United States
Department of
Agriculture

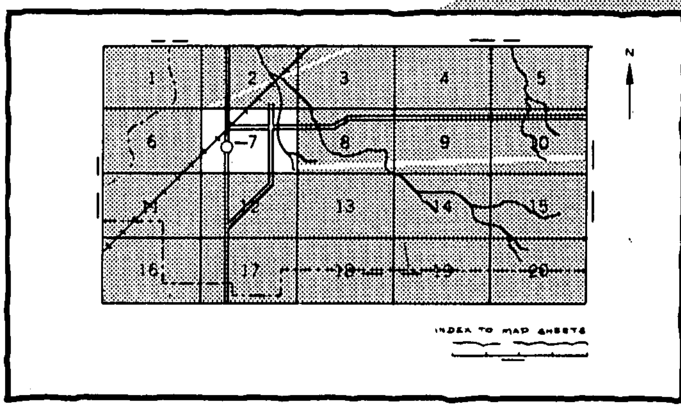
Soil
Conservation
Service

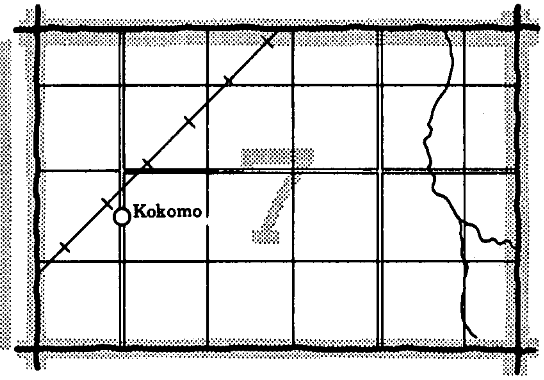
In cooperation with
Kansas
Agricultural
Experiment
Station

Soil Survey of Atchison County, Kansas

HOW TO USE

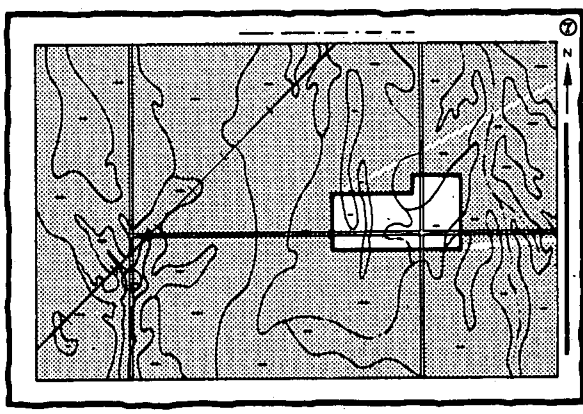
1. Locate your area of interest on the "Index to Map Sheets" (the last page of this publication).

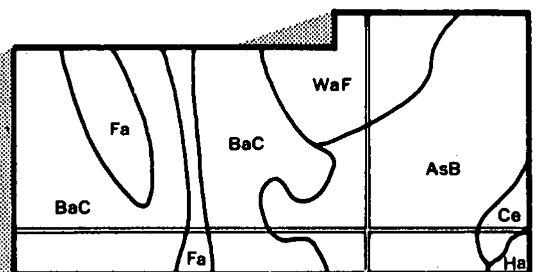




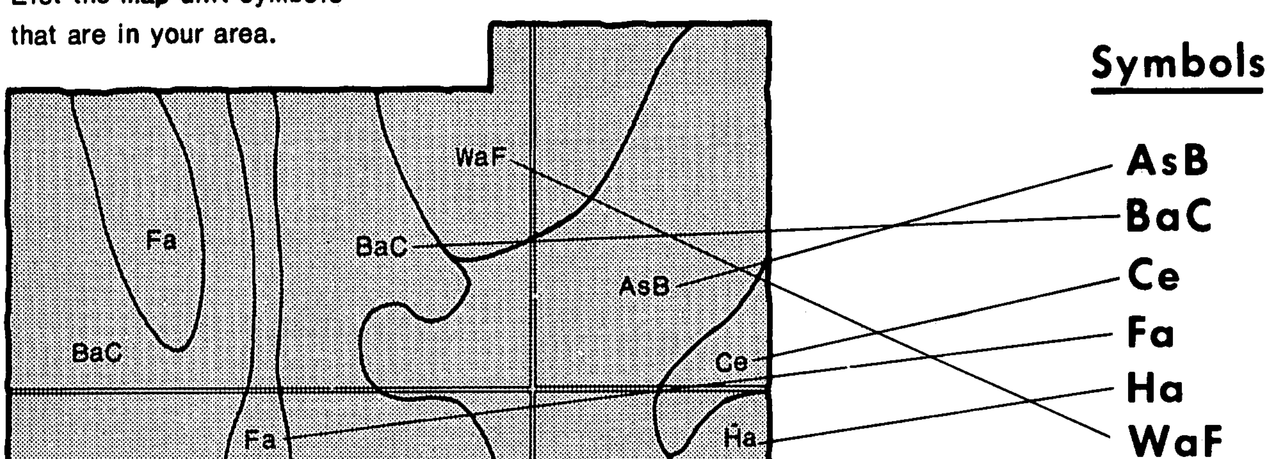
2. Note the number of the map sheet and turn to that sheet.

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



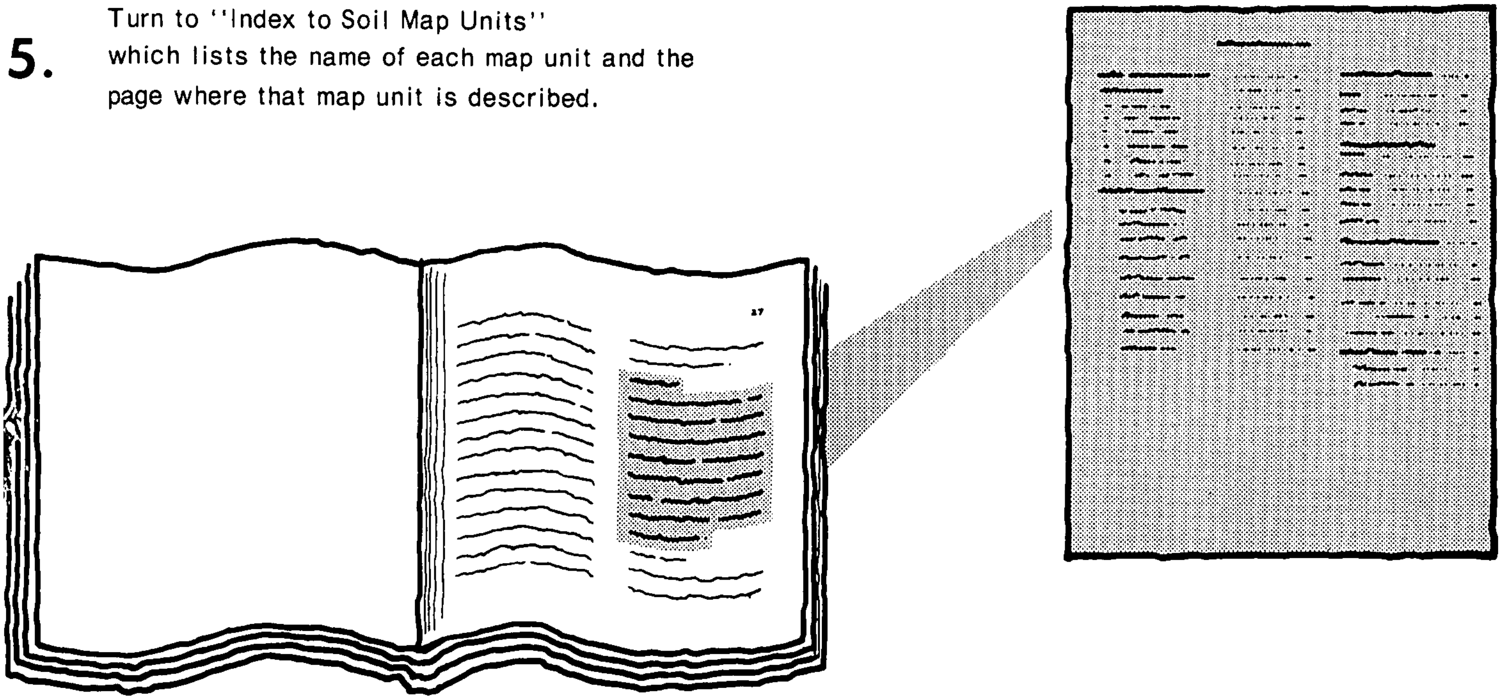


4. List the map unit symbols that are in your area.

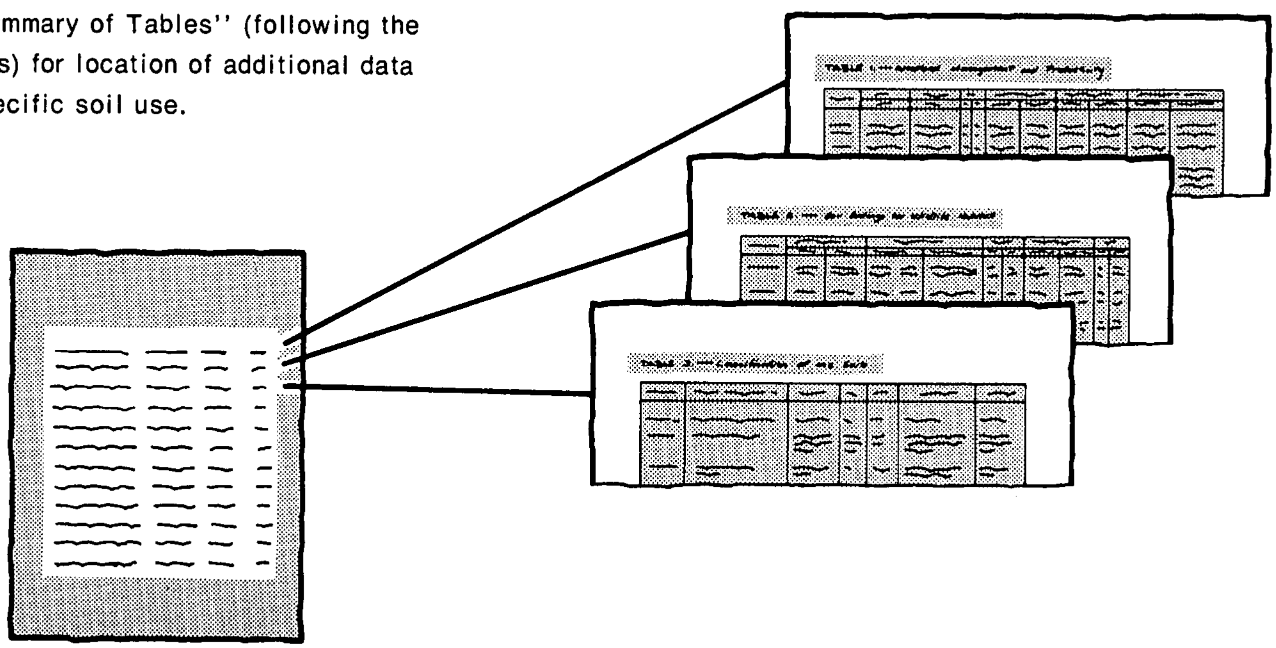


THIS SOIL SURVEY

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



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



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

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Atchison County Conservation District. Major fieldwork for this soil survey was completed in 1980. Soil names and descriptions were approved in 1981. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1981.

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

Cover: Terraces and grain sorghum residue between the terraces help to control erosion in this area of Grundy silty clay loam, 2 to 6 percent slopes.

Contents

Soil Series

Issued February 1984

Index to Map Units

Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in Atchison County, Kansas. 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 insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

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

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

John W. Tippie

John W. Tippie
State Conservationist
Soil Conservation Service

Soil Survey of
Atchison County, Kansas

By Kenneth H. Sallee and Cleveland E. Watts,
Soil Conservation Service

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

General Nature of the Survey Area

ATCHISON COUNTY is on the eastern border of Kansas, adjacent to Missouri (fig. 1). The county has a total area of 275,840 acres, or 431 square miles. In 1978, the population of the county was 17,748 and Atchison, the county seat, had a population of 10,694.

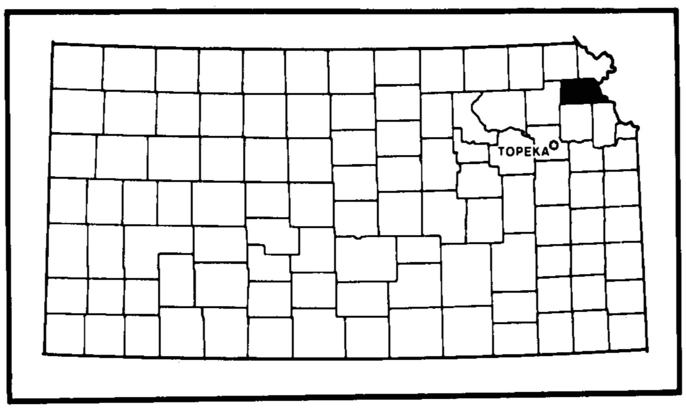


Figure 1.—Location of Atchison County in Kansas.

The eastern part of Atchison County is in the Iowa and Missouri Deep Loess Hills Land Resource Area, and the rest is in the Nebraska and Kansas Loess-Drift Hills Land Resource Area. In the Iowa and Missouri Deep Loess Hills area, the landscape is a succession of steep hills and deeply entrenched valleys adjoining the Missouri River Valley. The soils in that area are deep or moderately deep and generally have a silty or loamy subsoil. The slope of these soils decreases with distance from the river. The Nebraska and Kansas Loess-Drift Hills area ranges from nearly level to moderately steep. The soils generally are deep and formed in loamy glacial till or silty loess.

Farming is the most important agricultural enterprise in the county. Grain sorghum, soybeans, corn, and wheat are the main crops. Cattle and hogs are the main kinds of livestock.

Nearly all of the industry in Atchison County is within the City of Atchison. Manufactured items include metal products and products made from grain.

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

Climate

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

Atchison County has a continental climate typical of the interior of a large land mass in the middle latitudes. Such a climate is characterized by large daily and annual variations in temperature. Winters are cold because of the frequent outbreaks of air from the polar regions. Winter conditions prevail from December to February. Warm temperatures of summer last for about 6 months every year, and spring and fall are relatively short seasons. The warm temperatures provide a long growing season for crops in the county.

Atchison County is in the path of a fairly dependable current of moisture-laden air from the Gulf of Mexico. Precipitation is heaviest late in spring and early in summer. A large part usually comes in late evening or nighttime thunderstorms. Although the total precipitation is generally adequate for any crop, the distribution of the precipitation may cause problems in some years. Prolonged dry periods of several weeks duration are common during the growing season in this area. A surplus of precipitation often produces muddy fields that delay planting and harvest operations.

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

In winter the average temperature is 30.7 degrees F, and the average daily minimum temperature is 20.8 degrees. The lowest temperature on record, which occurred at Atchison on January 22, 1930, is -28 degrees. In summer the average temperature is 76 degrees, and the average daily maximum temperature is 87.1 degrees. The highest recorded temperature, which occurred at Atchison on August 14, 1936, is 111 degrees.

The total annual precipitation is about 35 inches. Of this, about 25 inches, or 71 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 19.92 inches. The heaviest 1-day rainfall during the period of record was 5.96 inches at Atchison on March 16, 1919.

Tornadoes and severe thunderstorms strike occasionally in Atchison County. These storms are usually local in extent and of short duration so that the risk of damage is small. Hail occurs during the warmer part of the year, but the storms are infrequent and local in extent. Crop damage by hail is less in this part of the state than it is in the western part.

The average seasonal snowfall is 20.5 inches. The greatest snow depth was 51.1 inches and occurred during the winter of 1925-26. On an average of 23 days, at least 1 inch of snow is on the ground, but it is unusual for the snow cover to last more than 7 consecutive days. The number of such days varies greatly from year to year.

The prevailing wind is from the south. Average windspeed is highest, 13 miles per hour, in April.

Natural Resources

Soil is the most important natural resource in the county. The crops produced and the livestock that graze the pastureland are marketable products that are affected by the soil.

Other resources of Atchison County are limestone and sand and gravel. Limestone, in large amounts, is quarried and used as road-surfacing material and as riprap along the Missouri River. Sand and gravel are available in small amounts from deposits in the glacial till.

How This Survey Was Made

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

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

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

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

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

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

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

Map Unit Composition

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

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

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

General Soil Map Units

The general soil map at the back of this publication shows 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, it consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up 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.

Soil Descriptions

1. Grundy-Pawnee Association

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

The soils in this association are on ridgetops and upper side slopes (fig. 2). The broad, smooth ridgetops are uniform in elevation. The side slopes generally have smooth, uniform slopes. Most areas of this association are drained by intermittent drainageways and creeks. Slope ranges from 0 to 7 percent.

This association makes up about 22 percent of the county. It is about 65 percent Grundy soils, 25 percent Pawnee soils, and 10 percent minor soils.

The somewhat poorly drained Grundy soils formed in loess on ridgetops and side slopes. Typically, the surface layer is black silty clay loam about 7 inches thick. The mottled subsoil is about 40 inches thick. The upper part of the subsoil is very dark gray, firm silty clay loam; the middle part is dark grayish brown, firm silty clay; and the lower part is dark grayish brown and grayish brown, firm silty clay. The substratum to a depth of about 60 inches is olive gray, mottled silty clay loam.

The moderately well drained Pawnee soils formed in glacial till on ridgetops and side slopes. Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The mottled subsoil is more than 52 inches thick. The upper part of the subsoil is very dark grayish brown, firm clay; the middle part is dark grayish brown and dark brown, firm clay; and the lower part is grayish brown, firm clay loam.

The minor soils in this association are Colo, Kennebec, Sharpsburg, and Shelby soils. The Colo and Kennebec soils are on flood plains along drainageways. Sharpsburg and Shelby soils have a less clayey subsoil than the Grundy and Pawnee soils. They are generally on steeper side slopes or narrower ridgetops.

The soils in this association are used mainly for cultivated crops. In some small areas they are used for hay or pasture. Corn, grain sorghum, soybeans, and small grains are the main crops. Controlling erosion and maintaining tilth and fertility are concerns of management.

2. Shelby-Pawnee-Grundy Association

Deep, nearly level to moderately steep, well drained to somewhat poorly drained soils that have a loamy or dominantly clayey subsoil; on uplands

The soils in this association are on ridgetops and side slopes of uplands that are dissected by narrow drainageways (fig. 3). Slope ranges from 0 to 25 percent.

This association makes up about 30 percent of the county. It is about 45 percent Shelby soils, 30 percent Pawnee soils, 15 percent Grundy soils, and 10 percent minor soils.

The well drained Shelby soils formed in glacial till on side slopes. Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The subsoil is friable clay loam about 39 inches thick. The upper part of the subsoil is very dark grayish brown and dark brown, the middle part is brown and mottled, and the lower part is dark yellowish brown and mottled. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam.

The moderately well drained Pawnee soils formed in glacial till on ridgetops and upper side slopes, between the Shelby soils and the Grundy soils. Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The mottled subsoil is more than 52 inches thick. The upper part of the subsoil is very dark grayish brown, firm clay; the middle part is dark grayish brown and grayish brown, firm clay; and the lower part is grayish brown, firm clay loam.

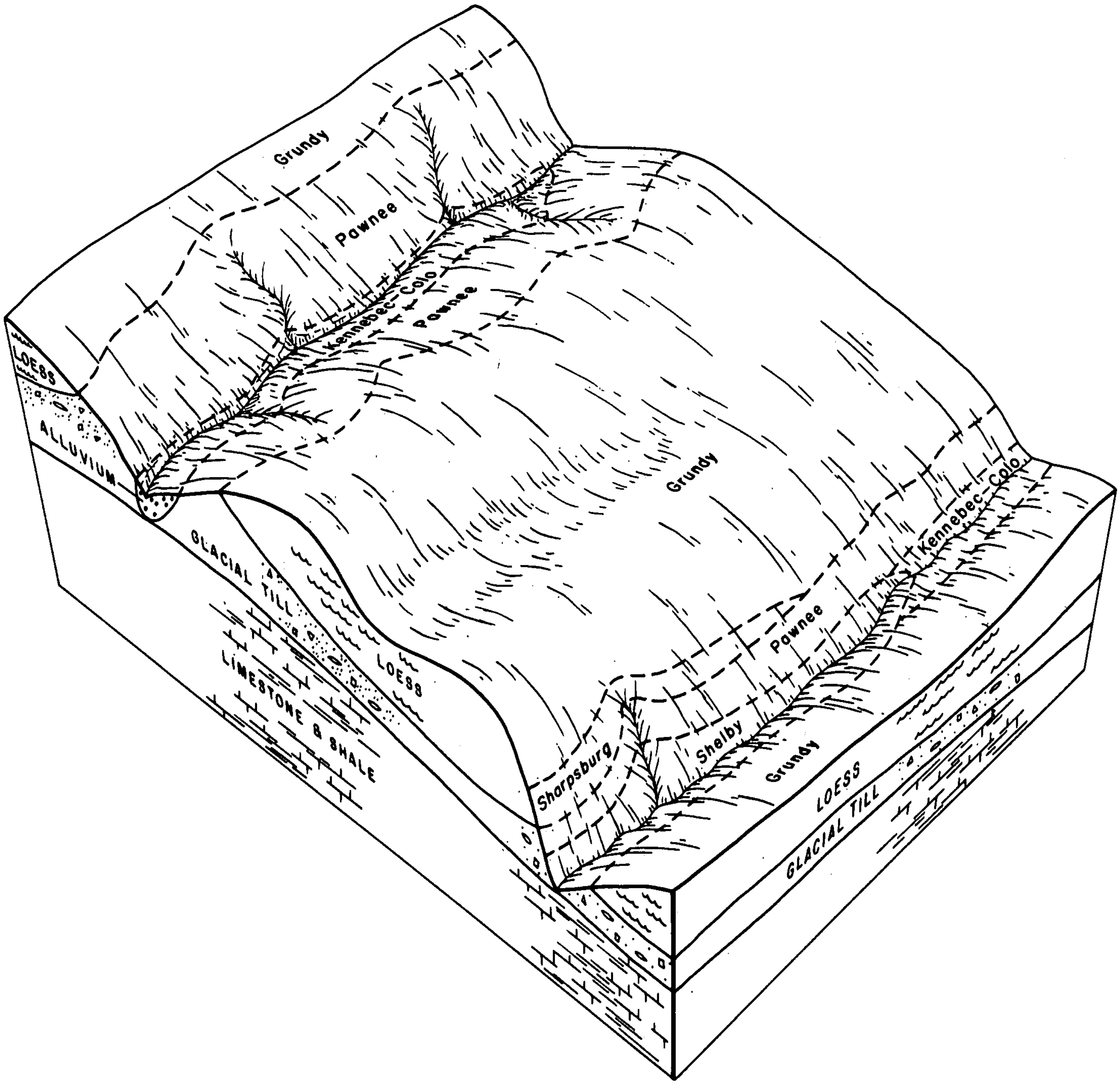


Figure 2.—Typical pattern of soils in the Grundy-Pawnee association.

The somewhat poorly drained Grundy soils formed in loess on broad ridgetops. Typically, the surface layer is black silty clay loam about 7 inches thick. The mottled subsoil is about 40 inches thick. The upper part of the subsoil is very dark gray, firm silty clay loam; the middle part is dark grayish brown, firm silty clay; and the lower part is dark grayish brown and grayish brown, firm silty clay. The substratum to a depth of about 60 inches is olive gray, mottled silty clay loam.

The minor soils in this association are Colo, Judson, Kennebec, and Sharpsburg soils. The silty Colo and Kennebec soils are on flood plains along drainageways.

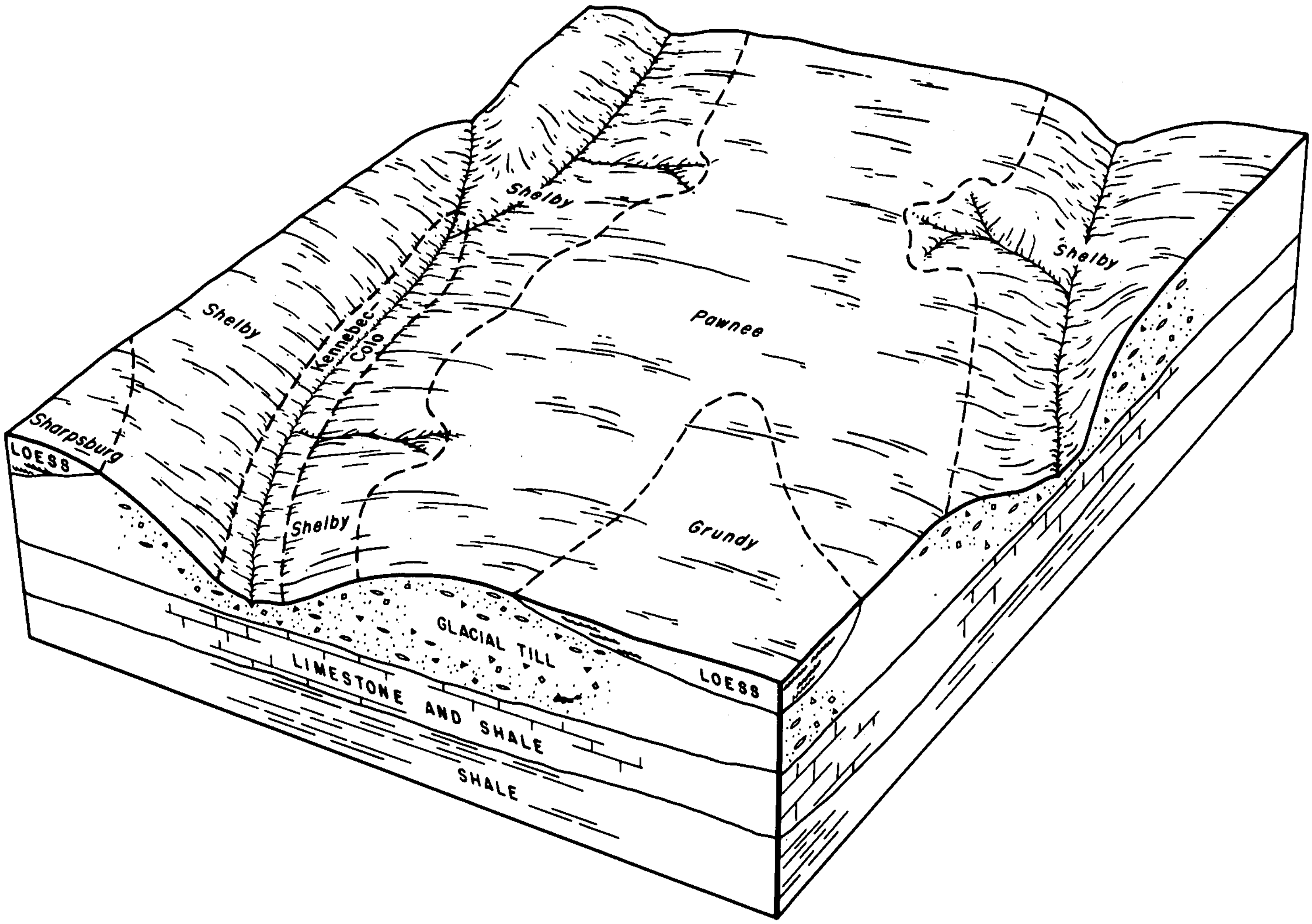


Figure 3.—Typical pattern of soils in the Shelby-Pawnee-Grundy association.

The well drained Judson soils are on foot slopes. Sharpsburg soils have a silty subsoil and are on narrow, convex ridgetops.

The soils in this association are used mainly for cultivated crops. In some small areas they are used for hay or pasture. Corn, grain sorghum, soybeans, and small grains are the main crops. Controlling erosion and maintaining tilth and fertility are concerns of management.

3. Sharpsburg-Shelby Association

Deep, gently sloping to moderately steep, moderately well drained and well drained soils that have a silty or loamy subsoil; on uplands

The soils in this association are on ridgetops and side slopes that are dissected by drainageways and creeks (fig. 4). Slope ranges from 1 to 25 percent.

This association makes up about 14 percent of the county. It is about 45 percent Sharpsburg soils, 35 percent Shelby soils, and 20 percent minor soils.

The moderately well drained Sharpsburg soils formed in loess on ridgetops and upper side slopes. Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick. The subsoil is silty clay loam about 47 inches thick. The friable upper part of the subsoil is very dark grayish brown, the firm middle part is dark brown, and the firm lower part is dark brown and dark yellowish brown and mottled. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam.

The well drained Shelby soils formed in glacial till on the lower side slopes along drainageways. Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The subsoil is friable clay loam about 39 inches thick. The upper part of the subsoil is very dark grayish brown and dark brown, the middle part is brown

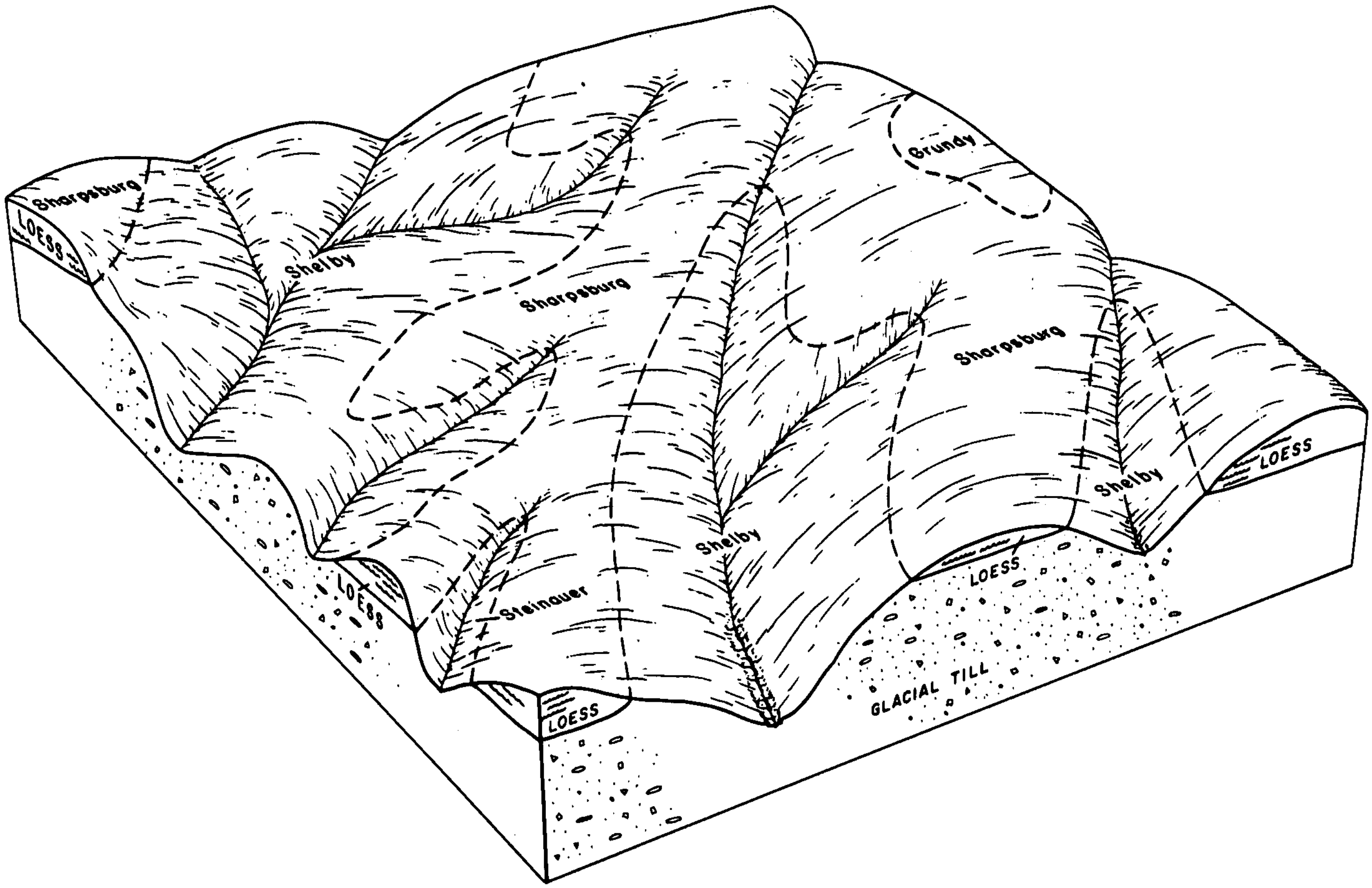


Figure 4.—Typical pattern of soils in the Sharpsburg-Shelby association.

and mottled, and the lower part is dark yellowish brown and mottled. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam.

The minor soils in this association are Grundy, Kennebec, and Steinauer soils. The somewhat poorly drained Grundy soils are on broad ridgetops. Kennebec soils are on flood plains along drainageways. The calcareous Steinauer soils are on the steeper side slopes.

The soils in this association are used mainly for cultivated crops. In some small areas they are used for hay or pasture. Corn, grain sorghum, soybeans, and small grains are the main cultivated crops. Controlling erosion and maintaining fertility are concerns in managing these soils in cultivated areas. Improving forage production is a concern in managing pastures of tame grass.

4. Knox-Armster-Gosport Association

Deep or moderately deep, strongly sloping to steep, well drained and moderately well drained soils that have a silty, loamy, or clayey subsoil; on uplands

The soils in this association are on ridgetops and side slopes that are deeply dissected by drainageways and creeks (fig. 5). Slope ranges from 6 to 45 percent.

This association makes up about 19 percent of the county. It is about 32 percent Knox soils, 30 percent Armster soils, 25 percent Gosport soils, and 13 percent minor soils.

The deep, well drained Knox soils formed in loess on ridgetops and side slopes. Typically, the surface layer is dark brown silty clay loam about 8 inches thick. The subsoil extends to a depth of more than 60 inches. The upper part of the subsoil is dark yellowish brown, friable silty clay loam. The lower part is dark yellowish brown, mottled, friable silt loam.

The deep, moderately well drained Armster soils formed in glacial till. They are on the lower side slopes along drainageways, and in some places they are on ridgetops. Typically, the surface layer is dark brown clay loam about 7 inches thick. The subsoil to a depth of more than 60 inches is dark brown and reddish brown, firm clay loam. The lower part of the subsoil is mottled.

The moderately deep, moderately well drained Gosport soils formed in material weathered from shale

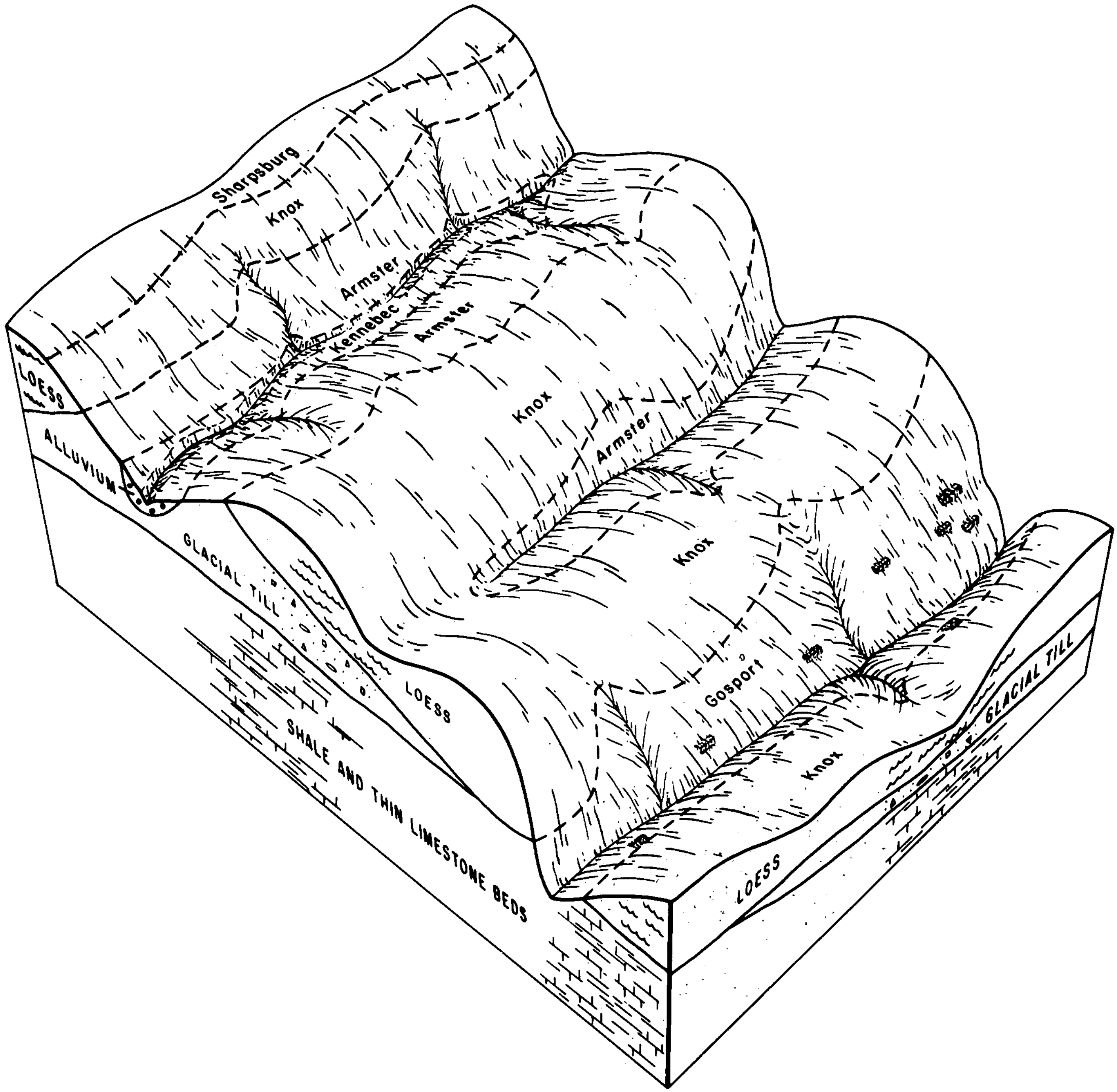


Figure 5.—Typical pattern of soils in the Knox-Armster-Gosport association.

on side slopes. Typically, the surface layer is very dark gray and very dark grayish brown silty clay loam about 8 inches thick. The mottled subsoil is about 27 inches thick. The upper part of the subsoil is dark yellowish brown, firm silty clay loam; the middle part is dark yellowish brown, very firm silty clay; and the lower part is light olive brown, firm silty clay loam. Shale is at a depth of about 35 inches.

The minor soils in this association are Judson, Kennebec, and Sharpsburg soils. The well drained

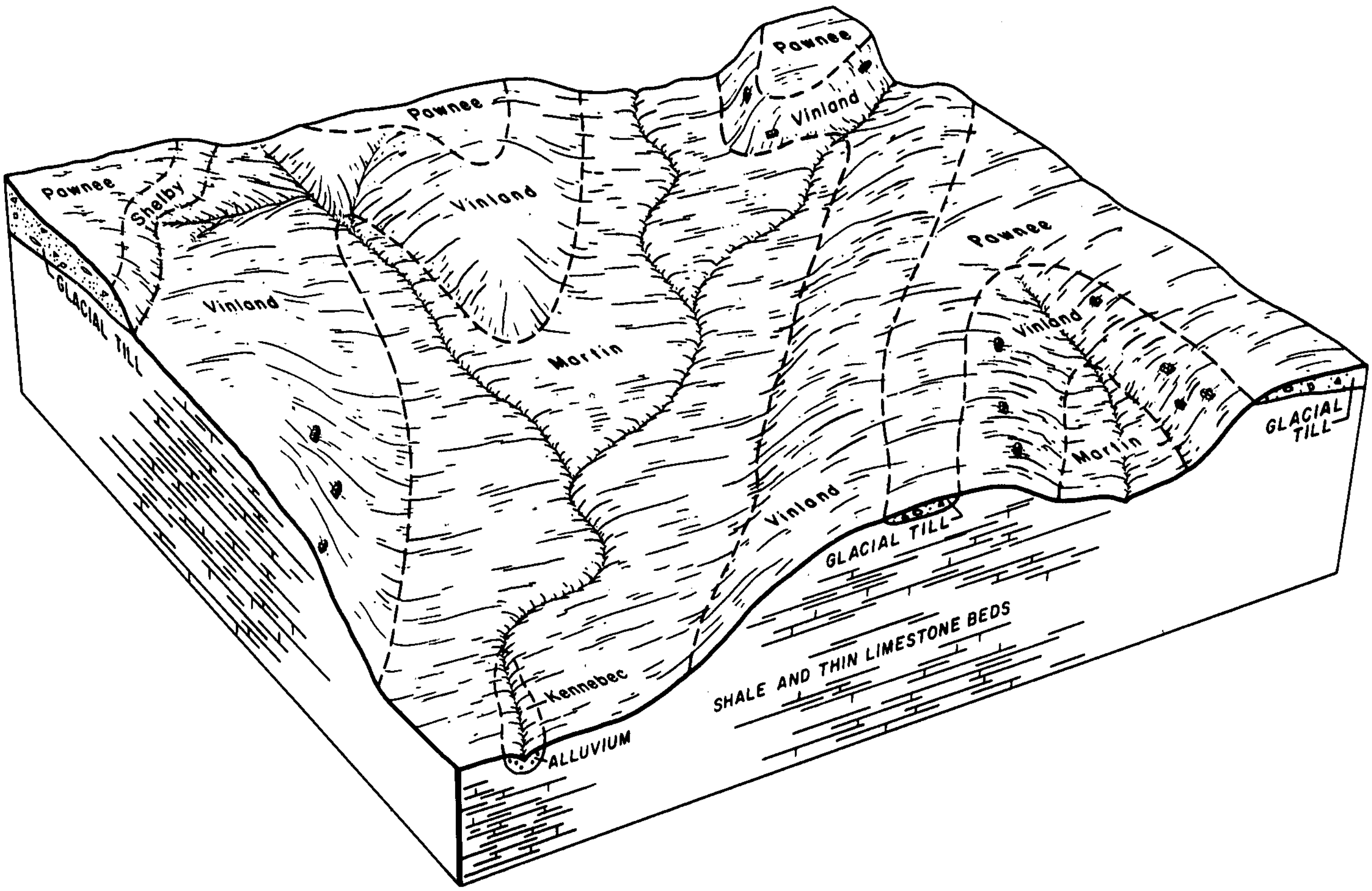


Figure 6.—Typical pattern of soils in the Martin-Vinland-Pawnee association.

Judson soils are on foot slopes. The Kennebec soils are on flood plains along drainageways. The moderately well drained Sharpsburg soils are on convex ridgetops.

The soils in this association are used mainly for pastureland and woodland. Some of the less sloping soils are used for cropland. The major management concerns are controlling erosion and maintaining the growth and vigor of the grasses and trees. An adequate plant cover and ground mulch help to reduce the runoff rate and prevent excessive soil loss.

5. Martin-Vinland-Pawnee Association

Deep or shallow, moderately sloping and strongly sloping, moderately well drained and somewhat excessively drained soils that have a silty, loamy, or clayey subsoil; on uplands

The soils in this association are on ridgetops and side slopes that are deeply dissected by drainageways (fig. 6). Slope ranges from 3 to 15 percent.

This association makes up about 3 percent of the county. It is about 40 percent Martin soils, 35 percent Vinland soils, 15 percent Pawnee soils, and 10 percent minor soils and outcrops of limestone.

The deep, moderately well drained Martin soils formed in material weathered from shale on the lower side slopes. Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The mottled subsoil is about 42 inches thick. The upper part of the subsoil is very dark brown, firm silty clay loam; the middle part is very dark grayish brown and dark grayish brown, very firm silty clay; and the lower part is olive brown, very firm silty clay. Olive and pale olive shale is at a depth of about 49 inches.

The shallow, somewhat excessively drained Vinland soils formed in material weathered from shale on side slopes. Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam about 4 inches thick. The substratum is grayish brown shaly silty clay loam about 7 inches thick. Weathered silty shale is at a depth of about 19 inches.

The deep, moderately well drained Pawnee soils formed in glacial till on ridgetops and the upper side slopes. Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The mottled subsoil is more than 52 inches thick. The upper part of the subsoil is very dark grayish brown, firm clay; the middle part is dark grayish brown and dark brown, firm clay; and the lower part is grayish brown, firm clay loam.

Of minor extent in this association are Gosport, Kennebec, and Shelby soils and outcrops of limestone. The moderately deep Gosport soils are on steep side slopes. The Kennebec soils are on flood plains along drainageways. The well drained Shelby soils are on side slopes above the Vinland soils.

The soils in this association are used mainly for pasture, hayland (fig. 7), and cultivated cropland. Some of the steeper soils and the soils along streams support trees. Grain sorghum and small grains are the main crops. Controlling erosion and maintaining fertility and tilth are concerns in managing areas used for crops. Maintaining an adequate and vigorous stand of grasses is the main concern of hayland and pasture management.

6. Kennebec-Wabash-Colo Association

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

The soils in this association are on flood plains of the Delaware River and its tributaries and Stranger Creek and Independence Creek. The soils are occasionally or frequently flooded. Slope ranges from 0 to 2 percent.

This association makes up about 9 percent of the county. It is about 40 percent Kennebec soils, 35 percent Wabash soils, 10 percent Colo soils, and 15 percent minor soils.

The moderately well drained Kennebec soils formed in silty alluvium. Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is black, friable silt loam about 25 inches thick. The subsoil is very dark brown, mottled, friable silt loam about 13 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown, mottled silt loam.

Figure 7.—An area of Vinland silty clay loam, 4 to 15 percent slopes, used for hayland.

The very poorly drained Wabash soils formed in clayey alluvium. Typically, the surface layer is black silty clay about 8 inches thick. The subsurface layer is black, very firm silty clay about 20 inches thick. The subsoil to a depth of more than 60 inches is very dark gray and dark gray, mottled very firm silty clay.

The poorly drained Colo soils formed in alluvium. Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The mottled subsurface layer is firm silty clay loam about 30 inches thick. The upper part is black, and the lower part is very dark gray. The substratum to a depth of about 60 inches is dark gray, mottled silty clay loam.

The minor soils in this association are Chase, Judson, and Reading soils. The somewhat poorly drained Chase soils are on stream terraces. The well drained Judson soils are on foot slopes. The moderately well drained Reading soils are on rarely flooded stream terraces.

The soils in this association are used mainly for cultivated crops. In some small areas they are used for hay, pasture, and woodland. Corn, soybeans, small grains, and grain sorghum are the main cultivated crops. Controlling flooding and maintaining fertility and tilth are concerns in managing cropland.

7. Haynie-Onawa Association

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

This association is on flood plains in the valley of the Missouri River. The soils are occasionally flooded. Slope ranges from 0 to 3 percent.

This association makes up about 3 percent of the county. It is about 50 percent Haynie soils, 40 percent Onawa soils, and 10 percent minor soils.

The moderately well drained Haynie soils formed in loamy alluvium. Typically, the calcareous surface layer is very dark grayish brown silt loam about 8 inches thick. The calcareous substratum to a depth of about 60 inches is stratified, mottled silt loam and very fine sandy loam. The upper part is dark grayish brown, and the lower part is grayish brown or brown.

The somewhat poorly drained Onawa soils formed in clayey and silty alluvium. Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum is dark grayish brown, mottled silty clay about 19 inches thick; and the lower part to a depth of about 60 inches is dark grayish brown, mottled silt loam.

The minor soils in this association are Aquents and Colo and Sarpy soils. The Aquents are in narrow pits that were dug when the levees were constructed. The poorly drained Colo soils are along creeks entering the valley of the Missouri River. The sandy Sarpy soils are on mounds.

The soils in this association are used mainly for cultivated crops. In some small areas along the Missouri River they support trees. Corn, soybeans, grain sorghum, and small grains are the main cultivated crops. Controlling flooding, improving surface drainage, and maintaining tilth and fertility are concerns in managing these soils in cultivated 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 "Use and Management of the Soils."

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

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

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

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases.* Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Grundy silty clay loam, 0 to 2 percent slopes, is one of several phases in the Grundy series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Knox-Gosport complex, 10 to 30 percent slopes, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. 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.

This survey includes *miscellaneous areas.* Such areas have little or no soil material and support little or no vegetation. Pits, quarries, is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown 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

Aq—Aquents, loamy. These nearly level, poorly drained and very poorly drained soils are in borrow pits, where soil material has been removed for fill, mainly in building levees. They are frequently flooded. The pits vary in depth. The sides of some pits are nearly vertical. The areas occur as long narrow tracts, mainly between the levees and the Missouri River.

The soils are dominantly loamy. In some areas, recently deposited sand covers the surface; and in a few areas, the soils are clayey.

Included with these soils in mapping are small areas of Haynie, Onawa, and Sarpy soils, which make up 10 to 15 percent of the unit. These included soils are in narrow undisturbed areas between the pits.

Most areas are cultivated to control the brush and trees. The soils are poorly suited to cultivated crops. The crops usually cannot be harvested because of the flooding and deposition of sand. Some areas are covered with a dense stand of willow and cottonwood. Water covers most areas for short periods in most years.

These areas have a good potential for habitat for waterfowl, deer, quail, and furbearers. Tree plantings and excavated ponds help increase wildlife populations.

The soils are generally unsuitable for building site development because flooding is a hazard. Overcoming this hazard is difficult without major flood-control measures.

These soils are not assigned to a capability class.

Ar—Armster clay loam, 6 to 12 percent slopes. This strongly sloping, moderately well drained soil is on side slopes and ridgetops. In some places, pebbles and a few cobbles are on the surface. Individual areas of this unit are irregular in shape and range from 10 to 180 acres in size.

Typically, the surface layer is dark brown clay loam about 7 inches thick. The subsoil to a depth of 60 inches is reddish brown, firm clay loam. The lower part of the subsoil is mottled. The surface layer is brown in areas where it has been mixed with the upper part of the subsoil by plowing. Also, in some places the subsoil is grayish brown.

Included with this soil in mapping, and making up 10 to 15 percent of the unit, are small areas of Knox, Martin and Sharpsburg soils and seep areas. The Knox and Sharpsburg soils are less sandy and less red and are on upper side slopes and on ridgetops. Martin soils are darker and are on foot slopes. Seep areas are on lower slopes.

Permeability of this Armster soil is moderately slow, and surface runoff is rapid. Reaction in the surface layer is slightly acid. Natural fertility is medium, and organic matter content is low. Tilth is fair. The available water capacity is high. The subsoil has high shrink-swell potential. A perched high water table is at a depth of 3 to 5 feet in winter and early in spring.

In most areas this soil is used for cultivated crops, mainly soybeans, grain sorghum, and wheat. The soil is poorly suited to cultivated crops. If it is used for cultivated crops, erosion is a hazard. Minimum tillage, terraces, farming on the contour, and grassed waterways or subsurface tile drainage systems help reduce runoff and erosion. Crop residue left on the soil surface helps to reduce runoff and erosion and increase the water infiltration rate. Subsurface tile drainage systems help to remove water from seep areas.

The use of this soil for pastureland or hayland is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Brush management, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees, and a few areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is controlled or removed. This can be accomplished by site preparation or prescribed burning or by spraying, cutting, or girdling. There are no hazards or limitations to be concerned about when planting or harvesting trees.

This soil is moderately well suited as a site for local roads and streets and for dwellings. The low strength and shrink-swell potential of the soil are limitations for roads. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material helps to prevent road damage caused by shrinking and swelling of the soil. Shrink-swell potential is a limitation to the use of this soil as a site for dwellings. Wetness is an additional limitation for dwellings with basements. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent damage caused by the wetness and the shrinking and swelling of the soil.

This soil is poorly suited to septic tank absorption fields. Moderately slow permeability and wetness are problems. Perimeter drains help to reduce wetness. Increasing the size of the absorption field helps to overcome the limitation of moderately slow permeability. The soil is moderately well suited to sewage lagoons. The slope needs to be modified for lagoons. If the less sloping areas are selected, construction of the lagoons will require less leveling and banking.

The capability subclass is IVe.

As—Armster clay loam, 12 to 20 percent slopes. This moderately steep, moderately well drained soil is on side slopes. In a few places, cobbles are on the surface. Individual areas of this unit are irregular in shape and range from 10 to 120 acres in size.

Typically, the surface layer is dark brown clay loam about 7 inches thick. The subsoil to a depth of more than 60 inches is reddish brown, firm clay loam. The lower part of the subsoil is mottled. The surface layer is brown in areas where it has been mixed with the upper part of the subsoil by plowing. In places the surface layer is sandy loam, gravelly loam, or gravelly clay loam.

Included with this soil in mapping are small areas of Gosport, Knox, Martin, and Vinland soils. The moderately deep Gosport soils are on the steeper side slopes. Knox soils are less sandy and less red and are on upper side slopes and on ridgetops. The shallow Vinland soils are on lower side slopes. Martin soils are darker and are on foot slopes. Also included are small areas where gullies have formed. Inclusions make up 10 to 15 percent of the unit.

Permeability of this Armster soil is moderately slow, and surface runoff is rapid. Natural fertility is low, and the organic matter content is low. The available water capacity is high. The subsoil has high shrink-swell potential. A perched high water table is at a depth of 3 to 5 feet in winter and early in spring.

Most of the acreage of this soil is in native grasses and trees. The soil is generally unsuited to cultivated crops because erosion is a severe hazard. It is best suited to pasture, hayland, and range.

The major problem in managing pasture and range is the hazard of erosion. Maintaining an adequate plant cover and ground mulch helps to reduce runoff and prevent excessive soil loss. Overstocking and overgrazing reduce the protective plant cover and cause surface compaction and excessive runoff. Brush management, proper stocking rates, uniform grazing, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the range in good condition.

This soil is suited to trees, and many areas remain in native hardwoods. The steepness of slope limits woodland use. Erosion, equipment limitations, and seedling mortality are the main concerns in management. Practicing selective cutting rather than clearcutting, placing haul roads on the contour, and preserving as much understory vegetation as possible help to control erosion. The slope of this soil makes the use of some equipment in logging and planting operations difficult. Use of special equipment and careful planning of logging and planting operations may help to overcome this problem. Proper site preparation helps to reduce seedling mortality.

This soil is poorly suited as a site for dwellings and local roads and streets because of the moderately steep slope and the shrink-swell potential. Low strength is an additional problem for local roads and streets. Land shaping is needed if roads or buildings are constructed. The soil erodes readily during construction. Quickly establishing a plant cover and mulching help to control excessive soil loss. For dwellings, the use of properly designed and reinforced foundations, foundation drains, and porous backfill material helps to prevent damage caused by the shrinking and swelling of the soil. Roads need to be designed so that the pavement and the base material are thick enough to compensate for the low strength of the soil material. The use of coarser grained base material helps to prevent road damage caused by shrinking and swelling of the soil.

The soil is generally unsuited as a site for septic tank absorption fields and sewage lagoons. Included areas of less sloping soils on foot slopes are favorable sites for lagoons.

The capability subclass is VIe.

Ch—Chase silty clay loam. This nearly level, somewhat poorly drained soil is on stream terraces. It is rarely flooded. Individual areas of this unit are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsurface layer is black silty clay loam about 4 inches thick. The subsoil is about 34 inches thick. The upper part is black, friable silty clay loam; the middle part is black, very firm silty clay; and the lower part is very dark gray, mottled, very firm silty clay. The substratum to a depth of about 60 inches is dark grayish brown, mottled silty clay. In some places the subsoil is less clayey.

Included with this soil in mapping are small areas of the very poorly drained Wabash soils. These soils are in lower-lying areas and make up less than 10 percent of the unit.

Permeability is slow in this Chase soil, and surface runoff is slow. Natural fertility is high, and the available water capacity is moderate. The surface layer is medium acid. Organic matter content is moderate. The subsoil has high shrink-swell potential. Tilth is good. A perched high water table is at a depth of 2 to 4 feet in spring.

In most areas this soil is used for cultivated crops. This soil is well suited to grain sorghum, corn, soybeans, and small grains and to grasses and legumes for hay and pasture. In spring, wetness may delay planting; but in summer, the soil is droughty because the clayey subsoil releases water slowly to the plants. Returning crop residue to the surface helps to increase the water infiltration rate and maintain fertility and tilth. Shallow drainage ditches help to reduce wetness.

This soil is suited to pasture, and some small areas are in pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the grass in good condition.

This soil is suited to trees, and a few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is controlled or removed. This can be accomplished by site preparation or by spraying, cutting, or girdling. Because of the wetness of the soil, the use of equipment is limited and seedling mortality is a hazard. Equipment is easier to use if the trees are harvested when the soil is relatively dry or frozen. Site preparation reduces the rate of seedling mortality.

The soil is generally unsuited to building site development because flooding is a hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Go—Gosport silty clay loam, 25 to 45 percent slopes. This steep, moderately well drained soil is on side slopes. Individual areas of this map unit are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is very dark gray and very dark grayish brown silty clay loam about 8 inches thick. The subsoil is about 27 inches thick. The upper part is dark yellowish brown, mottled, firm silty clay loam; the middle part is dark yellowish brown, mottled, firm silty clay; and the lower part is light olive brown, mottled, firm silty clay loam. Clayey shale is at a depth of about 35 inches. In some places the depth to shale is less than 20 inches.

Included with this soil in mapping, and making up about 10 to 15 percent of the map unit, are small areas of Armster, Knox, and Martin soils and limestone outcrops. The deep, well drained Armster and Knox soils are on ridgetops. The deep Martin soils are on foot slopes. Limestone outcrops are on the steeper areas.

Permeability of this Gosport soil is very slow, and the available water capacity is low. Runoff is rapid. Natural fertility and organic matter content are low. The surface layer is strongly acid. The subsoil has high shrink-swell potential.

Most of the acreage is woodland pasture. Oak, hickory, and green ash are the main trees in the eastern part of the county. Elm and hackberry are the main trees in the southwestern part. The soil is unsuited to cultivated crops because erosion is a severe hazard. Also, the steepness of slope restricts the use of equipment. Maintaining an adequate plant cover and ground mulch helps to reduce runoff and prevent excessive soil loss. Careful management of grazing is essential. Brush management, proper range use, and deferment of grazing are needed to keep the grasses in good condition.

This soil is moderately well suited to trees, and most areas remain in native hardwoods. Erosion hazard, limitations to the use of equipment, seedling mortality, and plant competition are management concerns. Practicing selective cutting rather than clearcutting, placing haul roads on the contour, and preserving as much understory vegetation as possible help to control erosion. The slope of this soil makes the use of some equipment in logging and planting operations difficult. Use of special equipment and careful planning of logging and planting operations may help to overcome this problem. Proper site preparation helps to reduce seedling mortality. High winds may blow down trees. Windthrow can be limited by using harvesting methods that do not leave trees standing alone or widely spaced.

The vegetation common to this soil provides habitat for many types of wildlife species, including squirrels, deer, quail, and numerous songbirds. Forest management practices can be used to enhance wildlife populations.

This soil is generally unsuited to building site development because of the steep slope.

The capability subclass is VIIe.

Gr—Grundy silty clay loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on broad ridgetops. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black friable silty clay loam about 5 inches thick. The subsoil is about 38 inches thick. The upper part is black, firm silty clay loam; the middle part is very dark gray and dark grayish brown, mottled, firm silty clay; and the lower part is grayish brown, mottled, firm silty clay. The substratum to a depth of about 60 inches is olive gray, mottled silty clay loam. In some areas the subsoil is clay loam or clay.

Included with this soil in mapping are small areas of the moderately well drained Sharpsburg soils on the lower side slopes. These soils make up less than 10 percent of the unit.

Permeability is slow in this Grundy soil, and runoff is slow. Available water capacity is moderate, and natural fertility is high. The surface layer is slightly acid. The subsoil has high shrink-swell potential. Tilth is good. A perched high water table is at a depth of 1 to 3 feet in spring.

In most areas this soil is used for cultivated crops. In some small areas it is used for pasture. This soil is well suited to grain sorghum, corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Wetness, however, may delay spring planting. In summer, the soil is droughty because the clayey subsoil releases water slowly. Leaving crop residue on the surface increases the water infiltration rate, reduces the runoff rate, and helps to prevent surface crusting and excessive soil loss. Shallow drainage ditches reduce wetness.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential and the wetness of the soil are limitations for buildings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable coarse material help to prevent structural damage caused by wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil are limitations on sites for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to prevent damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

This soil is generally unsuited to septic tank absorption fields because of slow permeability. It is well suited to sewage lagoons.

The capability subclass is IIw.

Gu—Grundy silty clay loam, 2 to 6 percent slopes. This moderately sloping, somewhat poorly drained soil is on uplands. Individual areas are irregular in shape and range in size from 10 to 80 acres.

Typically, the surface layer is black silty clay loam about 7 inches thick. The mottled subsoil is about 40 inches thick. The upper part is very dark gray, firm silty clay; the middle part is dark grayish brown, firm silty clay; and the lower part is grayish brown, firm silty clay. The substratum to a depth of about 60 inches is olive gray, mottled silty clay loam. In places the subsoil is less clayey. In some areas the upper part of the subsoil has been mixed with the surface soil by tillage and the surface layer is dark grayish brown silty clay. In places the subsoil is clay or clay loam.

Included with this soil in mapping, and making up 5 to 15 percent of the map unit, are small areas of Kennebec and Sharpsburg soils and seep spots. The moderately well drained Kennebec soils are on flood plains along drainageways. The moderately well drained Sharpsburg soils are on lower side slopes. Seep spots are on foot slopes.

Permeability is slow in the Grundy soil, and runoff is medium. Available water capacity is moderate. Natural fertility is high. The surface layer is slightly acid. The subsoil has high shrink-swell potential. Tilth is good. A perched high water table is at a depth of 1 to 3 feet in spring.

In most areas this soil is used for cultivated crops. It is well suited to corn, soybeans, grain sorghum, and small grains and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. The soil is wet in spring, but it is droughty in summer because the clayey subsoil releases water slowly. The wetness delays planting in some years. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or subsurface tile drains help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the water infiltration rate.

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

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential and the wetness of the soil are limitations for buildings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable coarse material help to prevent structural damage caused by wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil are limitations on sites for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to prevent road damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

The soil is generally unsuited to septic tank absorption fields because of slow permeability. It is well suited to sewage lagoons; however, some land shaping commonly is needed.

The capability subclass is IIe.

Gx—Grundy silty clay, 3 to 7 percent slopes, eroded. This moderately sloping, somewhat poorly drained soil is on uplands. Individual areas are irregular in shape and range from 10 to 70 acres in size.

Typically, the surface layer is very dark gray silty clay about 6 inches thick. The subsoil is about 36 inches thick. The upper part is very dark brown, firm silty clay; the middle part is dark grayish brown, mottled, firm silty clay; and the lower part is brown, mottled, firm silty clay. The substratum to a depth of about 60 inches is olive gray, mottled silty clay. In some areas the surface layer is silty clay loam and is thicker. Also, in some places the subsoil is clay or clay loam.

Included with this soil in mapping are small areas of Kennebec and Sharpsburg soils. The silty, moderately well drained Kennebec soils are on flood plains along drainageways. The moderately well drained Sharpsburg soils are on the lower side slopes. Seep spots are on foot slopes. Included soils make up 5 to 10 percent of the unit.

Permeability is slow in the Grundy soil, and runoff is medium. Available water capacity is moderate. Natural fertility is medium. The surface layer is slightly acid. The shrink-swell potential is high. The clayey surface soil is firm, and tilth is poor. A perched high water table is at a depth of 1 to 3 feet in spring.

Most of the acreage is cultivated. This soil is poorly suited to corn. It is better suited to soybeans, grain sorghum, and small grains and to grasses and legumes for pasture and hay. Further erosion is a hazard if cultivated crops are grown. The soil is wet in spring, but it is droughty in summer because the clayey soil releases water slowly. The wetness delays planting in some years. Terraces, contour farming, and grassed waterways or subsurface tile drains help to control runoff and erosion. Leaving crop residue on the surface and practicing minimum tillage reduce the runoff rate and increase the water infiltration rate and tilth.

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

This soil is poorly suited as a site for dwellings and local roads and streets. The shrink-swell potential and the wetness of the soil are limitations for buildings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable coarse material help to prevent structural damage caused by wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil limit the use of the soil as a site for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to prevent road damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts help to protect roads from frost damage.

The soil is generally unsuited to septic tank absorption fields because of slow permeability. It is well suited to sewage lagoons; however, some land shaping commonly is needed.

The capability subclass is IIIe.

Hn—Haynie silt loam. This nearly level, moderately well drained soil is on flood plains along the Missouri River and along some upland drainageways. In most areas it is occasionally flooded, but in the areas between levees and the Missouri River it is frequently flooded. Individual areas are long and irregular in shape and range from 10 to 400 acres in size.

Typically, the calcareous surface layer is very dark grayish brown silt loam about 8 inches thick. The calcareous substratum to a depth of about 60 inches is stratified, mottled silt loam and very fine sandy loam. The upper part is dark grayish brown, and the lower part is grayish brown or brown. In some places the dark surface layer is more than 10 inches thick and the depth to calcareous material is more than 10 inches.

Included with this soil in mapping are small areas of the excessively drained Sarpy soils and the somewhat poorly drained Onawa soils. The Onawa soils are in shallow depressions. The Sarpy soils are on higher ridges. These soils make up 5 to 10 percent of the unit.

Permeability is moderate in the Haynie soil, and runoff is slow. Reaction is mildly alkaline or moderately alkaline. Natural fertility is medium, and organic matter content is moderately low. Tilth is good. A perched seasonal high water table is at a depth of 4 to 6 feet.

Most of the acreage is used for cultivated crops. A few small areas are in pasture of tame grass. This soil is well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Floodwater, however, can damage crops. Crop residue management helps to maintain fertility and tilth.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture in good condition.

This soil is suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

The soil is generally unsuited to building site development because flooding is a hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Ho—Haynie-Onawa complex. This map unit consists of moderately well drained Haynie soils and somewhat poorly drained Onawa soils on flood plains along the Missouri River. These soils are nearly level. In most areas they are occasionally flooded, but in the areas between levees and the Missouri River they are frequently flooded. In some places the Onawa soils are subject to ponding.

Areas of this complex range from 20 to 500 acres in size. They are 50 to 60 percent Haynie soils and 30 to 40 percent Onawa soils. The Haynie soils are on the higher positions. The areas of Haynie soils and the areas of Onawa soils generally are so narrow that mapping them separately at the scale used is not practical.

Typically, the Haynie soils have a surface layer of very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 60 inches is dark grayish brown and grayish brown, mottled, stratified silt loam and very fine sandy loam. In some places the dark surface layer is more than 10 inches thick.

Typically, the Onawa soils have a surface layer of very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum, to a depth of 27 inches, is dark grayish brown, mottled silty clay. The lower part of the substratum to a depth of 60 inches is dark grayish brown, mottled, stratified silt loam and very fine sandy loam.

Included with these soils in mapping are small areas of the excessively drained Sarpy soils. The Sarpy soils are on sandy ridges. These soils make up 5 to 10 percent of the unit.

Permeability is moderate in the Haynie soils. It is slow in the upper part of the Onawa soils and moderate in the lower part. Runoff is slow. The Haynie soils have good tilth, and the Onawa soils have fair tilth. The shrink-swell potential is high in the Onawa soils. The seasonal high water table is at a depth of 4 to 6 feet in the Haynie soils and 2 to 4 feet in the Onawa soils. Natural fertility is medium, and organic matter content is moderately low.

Most of the acreage is used for cultivated crops. A few small areas are in pasture of tame grass. These soils are well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. The wetness, however, is a limitation, and the floodwater can damage crops. The Onawa soils are difficult to work because they are wet and they dry slowly in spring. As a result, tillage and harvest are delayed, especially during rainy periods. Surface ditches, surface bedding, and land grading and smoothing improve drainage. Crop residue management helps to maintain fertility and tilth.

These soils are suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soils in good condition.

A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing plants are controlled. Because of wetness, the use of equipment and plant competition are problems. The use of harvesting equipment is easier in fall and winter, when the soil is relatively dry or frozen. Site preparation and controlled burning, spraying, or cutting reduce the rate of seedling mortality and control plant competition. High winds may blow down trees. Windthrow can be limited by using harvesting methods that will not leave trees standing alone or widely spaced.

These soils are generally unsuitable for building site development because flooding is a severe hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Hs—Haynie-Sarpy complex. This map unit consists of moderately well drained Haynie soils and excessively drained Sarpy soils on flood plains along the Missouri River. These soils are undulating. In most areas they are occasionally flooded, but in the areas between levees and the Missouri River they are frequently flooded.

Areas of this complex are long and range from 10 to 200 acres in size. They are 50 to 65 percent Haynie soils and 30 to 40 percent Sarpy soils. The Sarpy soils are on slightly higher positions.

Typically, the Haynie soils have a surface layer of very dark grayish brown very fine sandy loam about 8 inches thick. The substratum to a depth of about 60 inches is dark grayish brown and grayish brown, mottled, stratified silt loam and very fine sandy loam. In some places the dark surface layer is more than 10 inches thick.

Typically, the Sarpy soils have a surface layer of dark grayish brown loamy fine sand about 6 inches thick. The substratum to a depth of about 60 inches is grayish brown and dark grayish brown fine sand.

Included with these soils in mapping are small areas of the somewhat poorly drained Onawa soils in shallow depressions. These included soils make up 5 to 10 percent of the unit.

Permeability is moderate in the Haynie soils and rapid in the Sarpy soils. Available water capacity is high in the Haynie soils and low in the Sarpy soils. Runoff is slow. The seasonal high water table is at a depth of 4 to 6 feet in the Haynie soils and at a depth of more than 6 feet in the Sarpy soils. Tilth is good. Organic matter content is low in the Sarpy soils and moderately low in the Haynie soils. Natural fertility is medium in the Haynie soils and low in the Sarpy soils. Reaction is mildly alkaline or moderately alkaline throughout all of the soils.

Most of the acreage is used for cultivated crops. These soils are suited to corn, grain sorghum, and small grains and to grasses and legumes for pasture and hay. The floodwater can damage crops. Soil blowing and the low available water capacity are additional management concerns on the Sarpy soils. Crop residue management and a protective plant cover help to control soil blowing. Applications of fertilizer help to maintain fertility and tilth. A cover of pasture grasses is effective in controlling soil blowing.

These soils are suited to trees. A few areas remain in native hardwoods. Selecting suitable species, preparing a site adequately, and controlling soil blowing help to obtain a good stand.

These soils are generally unsuitable as sites for buildings because flooding is a hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIIw.

Ju—Judson silt loam, 2 to 7 percent slopes. This moderately sloping, well drained soil is on foot slopes. In some places, pebbles and a few cobbles are on the surface. Individual areas are irregular in shape and range from 10 to 100 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsurface layer is about 5 inches thick. The upper part is very dark grayish brown, friable silt loam; and the lower part is dark brown, friable silty clay loam. The subsoil to a depth of about 60 inches is friable silty clay loam. The upper part is dark brown, and the lower part is dark yellowish brown.

Included with this soil in mapping, and making up about 5 percent of the unit, are small areas of the poorly drained Colo soils. These soils are in the lower lying, more nearly level areas.

Available water capacity is high in this Judson soil, and permeability is moderate. Runoff is medium. Tilth is good. Natural fertility is high, and organic matter content is moderate. The surface layer is slightly acid. The shrink-swell potential is moderate.

Most of the acreage is used for cultivated crops. The rest is in pasture of tame grass. This soil is well suited to corn, soybeans, small grains, and grain sorghum and to grasses and legumes for hay and pasture. Crop residue management helps to maintain fertility and tilth. Diversion terraces help to control the runoff from higher-lying areas on the side slopes.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings. Shrinking and swelling of the soil can be a problem. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable coarse material help to prevent structural damage caused by the shrinking and swelling. In some places, surface runoff from higher adjacent slopes can cause flooding. Diversion terraces help to reduce this hazard.

The soil is moderately well suited to use as a site for local roads and streets. Low soil strength and frost action are limitations to this use. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

This soil is well suited to septic tank absorption fields and is moderately well suited to sewage lagoons. Seepage and slope are limitations on sites for sewage lagoons. Sealing the lagoon helps reduce seepage. Some land shaping commonly is needed.

The capability subclass is IIe.

Ke—Kennebec silt loam. This nearly level, moderately well drained soil is on flood plains. It is subject to occasional floods that cause crop damage. Individual areas are long and irregular in shape and range from 10 acres to more than 200 acres. This soil is on the broad Delaware River flood plain, adjacent to the channel.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is black, friable silt loam about 25 inches thick. The subsoil is about 13 inches thick. It is very dark brown, friable, mottled silt loam. The substratum to a depth of about 60 inches is very dark grayish brown, mottled silt loam. In some places the surface layer is sandy loam.

Included with this soil in mapping are small areas of Reading soils. The Reading soils are on higher lying terraces that rarely flood. The included soils make up about 5 percent of this map unit.

Available water capacity is high in this Kennebec soil. Permeability is moderate, and runoff is slow. Natural fertility is high, and organic matter content is moderate. Tilth is good. The surface layer is medium acid. The shrink-swell potential is moderate. The seasonal high water table is at a depth of 3 to 5 feet.

Nearly all the acreage is used for cultivated crops. This soil is well suited to corn, soybeans, and grain sorghum and to grasses and legumes for hay and pasture. It is less suitable for wheat because early in spring the floodwater and the material deposited by the water can damage the crop. The flooding can damage other crops, too. Crop residue management helps to maintain fertility and tilth.

This soil is suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Because flooding is a severe hazard, this soil is generally unsuitable for building site development. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Kf—Kennebec silt loam, channeled. This nearly level, moderately well drained soil is on flood plains that are dissected by deeply entrenched drainageways. It is frequently flooded. Individual areas are long and narrow and are continuous along some streams. They range from 30 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is black silt loam about 25 inches thick. The subsoil is about 13 inches thick. It is very dark brown, mottled, friable silt loam. The substratum to a depth of about 60 inches is very dark grayish brown, mottled silt loam. In some areas the surface soil is thinner or lighter colored.

Included with this soil in mapping are small areas of Haynie and Sarpy soils. These soils make up less than 10 percent of this unit. The calcareous Haynie soils are in the higher areas adjacent to the stream channel. The sandy Sarpy soils are in the low areas along the channels.

Permeability is moderate in the Kennebec soil, and available water capacity is high. Runoff is slow. Organic matter content is moderate, and natural fertility is high. The surface layer is medium acid. The shrink-swell potential is moderate. The seasonal high water table is at a depth of 3 to 5 feet.

Nearly all the acreage is in native grass or trees. This soil is generally unsuited to cultivated crops because of flooding and because of the difficulty in using machinery along the meandering stream channel. Growth of the more desirable native grasses is restricted by the tree canopy. Maintaining control of woody vegetation and timely deferment of grazing help to increase stands of the more desirable grasses.

This soil is suited to trees, and most areas remain in native hardwoods. Trees are generally needed for streambank stabilization. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

The vegetation common to this soil provides habitat for many types of wildlife, such as deer, quail, furbearers, and numerous songbirds. Forest management practices can be used to enhance wildlife populations.

Because flooding is a severe hazard, this soil is generally unsuitable for building site development. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is Vw.

Kg—Kennebec-Colo silt loams. This complex consists of nearly level, moderately well drained and poorly drained soils on narrow flood plains of upland drainageways. These soils are subject to occasional floods of short duration that cause crop damage.

The map unit consists of 55 to 65 percent Kennebec soil and 25 to 35 percent Colo soil. The moderately well drained Kennebec soil is on the higher parts of the flood plain. The poorly drained Colo soil is in the lower lying depressional areas. Areas with deeper channels commonly are better drained. Individual areas of Kennebec and Colo soils are so intricately mixed or narrow that it is not practical to separate them at the scale used in mapping.

Typically, the Kennebec soil has a surface layer of black silt loam about 9 inches thick. The subsurface layer is black, friable silt loam about 28 inches thick. The subsoil is about 9 inches thick. It is very dark brown, mottled, friable silt loam. The substratum to a depth of about 60 inches is very dark grayish brown, mottled silt loam. In some areas the subsoil is brown.

Typically, the Colo soil has a surface layer of very dark grayish brown silt loam about 8 inches thick. The subsurface layer is about 30 inches thick. The upper part is black, mottled, friable silty clay loam. The lower part is very dark gray, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is dark gray, mottled silty clay loam.

Included with these soils in mapping, and making up about 10 percent of the map unit, are small areas of Chase soils. Chase soils dominantly have a clayey subsoil and are on stream terraces.

Permeability is moderate in the Kennebec soil and in the Colo soil. Available water capacity is high, and runoff is slow. Natural fertility is high. Tilth is good. The subsoil has moderate shrink-swell potential. The seasonal high water table is at a depth of 3 to 5 feet in the Kennebec soil and 1 to 3 feet in the Colo soil.

Most of the acreage is used for cultivated crops. These soils are well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for pasture and hay. The wetness in the Colo soil, however, is a limitation. Wetness delays planting and harvesting in some years. Flooding damages crops on both soils in some years. Crop residue management helps to maintain fertility and tilth. Field drainage ditches help remove excess surface water.

These soils are suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

These soils are suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. Because of wetness in the Colo soil, the use of equipment is limited and plant competition is a problem. The use of harvesting equipment is easier if the soil is relatively dry or frozen. Site preparation reduces the rate of seedling mortality. High winds may blow down trees. Windthrow may be limited by using harvesting methods that will not leave trees standing alone or widely spaced.

Because flooding is a severe hazard, these soils are generally unsuitable for building site development. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Kn—Knox silt loam, 18 to 30 percent slopes. This moderately steep, well drained soil is on dissected slopes and bluffs along the Missouri River and its tributaries. Individual areas are irregular in shape and range from 10 to 1,200 acres in size.

Typically, the surface layer is very dark brown silt loam about 8 inches thick. The subsurface layer is dark grayish brown silty clay loam about 5 inches thick (fig. 8). The upper part of the subsoil is dark yellowish brown, friable silty clay loam. The lower part to a depth of about 60 inches is brown, mottled, friable silt loam. The surface layer is brown silty clay loam in areas where it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Armster and Gosport soils. These soils are on the lower slopes. Armster soils contain more sand and gravel than the Knox soil. The Gosport soils are moderately deep over shale. Also included are small areas where gullies have formed. Inclusions make up less than 10 percent of the unit.

Permeability is moderate in the Knox soil, and runoff is rapid. Available water capacity is high. Natural fertility is medium, and organic matter content is low. The surface layer is medium acid. The subsoil has moderate shrink-swell potential.

In most areas this soil is used for range or pasture or supports trees. In some areas it is used for cultivated

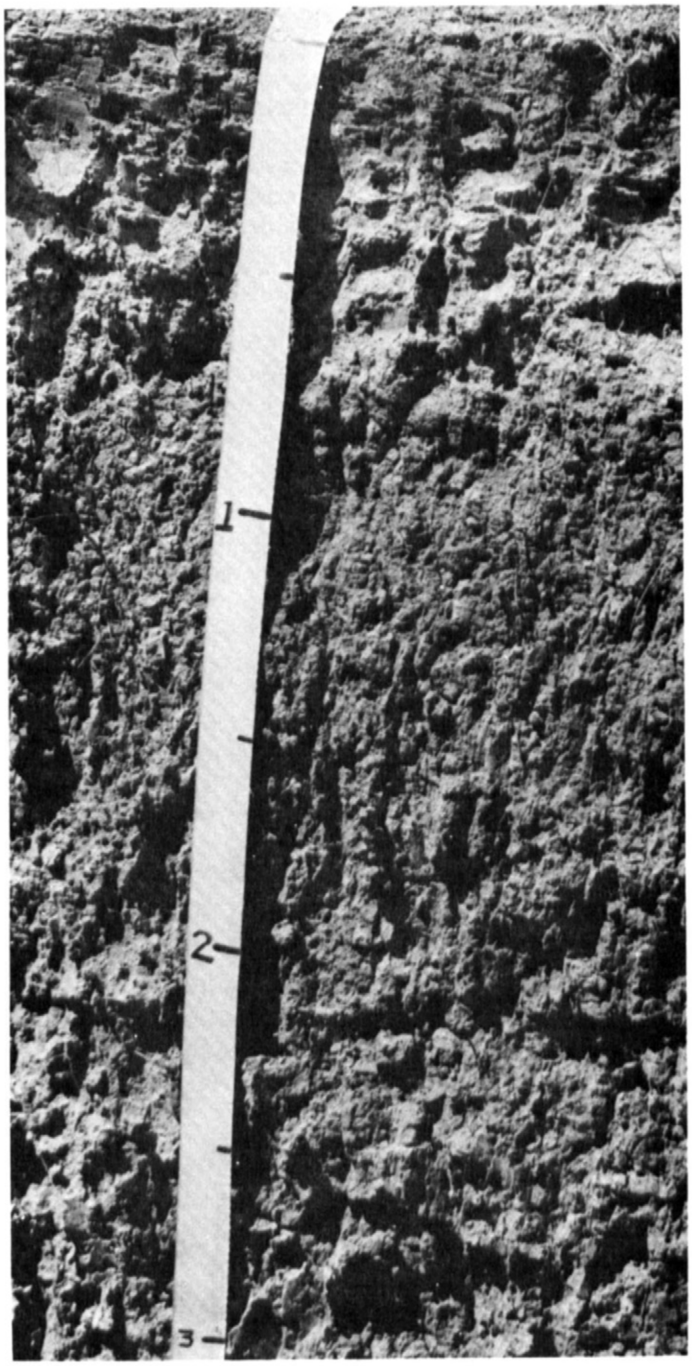


Figure 8.—Profile of Knox silt loam showing the lighter colored subsurface layer. Depth is marked in feet.

crops. The soil is generally unsuited to cultivated crops because erosion is a severe hazard. A cover of grasses is effective in preventing excessive soil loss. Bromegrass is the dominant species grown in pastures of tame grass. Proper stocking rates, even distribution of water and salt, fertilization, and controlling unwanted vegetation help to maintain or improve forage production in pastures. Some areas are used for hayland.

This soil is suited to rangeland, but many areas have been invaded by grasses of low productivity, such as bluegrass, and by weeds and brush. Reseeding with more desirable native grasses, such as bluestem, indiangrass, and switchgrass, may be needed to restore productivity. Spraying or using these areas as hayland helps to control brush. Native grass is a dependable source of forage during the summer.

This soil is suited to trees. Some areas remain in native hardwoods. Erosion, the equipment limitation, and seedling mortality are management concerns on this moderately steep soil. Selective cutting rather than clearcutting, placing haul roads on the contour, and preserving as much understory vegetation as possible help to control erosion. The slope of this soil makes the use of some equipment in logging and planting operations difficult. Use of special equipment and careful planning of logging and planting operations may help to overcome this problem. Proper site preparation helps to reduce seedling mortality.

The vegetation common to this soil provides habitat for many types of wildlife, including squirrels, deer, quail, and numerous songbirds. Forest management practices can be used to enhance wildlife populations.

This soil is generally unsuitable for building site development because of the moderately steep slope.

The capability subclass is VIe.

Kx—Knox silty clay loam, 10 to 18 percent slopes, eroded. This strongly sloping, well drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 900 acres in size.

Typically, the surface layer is dark brown silty clay loam about 8 inches thick. The subsoil to a depth of more than 60 inches is dark yellowish brown, friable silty clay loam in the upper part and dark yellowish brown, mottled, friable silt loam in the lower part. In some areas the surface layer is darker and is underlain by a lighter colored subsurface layer. In other areas the surface layer is brown silty clay loam because it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Armster and Gosport soils. These soils are on the lower side slopes. Armster soils contain more sand and gravel throughout than the Knox soil. The Gosport soils are moderately deep over shale. Also included are small areas where gullies have formed. Inclusions make up about 10 percent of the unit.

Permeability is moderate in the Knox soil, and runoff is rapid. Available water capacity is high. Natural fertility is medium, and organic matter content is low. The surface layer is medium acid. Tilth is good. The subsoil has moderate shrink-swell potential.

Most of the acreage is used for cultivated crops. Some areas are in trees or tame grasses. This soil is poorly suited to cultivated crops. Corn, soybeans, grain sorghum, and wheat are the main crops. Further erosion is a hazard if cultivated crops are grown. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or subsurface tile drains help to control runoff and prevent excessive soil loss. Before some irregular or complex slopes in the steeper areas can be terraced, cutting and filling may be needed. Crop residue left on the surface increases the water infiltration rate and thereby reduces runoff and erosion.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, brush control, and restricted grazing during wet periods help to keep the pasture and the soil in good condition. Controlled grazing and proper distribution of salt help to prevent the formation of paths and thus help to control erosion.

This soil is suited to trees. A few areas remain in native hardwoods. The erosion hazard, equipment limitations, and seedling mortality are woodland management concerns. Practicing selective cutting rather than clearcutting, placing haul roads on the contour, and preserving as much understory vegetation as possible help to control erosion. The slope of this soil makes the use of some equipment in logging and planting operations difficult. Use of special equipment and careful planning of logging and planting operations may help to overcome this problem. Proper site preparation helps to reduce seedling mortality.

This soil is moderately well suited to dwellings and local roads and streets. Slope is a limitation to those uses. If the soil is used as a construction site, land shaping will be needed. The soil erodes easily during construction. Quickly establishing a plant cover and mulching help to control excessive soil loss. The low strength of the soil and the hazard of frost action in the soil are additional limitations for local roads and streets. Roads need to be designed so that the pavement and the base material are thick enough to compensate for the low strength of the soil material. Providing good surface drainage and adequate side ditches and culverts helps to prevent road damage resulting from frost action.

This soil is poorly suited to septic tank absorption fields and sewage lagoons because of the slope. Septic tank systems should be designed so that the lateral lines are laid out on the contour and so that the effluent is evenly distributed. The less sloping areas on the lower part of side slopes are the best sites for sewage lagoons.

The capability subclass is IVe.

Ky—Knox-Gosport complex, 10 to 30 percent slopes. This complex consists of well drained Knox soils and moderately well drained Gosport soils on side slopes and narrow ridgetops. These soils are strongly sloping and moderately steep. Areas of this complex are irregular in shape and range from 20 to several hundred acres in size. They are about 60 percent Knox soils and about 30 percent Gosport soils. The Knox soils are on the higher and lower parts of side slopes and on ridgetops. The Gosport soils are on the steeper upper and middle parts of side slopes. The areas of Knox soils and the areas of Gosport soils are so intricately mixed that it is not practical to separate them at the scale used in mapping.

Typically, the Knox soils have a surface layer of very dark grayish brown, friable silt loam about 6 inches thick. The subsurface layer is dark grayish brown, friable silt loam about 4 inches thick. The subsoil, to a depth of 53 inches, is yellowish brown, friable silty clay loam. The substratum to a depth of about 60 inches is brown, friable silt loam.

Typically, the Gosport soils have a surface layer of very dark brown, friable silty clay loam about 5 inches thick. The subsurface layer is dark grayish brown silty clay loam about 3 inches thick. The subsoil is about 27 inches thick. The upper part is dark yellowish brown, mottled, firm silty clay loam; the middle part is brown, mottled, very firm silty clay; and the lower part is dark grayish brown, mottled, firm silty clay loam. Clayey shale is at a depth of about 35 inches.

Included with these soils in mapping, and making up about 15 percent of the complex, are small areas of Armster, Kennebec, and Judson soils and limestone rock outcrops. The deep, well drained Armster soils have a reddish subsoil and are on side slopes between the Knox and Gosport soils. The deep, dark, moderately well drained Kennebec soils are on flood plains. The deep, well drained Judson soils are on foot slopes. Limestone rock outcrops are on steeper areas.

Knox soils have moderate permeability and high available water capacity. Gosport soils have very slow permeability and low available water capacity. Surface runoff is rapid. The Knox soils have medium natural fertility and low organic matter content. The Gosport soils have low natural fertility and low organic matter content. The subsoil in Gosport soils has high shrink-swell potential.

About 15 percent of the acreage of this complex is used for cultivated crops, 50 percent is in tame grass pasture or rangeland, and the rest is covered with trees and shrubs. These soils are generally unsuited to cultivated crops because erosion is a severe hazard. Also, the rock outcrops restrict the use of tillage equipment. A cover of grasses is effective in preventing excessive soil loss. Bromegrass is the dominant species grown in pastures. Proper stocking rates, uniform distribution of water and salt, fertilization, and controlling unwanted vegetation help to maintain or increase forage production.

These soils are suited to rangeland; however, many areas have been invaded by plants that are low in productivity, such as bluegrass, weeds, and brush. Reseeding with more desirable native grasses, such as bluestems, indiangrass, and switchgrass may be needed to restore productivity. Spraying or using these areas as hayland helps to control brush. Native grass is a dependable source of forage during the summer.

These soils are suited to trees. Because of the moderately steep slopes, erosion and seedling mortality are hazards and the use of equipment is limited. Selective cutting rather than clearcutting, placing haul roads on the contour, and preserving as much understory vegetation as possible help to control erosion. The slope of the soils makes the use of some equipment in logging and planting operations difficult. Use of special equipment and careful planning of logging and planting operations may help to overcome this problem. Proper site preparation helps to reduce seedling mortality. High winds can blow down trees, but windthrow can be limited by using harvesting methods that will not leave trees standing alone or widely spaced.

The vegetation common to these soils provides habitat for many types of wildlife, including squirrels, deer, quail, and numerous songbirds. Forest management practices can be used to enhance wildlife populations.

These soils are generally unsuited to building site development because of the steepness of slope.

The capability subclass is VIe.

Mc—Martin silty clay loam, 3 to 7 percent slopes. This moderately sloping, moderately well drained soil is on side slopes of ridges and on foot slopes along drainageways. Individual areas are irregular in shape and range from 10 to 80 acres in size.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsoil is about 42 inches thick. The upper part is very dark brown, mottled, firm silty clay loam; the middle part is very dark grayish brown and dark grayish brown, mottled, very firm silty clay; and the lower part is olive brown, mottled, very firm silty clay. Olive and pale olive shale is at a depth of about 49 inches. In some areas the surface layer is silt loam. In other areas it is dark grayish brown silty clay because it has been mixed with the upper part of the subsoil by plowing. In a few places the subsoil is clay or clay loam.

Included with this soil in mapping are small areas of Judson and Vinland soils. The well drained Judson soils are on foot slopes. The shallow Vinland soils are on side slopes. Also included are small areas where gullies have formed. Inclusions make up 10 to 15 percent of the unit.

Permeability is slow in this Martin soil. Available water capacity is moderate, and runoff is rapid. Natural fertility is high. The subsoil has high shrink-swell potential. The surface layer is medium acid. Tilth is fair. Root penetration is restricted by the bedrock at a depth of about 49 inches.

Most of the acreage is used for cultivated crops. This soil is moderately well suited to corn, soybeans, grain sorghum, and small grains. If cultivated crops are grown, erosion is a hazard (fig. 9). Terraces, contour farming, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces runoff and erosion and increases the infiltration rate. Subsurface tile is needed in the seepy areas or other wet areas.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. Shrink-swell potential is a limitation to the use of this soil as a site for dwellings. Wetness is an additional limitation for dwellings with basements. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by the wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil are limitations for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to reduce road damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

The soil is generally unsuited to use as septic tank absorption fields because of its wetness and slow permeability. It is moderately well suited to use as a site for sewage lagoons. Slope and depth to bedrock are limitations to this use, and some land shaping is generally needed. In some areas the soil is more than 5 feet deep to bedrock and is well suited to lagoons.

The capability subclass is IIIe.

On—Onawa silty clay loam. This nearly level, somewhat poorly drained soil is on flood plains along the Missouri River. Most areas are flooded occasionally, and some low areas and channels are flooded frequently. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum is dark grayish brown, mottled, firm silty clay about 19 inches thick; and the lower part to a depth of about 60 inches is stratified dark grayish brown,

Figure 9.—An example of erosion in a wheat field that is not terraced. This is in an area of Martin silty clay loam, 3 to 7 percent slopes.

mottled silt loam. The soil is calcareous throughout. In some places the lower part of the substratum is silty clay.

Included with this soil in mapping are small areas of Haynie soils. The moderately well drained Haynie soils are in the higher areas. They are less clayey than the Onawa soil. Also included are slightly undulating areas of sandy overwash. Inclusions make up about 10 percent of the unit.

Permeability is slow in the upper part of the Onawa soil and moderate in the lower part. Runoff is slow. Available water capacity is high. Natural fertility is medium. Reaction is mildly alkaline or moderately alkaline throughout the soil. The seasonal high water table is at a depth of 2 to 4 feet. Tilth is fair. The shrink-swell potential in the upper part of the soil is high.

Most of the acreage is used for cultivated crops. Some small tracts are pastures of tame grass. This soil is well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Cultivated crops can be damaged by the flooding and the wetness. This somewhat poorly drained soil dries slowly. The wetness delays tillage and harvest, especially during rainy periods. Surface ditches, surface bedding, and land grading and smoothing improve drainage. Crop residue management helps to maintain fertility and tilth.

This soil is moderately well suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

A few small areas remain in native hardwoods. Because of the wetness of the soil, the use of equipment is limited and plant competition is a problem. Harvesting equipment is easier to use if the soil is relatively dry or frozen. Site preparation reduces the rate of seedling mortality. High winds can blow down trees, but windthrow can be limited by using harvesting methods that do not leave trees standing alone or widely spaced.

This soil is generally unsuitable for building site development because flooding is a severe hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIw.

Pc—Pawnee clay loam, 3 to 7 percent slopes. This moderately sloping, moderately well drained soil is on ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 80 acres in size.

Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The subsoil is more than 52 inches thick. The upper part of the subsoil is very dark grayish brown, mottled, firm clay; the middle part is dark grayish brown and dark brown, mottled, firm clay; and the lower part is grayish brown, mottled, firm clay loam. In some places the subsoil is silty clay. In other places the upper part of the subsoil has been mixed with the surface soil by tillage and the surface layer is dark grayish brown clay.

Included with this soil in mapping are small areas of Kennebec, Sharpsburg, and Shelby soils. The silty, moderately well drained Kennebec soils are on flood plains of drainageways. The well drained Shelby soils are on steeper slopes. The silty Sharpsburg soils are on ridgetops and upper side slopes. The included soils make up 5 to 15 percent of the map unit.

Permeability is slow, and surface runoff is rapid. Natural fertility is medium. The available water capacity is moderate. Reaction is medium acid in the surface layer. The subsoil has high shrink-swell potential. Tilth is good. A perched high water table is at a depth of 1 to 3 feet in spring.

Most of the acreage is used for cultivated crops. This soil is well suited to soybeans, grain sorghum, and small grains and to grasses and legumes for pasture and hay. It is suited to corn. If cultivated crops are grown, erosion is a hazard. The soil is wet in spring, but it is droughty in summer because the clayey subsoil releases water slowly. The wetness in spring delays planting in some years. Minimum tillage, terraces, contour farming, and grassed waterways or subsurface tile drains help to control runoff and erosion. Crop residue left on the surface reduces runoff and erosion and increases the water infiltration rate.

This soil is moderately well suited as a site for dwellings and local roads and streets. Shrink-swell potential is a limitation to the use of the soil as a site for dwellings. Wetness is an additional limitation for dwellings with basements. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil are limitations for local roads and streets. Roads need to be designed so that the pavement and the base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to reduce road damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

The soil is generally unsuited to use as septic tank absorption fields because of its slow permeability. It is moderately well suited to use as a site for sewage lagoons. Slope is a limitation to this use, and some land shaping is generally needed.

The capability subclass is IIIe.

Pd—Pawnee clay, 3 to 7 percent slopes, eroded. This moderately sloping, moderately well drained soil is on ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 40 acres in size.

Typically, the surface layer is very dark gray clay about 5 inches thick. The subsoil is about 33 inches thick. The upper part is very dark grayish brown, mottled, firm clay; the middle part is dark grayish brown, mottled, firm clay; and the lower part is grayish brown, mottled, firm clay. The substratum to a depth of about 60 inches is light brownish gray, mottled clay loam. In places the subsoil is silty clay. In some areas the surface layer is clay loam because the upper part of the subsoil has not been mixed with the surface soil by tillage.

Included with this soil in mapping are small areas of Kennebec and Shelby soils. The silty, moderately well drained Kennebec soils are on flood plains along drainageways. The well drained Shelby soils are on the steeper side slopes. Small areas of slick spots and gullies are also included. Inclusions make up less than 10 percent of the map unit.

Permeability of this Pawnee soil is slow, and runoff is rapid. Available water capacity is moderate. Natural fertility is low. The surface layer is medium acid. The subsoil has high shrink-swell potential. Tilth is poor. A perched high water table is at a depth of 1 to 3 feet in spring.

Most of the acreage is used for cultivated crops. This soil is poorly suited to corn, soybeans, and grain sorghum. It is better suited to small grains and to grasses and legumes for pasture and hay. If cultivated crops are grown, further erosion is a severe hazard. The soil is wet in spring, but it is droughty in summer because the clayey subsoil releases water slowly. The wetness delays planting in some years. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or subsurface tile drains help to control runoff and erosion. Returning crop residue to the soil helps to improve tilth and increase the water infiltration rate.

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

This soil is moderately well suited as a site for dwellings and local roads and streets. Shrink-swell potential is a limitation to the use of the soil as a site for dwellings. Wetness is an additional limitation for dwellings with basements. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by wetness and shrinking and swelling of the soil. The low strength and shrink-swell potential of the soil and the hazard of frost action in the soil are limitations for local roads and streets. Roads need to be designed so that the pavement and the base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to reduce road damage caused by shrinking and swelling of the soil. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from frost damage.

The soil is generally unsuited to use as septic tank absorption fields because of its slow permeability. It is moderately well suited to use as a site for sewage lagoons. Slope is a limitation to this use, and some land shaping is generally needed.

The capability subclass is IVe.

Pt—Pits, quarries. This map unit consists mainly of open excavations from which soil and underlying limestone and shale have been removed. Most areas of this map unit are on the bluffs along the Missouri River. In many areas the pits are steep, and vertical walls are common. In places, many feet of soil material was removed before the rock was excavated. Included in mapping are the adjacent piles of excavated material. Some of the pits are in areas of glacial till, where sand and gravel have been removed.

Areas of this map unit are generally unsuitable for most uses because of the vertical walls and rocks. Most of the limestone is used as riprap along the Missouri River. Some of the gravel, sand, and other soil material is used as material for roads.

This map unit is not assigned to a capability subclass.

Re—Reading silt loam. This nearly level, moderately well drained soil is on stream terraces. It is rarely flooded. Individual areas are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The subsurface layer is very dark grayish brown, friable silt loam about 5 inches thick. The mottled subsoil to a depth of about 60 inches is firm silty clay loam. The upper part is very dark grayish brown, the middle part is dark brown, and the lower part is brown.

Included with this soil in mapping are small depressional areas of the poorly drained Colo soils and small areas of the well drained Judson soils on foot slopes. These soils make up 5 to 10 percent of the map unit.

Permeability is moderately slow in this Reading soil, and runoff is slow. Available water capacity and natural fertility are high. Organic matter content is moderate. The surface layer is medium acid. Tilth is good. The subsoil has moderate shrink-swell potential. A perched high water table is at a depth of 3.5 to 6.0 feet in winter and spring.

Most of the acreage is used for cultivated crops. Some small tracts are in pasture of tame grass. This soil is well suited to corn, soybeans, small grains, and grain sorghum and to grasses and legumes for hay and pasture. Returning crop residue to the soil helps to maintain fertility and tilth.

This soil is well suited to trees, and a few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

This soil is generally unsuited to building site development because flooding is a severe hazard. Overcoming this hazard is difficult without major flood-control measures.

The capability class is I.

Sb—Sharpsburg silty clay loam, 1 to 4 percent slopes. This gently sloping, moderately well drained soil is on ridgetops. Individual areas are irregular in shape and range from 10 to many hundreds of acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick. The subsoil is about 47 inches thick. The upper part is very dark grayish brown, friable silty clay loam; the middle part is dark brown, firm silty clay loam; and the lower part is dark yellowish brown, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam.

Included with this soil in mapping are small areas of Grundy and Shelby soils. These soils make up 10 to 15 percent of the unit. The loamy Shelby soils are on the lower side slopes. The somewhat poorly drained Grundy soils are above the Shelby soils.

Permeability is moderately slow in this Sharpsburg soil, and runoff is medium. Available water capacity and natural fertility are high. The surface layer is slightly acid. The subsoil has high shrink-swell potential. Tilth is good.

Most of the acreage of this soil is used for cultivated crops. This soil is well suited to corn, soybeans, grain sorghum, and small grains. If cultivated crops are grown, erosion is a hazard. Terraces, contour farming, crop residue management, and grassed waterways or subsurface tile drains help to control runoff and erosion. Leaving crop residue on the surface reduces runoff and erosion and increases the water infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential of the soil can be a problem for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by the shrinking and swelling of the soil. The low strength of the soil and the hazard of frost action in the soil limit the use of this soil as a site for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to insure better road performance. Providing good surface drainage and adequate side ditches and culverts help protect roads from damage by frost action.

The soil is moderately well suited to septic tank absorption fields and sewage lagoons. The moderately slow permeability of this soil limits the absorption of effluent from septic tanks. Increasing the size of the absorption field helps to overcome this limitation. Slope on sites for sewage lagoons commonly needs to be modified. Seepage can also be a problem for sewage lagoons. Sealing the lagoon helps to reduce seepage.

The capability subclass is IIe.

Sc—Sharpsburg silty clay loam, 4 to 8 percent slopes. This moderately sloping, moderately well drained soil is on convex side slopes and ridgetops. Individual areas are irregular in shape and range from 10 to many hundreds of acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick. The subsoil is about 47 inches thick. The upper part is very dark grayish brown, friable silty clay loam; the middle part is dark brown, firm silty clay loam; and the lower part is dark yellowish brown, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam. The surface layer is dark brown in areas where it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Armster, Grundy, and Shelby soils. These soils make up 10 to 15 percent of the unit and are on lower side slopes. the Armster and Shelby soils contain more sand in the subsoil than Sharpsburg soils. The Grundy soils are somewhat poorly drained.

Permeability is moderately slow in this Sharpsburg soil, and runoff is rapid. Available water capacity and natural fertility are high. The surface layer is slightly acid. The subsoil has high shrink-swell potential. Tilth is good.

Most of the acreage is used for cultivated crops. This soil is moderately well suited to corn, soybeans, grain sorghum, and small grains and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. Terraces, contour farming, crop residue management, and grassed waterways or subsurface tile drains help to control runoff and erosion (fig. 10). Leaving crop residue on the surface reduces runoff and erosion and increases the water infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential of the soil can be a problem for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by the shrinking and swelling of the soil. The low strength of the soil and the hazard of frost action in the soil are limitations on sites for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to insure better road performance. Providing good surface drainage and adequate side ditches and culverts helps to protect roads from damage by frost action.

The soil is moderately well suited to septic tank absorption fields and sewage lagoons. The moderately slow permeability of this soil limits the absorption of effluent from septic tanks. Increasing the size of the absorption field helps to overcome this limitation. The slope on sites for sewage lagoons commonly needs to be modified. Seepage can also be a problem for sewage lagoons. Sealing the lagoon helps to reduce seepage.

The capability subclass is IIIe.

Sh—Shelby clay loam, 5 to 10 percent slopes. This deep, strongly sloping, well drained soil is on side slopes. Individual areas are irregular in shape and range from 10 to over 300 acres in size.

Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. The subsoil to a depth of about 47 inches is friable clay loam. The upper part is very dark grayish brown and dark brown, the middle part is brown and mottled, and the lower part is dark yellowish brown and mottled. The substratum to a depth

Figure 10.—Terraces and subsurface tile drainage systems are used to control runoff and erosion in this area of Sharpsburg silty clay loam, 4 to 8 percent slopes. The pipe at the center of this photo is an inlet to the tile drain.

of about 60 inches is light olive brown, mottled, firm clay loam. In areas where the upper part of the subsoil has been mixed with the surface soil by tillage, the surface layer is dark brown. In places the subsoil is reddish brown.

Included with this soil in mapping, and making up about 15 percent of the map unit, are small areas of Kennebec, Pawnee, and Sharpsburg soils and a few seep areas. The silty Kennebec soils are on flood plains. The moderately well drained Pawnee soils and the moderately well drained, silty Sharpsburg soils are on higher side slopes.

Permeability is moderately slow in this Shelby soil, and runoff is rapid. Natural fertility is medium. Organic matter content is moderate. The surface layer is medium acid. Tilth is good. The subsoil has moderate shrink-swell potential.

In most areas this soil is used for cultivated crops. It is moderately well suited to small grains, soybeans, grain sorghum, and corn. If cultivated crops are grown, erosion is a hazard. Minimum tillage, terraces, contour farming, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and improves water infiltration. Subsurface tile is needed in the seep areas.

A cover of tame grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential of the soil can be a problem for dwellings. Properly designing and reinforcing foundations and backfilling with porous material help to prevent damage caused by the shrinking and swelling of the soil. Included seep areas can be a problem for dwellings with basements. Installing foundation drains helps to prevent damage caused by wetness in these areas. The low strength of the soil is a limitation for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to insure better road performance.

This soil is moderately well suited to septic tank absorption fields and sewage lagoons. The moderately slow permeability somewhat restricts the absorption of effluent in septic tank systems. Increasing the size of absorption fields helps to overcome this limitation. The slope on sites for sewage lagoons generally needs to be modified. If the less sloping areas are selected, construction of the lagoon will require less leveling and banking.

The capability subclass is IIIe.

Sm—Shelby clay loam, 7 to 15 percent slopes, eroded. This strongly sloping, well drained soil is on side slopes in the uplands. Pebbles and a few cobbles are on the surface in some places. Individual areas are irregularly shaped and range from 20 to 150 acres in size or are long, narrow continuous areas.

Typically, the surface layer is very dark grayish brown clay loam about 5 inches thick. The subsoil is about 38 inches thick. The upper part is dark brown, firm clay loam; the middle part is brown, mottled, firm clay loam; and the lower part is dark yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is brown, mottled clay loam. In some areas the subsoil is reddish brown. In some areas the surface layer is brown clay loam because it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Kennebec, Martin, Sharpsburg, and Steinauer soils and small seep areas. The silty Kennebec soils are on flood plains along drainageways. The moderately well drained Martin soils are on foot slopes. The silty Sharpsburg soils are on ridgetops. The calcareous Steinauer soils are on the steeper areas within the unit. Also included are small areas where gullies have formed. Inclusions make up 10 to 15 percent of the unit.

Permeability is moderately slow in this Shelby soil. Available water capacity is high, and runoff is rapid. Natural fertility is low. The surface layer is medium acid. Tilth is fair. In some areas, cobblestones and gullies make tillage difficult. The subsoil has moderate shrink-swell potential.

Nearly all of the acreage has been used for cultivated crops, but some areas have been planted to tame grass and are used for pasture or hayland. The soil is poorly suited to cultivated crops. Soybeans, grain sorghum, and small grains are the main crops grown. Further erosion is a hazard if cultivated crops are grown. Minimum tillage, terraces, contour farming, and grassed waterways or subsurface tile drains help to control runoff and erosion. Leaving crop residue on the surface reduces runoff and erosion and increases the water infiltration rate. Subsurface tile drains are needed in the seep areas.

A cover of tame grass or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is moderately well suited as a site for dwellings and local roads and streets. The shrink-swell potential of the soil and the slope can be problems for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent structural damage caused by shrinking and swelling of the soil. Less land shaping will be needed if the least sloping sites are selected. The soil erodes readily during construction, but quickly establishing plant cover and mulching help to prevent excessive soil loss. Low strength is a limitation for local roads and streets. Roads need to be designed so that the pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to insure better road performance.

The soil is moderately well suited to use as septic tank absorption fields. Its moderately slow permeability somewhat restricts the absorption of effluent. Increasing the size of the absorption field helps to overcome this limitation. Septic tank systems should be designed so that the lateral lines are laid out on the contour and so that the effluent is evenly distributed. This soil is poorly suited to sewage lagoons because of the strong slope. Areas of included soils on foot slopes are better sites for lagoons.

The capability subclass is IVe.

Ss—Shelby-Steinauer loams, 12 to 25 percent slopes. These well drained soils are moderately steep. The Shelby soil is on the upper and lower, less steep, parts of side slopes; and the Steinauer soil is on the steeper part of the side slopes. Areas of this complex are irregular in shape and range from 10 to 70 acres in size. They are 40 to 70 percent Shelby soil and 20 to 40 percent Steinauer soil. The areas of these two soils are so intricately mixed or so small that it is not practical to separate them at the scale used in mapping.

Typically, the Shelby soil has a surface layer of very dark grayish brown loam about 6 inches thick. The subsoil, to a depth of about 41 inches, is friable clay loam. The upper part of the subsoil is dark brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is brown, mottled, firm clay loam. In some places the subsoil is calcareous. In other places the subsoil is reddish brown.

Typically the Steinauer soil has a surface layer of dark grayish brown loam about 6 inches thick. The subsurface layer is dark yellowish brown, friable loam about 7 inches thick. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam. In a few places the surface layer is gravelly or cobbly sandy loam.

Included with these soils in mapping are small areas of Kennebec and Vinland soils. The silty Kennebec soils are on flood plains along drainageways. The shallow Vinland soils are on lower side slopes. Also included are small areas where gullies have formed. Inclusions make up 10 to 15 percent of this complex.

Permeability is moderately slow, and runoff is rapid. The available water capacity is high. Natural fertility is medium in the Shelby soil and low in the Steinauer soil. Reaction in the surface layer is medium acid in the Shelby soil and is moderately alkaline in the Steinauer soil. The shrink-swell potential in the subsoil of both soils is moderate.

Nearly all of the acreage of this complex is used for pastureland or rangeland. Some areas are used as hayland. The soils are generally unsuited to cultivated crops because of the severe hazard of erosion.

A cover of native grasses prevents excessive soil loss and is a dependable source of forage during the summer. The native vegetation on rangeland dominantly is bluestem, indiangrass, and switchgrass, unless the livestock overgraze the site. Overgrazed areas are dominated first by sideoats grama, bluegrama, and forbs, and then, if overgrazing continues for several years, by Kentucky bluegrass and weeds. Brush management, proper stocking rates, and timely deferment of grazing help to maintain or to increase the stand of desirable plant species on rangeland.

On pastures of tame grass, proper stocking rates, rotation grazing, and fertilization help to maintain good forage production.

The soils in this complex are generally unsuitable for building development because of the moderately steep slope.

The capability subclass is VIe.

Vs—Vinland silty clay loam, 4 to 15 percent slopes. This soil is moderately sloping and strongly sloping and somewhat excessively drained. It is on side slopes. Individual areas are irregular in shape and range from 10 to 300 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam about 4 inches thick. The substratum is dark grayish brown, friable shaly silty clay loam. Shale bedrock is at a depth of about 19 inches. In places the depth to bedrock is more than 20 inches.

Included in mapping, and making up about 15 percent of the map unit, are small areas of Martin and Pawnee soils and limestone outcrop. The deep, moderately well drained Martin soils are on foot slopes. The moderately well drained Pawnee soils are on ridgetops. These soils are more than 40 inches deep over bedrock. The outcrops of limestone occur as narrow bands and ledges near the crest of ridges and on side slopes.

Permeability is moderate in this Vinland soil, and runoff is rapid. Available water capacity is low. Natural fertility is medium. The surface layer is slightly acid. The shrink-swell potential is moderate. Root development is restricted by the bedrock at a depth of about 19 inches.

Most of the acreage is in rangeland or pastureland. This soil is generally unsuited to cultivated crops because erosion is a severe hazard. Rock outcrop restricts the use of tillage equipment. A cover of grass is effective in preventing excessive soil loss. In many areas, brush and trees have invaded the rangeland. Proper stocking rates, uniform grazing, timely deferment of grazing, and brush management help to keep the range in good condition. Fertilization and pasture rotation help to increase forage production in pastures of tame grass.

This soil is moderately well suited to dwellings and local roads and streets. Shallowness to bedrock and slope are limitations for both uses. Deeper included soils on lesser slopes are more favorable sites. Shrink-swell potential can be a problem for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with suitable porous material help to prevent structural damage caused by shrinking and swelling of the soil. Roads need to be designed so that the surface pavement and base material are thick enough to compensate for the low strength of the soil material. Coarser grained base material can be used to insure better road performance.

The soil is generally unsuited to septic tank absorption fields and sewage lagoons because of its shallowness to bedrock. However, suitable sites for lagoons can

Figure 11.—Grain sorghum on Wabash silty clay. Vinland soils are on the upper side slopes, and Martin soils are on the foot slopes.

generally be located in areas of included soils on foot slopes.

The capability subclass is VIe.

Wa—Wabash silty clay loam. This nearly level, very poorly drained soil is on flood plains along the larger streams and along the Delaware River. It is occasionally flooded. Individual areas are irregular in shape and range from 10 to more than 80 acres in size.

Typically, the surface layer is very dark gray silty clay loam about 10 inches thick. The subsurface layer is black silty clay loam about 12 inches thick. Those layers have been deposited by flood water. The subsoil to a depth of about 60 inches is black, mottled, firm silty clay. In some places the subsoil is silty clay loam.

Included with this soil in mapping are small areas of Chase and Kennebec soils. These soils make up about 15 percent of the unit. The silty, moderately well drained

Kennebec soils are nearer the stream channel. The somewhat poorly drained Chase soils are on stream terraces.

Permeability is very slow in this Wabash soil, and runoff is slow. Available water capacity is moderate, and natural fertility is high. Tilth is good. The surface layer is slightly acid. The seasonal high water table is at a depth of 1 foot or less. At times, it is at the surface. The shrink-swell potential of the subsoil is high.

Most areas are farmed. This soil is moderately well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. In some places, surface drainage ditches are needed to drain lower areas where ponding occurs. Returning crop residue to the soil helps to maintain fertility and tilth.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Brush control, proper stocking rates, pasture rotation, timely deferment of grazing, and

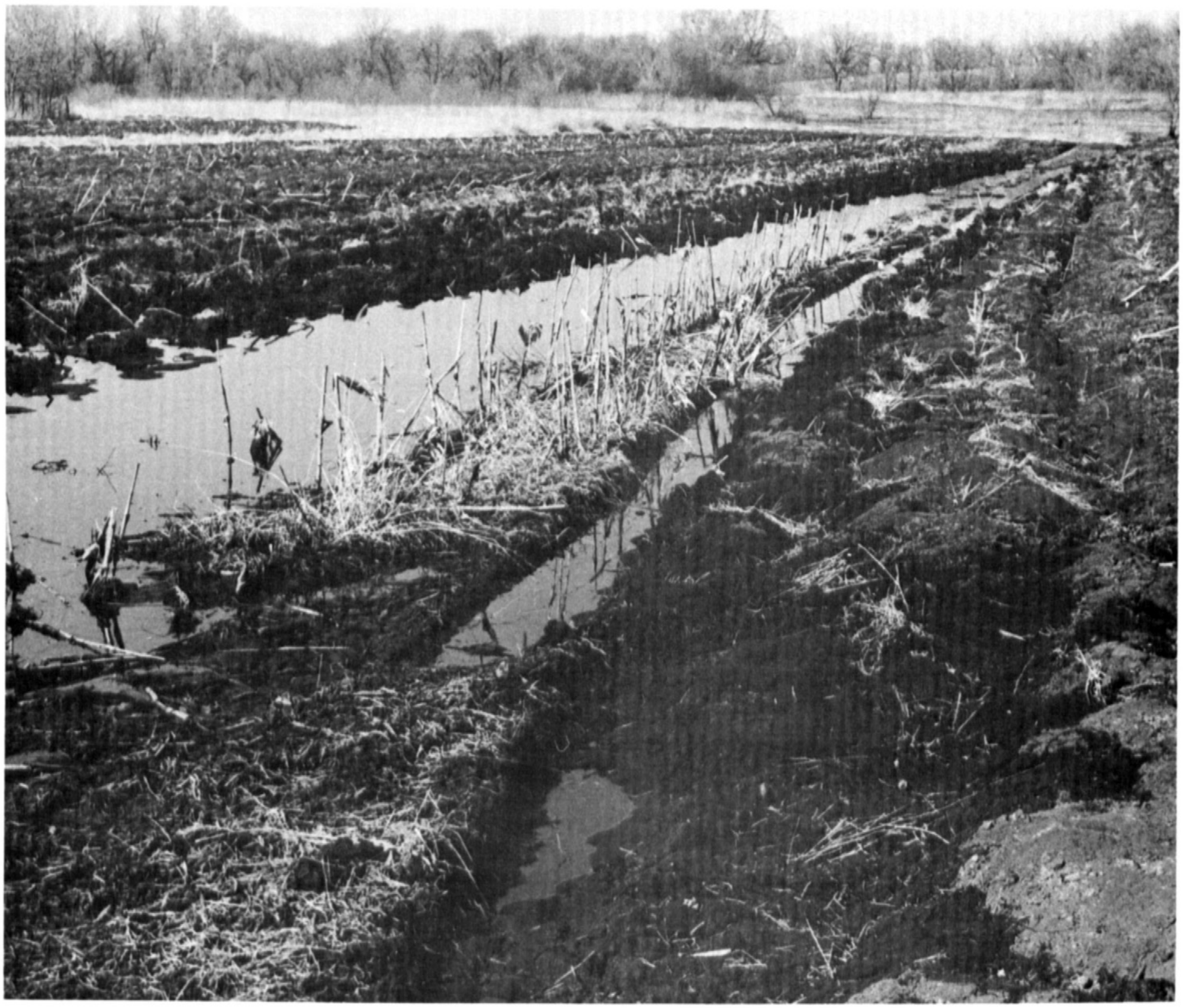


Figure 12.—Surface ditches and bedding help to improve drainage on Wabash soils.

restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees, and a few small areas remain in native hardwoods. Because of the wetness of the soil, the use of equipment is limited and plant competition is a problem. Harvesting equipment is easiest to use if the soil is relatively dry or frozen. Site preparation reduces the rate of seedling mortality. High winds can blow down trees, but windthrow can be limited by using harvesting methods that will not leave trees standing alone or widely spaced.

Because flooding is a severe hazard, this soil is generally unsuitable for building site development. Overcoming this hazard is difficult without major flood-control measures.

The capability subclass is IIIw.

Wb—Wabash silty clay. This nearly level, very poorly drained soil is in depressional areas on the flood plains of the larger streams and along the Delaware River. It is frequently flooded. Individual areas are long or irregular in shape and range from 10 to 40 acres in size.

Typically, the surface layer is black silty clay about 8 inches thick. The subsurface layer is black, very firm silty clay about 20 inches thick. The subsoil to a depth of about 60 inches is mottled, very firm silty clay. It is very dark gray in the upper part and dark gray in the lower part.

Included with this soil in mapping, and making up less than 10 percent of the unit, are small areas of somewhat poorly drained Chase soils and moderately well drained Kennebec soils. These soils are in slightly higher areas.

In areas of this Wabash soil, runoff and permeability are very slow. Shrink-swell potential is high, and available water capacity is moderate. The surface layer is slightly acid. Natural fertility is high. Tilth is poor. During winter and spring the high water table is at the surface or at a depth of 1 foot or less. It is at the surface at times.

Most of the acreage of this soil is used for cultivated crops. The rest is in woodland or tame grass pasture. This soil is moderately well suited to corn, grain sorghum, wheat, soybeans, grasses, and legumes (fig. 11). Cultivation is limited by wetness and ponding. The soil drains and dries slowly, and wetness delays tillage, especially during rainy periods. Grain sorghum and soybeans can be planted later than corn. Wheat can usually be planted in the fall, but harvesting may be delayed by wetness. Surface ditches, surface bedding, and land smoothing and grading help to improve drainage (fig. 12). Returning crop residue to the soil and timely tillage help to maintain soil fertility and tilth.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, will cause surface compaction and poor tilth. Proper stocking rates and restricted grazing during wet periods help to keep the pasture and the soil in good condition.

This soil has severe limitations for trees, but some areas remain in native hardwoods. Seedling mortality and plant competition are severe. Wetness and flooding limit the use of equipment. Site preparation and controlled burning, spraying, or cutting reduce the rate of seedling mortality and control plant competition. Harvesting equipment is easier to use if the soil is relatively dry or frozen. High winds can blow down trees, but windthrow can be limited by using harvesting methods that will not leave trees standing alone or widely spaced.

This soil is generally unsuited to building site development because of flooding. The flood hazard is difficult to overcome without major flood control measures.

The capability subclass is IIIw.

Prime Farmland

Prime farmland is one of several kinds of important farmlands defined by the U.S. Department of Agriculture. It is of major importance in providing 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, must 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 producing food, feed, forage, fiber, and oilseed crops. It may be in crops, pasture, woodland, or other land, but not urban and built-up land or water areas. It either is used for producing food or fiber or is available for those uses. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to economically produce a sustained high yield of crops. Prime farmland produces the highest yields with minimal inputs of energy and economic resources, and farming it results in the least damage to the environment.

Prime farmland usually 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 offices of the Soil Conservation Service.

In Atchison County, about 116,400 acres, or about 42 percent of the total acreage, meets the soil requirements for prime farmland. This land occurs as scattered areas throughout the county. The main crops grown on this land are grain sorghum, wheat, soybeans, and corn.

The map units in Atchison County that make up prime farmland are listed in this section. 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 in the back of this publication. The soil qualities that affect use and management are described in the section "Detailed Soil Map Units."

Some of these map units meet the requirements for prime farmland only in areas where the soil is drained. Onsite investigation is needed to determine whether or not a specific area of these map units is prime farmland.

The map units that meet the requirements for prime farmland are:

Ch	Chase silty clay loam
Gr	Grundy silty clay loam, 0 to 2 percent slopes
Gu	Grundy silty clay loam, 2 to 6 percent slopes
Hn	Haynie silt loam
Ho	Haynie-Onawa complex (where drained)
Ju	Judson silt loam, 2 to 7 percent slopes
Ke	Kennebec silt loam
Kg	Kennebec-Colo silt loams (where drained)
Mc	Martin silty clay loam, 3 to 7 percent slopes
On	Onawa silty clay loam (where drained)
Re	Reading silt loam
Sb	Sharpsburg silty clay loam, 1 to 4 percent slopes
Sc	Sharpsburg silty clay loam, 4 to 8 percent slopes
Wa	Wabash silty clay loam (where drained)
Wb	Wabash silty clay (where drained)

Use and Management of the Soils

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

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

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

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

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

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

Crops and Pasture

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

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

Crops

In 1978 and 1979, approximately 49 percent of the total land area in Atchison County was used for cultivated crops (*3*). Of that acreage, about 30 percent was used for grain sorghum, 29 percent for soybeans, 19 percent for corn, 15 percent for wheat, and 4 percent for alfalfa. The acreage planted to soybeans and sorghum has increased in the last 10 years. The acreage planted to other crops has decreased.

Soil erosion is the major management concern on about 80 percent of the cropland in Atchison County. Where the slope is more than 2 percent, erosion is a hazard. Loss of the surface layer through erosion is damaging because fertility is reduced when the less fertile subsoil or substratum is incorporated into a plow layer. On many sloping, eroded soils, productivity is reduced and harvesting difficult because small gullies have formed. Soil erosion also results in sedimentation of streams. Control of erosion minimizes the pollution of streams and water-impounding structures.

Returning crop residue to the soil surface provides a protective cover, reduces runoff, and increases infiltration. Keeping a protective cover on the soil for an extended period helps to prevent excessive soil loss.

Minimum tillage increases infiltration, reduces runoff, and helps to control erosion. It is practical on most soils in the survey area.

Terraces and grassed waterways reduce the length of slopes and thus help to control runoff and erosion. They are most practical on deep, well drained soils that have regular slopes. Knox and Sharpsburg soils are examples. Some soils are less suitable for terraces, diversions, and grassed waterways because they have steep and irregular slopes.

Contour farming helps to control erosion in many areas in the county. It is especially practical in areas that have been terraced.

In some areas, a combination of subsurface tile drainage and terracing is replacing the use of grassed waterways. This combination of methods can help to control erosion on the steeper, friable soils.

Soil drainage is a management concern on some soils on flood plains. Unless drained, the somewhat poorly drained Onawa soils, the poorly drained Colo soils, and the very poorly drained Wabash soils are so wet that crops are damaged. Artificial drainage is also needed in some of the seepy areas adjacent to Chase, Judson, Kennebec, Pawnee, and Shelby soils.

Soil fertility was naturally high in most soils in the uplands. Erosion, however, reduced the organic matter content and the fertility of those soils. The Colo, Kennebec, and other soils on flood plains are dominantly slightly acid or neutral and are naturally higher in content of plant nutrients than most other soils. The Judson and Reading soils, on terraces and foot slopes, are also high in fertility. The upland soils that formed in silty loess are naturally high in content of phosphorus and potassium, but additions of nitrogen fertilizer are needed to sustain high production.

Many upland soils are medium acid. On these soils, applications of lime may be needed to raise the pH level sufficiently for plants to grow well and for the chemical fertilizer to be effective. On all soils, additions of lime and fertilizer should be based on the results of soil tests, on farm records, on the needs of the crop, and on the expected yields.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. The surface layer of most of the soils used for crops in the survey area is silty or loamy. It is moderately dark, and moderate to low in content of organic matter. Generally, the structure of such soils is weak, and intense rainfall causes the formation of a crust on the surface. The crust reduces infiltration and increases runoff. Plowing under large amounts of crop residue or leaving large amounts on the surface of the soil improves the soil structure, helps to prevent surface crusting, and helps to control erosion. Minimum tillage helps control erosion on the more sloping soils. Fall plowing generally is not suitable on these soils because it results in extensive erosion.

Poor tilth is a problem on the clayey Grundy, Pawnee and Wabash soils, which stay wet for longer periods than other soils. If they are plowed or tilled when wet, they tend to be very cloddy when dry. As a result of the cloddiness, preparing a good seedbed is difficult. Fall plowing the more clayey bottomland soils results in good tilth in the spring.

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

Pasture

About 35 percent of Atchison County is pasture consisting of cool-season grasses, such as smooth brome, tall fescue, reed canarygrass, and orchardgrass. The pastures are scattered throughout the county. Some consist entirely of tame grasses, and others consist of tame and native grasses.

The main concerns in managing these areas are maintaining or improving the quality and quantity of forage, controlling erosion, and reducing water loss. Leaf development, root growth, flower-stalk formation, seed production, forage regrowth, and food storage in roots are concerns in obtaining maximum yields from forage plants.

Proper stocking rates help to keep the pasture in good condition. The number of livestock should be adjusted to the expected yield of pasture grass. Adjusting the number of livestock allows the pasture to provide forage for the entire grazing season.

Delaying grazing in spring until the soil is dry and firm helps to prevent trampling and surface compaction. Rotation grazing helps to prevent depletion of the pasture by allowing the grasses to recover after they have been grazed. Providing water and salt at a variety of locations results in uniform distribution of grazing.

Applying fertilizer helps to keep the pasture in good condition. The kind and amount should be based on the results of soil tests and on field observations. Mowing a pasture that has been grazed unevenly or has an excess of forage and spraying a pasture with approved herbicides help to control invading trees, brush, low-quality grasses, and broad-leaved weeds.

Yields Per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

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

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and harvesting that insures the smallest possible loss.

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

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils 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 grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

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

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

Class I soils have 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 limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

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

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

Woodland Management and Productivity

Keith A. Ticknor, forester, Soil Conservation Service, helped prepare this section.

Approximately 7.5 percent (20,200 acres) of Atchison County is forested. The woodland occurs in fairly large blocks in the eastern part of the county near the Missouri River. In the rest of the county it is in small, irregular tracts scattered along streams, on steep uplands, and in upland drainageways.

The woodland on the uplands is the oak-hickory forest type, and it has a white oak-red oak-hickory cover type. Associated species are numerous, the main ones being green ash, common hackberry, black walnut, American elm, red elm, mulberry, and Kentucky coffeetree. The woodland on the uplands occurs mostly on the Knox-Armster-Gosport soil association. Knox, Armster, and Gosport soils have fair to good potential for production of wood products. Armster soils support fewer species than the other soils of this association. The hickories are the most numerous.

The bottomland hardwoods forest type that has a silver maple-American elm cover type occurs on the Kennebec-Wabash-Colo soil association. Boxelder, black walnut, red mulberry, eastern cottonwood, and black willow are the most numerous associated species in this cover type. Many of the bottomland soils have good potential for producing high-value wood products such as walnut veneer. The bottomland soils produce high-value wood products within a short period, whereas the upland soils produce lower value, long-rotation products.

Several of the species in Atchison County, especially black walnut, eastern cottonwood, green ash, and the oak and hickory, have commercial value for wood products. In addition, the low-quality trees are valuable for firewood.

The acreage in woodland has been steadily declining during recent years. Most of this decline has occurred as the result of clearing woodland and converting it to cropland or pastureland. Only a small part of the woodland is managed for commercial wood production because most of the wooded areas are in private ownership and occupy only a small acreage of the farm unit.

Table 6 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The table lists the ordination (woodland suitability) symbol for each soil. Soils assigned the same ordination symbol require the same general management and have about the same potential productivity.

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

In table 6, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

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

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

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

Ratings of *windthrow hazard* are based on soil characteristics that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that few trees may be blown down by strong winds; *moderate*, that some trees will be blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

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

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

Windbreaks and Environmental Plantings

Keith A. Ticknor, forester, Soil Conservation Service, helped prepare this section.

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

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

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

Most farmsteads in Atchison County have trees around them in the form of windbreaks or environmental plantings. Some trees were present when the farmsteads were established, but many have been planted by the landowners. Siberian elm, bur oak, silver maple, honeylocust, green ash, lilac, boxelder, American sycamore, common hackberry, and eastern redcedar are some of the most common trees found on the farmsteads.

Planting trees is a continual process because old trees pass maturity and deteriorate; some trees are lost by storms, disease, or insect attacks; and new plantings are needed for new homes or expanding farmsteads. Windbreaks are especially important for reducing energy requirements.

In order for windbreaks or environmental plantings to meet their intended purpose, the species of trees or shrubs selected must be those adapted to the soils that are in the area. Matching the proper trees with the soil type is the first step toward insuring survival and a maximum rate of growth. Permeability, available water capacity, and fertility are soil characteristics that greatly affect the rate of growth for trees and shrubs.

Trees and shrubs are easy to establish on most sites and soil types in Atchison County. Weed and grass competition is the greatest threat to windbreak or environmental plantings; therefore, proper site preparation prior to planting and controlling weeds and other competition after planting are the major concerns when establishing and caring for trees and shrubs.

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

Recreation

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

Atchison County has several areas of scenic, geologic, and historic interest. Scenic bluffs overlooking the Missouri River provide a panoramic view of the countryside.

Numerous watershed lakes, farm ponds, and the Delaware River provide recreation opportunities on privately owned land (fig. 13). Warnock Lake, Atchison State Fishing Lake, Atchison County Lake, and a park adjoining the Missouri River are areas open to the public for camping, picnicking, swimming, and fishing. The

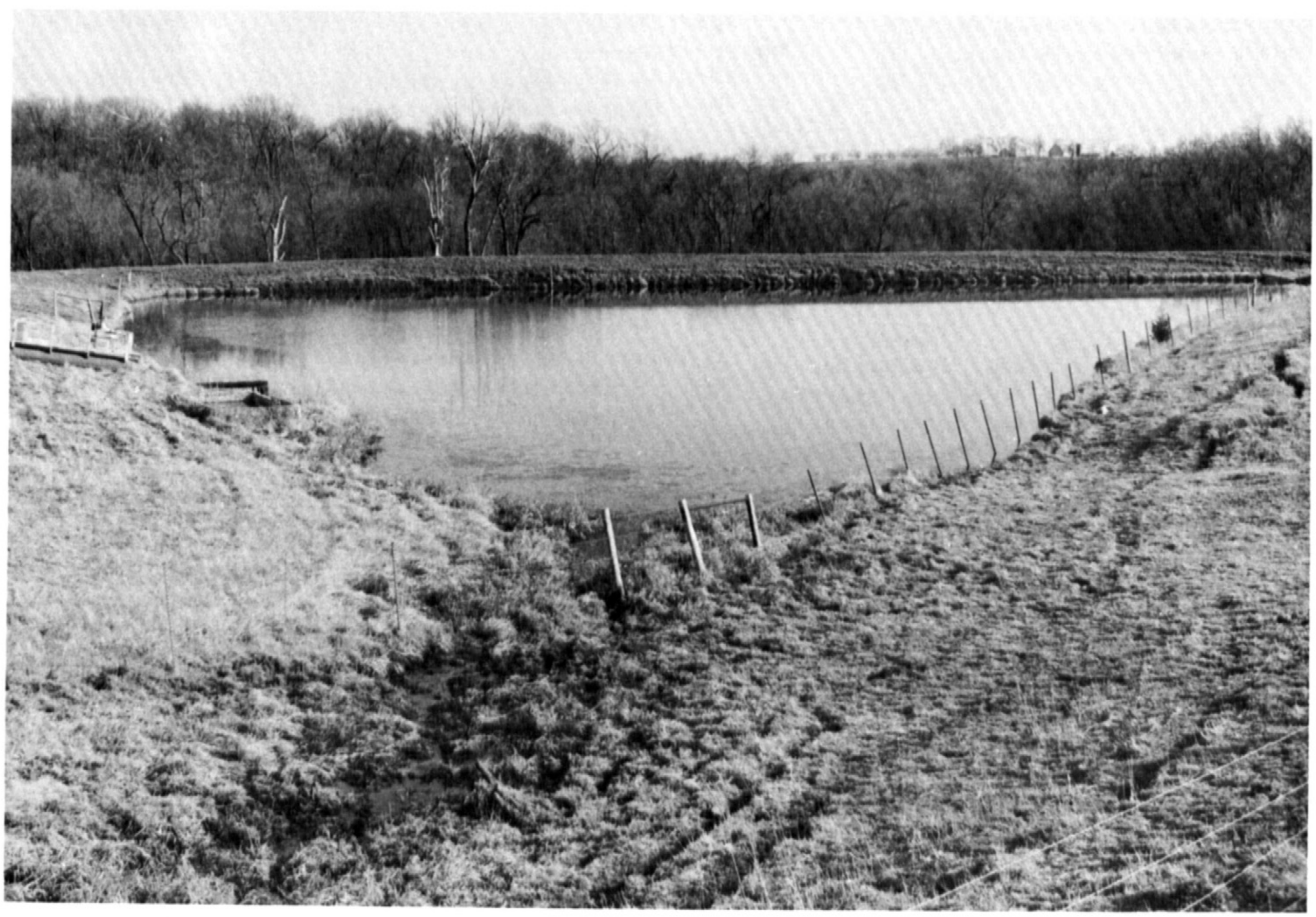


Figure 13.—Farm ponds can be used for recreation as well as a source of water for livestock. This pond is in an area of Grundy silty clay loam, 2 to 6 percent slopes.

potential for additional recreation development within the county is fair.

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 8, 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 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

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

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

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

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

Wildlife Habitat

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

The primary game species in Atchison County are the bobwhite quail, mourning dove, cottontail, fox squirrel, white-tailed deer, and several species of waterfowl. Some woodcock hunting is done along the wooded valleys of this part of the state.

Nongame species of wildlife are numerous due to the diverse number of habitat types. Cropland, woodland, and grassland are intermixed throughout the county. These habitat types create the desirable "edge habitat" conducive to many species.

Furbearers and waterfowl are common along the Delaware and Missouri Rivers and their tributaries. Trapping produces extra income for some county residents.

The lakes, farm ponds, and rivers within the county provide good to excellent fishing. Species commonly caught in the county are bass, bluegill, crappie, carp, and channel cat, bullhead catfish, and flathead catfish.

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

In table 9, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

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

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

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

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

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

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, hickory, cottonwood, hackberry, black walnut, willow, mulberry, and green ash. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, plum, fragrant sumac, 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 redcedar, pine, spruce, 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, prairie cordgrass, buttonbush, indigobush, rushes, sedges, and reeds.

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

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

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite quail, mourning dove, pheasant, 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, owls, woodcock, thrushes, woodpeckers, squirrels, opossum, raccoon, and white-tailed deer.

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

Engineering

Herbert R. Graves, Jr., civil engineer, Soil Conservation Service, helped prepare this section.

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

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

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

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

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

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

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

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

Building Site Development

Table 10 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

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

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

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

Sanitary Facilities

Table 11 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 11 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

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

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to 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 11 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock, flooding, large stones, and content of organic matter.

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

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

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

The ratings in table 11 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

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

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

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock 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 12 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

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

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

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

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

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 12, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

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

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

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

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

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

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

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

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

Water Management

Table 13 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 of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

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

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

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

In the areas of Knox soils and other soils that formed in loess, the depth of ravines and low shear strength are special problems that affect the design and construction of earthen dams. Many of the ravines are cut more than 20 feet below the valley floor. As a result, cutting core trenches is difficult, the amount of fill needed is increased, and longer metal pipes through the structure are needed. The Knox soils are susceptible to piping and erosion, especially in the steeper areas.

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

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

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

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

Soil Properties

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

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

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

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

Engineering Index Properties

Table 14 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

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

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

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

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

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

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

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

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

Physical and Chemical Properties

Table 15 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

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

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

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

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

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

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

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

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

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

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

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

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

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops.

They are extremely erodible, and vegetation is difficult to establish.

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

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

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

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

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

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

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

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

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

In table 15, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

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

Soil and Water Features

Table 16 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

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

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

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

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

In table 16, some soils are assigned to two hydrologic groups. Soils that have a seasonal high water table but can be drained are assigned first to a hydrologic group that denotes the drained condition and then to a hydrologic group that denotes the undrained condition; for example, B/D. Because there are different degrees of drainage and water table control, onsite investigation is needed to determine the hydrologic group of the soil in a particular location.

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

Table 16 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs, on the average, no more than once in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

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

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

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. Only saturated zones within a depth of about 6 feet are indicated. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 16 are the 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 16.

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 specified as 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 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 creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

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

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

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*6*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 17 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

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

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udoll (*Ud*, meaning humid, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludolls (*Hapl*, meaning minimal horizonation, plus *udoll*, the suborder of the Mollisols that have a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Hapludolls.

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

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

Soil Series and Their Morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (*5*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*6*). Unless otherwise stated, colors in the descriptions are for 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."

Armster Series

The Armster series consists of deep, moderately well drained, moderately slowly permeable soils on uplands. These soils formed in glacial till. Slope ranges from 6 to 20 percent.

Armster soils are similar to Shelby soils and are commonly adjacent to Gosport, Knox, and Sharpsburg soils. Shelby soils have a mollic epipedon. The Gosport soils are 20 to 40 inches deep over bedrock and are steeper than the Armster soils. Knox and Sharpsburg soils contain less sand than the Armster soils. They are on upper side slopes.

Typical pedon of Armster clay loam, 6 to 12 percent slopes, 500 feet north and 50 feet west of the southeast corner of sec. 16, T. 5 S., R. 20 E.

Ap—0 to 7 inches; dark brown (10YR 3/3) clay loam, dark yellowish brown (10YR 4/4) dry; weak fine granular structure; slightly hard, friable; few fine roots; few fine pebbles; slightly acid; clear smooth boundary.

Bt1—7 to 19 inches; reddish brown (5YR 4/4) clay loam, brown (7.5YR 5/4) dry; vertical streaks of dark brown (7.5YR 3/2); weak fine subangular blocky structure; hard, firm; few fine roots; few fine pebbles; medium acid; gradual smooth boundary.

Bt2—19 to 28 inches; reddish brown (5YR 4/4) clay loam, reddish brown (5YR 5/4) dry; common medium distinct grayish brown (10YR 5/2) mottles; moderate fine subangular blocky structure; very hard, firm; few fine roots; few fine pebbles; medium acid; gradual smooth boundary.

Bt3—28 to 54 inches; reddish brown (5YR 4/4) clay loam, brown (7.5YR 5/4) dry; common medium distinct grayish brown (10YR 5/2) mottles; moderate medium subangular blocky structure; very hard, firm; few fine roots; few fine pebbles; slightly acid; gradual smooth boundary.

BC—54 to 60 inches; reddish brown (5YR 4/4) and brown (7.5YR 5/4) clay loam; common medium distinct grayish brown (10YR 5/2) mottles; weak fine subangular blocky structure; very hard, firm; few fine pebbles; few fine lime concretions; neutral.

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

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3. It is dominantly clay loam, but the range includes loam. Some pedons have an E horizon. The Bt horizon has hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 4. Some pedons have common mottles of a higher chroma.

Chase Series

The Chase series consists of deep, somewhat poorly drained, slowly permeable soils on stream terraces. These soils formed in alluvium. Slope ranges from 0 to 2 percent.

Chase soils are commonly adjacent to the Martin and Wabash soils. Martin soils have a mollic epipedon less than 36 inches thick and are on upland side slopes. Wabash soils are more poorly drained and are on lower lying, slightly depressional flood plains.

Typical pedon of Chase silty clay loam, 500 feet south and 125 feet east of the center of sec. 2, T. 5 S., R. 20 E.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; hard, friable; few fine roots; medium acid; clear smooth boundary.

A—7 to 11 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine granular structure; hard, friable; few fine roots; many pores; medium acid; clear smooth boundary.

BA—11 to 16 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure; hard, friable; many pores; medium acid; clear smooth boundary.

Bt1—16 to 34 inches; black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; moderate medium and fine blocky structure; very hard, very firm; many pores; slightly acid; gradual smooth boundary.

Bt2—34 to 45 inches; very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) dry; common fine faint brown (10YR 4/3) mottles; weak very fine blocky structure; very hard, very firm; neutral; gradual smooth boundary.

Cg—45 to 60 inches; dark grayish brown (2.5Y 4/2) silty clay, gray (N 5/1) dry; common fine distinct dark brown (7.5YR 4/4) mottles; very weak blocky structure grading to massive with depth; very hard, firm; neutral.

The thickness of the solum ranges from 36 to 60 inches. Thickness of the mollic epipedon is more than 36 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silt loam. The Bt horizon has hue of 10YR or 2.5Y, value of 2 to 5, and chroma of 1 or 2. Reaction ranges from medium acid to neutral. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 or 2. Reaction ranges from slightly acid to mildly alkaline. Some pedons contain fine lime concretions.

Colo Series

The Colo series consists of deep, poorly drained, moderately permeable soils on flood plains. These soils formed in alluvium. Slope ranges from 0 to 2 percent.

Colo soils are similar to Wabash soils and are adjacent to Judson and Kennebec soils. The well drained Judson soils are on foot slopes. The moderately well drained Kennebec soils are on slightly higher flood plains. Wabash soils have a clayey subsoil and are very poorly drained.

Typical pedon of Colo silt loam in an area of Kennebec-Colo silt loams, 2,500 feet north and 300 feet west of the southeast corner of sec. 8, T. 7 S., R. 20 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; hard, friable; many fine roots; many pores; neutral; clear smooth boundary.

A1—8 to 23 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; few fine distinct dark brown (10YR 3/3) mottles; weak medium prismatic structure parting to weak fine subangular blocky; hard, friable; many fine roots; many pores; slightly acid; gradual smooth boundary.
A2—23 to 38 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few fine distinct brown (10YR 4/3) mottles; weak fine subangular blocky structure; hard, firm; few fine roots; few pores; slightly acid; gradual smooth boundary.
C—38 to 60 inches; dark gray (10YR 4/1) silty clay loam, gray (10YR 5/1) dry; many fine distinct brown (10YR 4/3) mottles; weak very fine subangular blocky structure; hard, firm; few pores; neutral.

The solum ranges from 36 to 50 inches in thickness. The mollic epipedon is more than 36 inches thick.

The Ap horizon is recent overwash material. It has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. It is dominantly silt loam, but it is silty clay loam in some pedons. It ranges from 8 to 16 inches in thickness. The part of the A horizon below the overwash material has hue of 10YR, value of 2 or 3, and chroma of 0 or 1. Some pedons are more clayey below a depth of 36 inches.

Gosport Series

The Gosport series consists of moderately deep, moderately well drained, very slowly permeable soils on uplands. These soils formed in material weathered from interbedded limestone and shale. Slope ranges from 10 to 45 percent.

Gosport soils are commonly adjacent to Armster, Knox, and Sharpsburg soils. These soils are more than 40 inches deep over bedrock, have an argillic horizon, and are on higher ridgetops or lower foot slopes.

Typical pedon of Gosport silty clay loam, 25 to 45 percent slopes, 3,400 feet north and 500 feet east of the southwest corner of sec. 34, T. 6 S., R. 21 E.

A1—0 to 5 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; moderate very fine granular structure; hard, friable; strongly acid; clear smooth boundary.
A2—5 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak very fine granular structure; hard, friable; strongly acid; clear smooth boundary.
BA—8 to 14 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; few very fine distinct strong brown (7.5YR 5/8) mottles; moderate medium subangular blocky structure; very hard, firm; strongly acid; gradual smooth boundary.
Bw—14 to 27 inches; dark yellowish brown (10YR 4/4) silty clay, light yellowish brown (10YR 6/4) dry; common very fine distinct yellowish red (5YR 4/6) mottles; moderate fine blocky structure; very hard, very firm; strongly acid; gradual smooth boundary.
BC—27 to 35 inches; light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) dry; streaked with strong brown (10YR 5/6) mottles; weak fine subangular blocky structure; very hard, firm; strongly acid.
Cr—35 inches; weathered clayey shale.

The thickness of the solum and the depth to shale range from 20 to 40 inches.

The Bw horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 4.

Grundy Series

The Grundy series consists of deep, somewhat poorly drained, slowly permeable soils on loess-covered uplands. Slope ranges from 0 to 7 percent.

Grundy soils are similar to Martin and Pawnee soils and are commonly adjacent to Pawnee, Sharpsburg, and Shelby soils. The moderately well drained Martin soils are on foot slopes. Pawnee soils contain more sand in the subsoil and are on lower side slopes. The Sharpsburg and Shelby soils have a less clayey subsoil than Grundy soils and are on lower side slopes.

Typical pedon of Grundy silty clay loam, 2 to 6 percent slopes, 1,500 feet west and 150 feet south of the northeast corner of sec. 5, T. 6 S., R. 19 E. (fig. 14).

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; hard, friable; many very fine and common fine roots; slightly acid; abrupt smooth boundary.
BA—7 to 14 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few fine faint brown (10YR 4/3) mottles; strong fine subangular blocky structure; hard, firm; few very fine and fine roots; medium acid; gradual smooth boundary.
Bt1—14 to 21 inches; very dark gray (10YR 3/1) silty clay, grayish brown (10YR 5/2) dry; common fine distinct dark yellowish brown (10YR 4/4) mottles; strong medium prismatic structure parting to moderate very fine blocky; very hard, firm; few fine roots; few fine very dark brown concretions; slightly acid; gradual smooth boundary.
Bt2—21 to 30 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; many medium distinct dark yellowish brown (10YR 4/4) and prominent yellowish red (5YR 4/6) mottles; weak fine blocky structure; very hard, firm; few fine roots; few fine very dark brown concretions; slightly acid; gradual smooth boundary.
BC—30 to 47 inches; grayish brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; few medium prominent yellowish red (5YR 4/6) mottles; weak

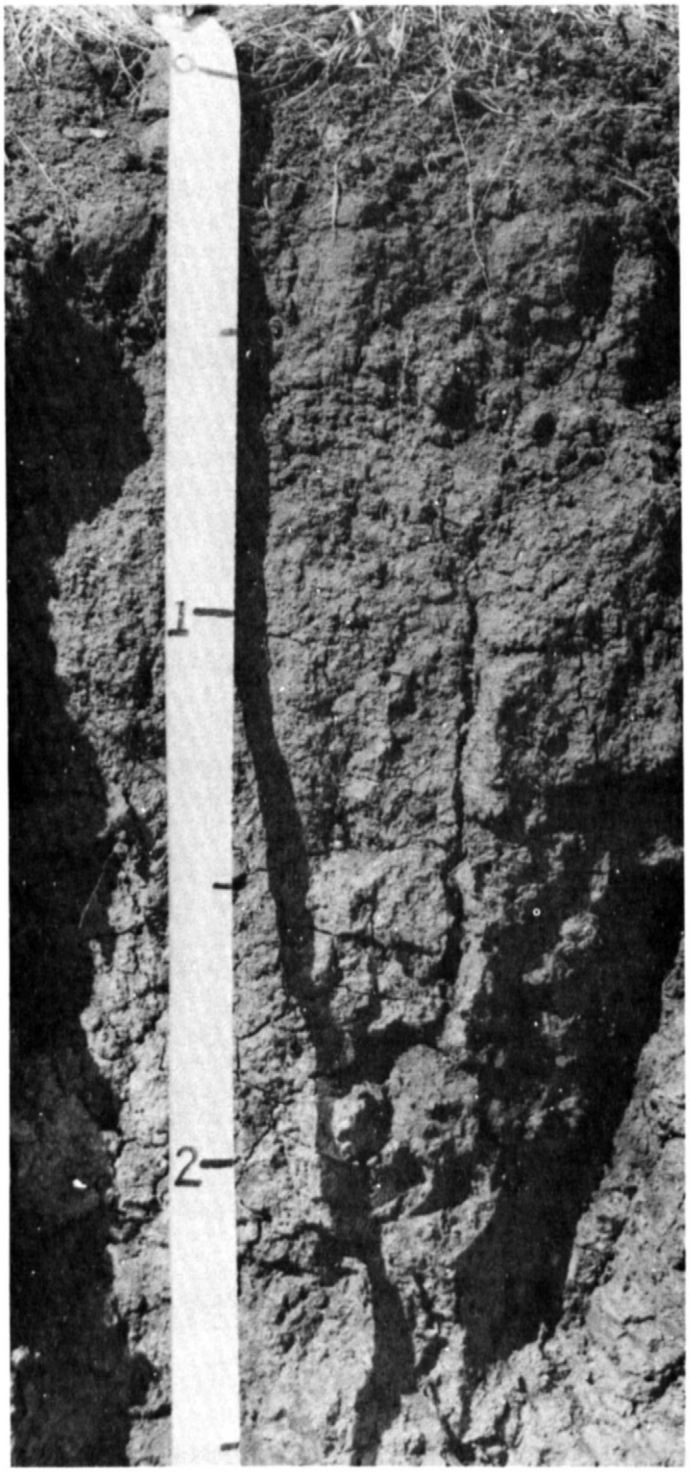


Figure 14.—Blocky structure is evident in this profile of a Grundy soil. Depth is marked in feet.

very fine blocky structure; very hard, firm; few fine roots; few fine very dark brown concretions; slightly acid; gradual smooth boundary.

C—47 to 60 inches; olive gray (5Y 5/2) silty clay loam, light olive gray (5Y 6/2) dry; many fine prominent yellowish red (5YR 5/6) mottles; massive; hard, firm; few very fine roots; few fine very dark brown concretions; neutral.

The thickness of the solum and the depth to lime are more than 40 inches. The mollic epipedon ranges from 11 to 24 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silty clay and silt loam. The Bt horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 to 3. It ranges from strongly acid to neutral. The C horizon has hue of 10YR, 2.5Y, or 5Y, value of 4 or 5, and chroma of 1 or 2.

Haynie Series

The Haynie series consists of deep, moderately well drained, moderately permeable soils that formed in alluvium. These soils are on flood plains along the Missouri River. Slope ranges from 0 to 3 percent.

Haynie soils are commonly adjacent to Onawa and Sarpy soils. The Onawa soils are clayey in the upper part of the control section. They are on slightly lower flood plains. The Sarpy soils are sandy. They are on ridges.

Typical pedon of Haynie silt loam, 2,500 feet east and 1,800 feet south of the northwest corner of sec. 17, T. 5 S., R. 21 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive; slightly hard, very friable; slight effervescence; mildly alkaline; clear smooth boundary.

C1—8 to 22 inches; dark grayish brown (10YR 4/2) silt loam with thin strata of very fine sandy loam, light brownish gray (10YR 6/2) dry; common fine distinct strong brown (7.5YR 5/6) mottles; massive; hard, very friable; slight effervescence; moderately alkaline; clear smooth boundary.

C2—22 to 31 inches; dark grayish brown (10YR 4/2) very fine sandy loam with thin strata of silt loam, light brownish gray (10YR 6/2) dry; few medium distinct yellowish brown (10YR 5/6) mottles; massive; soft, very friable; slight effervescence; moderately alkaline; clear smooth boundary.

C3—31 to 60 inches; stratified grayish brown (10YR 5/2) and brown (10YR 5/3) silt loam and very fine sandy loam with thin very dark gray (10YR 3/1) clayey strata, light brownish gray (10YR 6/2) dry; common medium distinct strong brown (7.5YR 5/6) mottles; massive; slightly hard, very friable; strong effervescence; moderately alkaline.

The thickness of the solum is 6 to 9 inches and is the same as that of the Ap or A horizon. The depth to lime ranges from 0 to 10 inches.

The A horizon is silt loam or very fine sandy loam. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 2 to 4.

Judson Series

The Judson series consists of deep, well drained, moderately permeable soils on foot slopes. These soils formed in alluvium. Slope ranges from 2 to 7 percent.

Judson soils are similar to Kennebec soils and are commonly adjacent to Colo, Kennebec, Knox, and Martin soils. The poorly drained Colo soils and moderately well drained Kennebec soils are on flood plains. The Knox and Martin soils are on side slopes above Judson soils. The Knox soils do not have a mollic epipedon. The Martin soils have a more clayey subsoil.

Typical pedon of Judson silt loam, 2 to 7 percent slopes, 300 feet east and 75 feet south of the northwest corner of sec. 10, T. 5 S., R. 20 E.

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

A—7 to 12 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 5/2) dry; moderate fine granular structure; hard, friable; many fine roots; many pores; slightly acid; gradual smooth boundary.

BA—12 to 31 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; moderate fine granular structure; hard, friable; many fine roots; many pores; slightly acid; gradual smooth boundary.

Bw—31 to 45 inches; dark brown (10YR 4/3) silty clay loam, yellowish brown (10YR 5/4) dry; moderate fine granular structure; hard, friable; few fine roots; many pores; neutral; gradual smooth boundary.

BC—45 to 60 inches; dark yellowish brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak fine granular structure; hard, friable; few fine roots; many pores; neutral.

The solum ranges from 40 to 60 inches in thickness. The mollic epipedon is more than 24 inches thick. The soil is slightly acid or neutral throughout.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The Bw horizon has hue of 10YR, value of 3 or 4, and chroma of 3 or 4. Some pedons contain mottles below a depth of 30 inches.

Kennebec Series

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

Kennebec soils are similar to Judson soils and are commonly adjacent to Colo and Wabash soils. The Colo soils are poorly drained and are on flood plains. The well drained Judson soils are on foot slopes. The Wabash soils are very poorly drained and are in depressions on flood plains.

Typical pedon of Kennebec silt loam, 4,200 feet east and 200 feet south of the northwest corner of sec. 32, T. 6 S., R. 17 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; massive; slightly hard, friable; many fine roots; medium acid; clear smooth boundary.

A1—9 to 21 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; slightly hard, friable, few fine roots; many pores; neutral; gradual smooth boundary.

A2—21 to 34 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; hard, friable; few fine roots; many pores; neutral; gradual smooth boundary.

AC—34 to 47 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; weak fine granular structure; hard, friable; few fine roots; neutral; gradual smooth boundary.

C—47 to 60 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; massive; hard, friable; many pores; neutral.

The solum and the mollic epipedon are more than 36 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. Some pedons have a layer of dark grayish brown (10YR 4/2) overwash. The C horizon has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. It is silt loam or silty clay loam.

Knox Series

The Knox series consists of deep, well drained, moderately permeable soils on loess-covered uplands. Slope ranges from 10 to 30 percent.

Knox soils are similar to Sharpsburg soils and are commonly adjacent to Armster, Gosport, and Sharpsburg soils. Sharpsburg soils have a mollic epipedon and are on smoother and broader slopes. Armster soils contain more sand in the subsoil and are on lower side slopes. Gosport soils are 20 to 40 inches deep over bedrock and are steeper.

Typical pedon of Knox silty clay loam, 10 to 18 percent slopes, eroded, 2,550 feet north and 500 feet west of the southeast corner of sec. 19, T. 5 S., R. 21 E.

Ap—0 to 8 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; massive; slightly hard, friable; many fine roots; medium acid; clear smooth boundary.
Bt1—8 to 21 inches; dark yellowish brown (10YR 4/4) silty clay loam, pale brown (10YR 6/3) dry; moderate medium subangular blocky structure; hard, friable; many fine roots; thin discontinuous clay films; slightly acid; gradual smooth boundary.
Bt2—21 to 45 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; weak medium subangular blocky structure; hard, friable; many fine roots; thin discontinuous clay films; slightly acid; diffuse smooth boundary.
BC—45 to 60 inches; dark yellowish brown (10YR 4/4) silt loam, light yellowish brown (10YR 6/4) dry; common fine faint yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; hard, friable; few roots; slightly acid.

The solum ranges from 36 to more than 60 inches in thickness. The epipedon is 6 to 9 inches thick.

The A horizon has hue of 10YR, value of 3, and chroma of 2 or 3. It is silt loam or silty clay loam. Some pedons have an E horizon, which has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. The Bt horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6. This horizon is silt loam or silty clay loam that ranges from 25 to 35 percent clay. The Bt horizon is slightly acid or medium acid.

Martin Series

The Martin series consists of deep, moderately well drained, slowly permeable soils on uplands and foot slopes. These soils formed in material weathered from shale. Slope ranges from 3 to 7 percent.

Martin soils are similar to Grundy and Pawnee soils and are commonly adjacent to Pawnee and Vinland soils, which are on the upper side slopes. Grundy and Pawnee soils have a mollic epipedon that is thinner than that of the Martin soils. The Vinland soils are less than 20 inches deep over shale.

Typical pedon of Martin silty clay loam, 3 to 7 percent slopes, 2,000 feet east and 100 feet north of the southwest corner of sec. 10, T. 7 S., R. 17 E.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; hard, firm; medium acid; clear smooth boundary.
BA—7 to 13 inches; very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium blocky structure; hard, firm; medium acid; gradual smooth boundary.
Bt1—13 to 27 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; few fine faint yellowish brown (10YR 5/6) mottles; vertical streaks of very dark brown (10YR 2/2); weak very fine blocky structure; extremely hard, very firm; few fine rock fragments; few fine black concretions; diffuse smooth boundary.
Bt2—27 to 39 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; common fine distinct olive yellow (2.5Y 6/6) mottles; vertical streaks of very dark brown (10YR 2/2); weak very fine blocky structure; extremely hard, very firm; few fine black concretions; neutral; diffuse smooth boundary.
BC—39 to 49 inches; olive brown (2.5Y 4/4) silty clay, light brownish gray (2.5Y 6/2) dry; common fine faint brownish yellow (10YR 6/6) mottles; weak fine subangular blocky structure; extremely hard, very firm; mildly alkaline; clear smooth boundary.
Cr—49 inches; olive (5Y 5/3) and pale olive (5Y 6/3) shale.

The thickness of the solum and the depth to shale are more than 40 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silty clay. The Bt horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 4. The darker colors are in the upper part of this horizon. The C horizon, if present, has variegated colors ranging in hue from 5YR or 2.5Y.

Onawa Series

The Onawa series consists of deep, somewhat poorly drained soils that are slowly permeable in the upper part of the profile and moderately permeable in the lower part. These soils formed in calcareous clayey and silty alluvium on flood plains. Slope ranges from 0 to 1 percent.

Onawa soils are commonly adjacent to Haynie soils. The Haynie soils are less clayey in the upper part of the profile than the Onawa soils. They are slightly higher on the landscape.

Typical pedon of Onawa silty clay loam, 1,900 feet east and 200 feet south of the northwest corner of sec. 29, T. 5 S., R. 21 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak medium blocky structure; very hard, firm; slight effervescence; moderately alkaline; clear smooth boundary.
Cg1—8 to 27 inches; dark grayish brown (10YR 4/2) silty clay, light brownish gray (10YR 6/2) dry; few fine distinct dark yellowish brown (10YR 4/6) mottles; weak medium subangular blocky structure; hard, firm; fine strata of slightly darker material;

slight effervescence; moderately alkaline; clear smooth boundary.

2Cg2—27 to 60 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; many fine distinct yellowish brown (10YR 5/6) mottles; massive; very hard, firm; fine strata of slightly dark material; slight effervescence; moderately alkaline.

Reaction is mildly alkaline or moderately alkaline throughout the profile.

The A horizon has hue of 10YR or 2.5Y, value of 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silt loam and silty clay. The silty clay control section ranges from 18 to 30 inches in thickness. The Cg and 2Cg horizons have hue of 10YR, 2.5Y, or 5Y; value of 4 or 5; and chroma of 2 or less. In some pedons the Cg horizon has very thin strata of silt loam, loam, very fine sandy loam, clay loam, and silty clay loam. The 2Cg horizon is silt loam or very fine sandy loam.

Pawnee Series

The Pawnee series consists of deep, moderately well drained, slowly permeable soils on uplands. These soils formed in glacial till. Slope ranges from 3 to 7 percent.

Pawnee soils are similar to Grundy and Martin soils and are commonly adjacent to Grundy, Kennebec, and Shelby soils on the landscape. The somewhat poorly drained Grundy soils are less sandy than the Pawnee soils. They are on higher slopes and broad loess-covered uplands. Martin soils have a thicker mollic epipedon and are on foot slopes. Kennebec soils do not have an argillic horizon and are on flood plains. Shelby soils have a less clayey subsoil and are generally steeper.

Typical pedon of Pawnee clay loam, 3 to 7 percent slopes, 2,100 feet west and 150 feet south of the northeast corner of sec. 2, T. 7 S., R. 19 E.

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

Bt1—8 to 15 inches; very dark grayish brown (10YR 3/2) clay, dark grayish brown (10YR 4/2) dry; few fine distinct strong brown (7.5YR 5/6) mottles; moderate medium subangular blocky structure; very hard, firm; few fine granite and chert pebbles; slightly acid; gradual smooth boundary.

Bt2—15 to 19 inches; dark grayish brown (10YR 4/2) clay, grayish brown (10YR 5/2) dry; common fine distinct strong brown (7.5YR 5/6) mottles; vertical cracks filled with very dark gray (10YR 3/1); moderate medium subangular blocky structure; very hard, firm; few fine black concretions; few fine granite and quartz pebbles; slightly acid; gradual smooth boundary.

Bt3—19 to 34 inches; dark brown (10YR 4/3) clay, brown (10YR 5/3) dry; many fine faint yellowish brown (10YR 5/6 and 5/8) mottles; vertical streaks of very dark gray (10YR 3/1); weak fine blocky structure; very hard, firm; many dark stains and concretions; few fine pebbles; slightly acid in the upper part and neutral in the lower part; diffuse boundary.

BC—34 to 60 inches; grayish brown (2.5Y 5/2) clay loam, light brownish gray (2.5Y 6/2) dry; many fine prominent yellowish red (5YR 4/6) and strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; hard, firm; few fine black concretions; neutral.

The thickness of the solum and the depth to lime are greater than 40 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly clay loam, but the range includes clay and loam. The Bt2 horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 or 3. It is slightly acid or neutral.

Reading Series

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

Reading soils are similar to Sharpsburg soils and are commonly adjacent to Chase, Colo, Judson, and Kennebec soils. The Sharpsburg soils contain more clay in the subsoil and are on uplands. The somewhat poorly drained Chase soils are on slightly lower stream terraces. The Colo and Kennebec soils are on flood plains. Their mollic epipedon is thicker than that of the Reading soils, and they do not have an argillic horizon. The well drained Judson soils are on foot slopes.

Typical pedon of Reading silt loam, 1,300 feet west and 1,500 feet south of the northeast corner of sec. 11, T. 5 S., R. 19 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable; medium acid; clear smooth boundary.

A—8 to 13 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine granular structure; slightly hard, friable; medium acid; clear smooth boundary.

BA—13 to 21 inches; very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 5/3) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure; hard, firm; medium acid; gradual smooth boundary.

Bt1—21 to 29 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine subangular blocky structure; very hard, firm; medium acid; gradual smooth boundary.

Bt2—29 to 41 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; common fine faint dark yellowish brown (10YR 4/4) mottles; weak medium subangular blocky structure; very hard, firm; slightly acid; gradual smooth boundary.

BC—41 to 60 inches; brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) dry; common medium faint yellowish brown (10YR 5/6) mottles; moderate fine granular structure; hard, firm; slightly acid.

The solum is more than 50 inches thick. The mollic epipedon is more than 24 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The Bt horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. Below the control section, it averages about 38 percent clay. It is medium acid or slightly acid. The C horizon if present, has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 to 4. It is silty clay loam or silty clay. It is slightly acid to moderately alkaline.

Sarpy Series

The Sarpy series consists of deep, excessively drained, rapidly permeable soils on flood plains. These soils formed in sandy alluvium along the Missouri River. Slope ranges from 1 to 5 percent.

Sarpy soils are commonly adjacent to Haynie and Onawa soils. The Haynie soils are more silty throughout than the Sarpy soils. The Onawa soils are clayey in the upper part.

Typical pedon of Sarpy loamy fine sand, in an area of Haynie-Sarpy complex, 2,200 feet north and 600 feet west of the southeast corner of sec. 18, T. 7 S., R. 22 E.

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) loamy fine sand, grayish brown (10YR 5/2) dry; massive; soft, very friable; slight effervescence; moderately alkaline; clear smooth boundary.

C—6 to 60 inches; stratified grayish brown (10YR 5/2) and dark grayish brown (10YR 4/2) fine sand, light gray (2.5Y 7/2) dry; massive; soft, very friable; slight effervescence; moderately alkaline.

The solum is less than 10 inches thick. Lime is at or near the surface. Reaction is neutral to moderately alkaline throughout the profile.

The A horizon has hue of 10YR, value of 3 to 5, and chroma of 1 to 3. It is dominantly loamy fine sand, but the range includes fine sand and fine sandy loam. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It is fine sand or loamy fine sand. Some pedons contain thin lenses of finer textured material.

Sharpsburg Series

The Sharpsburg series consists of deep, moderately well drained, moderately slowly permeable soils on loess-covered uplands. Slope ranges from 1 to 8 percent.

Sharpsburg soils are similar to Knox and Reading soils and are commonly adjacent to Armster, Grundy, Knox, and Shelby soils. Reading soils have a less clayey subsoil than the Sharpsburg soils and are on stream terraces. Armster soils are on side slopes below Sharpsburg soils and contain more sand in the subsoil. The somewhat poorly drained Grundy soils have a more clayey subsoil and are on smoother and broader slopes. Knox soils do not have a mollic epipedon and are on steeper slopes. Shelby soils have a less clayey subsoil than Sharpsburg soils and contain more sand throughout. They are on the lower side slopes.

Typical pedon of Sharpsburg silty clay loam, 4 to 8 percent slopes, 1,900 feet north and 150 feet west of the southeast corner of sec. 12, T. 5 S., R. 19 E.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; slightly hard, friable; slightly acid; clear smooth boundary.

BA—7 to 13 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; hard, friable; medium acid; gradual smooth boundary.

Bt1—13 to 21 inches; dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; moderate fine subangular blocky structure; hard, firm; many fine roots; medium acid; gradual smooth boundary.

Bt2—21 to 35 inches; dark brown (10YR 4/3) silty clay loam, light yellowish brown (10YR 6/4) dry; weak fine subangular blocky structure; few fine faint grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) mottles; hard, firm; few fine roots; medium acid; gradual smooth boundary.

BC—35 to 54 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; common fine faint yellowish brown (10YR 5/8) and grayish brown (2.5Y 5/2) mottles; weak fine subangular blocky structure; hard, firm; few fine roots; medium acid; gradual smooth boundary.

C—54 to 60 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; few fine faint yellowish brown (10YR 5/8) mottles; massive; hard, friable; slightly acid.

The solum ranges from 40 to 60 inches in thickness. The mollic epipedon ranges from 10 to 22 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2. The Bt horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. It is silty clay loam or silty clay that has 35 to 42 percent clay. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 6. It is silt loam or silty clay loam.

Shelby Series

The Shelby series consists of deep, well drained, moderately slowly permeable soils on uplands (fig. 15). These soils formed in glacial till. Slope ranges from 5 to 25 percent.

Shelby soils are similar to Armster soils and are commonly adjacent to Kennebec, Pawnee, and Sharpsburg soils. Armster soils do not have a mollic epipedon. Pawnee and Sharpsburg soils have a more clayey subsoil than the Shelby soils. Sharpsburg soils are on ridgetops or upper side slopes. Pawnee soils occupy higher ridgetops and side slopes. Kennebec soils have a thicker mollic epipedon and are on flood plains.

Typical pedon of Shelby clay loam, 5 to 10 percent slopes, 1,000 feet east and 100 feet north of the southwest corner of sec. 31, T. 6 S., R. 18 E.

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

BA—8 to 12 inches; very dark grayish brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; many fine roots; few fine pebbles; medium acid; gradual smooth boundary.

Bt1—12 to 18 inches; dark brown (10YR 3/3) clay loam, brown (10YR 4/3) dry; moderate medium granular structure; hard, friable; many fine roots; few fine pebbles; medium acid; gradual smooth boundary.

Bt2—18 to 34 inches; brown (10YR 4/3) clay loam, brown (10YR 5/3) dry; few very fine faint yellowish brown (10YR 5/6) mottles above 30 inches; common fine yellowish brown (10YR 5/6) mottles below 30 inches; moderate medium subangular blocky structure; hard, friable; many fine roots; few very fine pebbles; slightly acid; gradual smooth boundary.

BC—34 to 47 inches; dark yellowish brown (10YR 4/4) clay loam, yellowish brown (10YR 5/4) dry; many very fine faint yellowish brown (10YR 5/6) and few fine distinct strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; hard, friable; few fine roots; few fine black concretions; few small lime concretions; neutral; few fine pebbles; diffuse wavy boundary.

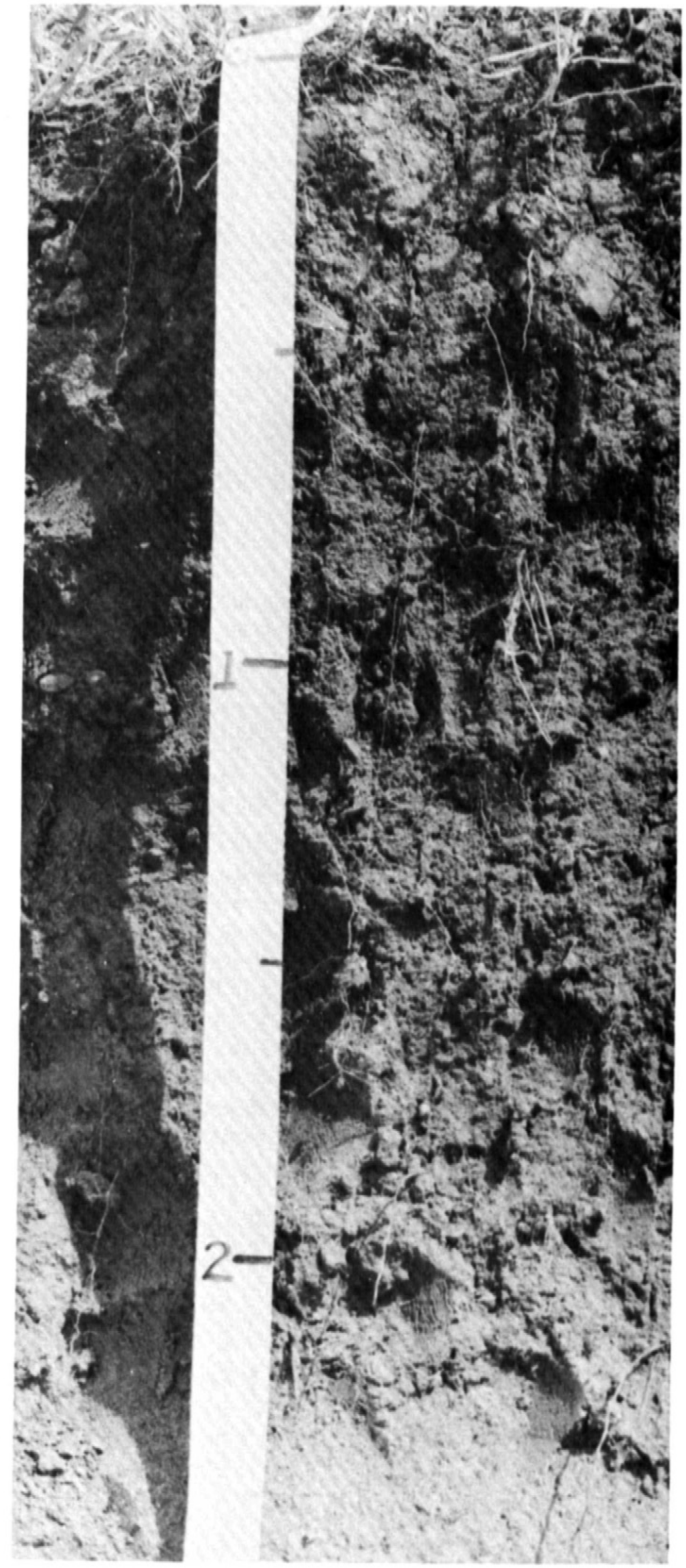


Figure 15.—Root development is not restricted in the deep Shelby soils. Depth is marked in feet.

C—47 to 60 inches; light olive brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) dry; common coarse distinct strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) mottles; massive; very hard, firm; few fine lime concretions; mildly alkaline; few fine pebbles.

The thickness of the solum ranges from 30 to more than 60 inches. The thickness of the mollic epipedon ranges from 10 to 24 inches. The depth to lime is more than 40 inches. The solum ranges from medium acid to neutral.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly clay loam, but the range includes loam and silt loam. The Bt horizon has hue of 10YR, value of 3 to 5, and chroma of 3 or 4. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. The lower part of the Bt horizon and the C horizon have few fine faint to many coarse prominent mottles. Pebbles and stones occur throughout some pedons but make up less than 20 percent of any horizon.

Steinauer Series

The Steinauer series consists of deep, well drained, moderately slowly permeable soils on uplands. These soils formed in glacial till. Slope ranges from 12 to 25 percent.

Steinauer soils are commonly adjacent to Kennebec, Martin, Pawnee, and Shelby soils. Steinauer soils are typically more sloping than these soils. The moderately well drained Kennebec soils are on flood plains. The Martin, Pawnee, and Shelby soils have an argillic horizon. Martin soils are on foot slopes. Pawnee soils are on upper side slopes and on ridgetops. Shelby soils typically are on upper and lower side slopes.

Typical pedon of Steinauer loam, in an area of Shelby-Steinauer loams, 12 to 25 percent slopes, 1,900 feet west and 100 feet north of the southeast corner of sec. 30, T. 5 S., R. 18 E.

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; hard, friable; few pebbles; many fine roots; many soft nodules of lime; strong effervescence; moderately alkaline; clear smooth boundary.

AC—6 to 13 inches; dark yellowish brown (10YR 4/4) loam, light yellowish brown (10YR 6/4) dry; common fine faint yellowish brown (10YR 5/8) mottles; moderate fine granular structure; hard, friable; few pebbles; many fine roots; many soft nodules of lime; violent effervescence; moderately alkaline; gradual smooth boundary.

C1—13 to 34 inches; light olive brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) dry; common medium faint yellowish brown (10YR 5/8) mottles; weak very fine subangular blocky structure; hard, firm; few pebbles; few dark films; common fine roots; many soft nodules of lime; violent effervescence; moderately alkaline; diffuse smooth boundary.

C2—34 to 60 inches; light olive brown (2.5Y 5/4) clay loam, pale yellow (2.5Y 7/4) dry; common medium distinct strong brown (7.5YR 5/6) mottles; weak very fine granular structure; hard, firm; few pebbles; few black stains; few fine roots; many soft nodules of lime; violent effervescence; moderately alkaline.

The thickness of the solum ranges from 8 to 21 inches. The content of pebbles ranges from 0 to 10 percent throughout the soil. The depth to lime ranges from 0 to 14 inches.

The A horizon has hue of 10YR, value of 4 or 5, and chroma of 2. It is dominantly loam, but the range includes clay loam. The AC horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It is loam or clay loam. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 or 4.

Vinland Series

The Vinland series consists of shallow, somewhat excessively drained, moderately permeable soils on uplands. These soils formed in material weathered from shale. Slope ranges from 4 to 15 percent.

Vinland soils are commonly adjacent to Martin and Pawnee soils. The Martin and Pawnee soils are more than 40 inches deep over bedrock. The Martin soils are on foot slopes, and the Pawnee soils are on the upper side slopes.

Typical pedon of Vinland silty clay loam, 4 to 15 percent slopes, 2,400 feet north and 150 feet west of the southeast corner of sec. 10, T. 7 S., R. 17 E.

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

Bw—8 to 12 inches; dark grayish brown (2.5Y 4/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; weak medium subangular blocky structure; 10 percent shale fragments 1/2 to 1 inch across; hard, friable; slightly acid; gradual smooth boundary.

C—12 to 19 inches; grayish brown (2.5Y 5/2) shaly silty clay loam, light brownish gray (2.5Y 6/2) dry; weak fine granular structure; hard, friable; slightly acid; clear wavy boundary.

Cr—19 inches; weathered silty shale.

The thickness of the solum and the depth to shale range from 10 to 20 inches. The mollic epipedon is 7 to 12 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The Bw horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. The C horizon has hue of 7.5YR, 10YR, or 2.5Y, value of 4 to 6, and chroma of 2 to 4.

Wabash Series

The Wabash series consists of deep, very poorly drained, very slowly permeable soils that formed in clayey alluvium. These soils are on the flood plains of the larger streams. Slope ranges from 0 to 2 percent.

Wabash soils are similar to Colo soils and are commonly adjacent to Kennebec and Chase soils. Colo soils are poorly drained and have a silty subsoil. The moderately well drained Kennebec soils are less clayey throughout than the Wabash soils and are nearer the stream channel. Chase soils have an argillic horizon and are on higher positions.

Typical pedon of Wabash silty clay, 1,100 feet east and 100 feet north of the southwest corner of sec. 29, T. 6 S., R. 17 E.

Ap—0 to 8 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; extremely hard, firm; slightly acid; gradual wavy boundary.

A—8 to 28 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; extremely hard, very firm; slightly acid; gradual smooth boundary.

Bg1—28 to 42 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine angular blocky structure; extremely hard, very firm; neutral; gradual smooth boundary.

Bg2—42 to 60 inches; dark gray (10YR 4/1) silty clay, gray (10YR 5/1) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine angular blocky structure; extremely hard, very firm; mildly alkaline.

The thickness of the solum ranges from 40 to more than 60 inches. The thickness of the mollic epipedon is more than 36 inches. Depth to lime is more than 40 inches.

The A horizon is silty clay or silty clay loam. The A horizon and upper part of the Bg horizon have hue of 10YR, value of 2 or 3, and chroma of 1. Color value of the lower part of the Bg horizon is 1 or 2 units higher than that of the upper part.

Formation of the Soils

Soil-forming processes act on deposited or accumulated geologic material. The characteristics of the soil at any given place are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, and (5) the length of time that the forces of soil formation have acted on the soil material. Each of these factors affects the formation of every soil, and each modifies the effects of the other four factors. The effects of each vary from place to place.

Parent Material

Parent material is the unconsolidated material in which soil forms. It forms as rocks are broken down by chemical weathering and by physical weathering, which involves freezing and thawing, wind blowing, and the grinding action of rivers and glaciers. In part of the county, glacial action increased the rate of weathering by scouring and grinding the rock. Wind action has also greatly influenced the type of parent material in which the soils formed.

Parent material influences the kind of soil that forms and the rate of formation. Many chemical and physical properties of the soil are inherited from the parent material.

The parent materials in Atchison County are residuum of interbedded shale and limestone, glacial sediment, loess, and alluvium.

Three different soils in the county formed in residuum of interbedded limestone and shale of the Shawnee Group of the Upper Pennsylvanian Period (*4*). The shallow Vinland soils, the moderately deep Gosport soils, and the deep Martin soils formed in residuum of shale. Bedrock of the Shawnee Group crops out on the bluffs along the Missouri River and along deeply entrenched drainageways.

The Armster, Pawnee, Shelby, and Steinauer soils formed in Kansan glacial till. All but the Steinaur soils are leached of lime to a depth of more than 30 inches. The till contains various amounts of gravel- and sand-size fragments of granite and quartz and other rocks. Stones as large as 10 feet in diameter occur in some areas. In places the till contains local limestone and shale.

Loess is the parent material throughout much of the county. The loess is more than 40 feet thick near the Missouri River Valley and thins out and is more clayey as distance from the Missouri River increases. The Grundy, Knox, and Sharpsburg soils formed in silty loess.

Alluvium is the sediment deposited on flood plains by rivers and their tributaries. It ranges from sandy to clayey. The coarser sediments are near the stream, and the finer sediments are farther away, in the lower depressions. The Sarpy soils formed in sandy alluvium; the Haynie soils formed in loamy alluvium; and the Onawa soils formed in clayey alluvium over loamy alluvium. All three soils are calcareous and occur mainly along the Missouri River. The Colo and Kennebec soils formed in silty alluvium along the tributaries of the Missouri River and the Delaware River. The Wabash soils formed in clayey alluvium along the Delaware River and Stranger Creek. The Chase soils formed in clayey alluvium on stream terraces. The Judson and Reading soils formed in silty alluvium on stream terraces and foot slopes.

Climate

Climate influences both the physical and chemical weathering processes and the biological forces at work in the soil material. Temperature affects the decomposition of organic matter, the growth of organisms, and the rate of chemical reaction in the soils. If the supply of moisture is adequate, the soil-forming processes become more active as the soil temperature increases. These processes are limited by inadequate or excess moisture.

The soils of Atchison County formed under a moist, humid to subhumid climate. Summers are hot, and winters are moderately cold. The average annual precipitation is about 35 inches.

The moderate amount of precipitation in the county has favored the growth of tall grasses. The downward movement of water is one of the main factors affecting the transformation of loess into a soil that has distinct horizons. As water moves downward through the soil, calcium carbonate and salts are leached from the upper part of the soil and either form a lower horizon of enrichment or are carried out of the profile. The translocation of clay is partly caused by the downward movement of water.

Plant and Animal Life

Plants and animals furnish organic matter to the soil and transport soil and plant material from one layer to another. Organic matter creates a favorable environment for biological activity within the soil by providing food for micro-organisms. These organisms affect the chemical, physical, and biological processes of soil formation.

Most of the soils in Atchison County formed under tall prairie grasses. These grasses added much organic matter to the soil, darkened the upper layers, and strengthened the soil structure.

Relief

Relief influences soil formation through its effect on runoff, drainage, erosion, soil temperature, and plant cover. The amount of water that enters the soil depends partly on topography. In areas of the steeper soils—the moderately steep Steinauer soils, for example—the loss of water through runoff and the continual removal of surface soil slow down the rate of soil formation. The rate of soil formation is more rapid in the gently sloping to strongly sloping Shelby soils, which are dark to a greater depth. It is most rapid in the nearly level and gently sloping soils, such as the Pawnee soils.

Time

The length of time that is needed for a soil to form depends mainly on the other factors of soil formation. Soils form slowly if the climate is dry and the vegetation is sparse and much more rapidly if the climate is moist and the vegetation is dense.

Some soils in Atchison County do not have distinct horizons because they have not been subject to the processes of soil formation for a long enough period. The moderately steep Steinauer soils constantly lose soil material. As a result, they show minimal evidence of soil formation. The Haynie soils have weakly expressed horizons because they formed in recently deposited alluvial sediment. The nearly level and gently sloping Grundy soils have been in place long enough for well defined, genetically related horizons to form.

References

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

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

(3) Kansas State Board of Agriculture. 1979. 1978-1979 farm facts. Spec. Rep. Kans. Crop & Kans. Cattle Mark. Stat., 96 pp., illus.

(4) Merriam, Daniel F. 1963. The geological history of Kansas. Univ. Kans. Geol. Surv. Bull. 162, 317 pp., illus.

(5) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 pp., illus.

(6) United States Department of Agriculture. 1975. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. Soil Conserv. Serv., U.S. Dep. Agric. Handb. 436, 754 pp., illus.

Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

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

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

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

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

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.

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

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

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

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

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

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

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

Sticky.—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.

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.

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

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

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.

Edge habitat. The zone of transition from one type of plant cover to another.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

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.

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

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.

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

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual.* The major horizons of mineral soil are as follows:

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

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of another horizon.

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

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

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, the Arabic numeral 2 precedes the letter C.

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

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

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

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

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

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

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

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

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

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

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

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.

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

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.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor, on the basis of how much the present plant community has departed from the potential.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

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

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

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.

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.

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

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

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

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. Includes all subdivisions of these horizons.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

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

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.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1951-76 at Atchison, Kansas]

Month	Temperature					Precipitation				
	Average daily maximum	Average daily minimum	Average	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	In	In	In		In
January-----	36.8	17.1	27.0	67	-12	0.94	0.22	1.47	3	5.6
February----	43.5	22.8	33.2	72	- 6	1.13	0.21	1.92	3	4.2
March-------	52.5	30.6	41.6	82	5	2.36	0.81	3.40	4	3.8
April-------	66.7	43.2	55.0	89	24	3.20	1.83	4.20	6	0.7
May---------	76.0	53.4	64.7	92	33	4.34	2.64	6.00	7	0
June--------	84.0	62.5	73.3	97	47	5.15	2.57	7.69	8	0
July--------	89.3	67.1	78.2	103	51	4.27	1.38	6.78	5	0
August------	88.0	65.1	76.6	101	50	3.92	1.88	5.97	5	0
September---	79.4	56.1	67.8	98	37	4.39	1.84	6.54	7	0
October-----	69.7	45.9	57.8	92	25	2.80	0.83	4.93	5	0
November----	53.6	32.6	43.1	77	8	1.70	0.11	3.10	3	1.4
December----	41.1	22.6	31.9	67	- 8	1.24	0.58	1.92	3	4.8
Year------	65.1	43.3	54.2	104	-12	35.44	24.31	51.50	59	20.5

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-76 at Atchison, Kansas]

Probability	Temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 10	April 22	May 5
2 years in 10 later than--	April 5	April 17	April 30
5 years in 10 later than--	March 27	April 7	April 20
First freezing temperature in fall:			
1 year in 10 earlier than--	October 24	October 14	October 6
2 years in 10 earlier than--	October 29	October 19	October 10
5 years in 10 earlier than--	November 8	October 28	October 20

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-76 at Atchison, Kansas]

Probability	Length of growing season if daily minimum temperature is--		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	204	183	164
8 years in 10	211	190	171
5 years in 10	226	204	183
2 years in 10	240	217	195
1 year in 10	248	224	201

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

Map symbol	Soil name	Acres	Percent
Aq	Aquents, loamy	82	*
Ar	Armster clay loam, 6 to 12 percent slopes	9,400	3.4
As	Armster clay loam, 12 to 20 percent slopes	8,700	3.1
Ch	Chase silty clay loam	1,750	0.6
Go	Gosport silty clay loam, 25 to 45 percent slopes	12,200	4.4
Gr	Grundy silty clay loam, 0 to 2 percent slopes	10,000	3.6
Gu	Grundy silty clay loam, 2 to 6 percent slopes	41,600	15.1
Gx	Grundy silty clay, 3 to 7 percent slopes, eroded	790	0.3
Hn	Haynie silt loam	1,100	0.4
Ho	Haynie-Onawa complex	3,400	1.2
Hs	Haynie-Sarpy complex	440	0.2
Ju	Judson silt loam, 2 to 7 percent slopes	2,500	0.9
Ke	Kennebec silt loam	5,500	2.0
Kf	Kennebec silt loam, channeled	5,400	2.0
Kg	Kennebec-Colo silt loams	11,900	4.3
Kn	Knox silt loam, 18 to 30 percent slopes	4,200	1.5
Kx	Knox silty clay loam, 10 to 18 percent slopes, eroded	9,800	3.6
Ky	Knox-Gosport complex, 10 to 30 percent slopes	5,900	2.1
Mc	Martin silty clay loam, 3 to 7 percent slopes	3,400	1.2
On	Onawa silty clay loam	1,400	0.5
Pc	Pawnee clay loam, 3 to 7 percent slopes	39,600	14.4
Pd	Pawnee clay, 3 to 7 percent slopes, eroded	2,900	1.1
Pt	Pits, quarries	440	0.2
Re	Reading silt loam	1,600	0.6
Sb	Sharpsburg silty clay loam, 1 to 4 percent slopes	1,950	0.7
Sc	Sharpsburg silty clay loam, 4 to 8 percent slopes	22,100	8.0
Sh	Shelby clay loam, 5 to 10 percent slopes	7,000	2.5
Sm	Shelby clay loam, 7 to 15 percent slopes, eroded	39,200	14.2
Ss	Shelby-Steinauer loams, 12 to 25 percent slopes	7,300	2.7
Vs	Vinland silty clay loam, 4 to 15 percent slopes	3,400	1.2
Wa	Wabash silty clay loam	3,600	1.3
Wb	Wabash silty clay	4,600	1.7
	Water	2,688	1.0
	Total	275,840	100.0

* Less than 0.1 percent.

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

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Winter wheat	Smooth bromegrass
	Bu	Bu	Bu	Bu	AUM*
Aq. Aquents					
Ar. Armster	60	60	30	32	5.0
As. Armster	---	---	---	---	5.0
Ch. Chase	82	85	36	50	7.0
Go. Gosport	---	---	---	---	1.0
Gr. Grundy	80	80	36	44	6.5
Gu. Grundy	75	75	32	40	6.0
Gx. Grundy	55	60	24	32	5.0
Hn. Haynie	96	90	36	42	6.5
Ho. Haynie-Onawa	85	85	35	40	6.0
Hs. Haynie-Sarpy	60	60	26	32	4.2
Ju. Judson	110	95	44	46	7.3
Ke. Kennebec	100	90	36	46	7.1
Kf. Kennebec	---	---	---	---	7.0
Kg. Kennebec-Colo	95	85	36	42	6.6
Kn. Knox	---	---	---	---	4.5
Kx. Knox	75	70	28	34	5.0
Ky. Knox-Gosport	---	---	---	---	4.3
Mc. Martin	75	80	32	40	5.5
On. Onawa	85	80	32	38	5.3
Pc. Pawnee	64	70	30	38	5.5

See footnote at end of table.

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

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Winter wheat	Smooth bromegrass
	Bu	Bu	Bu	Bu	AUM*
Pd-------------------------- Pawnee	50	55	25	30	4.5
Pt. Pits					
Re-------------------------- Reading	95	95	44	52	7.0
Sb-------------------------- Sharpsburg	95	90	38	44	6.7
Sc-------------------------- Sharpsburg	90	85	36	42	6.5
Sh-------------------------- Shelby	80	80	32	42	6.0
Sm-------------------------- Shelby	70	70	28	34	5.5
Ss-------------------------- Shelby-Steinauer	---	---	---	---	3.0
Vs-------------------------- Vinland	---	---	---	---	3.0
Wa-------------------------- Wabash	75	85	34	42	6.0
Wb-------------------------- Wabash	60	75	30	36	5.0

* Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

TABLE 6.--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	Trees to plant
Ar----------------- Armster	4o	Slight	Slight	Slight	Slight	White oak-----------	55	Pin oak, green ash, northern red oak, black oak.
						Northern red oak----	60	
						Hackberry-----------	---	
						Shagbark hickory----	---	
As----------------- Armster	4r	Moderate	Moderate	Moderate	Slight	White oak-----------	55	Pin oak, green ash, northern red oak, black oak.
						Northern red oak----	60	
						Hackberry-----------	---	
						Shagbark hickory----	---	
Ch----------------- Chase	3c	Slight	Moderate	Moderate	Slight	Bur oak-------------	62	Bur oak, green ash, eastern cottonwood, hackberry.
						Hackberry-----------	60	
						Green ash-----------	60	
						Eastern cottonwood--	66	
						Black walnut--------	55	
Go----------------- Gosport	5c	Severe	Severe	Severe	Severe	White oak-----------	45	Green ash, hackberry, bur oak.
						Northern red oak----	45	
						Shagbark hickory----	---	
						Hackberry-----------	---	
Hn----------------- Haynie	1o	Slight	Slight	Slight	Slight	Eastern cottonwood--	110	Black walnut, eastern cottonwood.
						American sycamore---	82	
						Black walnut--------	---	
						Green ash-----------	---	
						Black willow--------	---	
Ho*:								
Haynie------------	1o	Slight	Slight	Slight	Slight	Eastern cottonwood--	110	Black walnut, eastern cottonwood.
						American sycamore---	82	
						Black walnut--------	---	
						Green ash-----------	---	
						Black willow--------	---	
Onawa-------------	4w	Slight	Severe	Severe	Severe	Eastern cottonwood--	85	Eastern cottonwood, green ash.
						Silver maple--------	---	
						Black willow--------	---	
Hs*:								
Haynie------------	1o	Slight	Slight	Slight	Slight	Eastern cottonwood--	110	Black walnut, eastern cottonwood.
						American sycamore---	82	
						Black walnut--------	---	
						Green ash-----------	---	
Sarpy-------------	3s	Slight	Slight	Severe	Slight	Eastern cottonwood--	95	Eastern cottonwood, American sycamore, black willow.
						Silver maple--------	90	
						Black willow--------	---	
Ke, Kf------------- Kennebec	2o	Slight	Slight	Slight	Slight	Black walnut--------	79	Black walnut, bur oak, hackberry, green ash, eastern cottonwood, American sycamore.
						Bur oak-------------	63	
						Hackberry-----------	---	
						Green ash-----------	---	
						Eastern cottonwood--	---	
Kg*:								
Kennebec----------	2o	Slight	Slight	Slight	Slight	Black walnut--------	79	Black walnut, bur oak, hackberry, green ash, eastern cottonwood, American sycamore.
						Bur oak-------------	63	
						Hackberry-----------	---	
						Green ash-----------	---	
						Eastern cottonwood--	---	

See footnote at end of table.

TABLE 6.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Potential productivity: Common trees	Site index	Trees to plant
Kg*:								
Colo	5w	Slight	Severe	Moderate	Moderate	Eastern cottonwood	90	Bur oak, hackberry, green ash, eastern cottonwood.
						Black walnut	68	
						Bur oak	---	
						Hackberry	---	
Kn, Kx Knox	3r	Moderate	Moderate	Moderate	Slight	White oak	65	Green ash, black walnut, hackberry.
						Green ash	---	
						Northern red oak	---	
						Shagbark hickory	---	
Ky*:								
Knox	3r	Moderate	Moderate	Moderate	Slight	White oak	65	Green ash, black walnut, hackberry.
						Green ash	---	
						Northern red oak	---	
						Shagbark hickory	---	
Gosport	5c	Moderate	Moderate	Severe	Severe	White oak	45	Green ash, hackberry, bur oak.
						Northern red oak	45	
						Shagbark hickory	---	
						Hackberry	---	
On Onawa	4w	Slight	Severe	Severe	Severe	Eastern cottonwood	85	Eastern cottonwood, green ash.
						Silver maple	---	
						Black willow	---	
Re Reading	2o	Slight	Slight	Slight	Slight	Black walnut	73	Black walnut, green ash, hackberry, bur oak, eastern cottonwood, northern red oak.
						Hackberry	69	
						Bur oak	60	
						Shagbark hickory	62	
						Northern red oak	---	
Wa Wabash	4w	Slight	Severe	Moderate	Moderate	Green ash	70	Pin oak, pecan, eastern cottonwood, green ash.
						Hackberry	66	
Wb Wabash	4w	Slight	Severe	Severe	Moderate	Green ash	70	Pin oak, pecan, eastern cottonwood, green ash.
						Hackberry	66	

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--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
Aq*. Aquents					
Ar, As Armster	---	Lilac, autumn-olive, Amur honeysuckle, Amur maple.	Eastern redcedar, hackberry, green ash, bur oak, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---
Ch Chase	---	American plum, Amur honeysuckle, Peking cotoneaster, lilac.	Eastern redcedar	Austrian pine, eastern white pine, bur oak, green ash, hackberry, honeylocust.	Eastern cottonwood.
Go Gosport	Lilac	Manchurian crabapple, Amur honeysuckle, Siberian peashrub, autumn-olive.	Eastern redcedar, Austrian pine, hackberry, green ash, Russian-olive, Scotch pine.	Honeylocust	---
Gr, Gu, Gx Grundy	Lilac	Siberian peashrub, Manchurian crabapple, Amur honeysuckle, autumn-olive.	Eastern redcedar, hackberry, Russian-olive, Austrian pine, green ash, Scotch pine.	Honeylocust	---
Hn Haynie	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Russian-olive, osageorange, eastern redcedar, Washington hawthorn.	Green ash, hackberry, honeylocust, bur oak.	Eastern cottonwood.
Ho*:					
Haynie	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Russian-olive, osageorange, eastern redcedar, Washington hawthorn.	Green ash, hackberry, honeylocust, bur oak.	Eastern cottonwood.
Onawa	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Osageorange, eastern redcedar, Russian-olive, Washington hawthorn.	Hackberry, bur oak, green ash, honeylocust.	Eastern cottonwood.
Hs*:					
Haynie	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Russian-olive, osageorange, eastern redcedar, Washington hawthorn.	Green ash, hackberry, honeylocust, bur oak.	Eastern cottonwood.
Sarpy	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Washington hawthorn, Russian-olive, eastern redcedar, osageorange.	Hackberry, green ash, honeylocust, bur oak.	Eastern cottonwood.
Ju Judson	---	Amur honeysuckle, Amur maple, autumn-olive, lilac.	Hackberry, bur oak, green ash, Russian-olive, eastern redcedar.	Honeylocust, Austrian pine, eastern white pine.	---

See footnote at end of table.

TABLE 7.--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
Ke, Kf: Kennebec	---	Amur maple, Amur honeysuckle, lilac, autumn-olive.	Eastern redcedar	Austrian pine, hackberry, pin oak, green ash, honeylocust.	Eastern white pine, eastern cottonwood.
Kg*: Kennebec	---	Amur maple, Amur honeysuckle, lilac, autumn-olive.	Eastern redcedar	Austrian pine, hackberry, pin oak, green ash, honeylocust.	Eastern white pine, eastern cottonwood.
Colo	---	Amur privet, Amur honeysuckle, lilac.	Eastern redcedar, blue spruce, Washington hawthorn.	Eastern white pine, pin oak, Austrian pine, honeylocust, hackberry.	Eastern cottonwood.
Kn, Kx: Knox	---	Amur honeysuckle, autumn-olive, lilac, Amur maple.	Hackberry, eastern redcedar, green ash, bur oak, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---
Ky*: Knox	---	Amur honeysuckle, autumn-olive, lilac, Amur maple.	Hackberry, eastern redcedar, green ash, bur oak, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---
Gosport	Lilac	Manchurian crabapple, Amur honeysuckle, Siberian peashrub, autumn-olive.	Eastern redcedar, Austrian pine, hackberry, green ash, Russian-olive, Scotch pine.	Honeylocust	---
Mc: Martin	Peking cotoneaster, lilac.	Amur honeysuckle, Siberian peashrub, Manchurian crabapple.	Green ash, hackberry, Austrian pine, eastern redcedar, Russian-olive.	Honeylocust, Siberian elm.	---
On: Onawa	Blackhaw	Tatarian honeysuckle, Siberian peashrub.	Osageorange, eastern redcedar, Russian-olive, Washington hawthorn.	Hackberry, bur oak, green ash, honeylocust.	Eastern cottonwood.
Pc, Pd: Pawnee	Amur honeysuckle, lilac, Siberian peashrub, Peking cotoneaster.	Eastern redcedar, Manchurian crabapple.	Austrian pine, Russian-olive, green ash, hackberry, honeylocust.	Siberian elm	---
Pt*. Pits					
Re: Reading	---	American plum, lilac, Peking cotoneaster, Amur honeysuckle.	Eastern redcedar	Austrian pine, green ash, bur oak, honeylocust, hackberry, eastern white pine.	Eastern cottonwood.
Sb, Sc: Sharpsburg	---	Amur maple, Amur honeysuckle, lilac, autumn-olive.	Green ash, hackberry, bur oak, eastern redcedar, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---

See footnote at end of table.

TABLE 7.--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
Sh, Sm: Shelby	---	Autumn-olive, lilac, Amur honeysuckle, Amur maple.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---
Ss*:					
Shelby	---	Autumn-olive, lilac, Amur honeysuckle, Amur maple.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---
Steinauer	Fragrant sumac, Tatarian honeysuckle.	Siberian peashrub	Black locust, northern catalpa, eastern redcedar, honeylocust, green ash, bur oak, Russian-olive.	Siberian elm	---
Vs. Vinland					
Wa, Wb: Wabash	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Austrian pine, green ash, northern red oak, golden willow, honeylocust, silver maple.	Eastern cottonwood.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--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
Aq*. Aquents				
Ar------- Armster	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Severe: erodes easily.
As------- Armster	Severe: slope.	Severe: slope.	Severe: slope.	Severe: erodes easily.
Ch------- Chase	Severe: flooding.	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Severe: erodes easily.
Go------- Gosport	Severe: slope, percs slowly.	Severe: slope, percs slowly.	Severe: slope, percs slowly.	Severe: slope, erodes easily.
Gr, Gu------- Grundy	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
Gx------- Grundy	Severe: wetness, too clayey.	Severe: too clayey.	Severe: too clayey, wetness.	Severe: too clayey.
Hn------- Haynie	Severe: flooding.	Slight-------	Moderate: flooding.	Slight.
Ho*:				
Haynie-------	Severe: flooding.	Slight-------	Moderate: flooding.	Slight.
Onawa-------	Severe: flooding.	Moderate: wetness.	Moderate: wetness, flooding.	Slight.
Hs*:				
Haynie-------	Severe: flooding.	Slight-------	Moderate: flooding.	Slight.
Sarpy-------	Severe: flooding.	Slight-------	Moderate: slope, flooding.	Slight.
Ju------- Judson	Slight-------	Slight-------	Moderate: slope.	Slight.
Ke------- Kennebec	Severe: flooding.	Slight-------	Moderate: flooding.	Slight.
Kf------- Kennebec	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.
Kg*:				
Kennebec-------	Severe: flooding.	Slight-------	Moderate: flooding.	Slight.
Colo-------	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
Kn, Kx------- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Ky*:				
Knox	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Gosport	Severe: slope, percs slowly.	Severe: slope, percs slowly.	Severe: slope, percs slowly.	Severe: erodes easily.
Mc Martin	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight.
On Onawa	Severe: flooding.	Moderate: wetness.	Moderate: wetness, flooding.	Slight.
Pc Pawnee	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Severe: erodes easily.
Pd Pawnee	Severe: too clayey, wetness.	Severe: too clayey.	Severe: too clayey, wetness.	Severe: too clayey, erodes easily.
Pt*. Pits				
Re Reading	Severe: flooding.	Moderate: percs slowly.	Moderate: percs slowly.	Slight.
Sb Sharpsburg	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight.
Sc Sharpsburg	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight.
Sh Shelby	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight.
Sm Shelby	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight.
Ss*:				
Shelby	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Steinauer	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Vs Vinland	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Slight.
Wa Wabash	Severe: flooding, wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.
Wb Wabash	Severe: flooding, wetness, percs slowly.	Severe: wetness, too clayey, percs slowly.	Severe: too clayey, wetness.	Severe: wetness, too clayey.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--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
Aq*. Aquents										
Ar-------- Armster	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
As-------- Armster	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Ch-------- Chase	Good	Good	Good	Good	Good	Good	Fair	Good	Good	Fair.
Go-------- Gosport	Very poor.	Poor	Fair	Fair	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
Gr, Gu-------- Grundy	Fair	Good	Fair	Good	Good	Fair	Fair	Fair	Good	Fair.
Gx-------- Grundy	Fair	Good	Fair	Good	Good	Poor	Very poor.	Fair	Good	Very poor.
Hn-------- Haynie	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Ho*:										
Haynie--------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Onawa--------	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
Hs*:										
Haynie--------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Sarpy--------	Poor	Poor	Fair	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
Ju-------- Judson	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Ke-------- Kennebec	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Kf-------- Kennebec	Poor	Poor	Good	Good	Good	Poor	Poor	Poor	Good	Poor.
Kg*:										
Kennebec--------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Colo--------	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
Kn, Kx-------- Knox	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Ky*:										
Knox--------	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Gosport--------	Very poor.	Poor	Fair	Fair	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
Mc-------- Martin	Fair	Good	Good	Fair	Fair	Poor	Very poor.	Good	Fair	Very poor.

See footnote at end of table.

TABLE 9.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
On-------------------- Onawa	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
Pc, Pd--------------- Pawnee	Fair	Good	Good	Fair	Fair	Very poor.	Good	Good	Fair	Poor.
Pt*. Pits										
Re-------------------- Reading	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Sb-------------------- Sharpsburg	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Sc-------------------- Sharpsburg	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Sh, Sm--------------- Shelby	Fair	Good	Fair	Good	Good	Poor	Poor	Fair	Good	Poor.
Ss*:										
Shelby---------------	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
Steinauer------------	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Vs-------------------- Vinland	Poor	Poor	Fair	Fair	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
Wa-------------------- Wabash	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
Wb-------------------- Wabash	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Aq*. Aquents					
Ar----------------- Armster	Moderate: too clayey, wetness, slope.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, shrink-swell.
As----------------- Armster	Severe: slope.	Severe: shrink-swell, slope.	Severe: slope, shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, slope, shrink-swell.
Ch----------------- Chase	Severe: wetness.	Severe: flooding, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, shrink-swell.	Severe: low strength, frost action.
Go----------------- Gosport	Severe: slope.	Severe: shrink-swell, slope.	Severe: slope, shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, slope, shrink-swell.
Gr, Gu, Gx--------- Grundy	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.
Hn----------------- Haynie	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding, frost action.
Ho*: Haynie------------	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding, frost action.
Onawa-------------	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: flooding, low strength, frost action.
Hs*: Haynie------------	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding, frost action.
Sarpy-------------	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
Ju----------------- Judson	Slight------------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
Ke, Kf------------- Kennebec	Moderate: wetness, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding, frost action, low strength.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Kg*:					
Kennebec	Moderate: wetness, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding, frost action, low strength.
Colo	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, low strength, frost action.
Kn, Kx: Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope, frost action.
Ky*:					
Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope, frost action.
Gosport	Severe: slope.	Severe: shrink-swell, slope.	Severe: slope, shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, slope, shrink-swell.
Mc: Martin	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, frost action, shrink-swell.
On: Onawa	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: flooding, low strength, frost action.
Pc, Pd: Pawnee	Severe: wetness.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: low strength, frost action, shrink-swell.
Pt*. Pits					
Re: Reading	Moderate: too clayey, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, frost action.
Sb: Sharpsburg	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.
Sc: Sharpsburg	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
Sh: Shelby	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.
Sm: Shelby	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Ss*:					
Shelby	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.
Steinauer	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, low strength.
Vs: Vinland	Severe: depth to rock.	Moderate: shrink-swell, slope, depth to rock.	Severe: depth to rock.	Severe: slope.	Moderate: depth to rock, low strength, slope.
Wa, Wb: Wabash	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, wetness, flooding.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Aq*. Aquents					
Ar Armster	Severe: wetness, percs slowly.	Severe: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
As Armster	Severe: wetness, percs slowly, slope.	Severe: slope.	Severe: wetness, slope, too clayey.	Severe: wetness, slope.	Poor: too clayey, hard to pack, slope.
Ch Chase	Severe: wetness, percs slowly.	Slight	Severe: too clayey.	Moderate: flooding, wetness.	Poor: too clayey, hard to pack.
Go Gosport	Severe: depth to rock, percs slowly, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, hard to pack, slope.
Gr Grundy	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Gu, Gx Grundy	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Hn Haynie	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Good.
Ho*:					
Haynie	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Good.
Onawa	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: flooding, seepage, wetness.	Severe: wetness, flooding, seepage.	Fair: wetness.
Hs*:					
Haynie	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Good.
Sarpy	Severe: flooding, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, too sandy.	Severe: flooding, seepage.	Poor: seepage, too sandy.
Ju Judson	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
Ke, Kf Kennebec	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Fair: wetness.

See footnote at end of table.

TABLE 11.--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
Kg*:					
Kennebec	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Fair: wetness.
Colo	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness, hard to pack.
Kn, Kx Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Ky*:					
Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Gosport	Severe: depth to rock, percs slowly, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, hard to pack, slope.
Mc Martin	Severe: wetness, percs slowly.	Moderate: depth to rock, slope.	Severe: depth to rock, too clayey.	Moderate: depth to rock, wetness.	Poor: too clayey, hard to pack.
On Onawa	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: flooding, seepage, wetness.	Severe: wetness, flooding, seepage.	Fair: wetness.
Pc, Pd Pawnee	Severe: percs slowly, wetness.	Moderate: slope.	Severe: too clayey, wetness.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Pt*. Pits					
Re Reading	Severe: wetness, percs slowly.	Moderate: seepage, wetness.	Moderate: flooding, wetness, too clayey.	Moderate: flooding.	Fair: too clayey, thin layer.
Sb, Sc Sharpsburg	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Sh Shelby	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Sm Shelby	Severe: percs slowly.	Severe: slope.	Moderate: too clayey, slope.	Moderate: slope.	Fair: too clayey, slope.
Ss*:					
Shelby	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Steinauer	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Vs Vinland	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.

See footnote at end of table.

TABLE 11.--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
Wa, Wb-------------- Wabash	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack, wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Aq*. Aquents				
Ar----- Armster	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
As----- Armster	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, slope.
Ch----- Chase	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Go----- Gosport	Poor: area reclaim, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, slope.
Gr, Gu, Gx----- Grundy	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Hn----- Haynie	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Ho*:				
Haynie-----	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Onawa-----	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Hs*:				
Haynie-----	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Sarpy-----	Good-----	Probable-----	Improbable: too sandy.	Poor: too sandy.
Ju----- Judson	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Ke, Kf----- Kennebec	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Kg*:				
Kennebec-----	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Colo-----	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Kn, Kx----- Knox	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Ky*:				
Knox-----	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Ky*:				
Gosport	Poor: area reclaim, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, slope.
Mc-- Martin	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
On-- Onawa	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Pc-- Pawnee	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Pd-- Pawnee	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Pt*. Pits				
Re-- Reading	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Sb, Sc-- Sharpsburg	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Sh-- Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Sm-- Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, slope.
Ss*:				
Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Severe: slope.
Steinauer	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Vs-- Vinland	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
Wa-- Wabash	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
Wb-- Wabash	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Aq*. Aquents						
Ar, As: Armster	Severe: slope.	Moderate: hard to pack, wetness.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
Ch: Chase	Slight	Severe: hard to pack.	Percs slowly, frost action.	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Erodes easily, percs slowly.
Go: Gosport	Severe: slope.	Severe: hard to pack.	Deep to water	Percs slowly, depth to rock, rooting depth.	Slope, depth to rock, erodes easily.	Slope, erodes easily, depth to rock.
Gr: Grundy	Slight	Severe: hard to pack.	Percs slowly, frost action.	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
Gu: Grundy	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Wetness, percs slowly, slope.	Erodes easily, wetness.	Wetness, erodes easily.
Gx: Grundy	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Wetness, slow intake, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
Hn: Haynie	Moderate: seepage.	Severe: piping.	Deep to water	Erodes easily, flooding.	Erodes easily	Erodes easily.
Ho*:						
Haynie	Moderate: seepage.	Severe: piping.	Deep to water	Erodes easily, flooding.	Erodes easily	Erodes easily.
Onawa	Severe: seepage.	Severe: piping.	Flooding, frost action, percs slowly.	Wetness, flooding, percs slowly.	Not needed	Not needed.
Hs*:						
Haynie	Moderate: seepage.	Severe: piping.	Deep to water	Erodes easily, flooding.	Erodes easily	Erodes easily.
Sarpy	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake, soil blowing.	Too sandy, soil blowing.	Droughty.
Ju: Judson	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
Ke, Kf: Kennebec	Moderate: seepage.	Moderate: thin layer, piping, wetness.	Deep to water	Flooding	Favorable	Favorable.
Kg*:						
Kennebec	Moderate: seepage.	Moderate: thin layer, piping, wetness.	Deep to water	Flooding	Favorable	Favorable.
Colo	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Flooding, wetness.	Wetness	Wetness.
Kn, Kx: Knox	Severe: slope.	Severe: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
Ky*:						
Knox	Severe: slope.	Severe: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
Gosport	Severe: slope.	Severe: hard to pack.	Deep to water	Percs slowly, depth to rock, rooting depth.	Slope, depth to rock, erodes easily.	Slope, erodes easily, depth to rock.
Mc Martin	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, frost action, slope.	Wetness, percs slowly.	Erodes easily, wetness.	Erodes easily, percs slowly.
On Onawa	Severe: seepage.	Severe: piping.	Flooding, frost action, percs slowly.	Wetness, flooding, percs slowly.	Not needed	Not needed.
Pc Pawnee	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Percs slowly, erodes easily.	Erodes easily, percs slowly.	Erodes easily.
Pd Pawnee	Moderate: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Slow intake, percs slowly, erodes easily.	Erodes easily, percs slowly.	Erodes easily.
Pt*. Pits						
Re Reading	Moderate: seepage.	Slight	Deep to water	Favorable	Erodes easily	Erodes easily.
Sb Sharpsburg	Moderate: seepage.	Slight	Deep to water	Favorable	Erodes easily	Erodes easily.
Sc Sharpsburg	Moderate: seepage, slope.	Slight	Deep to water	Slope	Erodes easily	Erodes easily.
Sh Shelby	Moderate: slope.	Slight	Deep to water	Slope	Favorable	Favorable.
Sm Shelby	Severe: slope.	Slight	Deep to water	Slope	Slope	Slope.
Ss*:						
Shelby	Severe: slope.	Slight	Deep to water	Slope	Slope	Slope.
Steinauer	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope	Slope.
Vs Vinland	Severe: depth to rock, slope.	Severe: piping.	Deep to water	Depth to rock, slope.	Slope, depth to rock.	Slope, depth to rock.
Wa Wabash	Slight	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness, droughty.	Wetness, percs slowly.	Wetness, droughty, percs slowly.
Wb Wabash	Slight	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness, droughty, slow intake.	Wetness, percs slowly.	Wetness, droughty, percs slowly.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

[The symbol > 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	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
Aq*. Aquents											
Ar, As------------ Armster	0-7	Clay loam----------	CL	A-7	0	95-100	80-95	70-90	55-80	40-50	25-35
	7-60	Clay loam, clay	CL, CH	A-7	0	95-100	80-95	70-90	55-80	45-60	25-35
Ch---------------- Chase	0-11	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	90-100	35-45	15-25
	11-45	Silty clay, silty clay loam, clay.	CH, CL	A-7, A-6	0	100	100	95-100	90-100	35-65	20-45
	45-60	Silty clay loam, silty clay.	CH, CL	A-7, A-6	0	100	100	95-100	90-100	35-60	20-40
Go---------------- Gosport	0-8	Silty clay loam	ML, MH	A-7	0	100	100	95-100	85-100	41-55	11-20
	8-35	Silty clay loam, silty clay.	CH	A-7	0	100	100	95-100	85-100	50-65	35-50
	35	Weathered bedrock	---	---	---	---	---	---	---	---	---
Gr, Gu------------ Grundy	0-7	Silty clay loam	CH, CL	A-7	0	100	100	95-100	90-100	40-55	20-35
	7-14	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	95-100	90-100	45-55	25-35
	14-47	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	90-100	50-70	30-45
	47-60	Silty clay loam	CH, CL	A-7	0	100	100	90-100	90-100	40-55	25-35
Gx---------------- Grundy	0-6	Silty clay--------	CH, CL	A-7	0	100	100	95-100	90-100	45-55	25-35
	6-60	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	90-100	50-70	30-45
Hn---------------- Haynie	0-8	Silt loam---------	CL-ML, CL	A-4, A-6	0	100	100	85-100	70-100	25-40	5-15
	8-60	Silt loam, very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	85-100	25-35	5-15
Ho*:											
Haynie-----------	0-8	Very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	70-100	25-40	5-15
	8-60	Silt loam, very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	85-100	25-35	5-15
Onawa------------	0-8	Silty clay loam	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	8-27	Silty clay--------	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	27-60	Silt loam, very fine sandy loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	25-40	5-20
Hs*:											
Haynie-----------	0-7	Silt loam---------	CL-ML, CL	A-4, A-6	0	100	100	85-100	70-100	25-40	5-15
	7-60	Silt loam, very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	85-100	25-35	5-15
Sarpy------------	0-6	Loamy fine sand	SM	A-2-4	0	100	100	60-80	15-35	---	NP
	6-60	Fine sand, loamy fine sand, sand.	SM, SP, SP-SM	A-2-4, A-3	0	100	100	60-80	2-35	---	NP
Ju---------------- Judson	0-12	Silt loam---------	CL, CL-ML	A-6, A-7, A-4	0	100	100	100	95-100	25-50	5-25
	12-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
Ke, Kf------------ Kennebec	0-47	Silt loam---------	CL	A-6, A-7	0	100	100	95-100	90-100	25-45	10-20
	47-60	Silt loam, silty clay loam.	CL, CL-ML	A-6, A-4	0	100	100	95-100	90-100	25-40	5-15
Kg*:											
Kennebec---------	0-37	Silt loam---------	CL	A-6, A-7	0	100	100	95-100	90-100	25-45	10-20
	37-60	Silt loam, silty clay loam.	CL, CL-ML	A-6, A-4	0	100	100	95-100	90-100	25-40	5-15
Colo-------------	0-8	Silt loam---------	CL, CL-ML	A-4, A-6	0	100	100	95-100	95-100	25-40	5-15
	8-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
Kn----------------Knox	0-8	Silt loam--------	CL-ML, CL	A-4	0	100	100	95-100	90-100	20-30	5-10
	8-45	Silty clay loam, silt loam.	CL	A-6	0	100	100	95-100	95-100	30-40	10-20
	45-60	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	95-100	90-100	25-35	5-15
Kx----------------Knox	0-8	Silty clay loam	CL	A-6	0	100	100	95-100	95-100	30-35	11-15
	8-45	Silty clay loam, silt loam.	CL	A-6	0	100	100	95-100	95-100	30-40	10-20
	45-60	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	95-100	90-100	25-35	5-15
Ky*:											
Knox------------	0-8	Silt loam--------	CL-ML, CL	A-4	0	100	100	95-100	90-100	20-30	5-10
	8-45	Silty clay loam, silt loam.	CL	A-6	0	100	100	95-100	95-100	30-40	10-20
	45-60	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	95-100	90-100	25-35	5-15
Gosport---------	0-8	Silty clay loam	ML, MH	A-7	0	100	100	95-100	85-100	41-55	11-20
	8-35	Silty clay loam, silty clay.	CH	A-7	0	100	100	95-100	85-100	50-65	35-50
	35	Weathered bedrock	---	---	---	---	---	---	---	---	---
Mc----------------Martin	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	80-100	35-45	15-25
	13-49	Silty clay, clay	CH, CL	A-7	0	100	100	95-100	80-100	40-70	25-40
	49	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
On----------------Onawa	0-8	Silty clay loam	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	8-27	Silty clay--------	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	27-60	Silt loam, very fine sandy loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	25-40	5-20
Pc----------------Pawnee	0-8	Clay loam--------	CL	A-6	0	95-100	95-100	85-100	70-90	30-40	10-20
	8-34	Clay-------------	CH	A-7	0	95-100	95-100	85-100	70-85	50-70	25-45
	34-60	Clay loam, sandy clay loam.	CL, CH	A-7, A-6	0	95-100	95-100	80-100	70-90	35-55	20-40
Pd----------------Pawnee	0-5	Clay-------------	CH	A-7	0	95-100	95-100	85-100	70-85	50-70	25-45
	5-38	Clay-------------	CH	A-7	0	95-100	95-100	85-100	70-85	50-70	25-45
	38-60	Clay loam, sandy clay loam.	CL, CH	A-7, A-6	0	95-100	95-100	80-100	70-90	35-55	20-40
Pt*. Pits											
Re----------------Reading	0-13	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	90-100	85-100	25-40	5-20
	13-41	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	90-100	35-50	15-30
	41-60	Silty clay loam, clay loam, silty clay.	CL	A-6, A-7	0	100	100	95-100	80-100	35-50	15-30
Sb, Sc------------Sharpsburg	0-13	Silty clay loam	CL, CH	A-7, A-6	0	100	100	100	95-100	35-55	18-32
	13-54	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	100	95-100	40-60	20-35
	54-60	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	20-30
Sh, Sm------------Shelby	0-12	Clay loam--------	CL	A-6, A-7-6	0	90-95	85-95	75-90	55-70	35-45	15-25
	12-47	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
	47-60	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
Ss*:											
Shelby----------	0-6	Loam-------------	CL	A-6	0	95-100	85-95	75-90	55-70	30-40	10-20
	6-47	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
	47-60	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
Steinauer-------	0-6	Loam-------------	CL-ML, CL	A-4, A-6, A-7	0-5	95-100	95-100	85-95	60-70	25-45	4-20
	6-60	Loam, clay loam	CL	A-6, A-7	0-5	95-100	95-100	90-100	60-75	20-45	10-26

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Vs---------------- Vinland	0-12	Silty clay loam	ML, CL	A-6, A-7	0-5	80-100	75-100	70-100	65-95	30-50	10-25
	12-19	Silty clay loam, shaly silty clay loam, loam.	ML, SM, CL-ML, SM-SC	A-4, A-6, A-7	0	90-100	70-100	50-100	35-95	25-50	5-20
	19	Weathered bedrock	---	---	---	---	---	---	---	---	---
Wa---------------- Wabash	0-22	Silty clay loam	CL, CH	A-6, A-7	0	100	100	100	95-100	30-55	12-35
	22-60	Silty clay, clay	CH	A-7	0	100	100	100	95-100	52-78	30-55
Wb---------------- Wabash	0-8	Silty clay--------	CH	A-7	0	100	100	100	95-100	50-75	30-50
	8-60	Silty clay, clay	CH	A-7	0	100	100	100	95-100	52-78	30-55

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--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/cm3	In/hr	In/in	pH					Pct
Aq*. Aquents											
Ar, As----------- Armster	0-7	27-40	1.35-1.45	0.2-0.6	0.10-0.18	4.5-7.3	Moderate-----	0.37	5	6	.5-1
	7-60	35-48	1.35-1.45	0.2-0.6	0.10-0.18	4.5-7.3	High---------	0.37			
Ch--------------- Chase	0-11	27-35	1.30-1.45	0.2-0.6	0.21-0.23	5.6-7.3	Moderate-----	0.37	5	7	2-4
	11-45	35-55	1.35-1.45	0.06-0.2	0.11-0.19	5.6-7.8	High---------	0.28			
	45-60	27-50	1.35-1.45	0.06-0.2	0.11-0.18	6.1-8.4	High---------	0.28			
Go--------------- Gosport	0-8	27-34	1.30-1.40	0.2-0.6	0.14-0.16	5.1-7.3	Moderate-----	0.43	4	6	.5-1
	8-35	36-60	1.50-1.60	<0.06	0.12-0.14	3.6-5.5	High---------	0.32			
	35	---	---	---	---	---	-------------	----			
Gr, Gu----------- Grundy	0-7	28-35	1.35-1.45	0.2-0.6	0.18-0.20	5.6-7.3	High---------	0.37	4	6	2-4
	7-14	32-45	1.35-1.45	0.2-0.6	0.18-0.20	5.6-6.5	High---------	0.37			
	14-47	40-50	1.30-1.40	0.06-0.2	0.11-0.13	5.1-7.3	High---------	0.37			
	47-60	28-35	1.35-1.40	0.06-0.2	0.18-0.20	5.6-7.3	High---------	0.37			
Gx--------------- Grundy	0-6	40-45	1.35-1.50	0.2-0.6	0.18-0.20	5.6-7.3	High---------	0.37	4	4	.5-2
	6-60	40-50	1.30-1.40	0.06-0.2	0.11-0.13	5.1-7.3	High---------	0.37			
Hn--------------- Haynie	0-8	15-25	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37	5	4L	1-3
	8-60	15-18	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37			
Ho*:											
Haynie----------	0-8	15-25	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37	5	4L	1-3
	8-60	15-18	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37			
Onawa-----------	0-27	38-55	1.30-1.35	0.2-0.6	0.12-0.14	7.4-8.4	High---------	0.32	5	4	1-3
	27-60	12-18	1.40-1.50	0.6-6.0	0.20-0.22	7.4-8.4	Low----------	0.43			
Hs*:											
Haynie----------	0-8	15-25	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37	5	4L	1-3
	8-60	15-18	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37			
Sarpy-----------	0-6	2-5	1.20-1.50	>6.0	0.05-0.09	6.6-8.4	Low----------	0.15	5	2	<1
	6-60	2-5	1.20-1.50	>6.0	0.05-0.09	6.6-8.4	Low----------	0.15			
Ju--------------- Judson	0-12	25-32	1.30-1.35	0.6-2.0	0.21-0.23	6.1-7.3	Moderate-----	0.28	5	7	3-5
	12-60	30-35	1.35-1.45	0.6-2.0	0.21-0.23	6.1-7.3	Moderate-----	0.43			
Ke, Kf----------- Kennebec	0-47	22-30	1.25-1.35	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.32	5	6	3-6
	47-60	24-28	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.43			
Kg*:											
Kennebec--------	0-37	22-30	1.25-1.35	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.32	5	6	5-6
	37-60	24-28	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.43			
Colo------------	0-8	20-26	1.25-1.30	0.6-2.0	0.22-0.24	6.6-7.3	Moderate-----	0.28	5	6	3-5
	8-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.28			
Kn--------------- Knox	0-8	18-27	1.20-1.30	0.6-2.0	0.22-0.24	5.6-7.3	Low----------	0.32	5	6	.5-3
	8-45	25-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.43			
	45-60	18-27	1.20-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.43			
Kx--------------- Knox	0-8	27-30	1.20-1.30	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.32	5	6	.5-3
	8-45	25-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.43			
	45-60	18-27	1.20-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.43			

See footnote at end of table.

TABLE 15.--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/cm^3	In/hr	In/in	pH					Pct
Ky*:											
Knox	0-8	18-27	1.20-1.30	0.6-2.0	0.22-0.24	5.6-7.3	Low	0.32	5	6	1-3
	8-45	25-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.3	Moderate	0.43			
	45-60	18-27	1.20-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.43			
Gosport	0-8	27-34	1.30-1.40	0.2-0.6	0.14-0.16	5.1-7.3	Moderate	0.43	2	4	1-2
	8-35	36-60	1.50-1.60	<0.06	0.12-0.14	3.6-5.5	High	0.32			
	35	---	---	---	---	---	-------------	----			
Mc: Martin	0-13	27-40	1.35-1.40	0.2-0.6	0.21-0.23	5.6-6.5	Moderate	0.37	4	7	2-4
	13-49	40-55	1.40-1.50	0.06-0.2	0.12-0.18	5.6-7.8	High	0.37			
	49	---	---	---	---	---	-------------	----			
On: Onawa	0-27	38-55	1.30-1.35	0.2-0.6	0.12-0.14	7.4-8.4	High	0.32	5	4	1-3
	27-60	12-18	1.40-1.50	0.6-6.0	0.20-0.22	7.4-8.4	Low	0.43			
Pc: Pawnee	0-8	30-38	1.40-1.50	0.2-0.6	0.17-0.19	5.6-7.3	Moderate	0.37	4	6	3-4
	8-34	40-50	1.50-1.70	0.06-0.2	0.09-0.11	6.1-8.4	High	0.37			
	34-60	25-35	1.40-1.50	0.06-0.2	0.14-0.16	6.1-8.4	High	0.37			
Pd: Pawnee	0-5	40-46	1.40-1.50	0.06-0.2	0.09-0.11	5.6-7.3	High	0.37	3	4	1-2
	5-38	40-50	1.50-1.70	0.06-0.2	0.09-0.11	6.1-8.4	High	0.37			
	38-60	25-35	1.40-1.50	0.06-0.2	0.14-0.16	7.4-8.4	High	0.37			
Pt*. Pits											
Re: Reading	0-13	18-27	1.35-1.40	0.6-2.0	0.22-0.24	5.6-7.3	Low	0.32	5	6	2-4
	13-41	27-35	1.40-1.50	0.2-2.0	0.18-0.20	5.6-7.3	Moderate	0.43			
	41-60	30-42	1.40-1.50	0.2-2.0	0.13-0.20	6.1-8.4	Moderate	0.43			
Sb, Sc: Sharpsburg	0-13	25-27	1.30-1.35	0.6-2.0	0.21-0.23	5.1-6.5	Moderate	0.32	5	7	3-4
	13-54	36-42	1.35-1.40	0.2-0.6	0.18-0.20	5.1-6.0	Moderate	0.43			
	54-60	28-32	1.40-1.45	0.6-2.0	0.18-0.20	6.1-6.5	Moderate	0.43			
Sh, Sm: Shelby	0-12	27-35	1.50-1.55	0.2-0.6	0.16-0.18	5.6-7.3	Moderate	0.28	4	6	1-3
	12-47	30-35	1.55-1.75	0.2-0.6	0.16-0.18	5.6-7.8	Moderate	0.28			
	47-60	30-35	1.75-1.85	0.2-0.6	0.16-0.18	6.6-8.4	Moderate	0.37			
Ss*:											
Shelby	0-6	24-27	1.50-1.55	0.6-2.0	0.20-0.22	5.6-7.3	Moderate	0.28	5	6	3-4
	6-47	30-35	1.55-1.75	0.2-0.6	0.16-0.18	5.6-7.8	Moderate	0.28			
	47-60	30-35	1.75-1.85	0.2-0.6	0.16-0.18	6.6-8.4	Moderate	0.37			
Steinauer	0-6	16-24	1.40-1.60	0.6-2.0	0.20-0.22	7.4-8.4	Low	0.32	5	4L	.5-2
	6-60	16-30	1.30-1.60	0.2-2.0	0.14-0.19	7.9-8.4	Moderate	0.32			
Vs: Vinland	0-12	15-35	1.20-1.40	0.6-2.0	0.21-0.24	5.6-7.8	Moderate	0.32	2	7	2-4
	12-19	15-35	1.30-1.70	0.6-2.0	0.15-0.22	5.6-7.8	Moderate	0.32			
	19	---	---	---	---	---	-------------	----			
Wa: Wabash	0-22	20-35	1.35-1.50	0.06-0.2	0.21-0.24	5.6-7.3	High	0.37	5	7	2-4
	22-60	40-60	1.20-1.45	<0.06	0.08-0.12	5.6-7.8	Very high	0.28			
Wb: Wabash	0-8	40-46	1.25-1.45	<0.06	0.12-0.14	5.6-7.3	Very high	0.28	5	4	2-4
	8-60	40-60	1.20-1.45	<0.06	0.08-0.12	5.6-7.8	Very high	0.28			

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--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 more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
Aq*. Aquents												
Ar, As------------- Armster	C	None---------	---	---	3.0-5.0	Perched	Nov-Mar	>60	---	Moderate	High------	Moderate.
Ch----------------- Chase	C	Rare---------	---	---	2.0-4.0	Perched	Feb-May	>60	---	High------	High------	Low.
Go----------------- Gosport	C	None---------	---	---	>6.0	---	---	20-40	Soft	Moderate	High------	High.
Gr, Gu, Gx--------- Grundy	C	None---------	---	---	1.0-3.0	Perched	Mar-May	>60	---	High------	High------	Moderate.
Hn----------------- Haynie	B	Occasional	Very brief	Feb-Nov	4.0-6.0	Perched	Mar-May	>60	---	High------	Low-------	Low.
Ho*:												
Haynie------------	B	Occasional	Very brief	Feb-Nov	4.0-6.0	Perched	Mar-May	>60	---	High------	Low-------	Low.
Onawa-------------	D	Occasional	Brief------	Feb-Nov	2.0-4.0	Apparent	Nov-Jul	>60	---	High------	High------	Low.
Hs*:												
Haynie------------	B	Occasional	Very brief	Feb-Nov	4.0-6.0	Perched	Mar-May	>60	---	High------	Low-------	Low.
Sarpy-------------	A	Occasional	Brief to long.	Nov-Jun	>6.0	---	---	>60	---	Low-------	Low-------	Low.
Ju----------------- Judson	B	None---------	---	---	>6.0	---	---	>60	---	High------	Moderate	Low.
Ke----------------- Kennebec	B	Occasional	Brief------	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	High------	Moderate	Low.
Kf----------------- Kennebec	B	Frequent----	Brief------	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	High------	Moderate	Low.
Kg*:												
Kennebec----------	B	Occasional	Brief------	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	High------	Moderate	Low.
Colo--------------	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High------	High------	Moderate.
Kn, Kx------------- Knox	B	None---------	---	---	>6.0	---	---	>60	---	High------	Low-------	Low.
Ky*:												
Knox--------------	B	None---------	---	---	>6.0	---	---	>60	---	High------	Low-------	Low.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
Ky*:												
Gosport----------	C	None--------	---	---	>6.0	---	---	20-40	Soft	Moderate	High-----	High.
Mc---------------- Martin	C	None--------	---	---	2.0-3.0	Perched	Dec-Apr	40-60	Soft	High-----	High-----	Low.
On---------------- Onawa	D	Occasional	Brief-----	Feb-Nov	2.0-4.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
Pc, Pd------------ Pawnee	D	None--------	---	---	1.0-3.0	Perched	Mar-May	>60	---	High-----	High-----	Low.
Pt*. Pits												
Re---------------- Reading	C	Rare--------	---	---	3.5-6.0	Perched	Dec-Apr	>60	---	High-----	Moderate	Low.
Sb, Sc------------ Sharpsburg	B	None--------	---	---	>6.0	---	---	>60	---	High-----	Moderate	Moderate.
Sh, Sm------------ Shelby	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
Ss*:												
Shelby-----------	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
Steinauer--------	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	High-----	Low.
Vs---------------- Vinland	D	None--------	---	---	>6.0	---	---	10-20	Soft	Moderate	Moderate	Low.
Wa, Wb------------ Wabash	D	Occasional	Brief to long.	Nov-May	0-1.0	Apparent	Nov-May	>60	---	Moderate	High-----	Moderate.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Aquents	Loamy, mixed (calcareous), mesic Fluvaquents
Armster	Fine, montmorillonitic, mesic Mollic Hapludalfs
Chase	Fine, montmorillonitic, mesic Aquic Argiudolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Gosport	Fine, illitic, mesic Typic Dystrochrepts
Grundy	Fine, montmorillonitic, mesic Aquic Argiudolls
Haynie	Coarse-silty, mixed (calcareous), mesic Mollic Udifluvents
Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Knox	Fine-silty, mixed, mesic Mollic Hapludalfs
Martin	Fine, montmorillonitic, mesic Aquic Argiudolls
Onawa	Clayey over loamy, montmorillonitic (calcareous), mesic Mollic Fluvaquents
Pawnee	Fine, montmorillonitic, mesic Aquic Argiudolls
Reading	Fine-silty, mixed, mesic Typic Argiudolls
Sarpy	Mixed, mesic Typic Udipsamments
Sharpsburg	Fine, montmorillonitic, mesic Typic Argiudolls
Shelby	Fine-loamy, mixed, mesic Typic Argiudolls
Steinauer	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Vinland	Loamy, mixed, mesic, shallow Typic Hapludolls
Wabash	Fine, montmorillonitic, mesic Vertic Haplaquolls

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983 O - 407-061 QL 3

NRCS Accessibility Statement