope, too clayey, large stones.	Severe: slope.	Poor: too clayey, small stones, slope.
19B Marion	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness.	Severe: wetness.	Poor: wetness.
22C2, 22D2 Keswick	Severe: wetness, percs slowly.	Severe: slope.	Severe: wetness.	Severe: wetness.	Poor: wetness.
23B2 Leonard	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
24F Winnegan	Severe: wetness, percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
27B, 27B2 Mexico	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
28 Twomile	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: wetness.
33 Belknap	Severe: flooding, wetness, percs slowly.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: wetness.
34 Putnam	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
45B Gifford	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
47------------------ Chariton	Severe: wetness, percs slowly.	Slight-----------	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
56B----------------- Jemerson	Severe: wetness.	Moderate: seepage, slope.	Severe: wetness.	Moderate: flooding, wetness.	Fair: too clayey.
74C2---------------- Winnegan	Severe: wetness, percs slowly.	Severe: slope.	Severe: depth to rock, too clayey.	Moderate: depth to rock, wetness.	Poor: too clayey, hard to pack.
74D2---------------- Winnegan	Severe: wetness, percs slowly.	Severe: slope.	Severe: depth to rock, too clayey.	Moderate: depth to rock, wetness, slope.	Poor: too clayey, hard to pack.
90B----------------- Lenzburg	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey, small stones.
90F----------------- Lenzburg	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
100. Udorthents					

TABLE 13.--CONSTRUCTION MATERIALS

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
10C2, 10C3------------ Armstrong	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
18F------------------- Goss	Fair: shrink-swell, large stones, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, small stones, area reclaim.
19B------------------- Marion	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
22C2, 22D2------------ Keswick	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
23B2------------------ Leonard	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
24F------------------- Winnegan	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
27B, 27B2------------- Mexico	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
28-------------------- Twomile	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
33-------------------- Belknap	Fair: thin layer, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
34-------------------- Putnam	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
45B------------------- Gifford	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
47-------------------- Chariton	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
56B------------------- Jemerson	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
74C2, 74D2------------ Winnegan	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
90B------------------- Lenzburg	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
90F: Lenzburg	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim, slope.
100. Udorthents				

TABLE 14.--WATER MANAGEMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
10C2 Armstrong	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Slope, wetness, percs slowly.	Wetness, percs slowly.	Wetness, percs slowly.
10C3 Armstrong	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Slope, wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
18F Goss	Severe: slope.	Severe: large stones.	Deep to water	Slope, large stones, droughty.	Slope, large stones.	Large stones, slope, droughty.
19B Marion	Moderate: slope.	Moderate: wetness.	Percs slowly, slope.	Wetness, percs slowly, slope.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.
22C2 Keswick	Moderate: slope.	Moderate: wetness.	Percs slowly, frost action, slope.	Slope, wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
22D2 Keswick	Severe: slope.	Moderate: wetness.	Percs slowly, frost action, slope.	Slope, wetness, percs slowly.	Slope, erodes easily, wetness.	Wetness, slope, erodes easily.
23B2 Leonard	Moderate: slope.	Severe: wetness.	Percs slowly, frost action, slope.	Wetness, percs slowly, slope.	Erodes easily, wetness.	Wetness, erodes easily.
24F Winnegan	Severe: slope.	Moderate: wetness.	Percs slowly, slope.	Slope, wetness, percs slowly.	Slope, wetness.	Slope, percs slowly.
27B, 27B2 Mexico	Slight	Moderate: hard to pack, wetness.	Percs slowly	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily, percs slowly.
28 Twomile	Moderate: seepage.	Moderate: wetness.	Percs slowly, flooding, frost action.	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.
33 Belknap	Moderate: seepage.	Severe: piping, wetness.	Flooding, frost action.	Wetness, erodes easily.	Erodes easily, wetness.	Wetness, erodes easily.
34 Putnam	Slight	Severe: wetness.	Percs slowly	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.
45B Gifford	Slight	Severe: wetness.	Percs slowly	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
47 Chariton	Moderate: seepage.	Severe: hard to pack, wetness.	Percs slowly, frost action.	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
56B--------------- Jemerson	Moderate: seepage.	Moderate: thin layer, piping, wetness.	Deep to water	Erodes easily	Erodes easily	Erodes easily.
74C2-------------- Winnegan	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, slope.	Slope, wetness, droughty.	Erodes easily, wetness.	Erodes easily, droughty.
74D2-------------- Winnegan	Severe: slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, slope.	Slope, wetness.	Slope, erodes easily, wetness.	Slope, erodes easily.
90B--------------- Lenzburg	Moderate: slope.	Moderate: piping.	Deep to water	Slope, erodes easily.	Erodes easily	Erodes easily.
90F--------------- Lenzburg	Severe: slope.	Moderate: piping.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
100. Udorthents						

TABLE 15.--ENGINEERING INDEX PROPERTIES

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 10 inches	Frag- ments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct	Pct					Pct	
10C2----------- Armstrong	0-4	Loam----------	CL, CL-ML	A-6, A-4	0	0-5	90-100	80-95	75-90	55-80	20-30	5-15
	4-46	Clay loam, clay, silty clay loam.	CL, CH, ML, MH	A-7	0	0-5	90-100	80-95	70-90	55-80	45-70	20-35
	46-60	Clay loam-----	CL	A-6	0	0-5	90-100	80-95	70-90	55-80	30-40	15-20
10C3----------- Armstrong	0-3	Clay loam-----	CL	A-6, A-7	0	0-5	90-100	80-95	75-90	55-80	35-45	15-25
	3-42	Clay loam, clay, silty clay loam.	CL, CH, ML, MH	A-7	0	0-5	90-100	80-95	70-90	55-80	45-70	20-35
	42-60	Clay loam-----	CL	A-6	0	0-5	90-100	80-95	70-90	55-80	30-40	15-20
18F------------ Goss	0-5	Cobbly silt loam.	ML, CL, CL-ML	A-4	0	10-20	65-85	65-75	65-75	65-75	20-30	2-10
	5-20	Very cobbly silty clay loam, very cobbly silt loam.	GM, GC, GM-GC	A-2	0	10-40	40-60	35-55	30-50	25-35	20-30	2-10
	20-60	Cobbly silty clay loam, very cobbly silty clay, very cobbly clay.	GC, SC	A-7, A-2-7	0	10-45	45-70	20-65	20-50	20-45	50-70	30-40
19B------------ Marion	0-9	Silt loam-----	ML, CL	A-4, A-6	0	0	100	100	90-100	90-100	30-40	5-15
	9-29	Silty clay----	CH	A-7	0	0	100	100	95-100	90-100	50-65	30-40
	29-49	Silty clay loam.	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-45	20-25
	49-60	Silty clay loam, silt loam.	CL	A-6, A-7	0	0	100	100	90-100	85-100	30-45	15-25
22C2----------- Keswick	0-7	Silt loam-----	CL, CL-ML	A-6, A-4	0	0-5	90-100	80-100	75-90	60-80	20-30	5-15
	7-51	Clay loam, clay.	CH, CL	A-7	0	0-5	90-100	80-100	70-90	55-80	40-70	20-40
	51-60	Clay loam-----	CL	A-6	0	0-5	90-100	80-100	70-90	55-80	30-40	15-25
22D2----------- Keswick	0-5	Loam----------	CL, CL-ML	A-6, A-4	0	0-5	90-100	80-100	75-90	60-80	20-30	5-15
	5-16	Clay loam, clay.	CH, CL	A-7	0	0-5	90-100	80-100	70-90	55-80	40-70	20-40
	16-60	Clay loam-----	CL	A-6	0	0-5	90-100	80-100	70-90	55-80	30-40	15-25
23B2----------- Leonard	0-6	Silty clay loam.	CL	A-6, A-7	0	0	100	95-100	90-100	85-100	30-45	15-25
	6-19	Silty clay loam, silty clay.	CL	A-6, A-7	0	0	100	95-100	90-100	85-100	35-50	20-30
	19-25	Silty clay, clay, silty clay loam.	CH	A-7	0	0	100	95-100	85-100	80-100	55-70	30-40
	25-60	Silty clay, clay loam, silty clay loam.	CL, CH	A-7	0	0	95-100	95-100	80-95	75-90	45-60	25-35

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 10 inches	Frag- ments 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct	Pct					Pct	
24F----------- Winnegan	0-7	Silt loam-----	CL-ML, CL	A-4, A-6	0	0	95-100	95-100	80-90	60-80	20-30	5-15
	7-39	Clay loam, clay.	CL	A-7	0	0	95-100	95-100	85-95	65-85	40-50	20-30
	39-60	Clay loam, loam.	CL	A-6	0	0	95-100	95-100	85-95	60-80	25-40	10-20
27B----------- Mexico	0-9	Silt loam-----	CL-ML, CL	A-4, A-6	0	0	100	100	95-100	90-100	25-40	5-15
	9-13	Silty clay loam, silty clay.	CL, CH	A-7	0	0	100	100	95-100	90-100	45-60	25-35
	13-29	Silty clay, clay.	CH	A-7	0	0	100	100	95-100	95-100	60-75	30-45
	29-52	Silty clay loam, silty clay.	CL, CH	A-7	0	0	100	100	95-100	90-100	45-60	25-35
	52-60	Silty clay loam, clay loam, silty clay.	CL, CH	A-7	0	0	100	95-100	90-100	70-100	40-65	15-40
27B2---------- Mexico	0-5	Silty clay loam.	CL, CH, ML, MH	A-7	0	0	100	100	95-100	90-100	40-55	15-25
	5-16	Silty clay loam, silty clay.	CL, CH	A-7	0	0	100	100	95-100	90-100	45-60	25-35
	16-47	Silty clay, clay.	CH	A-7	0	0	100	100	95-100	95-100	60-75	30-45
	47-60	Silty clay loam, clay loam, silty clay.	CL, CH	A-7	0	0	100	95-100	90-100	70-100	40-65	15-40
28------------ Twomile	0-9	Silt loam-----	CL-ML, CL	A-4	0	0	100	100	95-100	90-100	20-30	4-9
	9-23	Silt loam, silt.	CL-ML, CL	A-4	0	0	100	100	95-100	90-100	20-30	4-9
	23-60	Silty clay loam, silt loam.	CL	A-6, A-7	0	0	100	95-100	90-100	85-95	30-45	15-25
33------------ Belknap	0-11	Silt loam-----	ML, CL, CL-ML	A-4	0	0	100	95-100	90-100	80-100	20-30	2-8
	11-60	Silt loam-----	ML, CL-ML, CL	A-4, A-6	0	0	100	95-100	90-100	80-100	20-35	NP-12
34------------ Putnam	0-8	Silt loam-----	CL, ML	A-6, A-4	0	0	100	100	90-100	85-100	30-40	5-15
	8-16	Silt loam-----	CL, ML	A-4, A-6	0	0	100	100	90-100	85-100	30-40	5-15
	16-30	Silty clay, clay.	CH	A-7	0	0	100	100	95-100	90-100	60-70	35-45
	30-46	Silty clay loam, silty clay.	CH	A-7	0	0	100	100	95-100	90-100	50-65	25-40
	46-60	Silty clay loam.	CL	A-7	0	0	100	100	95-100	90-100	40-50	20-30

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 10 inches	Fragments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
45B----------- Gifford	0-7	Silt loam-----	CL	A-6	0	0	100	100	90-100	85-95	30-40	10-20
	7-10	Silty clay loam.	CL	A-6	0	0	100	100	90-100	85-95	30-40	10-20
	10-27	Silty clay, silty clay loam.	CH	A-7	0	0	100	100	95-100	95-100	50-65	30-40
	27-45	Silty clay loam, clay loam.	CL	A-6, A-7	0	0	100	100	85-100	75-90	35-45	20-25
	45-60	Loam, silt loam.	CL	A-6	0	0	100	100	95-100	85-100	30-40	10-20
47------------ Chariton	0-9	Silt loam-----	CL-ML, CL	A-4, A-6	0	0	100	100	90-100	70-90	25-35	5-15
	9-16	Silt loam-----	CL-ML	A-4, A-6	0	0	100	100	90-100	70-90	25-35	5-15
	16-46	Silty clay----	CH	A-7	0	0	100	100	95-100	90-95	55-75	40-50
	46-60	Silty clay loam.	CL, CH	A-7	0	0	100	100	95-100	85-95	45-55	25-35
56B----------- Jemerson	0-16	Silt loam-----	CL-ML, CL	A-4, A-6	0	0	100	100	90-100	70-90	24-30	6-11
	16-43	Silt loam, silty clay loam.	CL	A-6	0	0	100	100	90-100	70-95	25-40	11-20
	43-60	Silt loam, loam.	CL-ML, CL	A-4, A-6	0	0	95-100	95-100	85-100	60-90	25-35	7-15
74C2---------- Winnegan	0-4	Clay loam-----	CL	A-6	0	0	95-100	95-100	80-90	65-80	25-40	11-20
	4-35	Clay loam, clay.	CL, CH	A-7	0	0	95-100	95-100	85-95	65-85	45-60	20-30
	35-47	Silty clay loam, silty clay.	CL, CH, ML, MH	A-7	0	0	95-100	95-100	90-100	80-95	40-55	15-25
	47-60	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
74D2---------- Winnegan	0-5	Loam----------	CL-ML, CL	A-4, A-6	0	0	95-100	95-100	80-90	60-80	20-30	5-15
	5-27	Clay loam, clay.	CL, CH	A-7	0	0	95-100	95-100	85-95	65-85	45-60	20-30
	27-40	Silty clay loam, silty clay.	CL, CH, ML, MH	A-7	0	0	95-100	95-100	90-100	80-95	40-55	15-25
	40-60	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
90B----------- Lenzburg	0-1	Silty clay loam.	CL	A-6, A-7	0-1	2-10	80-100	75-100	65-95	55-85	35-50	15-25
	1-60	Silt loam, silty clay loam, clay loam.	CL	A-6, A-7	0-2	2-10	80-95	75-90	70-90	55-85	25-45	10-25
90F----------- Lenzburg	0-5	Clay loam-----	CL	A-6, A-7	0-1	2-10	80-100	75-100	65-95	55-85	35-50	15-25
	5-60	Silt loam, silty clay loam, clay loam.	CL	A-6, A-7	0-2	2-10	80-95	75-90	70-90	55-85	25-45	10-25
100. Udorthents												

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

(The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated)

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
10C2-------------	0-4	22-27	1.45-1.50	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.32	3	6	2-3
Armstrong	4-46	36-60	1.45-1.55	0.06-0.2	0.11-0.16	4.5-6.5	High---------	0.32			
	46-60	30-36	1.55-1.70	0.2-0.6	0.14-0.16	5.1-7.8	Moderate-----	0.32			
10C3-------------	0-3	35-42	1.45-1.50	0.2-0.6	0.18-0.20	5.6-7.3	Moderate-----	0.37	2	4	1-2
Armstrong	3-42	36-60	1.45-1.55	0.06-0.2	0.11-0.16	4.5-6.5	High---------	0.32			
	42-60	30-36	1.55-1.70	0.2-0.6	0.14-0.16	5.1-7.8	Moderate-----	0.32			
18F--------------	0-5	10-27	1.10-1.30	2.0-6.0	0.06-0.17	4.5-6.5	Low----------	0.24	2	8	1-2
Goss	5-20	20-30	1.10-1.30	2.0-6.0	0.06-0.10	4.5-6.0	Low----------	0.10			
	20-60	35-60	1.30-1.50	0.6-2.0	0.04-0.09	4.5-6.0	Moderate-----	0.10			
19B--------------	0-9	12-27	1.30-1.45	0.6-2.0	0.22-0.24	4.5-7.3	Low----------	0.43	3	6	1-2
Marion	9-29	48-60	1.30-1.65	<0.06	0.11-0.13	3.6-5.5	High---------	0.32			
	29-49	30-40	1.30-1.55	0.06-0.2	0.15-0.17	3.6-6.0	Moderate-----	0.43			
	49-60	24-35	1.35-1.45	0.2-0.6	0.15-0.18	5.1-6.5	Moderate-----	0.43			
22C2-------------	0-7	22-27	1.45-1.50	0.6-2.0	0.17-0.22	4.5-7.3	Moderate-----	0.37	3	6	1-2
Keswick	7-51	35-60	1.45-1.60	0.06-0.2	0.11-0.15	4.5-6.0	High---------	0.37			
	51-60	30-40	1.60-1.75	0.2-0.6	0.12-0.16	4.5-7.8	Moderate-----	0.37			
22D2-------------	0-5	22-27	1.45-1.50	0.6-2.0	0.17-0.22	4.5-7.3	Moderate-----	0.37	3	6	1-2
Keswick	5-16	35-60	1.45-1.60	0.06-0.2	0.11-0.15	4.5-6.0	High---------	0.37			
	16-60	30-40	1.60-1.75	0.2-0.6	0.12-0.16	4.5-7.8	Moderate-----	0.37			
23B2-------------	0-6	27-35	1.20-1.40	0.2-0.6	0.22-0.24	6.1-7.3	Moderate-----	0.37	3	7	1-2
Leonard	6-19	35-45	1.30-1.45	0.06-0.2	0.11-0.13	4.5-6.5	High---------	0.37			
	19-25	35-50	1.20-1.35	0.06-0.2	0.10-0.12	4.5-6.5	High---------	0.37			
	25-60	32-50	1.25-1.40	0.06-0.2	0.11-0.14	5.1-7.8	High---------	0.37			
24F--------------	0-7	18-27	1.20-1.40	0.6-2.0	0.20-0.24	4.5-7.3	Low----------	0.32	3	6	.5-1
Winnegan	7-39	35-45	1.35-1.55	0.06-0.2	0.09-0.15	4.5-6.5	High---------	0.32			
	39-60	20-35	1.40-1.60	0.2-0.6	0.09-0.15	7.4-8.4	Moderate-----	0.32			
27B--------------	0-9	15-27	1.20-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Low----------	0.43	3	6	2-4
Mexico	9-13	35-50	1.25-1.45	0.2-0.6	0.12-0.16	4.5-6.0	High---------	0.32			
	13-29	50-60	1.25-1.45	<0.06	0.08-0.12	4.5-6.0	High---------	0.32			
	29-52	35-50	1.25-1.45	0.2-0.6	0.12-0.16	5.1-7.3	High---------	0.32			
	52-60	27-50	1.25-1.45	<0.6	0.12-0.18	5.1-7.3	High---------	0.32			
27B2-------------	0-5	27-35	1.30-1.50	0.2-0.6	0.16-0.20	5.1-7.3	Moderate-----	0.43	2	7	1-2
Mexico	5-16	35-50	1.25-1.45	0.2-0.6	0.12-0.16	4.5-6.0	High---------	0.32			
	16-47	50-60	1.25-1.45	<0.06	0.08-0.12	4.5-6.0	High---------	0.32			
	47-60	27-50	1.25-1.45	<0.6	0.12-0.18	5.1-7.3	High---------	0.32			
28---------------	0-9	10-18	1.35-1.45	0.6-2.0	0.22-0.24	4.5-7.3	Low----------	0.43	5	5	1-2
Twomile	9-23	10-18	1.35-1.45	0.6-2.0	0.22-0.24	4.5-6.0	Low----------	0.43			
	23-60	25-35	1.30-1.40	0.06-0.2	0.08-0.10	3.6-6.5	Moderate-----	0.43			
33---------------	0-11	8-18	1.35-1.55	0.6-2.0	0.21-0.25	4.5-7.3	Low----------	0.37	5	5	1-2
Belknap	11-60	12-18	1.40-1.60	0.6-2.0	0.21-0.24	4.5-6.0	Low----------	0.37			
34---------------	0-8	12-27	1.30-1.45	0.6-2.0	0.22-0.24	4.5-7.3	Low----------	0.43	3	6	2-3
Putnam	8-16	12-27	1.30-1.50	0.6-2.0	0.20-0.22	4.5-6.5	Low----------	0.43			
	16-30	48-60	1.20-1.40	<0.06	0.09-0.11	3.6-5.5	High---------	0.28			
	30-46	35-48	1.25-1.45	0.06-0.2	0.12-0.16	3.6-5.5	High---------	0.37			
	46-60	27-35	1.30-1.50	0.06-0.2	0.14-0.18	5.1-6.5	Moderate-----	0.43			

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
45B-------------- Gifford	0-7	20-27	1.30-1.45	0.6-2.0	0.22-0.24	5.1-7.3	Low----------	0.43	3	6	1-2
	7-10	27-35	1.30-1.45	0.2-0.6	0.18-0.20	5.1-6.5	Low----------	0.43			
	10-27	35-50	1.30-1.45	<0.06	0.11-0.14	5.1-7.3	High---------	0.32			
	27-45	25-35	1.35-1.50	0.06-0.2	0.18-0.20	5.6-7.3	Moderate-----	0.43			
	45-60	18-27	1.30-1.45	0.2-0.6	0.20-0.22	5.6-7.3	Low----------	0.43			
47--------------- Chariton	0-9	18-27	1.35-1.50	0.6-2.0	0.22-0.24	5.1-7.3	Low----------	0.37	3	6	2-4
	9-16	15-24	1.35-1.50	0.6-2.0	0.20-0.22	5.1-6.5	Low----------	0.37			
	16-46	48-60	1.35-1.45	0.06-0.2	0.11-0.13	5.1-7.3	High---------	0.28			
	46-60	32-40	1.35-1.45	0.2-0.6	0.18-0.20	6.1-7.8	Moderate-----	0.43			
56B-------------- Jemerson	0-16	12-20	1.25-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Low----------	0.37	5	6	1-2
	16-43	18-35	1.30-1.50	0.6-2.0	0.18-0.22	5.1-7.3	Moderate-----	0.37			
	43-60	15-27	1.30-1.45	0.6-2.0	0.18-0.22	5.1-7.3	Low----------	0.37			
74C2------------- Winnegan	0-4	27-40	1.20-1.40	0.2-0.6	0.17-0.19	4.5-7.3	Moderate-----	0.32	3	6	.5-1
	4-35	35-60	1.35-1.55	0.06-0.2	0.09-0.15	4.5-7.3	High---------	0.32			
	35-47	30-50	1.35-1.55	0.06-0.2	0.09-0.15	7.4-8.4	High---------	0.37			
	47-60	---	---	0.01-0.2	---	---	-------------	----			
74D2------------- Winnegan	0-5	18-27	1.20-1.40	0.6-2.0	0.20-0.24	4.5-7.3	Low----------	0.32	3	6	.5-1
	5-27	35-60	1.35-1.55	0.06-0.2	0.09-0.15	4.5-7.3	High---------	0.32			
	27-40	30-50	1.35-1.55	0.06-0.2	0.09-0.15	7.4-8.4	High---------	0.37			
	40-60	---	---	0.01-0.2	---	---	-------------	----			
90B-------------- Lenzburg	0-1	27-35	1.30-1.60	0.6-2.0	0.17-0.22	6.6-8.4	Moderate-----	0.37	5	6	.5-1
	1-60	20-35	1.30-1.60	0.2-0.6	0.15-0.18	6.6-8.4	Moderate-----	0.37			
90F-------------- Lenzburg	0-5	27-35	1.30-1.60	0.6-2.0	0.17-0.22	6.6-8.4	Moderate-----	0.37	5	6	.5-1
	5-60	20-35	1.30-1.60	0.2-0.6	0.15-0.18	6.6-8.4	Moderate-----	0.37			
100. Udorthents											

TABLE 17.--SOIL AND WATER FEATURES

("Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
10C2, 10C3 Armstrong	C	None	---	---	1.0-3.0	Perched	Nov-Apr	>60	---	High	High	Moderate.
18F Goss	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
19B Marion	D	None	---	---	1.0-2.0	Perched	Nov-May	>60	---	Moderate	High	High.
22C2, 22D2 Keswick	C	None	---	---	1.0-3.0	Perched	Nov-Apr	>60	---	High	High	Moderate.
23B2 Leonard	D	None	---	---	0.5-2.0	Perched	Nov-May	>60	---	High	High	Moderate.
24F Winnegan	C	None	---	---	2.0-3.5	Perched	Nov-Apr	>60	---	Moderate	High	High.
27B, 27B2 Mexico	D	None	---	---	1.0-2.5	Perched	Nov-May	>60	---	Moderate	High	Moderate.
28 Twomile	C/D	Occasional	Very brief to brief.	Nov-May	1.0-2.0	Perched	Nov-May	>60	---	High	High	High.
33 Belknap	C	Frequent	Brief to long.	Nov-May	1.0-3.0	Apparent	Nov-May	>60	---	High	High	High.
34 Putnam	D	None	---	---	0.5-1.5	Perched	Nov-May	>60	---	Moderate	High	High.
45B Gifford	D	None	---	---	0.5-2.0	Perched	Nov-May	>60	---	Moderate	High	Moderate.
47 Chariton	C	Rare	---	---	0-1.5	Perched	Nov-May	>60	---	High	High	Moderate.
56B Jemerson	B	Rare	---	---	3.5-5.0	Apparent	Nov-Apr	>60	---	High	Moderate	Moderate.
74C2, 74D2 Winnegan	C	None	---	---	2.0-3.5	Perched	Nov-Apr	40-60	Soft	Moderate	High	High.
90B, 90F Lenzburg	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.

TABLE 18.--CLASSIFICATION OF THE SOILS

(An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series)

Soil name	Family or higher taxonomic class
Armstrong	Fine, montmorillonitic, mesic Aquollic Hapludalfs
Belknap	Coarse-silty, mixed, acid, mesic Aeric Fluvaquents
*Chariton	Fine, montmorillonitic, mesic Mollic Albaqualfs
Gifford	Fine, montmorillonitic, mesic Vertic Ochraqualfs
Goss	Clayey-skeletal, mixed, mesic Typic Paleudalfs
Jemerson	Fine-silty, mixed, mesic Typic Hapludalfs
Keswick	Fine, montmorillonitic, mesic Aquic Hapludalfs
*Lenzburg	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Leonard	Fine, montmorillonitic, mesic, sloping Vertic Ochraqualfs
Marion	Fine, montmorillonitic, mesic Albaquic Hapludalfs
Mexico	Fine, montmorillonitic, mesic Udollic Ochraqualfs
Putnam	Fine, montmorillonitic, mesic Mollic Albaqualfs
Twomile	Fine-silty, mixed, mesic Typic Albaqualfs
Udorthents	Typic Udorthents
Winnegan	Fine, mixed, mesic Typic Hapludalfs

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