United States
Department of
Agriculture

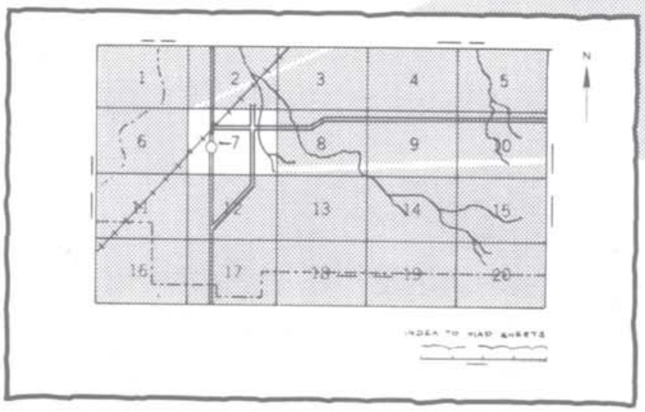
Soil
Conservation
Service

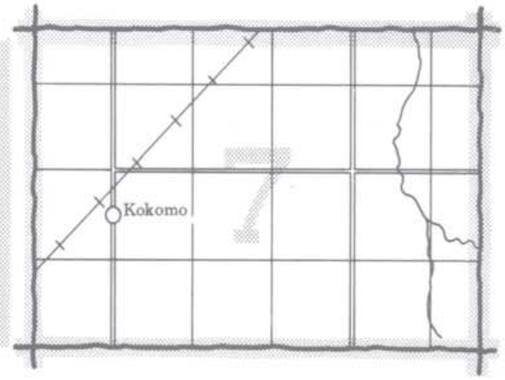
In Cooperation with
Minnesota
Agricultural
Experiment Station

Soil Survey of Pennington County Minnesota

HOW TO USE

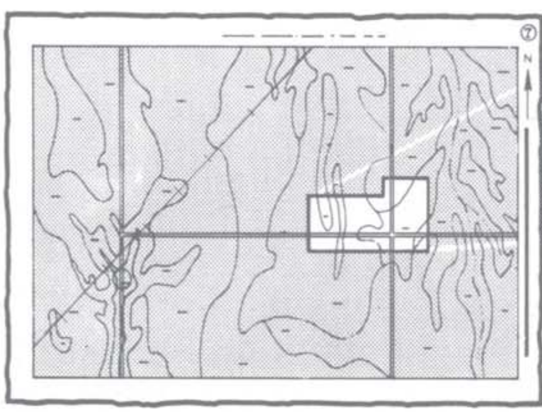
1. Locate your area of interest on the "Index to Map Sheets" (the last page of this publication).

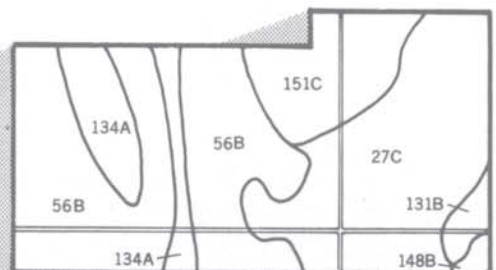




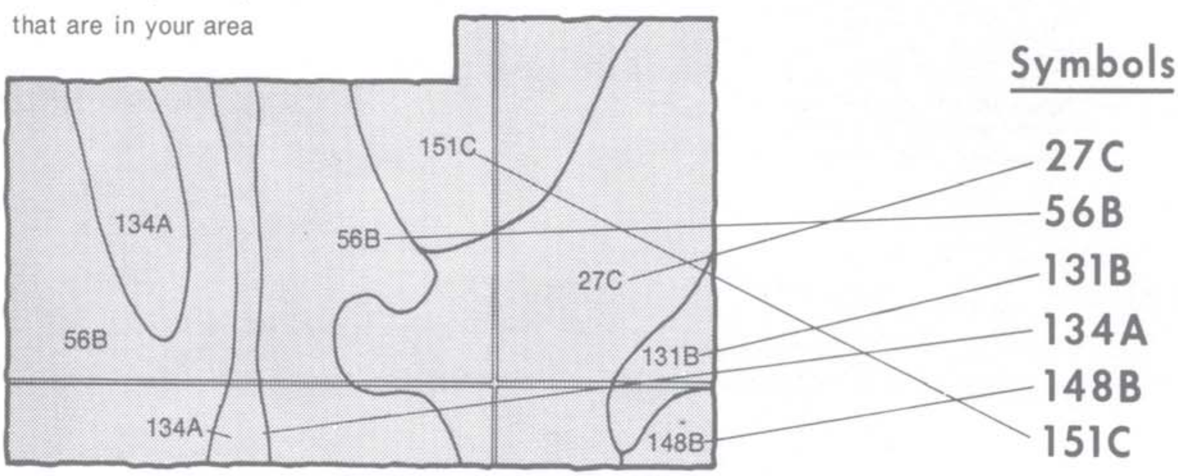
2. Note the number of the map sheet and turn to that sheet.

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



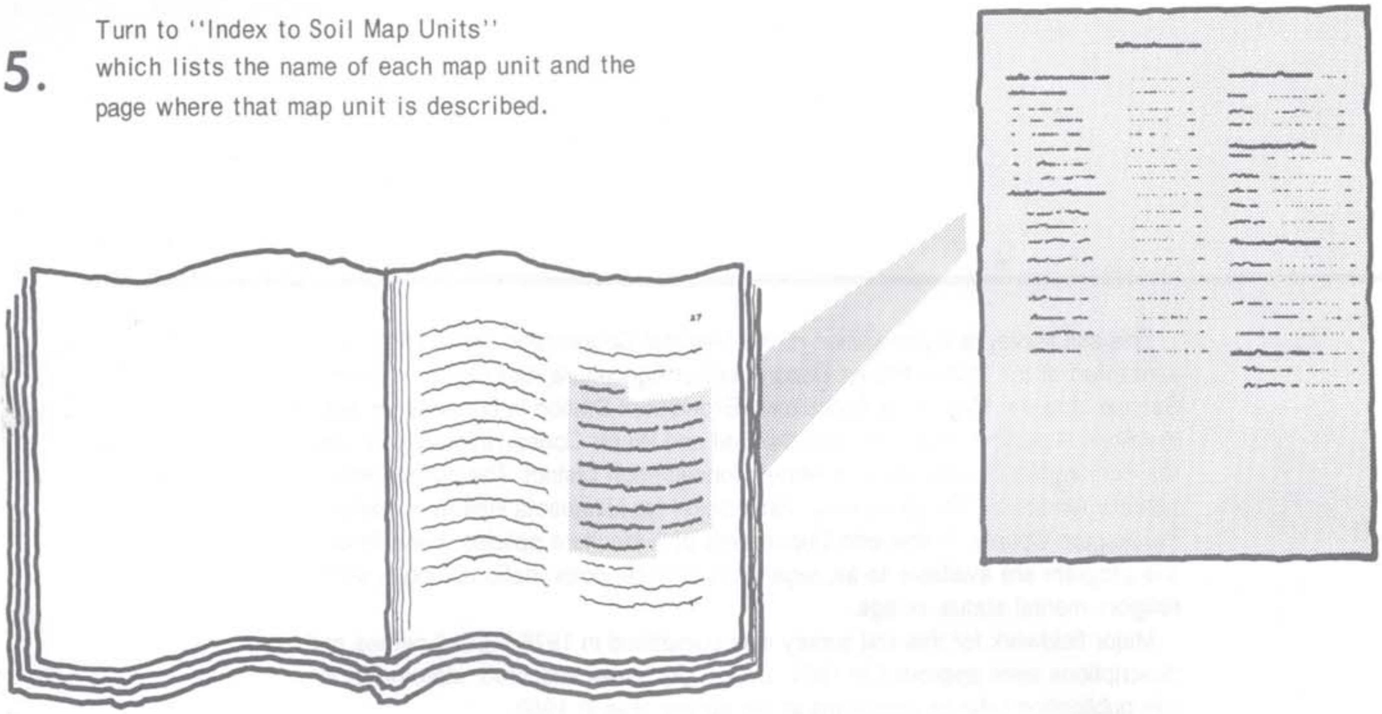


4. List the map unit symbols that are in your area

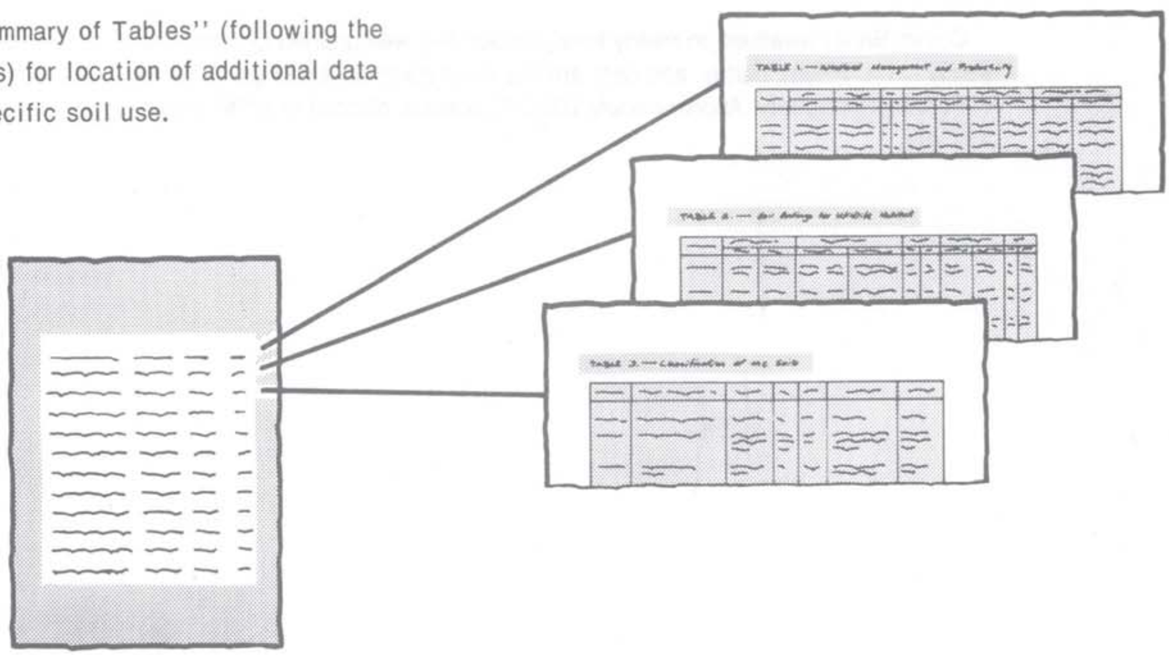


THIS SOIL SURVEY

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, Soil Conservation Service, and the Minnesota Agricultural Experiment Station in cooperation with the Agricultural Extension Service, the Soil and Water Conservation Board, and the Pennington County Soil and Water Conservation District. The survey was partially funded by the Legislative Commission for Minnesota Resources and Pennington County. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in 1975-80. Soil names and descriptions were approved in 1981. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1980.

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: Barley swathes on nearly level, moderately well drained Linveldt fine sandy loam. Wheat, barley, and oats are the most common small grains grown in Pennington County. Approximately 200,000 acres is planted to small grains annually.

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 Pennington County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

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

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. 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.

Donald G. Ferren
State Conservationist
Soil Conservation Service

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Soil Survey of
Pennington County, Minnesota

By R. B. Heschke, Soil Conservation Service

Soils surveyed by W. J. Aas, R. W. Diers, R. B. Heschke, and
J. U. Schulzetenberg, Soil Conservation Service, and
M. D. Oja, Minnesota Agricultural Experiment Station

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

PENNINGTON COUNTY is in the northwestern part of Minnesota (fig. 1). Thief River Falls is the county seat. The total area of the county is 398,080 acres. Farming is the principal business enterprise. Small grains, sunflowers, and hay are the main crops. Small acreages of corn, flax, and specialty crops are also grown. Dairy and beef cattle operations are the main livestock enterprises.

The soils in Pennington County formed on a glacial lake plain in mineral and organic material (*3*). The soils are mainly dark and range from sand to clay. The native vegetation of Pennington County was mainly tall prairie grasses, wetland reeds, and sedges. Hardwood trees encroached into the county from the east, however, and the soils in the eastern half of the county show the influence of forest vegetation.

The first soil survey of Pennington County was published in 1916 (*4*). This survey updates the first survey and provides additional information and larger maps that show more detail.

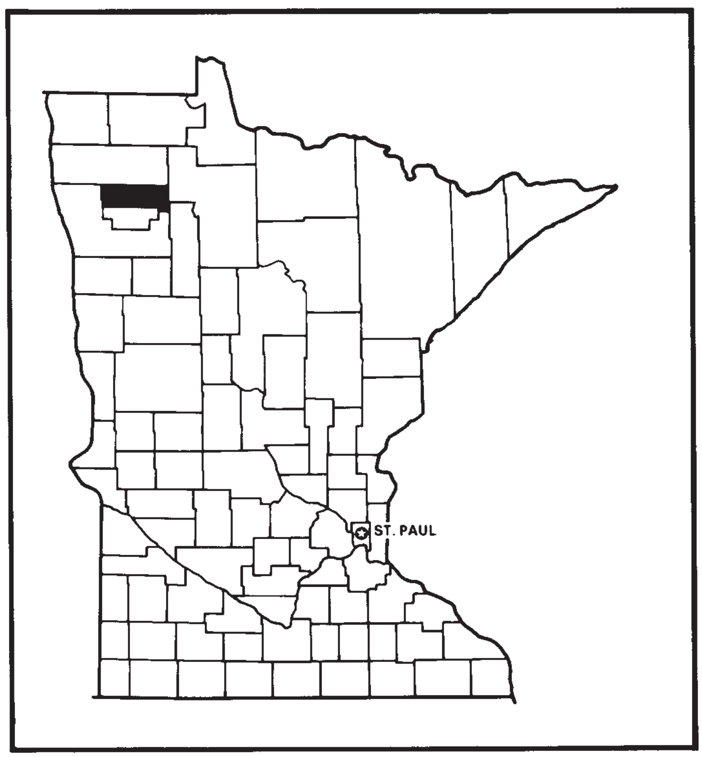

Figure 1.—Location of Pennington County in Minnesota.

General Nature of the Survey Area

This section gives general information concerning Pennington County. It describes the physiography, relief, and drainage; climate; history and development; transportation and markets; and farming.

Physiography, Relief, and Drainage

All of Pennington County has been influenced by the waters of Glacial Lake Agassiz. As the water level of this lake receded, a succession of beach ridges formed, mostly notably in the western third of the county. A number of small basins also formed. Lacustrine sands, silts, and clays were deposited in these basins. Changing eddies and currents caused the formation of sandbars, which occur throughout the county. Calcareous loam and clay loam glacial till underlies these deposits.

The highest elevation in Pennington County is 1,186 feet above sea level. It is in Reiner Township in the northeastern part of the county. The lowest elevation is 974 feet. It is in Bray Township along the western edge of the county. Elevation throughout the county is about 212 feet.

Pennington County is mainly drained by the Red Lake River, which flows into the Red River of the North. The Clearwater, Thief, and Black Rivers are tributaries of the Red Lake River and drain most of the county. Natural draws and creeks together with a system of legal ditches and agricultural drainage systems remove excess water from farming and residential areas.

Climate

Pennington County is usually quite warm in summer with frequent spells of hot weather and occasional cool days. It is very cold in winter, when arctic air frequently surges over the area. Most precipitation falls during the warm period and is normally heaviest late in spring and early in summer. Snowfall in winter is normally not very heavy, and because it is blown into drifts, the ground is mostly free of snow.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Thief River Falls, Minnesota, for the period 1951 to 1972. 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 6 degrees F, and the average daily minimum temperature is -4 degrees. The lowest temperature on record, which occurred at Thief River Falls on January 18, 1970, is -44 degrees. In summer the average temperature is 66 degrees, and the average daily maximum temperature is 78 degrees. The highest recorded temperature, which occurred on May 21, 1964, is 100 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (40 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

Of the total annual precipitation, 18 inches, or 75 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 14 inches. The heaviest 1-day rainfall during the period of record was 3.6 inches at Thief River Falls on July 12, 1965. Thunderstorms occur on about 35 days each year, and most occur in summer.

The average seasonal snowfall is 45 inches. The greatest snow depth at any one time during the period of record was 41 inches. On an average of 54 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in summer and 50 percent in winter. The prevailing wind is from the north. Average windspeed is highest, 14 miles per hour, in spring.

Several times each winter, storms with snow and high wind bring blizzard conditions to the area. Hail during summer thunderstorms occurs in small, scattered areas.

Climatic data for this section were especially prepared for the Soil Conservation Service by the National Climatic Center, Asheville, North Carolina.

History and Development

Pennington County was established in November, 1910, when voters elected to separate from Red Lake County. The county was named after and in honor of Edmund Pennington, president of the Soo Line Railways.

The village of St. Hilaire was platted in 1882. Thief River Falls was platted in 1887 and was organized as a city in 1896. In 1904, the Red Lake Indian Reservation in the eastern part of the county was opened for settlement.

The population of Pennington County in 1940 was 12,900. In 1965, the population was 11,900, and in 1980, the population was 15,258.

Transportation and Markets

In the first half of the nineteenth century, transportation in this area was by way of the Pembina Trail. Oxcarts traveled along the McCauleyville Ridge in the western part of Pennington County.

Today the Soo Line Railroad and the Burlington Northern Railroad cross the county from south to north. Republic Airlines has flights between Thief River Falls (fig. 2) and Minneapolis-St. Paul.

A network of all weather roads services the county. Trunk Highways 32 and 59 cross the county from south to north, and Trunk Highway 1 crosses the county from east to west. These highways together with a number of paved or blacktopped county and state-aid roads and highways connect a large number of gravel surfaced roads and furnish farmers with access to markets and trade centers.

Grain is shipped by truck to elevators in Thief River Falls, St. Hilaire, and Hazel. Grain shipments to Duluth or Minneapolis-St. Paul are by railroad or truck. Large quantities of grain are stored on the farm, and this type of storage is increasing.

Figure 2.—Thief River Falls, county seat of Pennington County. The Red Lake River flows through the town.

Beef and feeder cattle are shipped by truck to markets in West Fargo and South St. Paul. Dairy products are marketed locally or in adjacent counties.

Farming

Wheat, oats, and barley are the dominant small grain cash crops grown in Pennington County. Winter rye is grown on the well drained, gravel and sand beach ridges. Small acreages of flax and buckwheat are also grown in the county.

Sunflowers have become an important cash crop. Both oilseed and confectionary types are grown. The acreage of this crop is increasing, and many of the crops are raised under contract.

Some livestock-oriented operations are scattered throughout the county. These farming operations are fewer than grain raising operations.

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 resulting in gradual changes in characteristics. 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. Therefore, 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 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 and 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 to precisely define and locate the soil is needed to plan for intensive uses in small areas.

General Soil Map Units

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

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

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

Descriptions of the general soil map units follow.

Areas Dominated by Nearly Level Soils that Formed in Glacial Till

These are poorly drained to moderately well drained, nearly level soils that formed mostly in loamy glacial till on glacial lake plains. They formed under prairie and deciduous hardwood savanna vegetation.

Two of the soil associations of Pennington County are in this group.

1. Roliss-Vallers Association

Poorly drained, medium textured soils

This association is on glacial lake plains (fig. 3). These soils formed under prairie vegetation. Slopes range from 0 to 2 percent.

This association makes up about 10 percent of Pennington County. It is about 35 percent Roliss soils and 20 percent Vallers soils. The rest consists of soils of minor extent.

The poorly drained Roliss soils are in slightly concave positions on glacial lake plains. Typically, the surface layer is black loam about 7 inches thick. The subsoil is dark gray, mottled, calcareous loam about 6 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled clay loam in the upper part and olive gray, mottled, calcareous loam and silt loam in the lower part.

The poorly drained Vallers soils are on nearly level or slightly concave positions on glacial lake plains. Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark gray loam about 4 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, mottled, highly calcareous clay loam in the upper part and light brownish gray, mottled, calcareous loam in the lower part.

Of minor extent in this association are the Grimstad, Hamerly, Hamre, Kittson, Mavie, and Rockwell soils. The moderately well drained Grimstad, Hamerly, and Kittson soils are on slightly convex rises. The very poorly drained Hamre soils have a thin organic surface layer. The poorly drained Rockwell and Mavie soils have a 20- to 40-inch sandy mantle over calcareous, loam glacial till.

About 90 percent of the soils in this association has been or is being cleared for farming. Most of the acreage is farmed to small grains, sunflowers, and hay. Small woodlots of bur oak and aspen are scattered throughout this association. Most of the soils have a network of surface ditches to improve the drainage of the soils.

These soils are well suited to cultivated crops, hayland, and pasture. Wetness is the main limitation for farming. Soil blowing is a hazard in unprotected areas. Vallers soils have a high lime zone near the surface that restricts the availability of potassium and phosphorus to some crops.

The soils of this association are poorly suited to building site development and to sanitary facilities because of the seasonal high water table.

2. Smiley-Reiner Association

Poorly drained and moderately well drained, moderately fine textured and moderately coarse textured, noncalcareous soils

This association is on glacial lake plains (fig. 4). These soils formed under hardwood savanna vegetation. Slopes range from 0 to 3 percent.

This association makes up about 48 percent of Pennington County. It is about 50 percent Smiley soils and 20 percent Reiner soils. The rest consists of soils of minor extent.

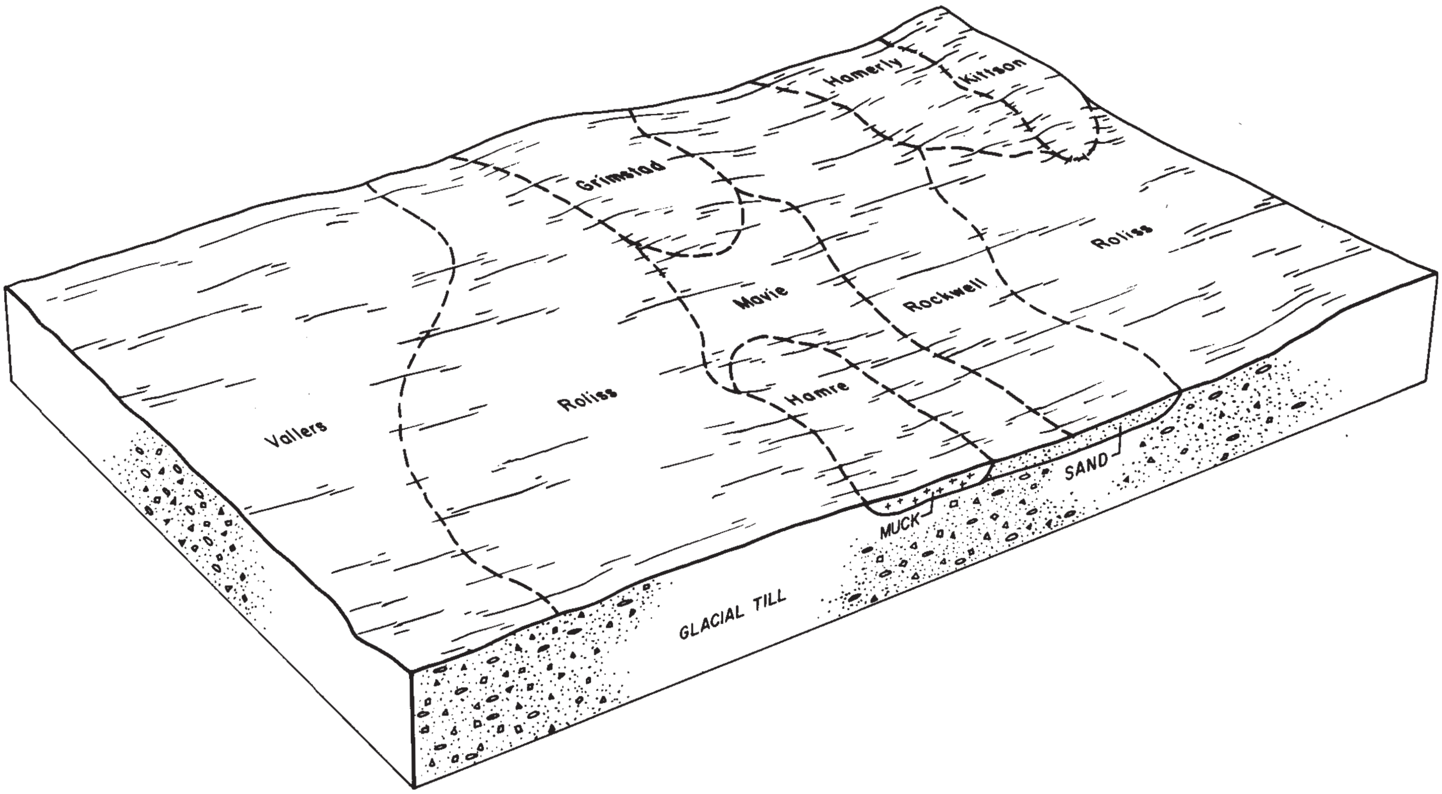

Figure 3.—Relationship of soils, underlying material, and landforms in the Roliss-Vallers association.

The poorly drained Smiley soils are on plane or slightly concave positions on glacial lake plains. Typically, the surface layer is black sandy clay loam about 12 inches thick. The subsoil is olive gray, mottled clay loam about 7 inches thick. The underlying material to a depth of about 60 inches is olive gray, mottled, calcareous loam and clay loam.

The moderately well drained Reiner soils are on slightly convex rises on glacial lake plains. Typically, the surface layer is black fine sandy loam about 7 inches thick. The next layer is olive brown loam and grayish brown silt loam about 2 inches thick. The subsoil is olive brown clay loam about 8 inches thick. The underlying material to a depth of about 60 inches is brown, grayish brown, and light olive brown, mottled, calcareous loam.

Of minor extent in this association are the very poorly drained Hamre soils in enclosed bog depressions or narrow drainageways, the poorly drained Kratka soils on flats of slightly concave positions, and the moderately well drained Linveldt soils on convex rises.

About 90 percent of the acreage in this association has been cleared or is being cleared for farming. Most of the acreage is farmed to small grains, sunflowers, and hay. Small woodlots of bur oak and aspen are scattered throughout the association. Most of the soils have a network of surface ditches to improve the drainage of the soils.

These soils are well suited to cultivated crops, hayland, and pasture. Wetness is the main limitation for farming. Soil blowing is a hazard in unprotected areas.

The soils of this association are fairly suited to poorly suited to building site development. The seasonal high water table is the main limitation, especially in the poorly drained soils. The standard septic tank absorption field does not function properly in most soils of this association because of the seasonal high water table.

Areas Dominated by Nearly Level Soils that Formed in Lacustrine Sediment and Water Modified Glacial Till

These are poorly drained to moderately well drained, nearly level soils that formed mostly in a 20- to 40-inch, moderately coarse textured mantle overlying loamy glacial till. They formed under prairie and deciduous hardwood savanna vegetation.

Two of the soil associations of Pennington County are in this group.

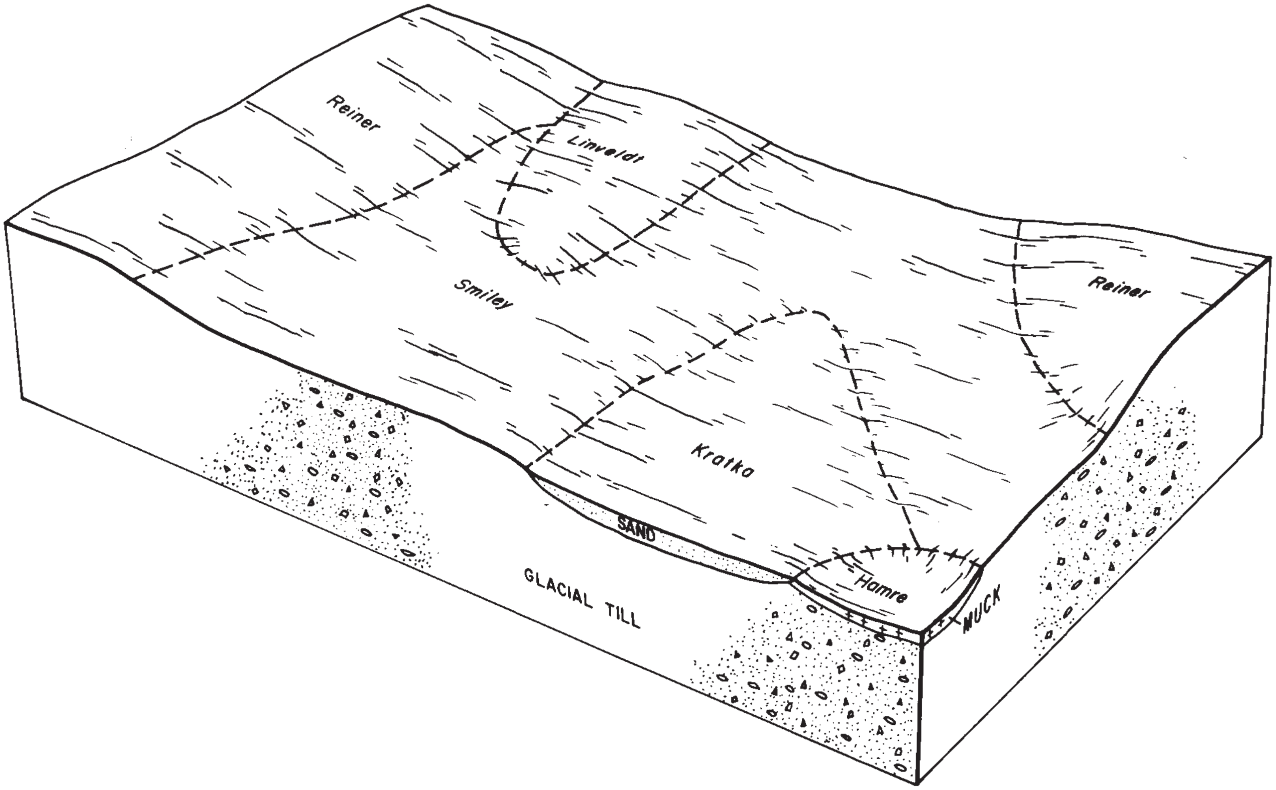

Figure 4.—Relationship of soils, underlying material, and landforms in the Smiley-Reiner association.

3. Grimstad-Rockwell-Foldahl Association

Moderately well drained and poorly drained, moderately coarse textured, dominantly calcareous soils

This association is on glacial lake plains. These soils formed under prairie vegetation. Slopes range from 0 to 2 percent.

This association makes up about 2 percent of the county. It is about 30 percent Grimstad soils, 25 percent Rockwell soils, and 20 percent Foldahl soils. The rest consists of soils of minor extent.

The moderately well drained Grimstad soils are on nearly level, slightly convex rises on glacial lake plains. Typically, the surface layer is black, highly calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown and grayish brown, highly calcareous loamy fine sand in the upper part, grayish brown and light olive brown, mottled, calcareous fine sand in the middle part, and grayish brown, mottled, calcareous loam in the lower part.

The poorly drained Rockwell soils are in nearly level, concave or plane positions on glacial lake plains. Typically, the surface layer is black, calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark gray and dark grayish brown, mottled, highly calcareous fine sandy loam and fine sand in the upper part, grayish brown and light brownish gray, mottled, calcareous fine sand and sand in the middle part, and light brownish gray, mottled, calcareous loam in the lower part.

The moderately well drained Foldahl soils are on nearly level, slightly convex rises on glacial lake plains. Typically, the surface layer is black fine sandy loam about 9 inches thick. The subsoil is about 15 inches thick. It is very dark grayish brown fine sand in the upper part and yellowish brown, mottled fine sand in the lower part. The underlying material to a depth of about 60 inches is light brownish gray and grayish brown, mottled, calcareous loam.

Of minor extent in this association are the Flaming, Kratka, and Rosewood soils. The moderately well drained Flaming soils are sandy throughout and are in positions on the landscape similar to those of Grimstad and Foldahl soils. The poorly drained Kratka soils have a 20- to 40-inch sandy mantle over loamy till and do not have a strongly calcareous upper layer. The poorly drained Rosewood soils are calcareous sand throughout. Kratka and Rosewood soils are in positions on the landscape similar to those of the Rockwell soils.

Most areas of this association are farmed to small grains, sunflowers, and hay, or they are used for pasture. Small woodlots of mixed bur oak and aspen are scattered throughout the association. Most of the acreage has a network of surface ditches to improve the drainage of the soils.

These soils are well suited to cultivated crops, hayland, and pasture. The sandy layers in the upper part of the profile cause these soils to be droughty during extended dry periods. Soil blowing is a hazard in unprotected areas. The Grimstad and Rockwell soils have a high lime zone near the surface that restricts the availability of potassium and phosphorus for plant growth.

The soils of this association are poorly suited to building site development. The seasonal high water table is the main limitation, especially in the poorly drained soils. The standard septic tank absorption field does not function properly in most soils of this association because of the seasonal high water table.

4. Kratka-Linveldt Association

Poorly drained and moderately well drained, moderately coarse textured, noncalcareous soils

This association is on lake plains. These soils formed under hardwood savanna vegetation. Slopes range from 0 to 3 percent.

This association makes up about 12 percent of Pennington County. It is about 45 percent Kratka soils and 15 percent Linveldt soils. The rest consists of soils of minor extent.

The poorly drained Kratka soils are on nearly level or slightly concave positions on glacial lake plains. Typically, the surface layer is black fine sandy loam about 11 inches thick. The subsoil is dark grayish brown, mottled loamy fine sand about 7 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled sand in the upper part and olive gray, mottled, calcareous loam in the lower part.

The moderately well drained Linveldt soils are on slightly convex rises on glacial lake plains. Typically, the surface layer is black fine sandy loam about 10 inches thick. The subsoil is about 9 inches thick. The upper part is dark brown sandy loam, and the lower part is dark brown and brown loam. The underlying material to a depth of about 60 inches is yellowish brown and light olive brown, mottled sand in the upper part and dark grayish brown, mottled, calcareous loam in the lower part.

Of minor extent in this association are the Smiley, Eckvoll, Reiner, and Hamre soils. The poorly drained Smiley soils are on nearly level or slightly concave positions and formed in loamy glacial till. The moderately well drained Eckvoll soils are on slight rises and formed in a mantle of sandy sediment underlain by loamy glacial till. The moderately well drained Reiner soils are on slightly convex rises and formed in loamy glacial till. The very poorly drained Hamre soils are in enclosed bog depressions or narrow drainageways and formed in organic sediment that overlies the loamy glacial till.

About 90 percent of the soils in this association has been cleared or is in the process of being cleared for farming. Most of the acreage is farmed to small grains, sunflowers, and hay. Small woodlots of bur oak and aspen are scattered throughout this association. Most of the soils have a network of surface ditches to improve the drainage of the soils.

These soils are well suited to cultivated crops, hayland, and pasture. Wetness is the main limitation for farming. The Kratka and Linveldt soils may be droughty for shallow-rooted plants during dry periods. Soil blowing is a hazard in unprotected areas.

The soils of this association are poorly suited to fairly suited to building site development. The seasonal high water table is the main limitation, especially in the poorly drained soils. The standard septic tank absorption field does not function properly in most of the soils because of the seasonal high water table.

Areas Dominated by Nearly Level and Gently Sloping Soils that Formed in Lacustrine Sediment

These are poorly drained to well drained, nearly level to gently sloping soils that formed mostly in coarse textured to fine textured, lacustrine sediment on glacial lake plains. They formed under prairie or hardwood savanna vegetation.

Four of the soil associations of Pennington County are in this group.

5. Lohnes-Karlstad Association

Well drained and moderately well drained, coarse textured and moderately coarse textured, noncalcareous soils

This association is on remnants of glacial lake beach ridges on glacial lake plains (fig. 5). These soils formed under prairie and hardwood savanna vegetation. Slopes range from 0 to 6 percent.

This association makes up about 7 percent of Pennington County. It is about 50 percent Lohnes soils and 15 percent Karlstad soils. The rest consists of soils of minor extent.

The well drained Lohnes soils are on slightly convex, remnant glacial lake beach ridges. Typically, the surface layer is black loamy coarse sand about 9 inches thick. The next layer is very dark grayish brown loamy coarse sand about 5 inches thick. The underlying material to a depth of about 60 inches is brown, stratified coarse sand, very gravelly sand, and gravelly coarse sand.

The moderately well drained Karlstad soils are in slightly concave swales on remnant glacial lake beach ridges. Typically, the surface layer is very dark brown sandy loam about 3 inches thick. The subsurface layer is grayish brown and brown loamy sand about 6 inches thick. The subsoil is about 10 inches thick. It is dark brown sandy loam in the upper part and dark brown gravelly sandy loam in the lower part. The underlying

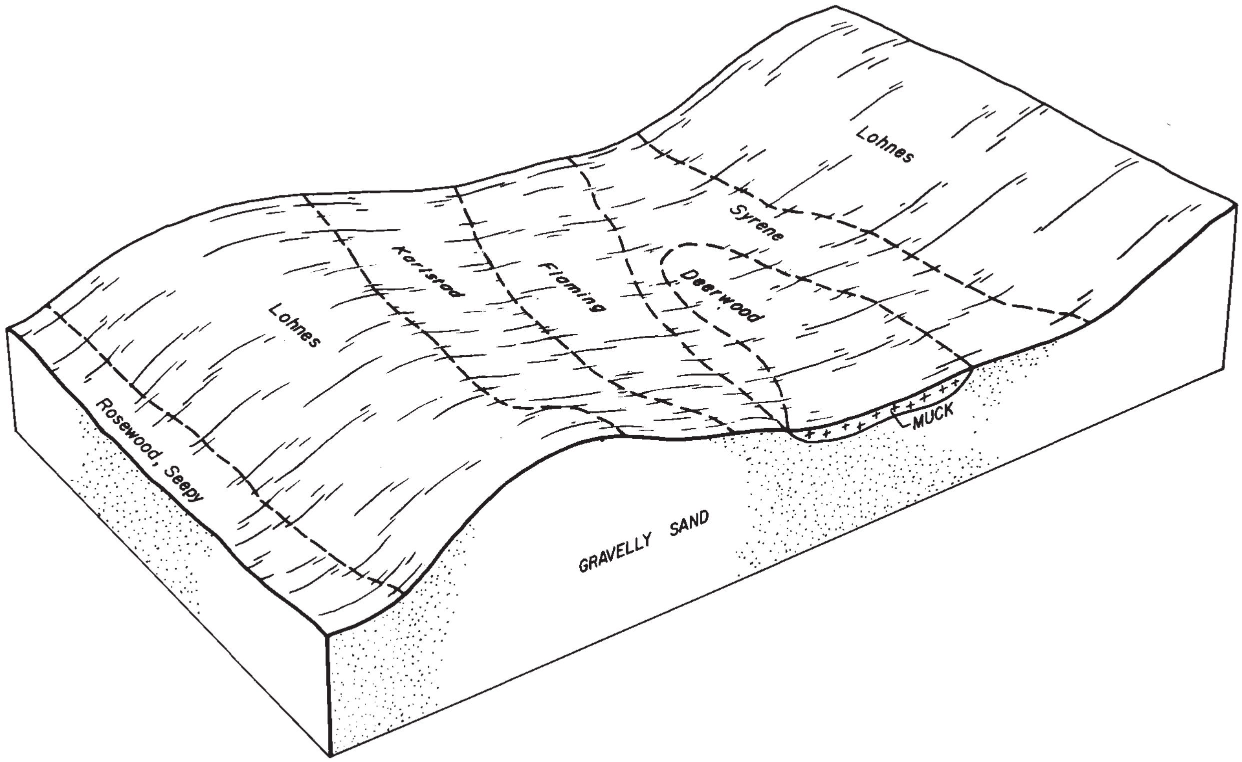

Figure 5.—Relationship of soils, underlying material, and landforms in the Lohnes-Karlstad association.

material to a depth of about 60 inches is brown, light yellowish brown, and light brownish gray, mottled, calcareous sand and gravelly coarse sand.

Of minor extent in this association are Deerwood, Rosewood, seepy, Syrene, and Flaming soils. The very poorly drained Rosewood, seepy soils are sandy throughout and are usually adjacent to the west edge of ridges. These soils are saturated with water near the surface most of the growing season. They are continually recharged with water seeping from the adjacent, porous beach ridge. The very poorly drained Deerwood soils and poorly drained Syrene soils are in small depressions and swales on the main ridges and along the edge of the ridges. The moderately well drained Flaming soils are in slightly concave swales on the ridges.

About 60 percent of the acreage of this association has been cleared of trees and typically is farmed to small grains and hay, or it is used for pasture. Much of the wooded area supports bur oak and provides wildlife habitat. Recently, the wooded areas are being increasingly used for residential development. Small gravel pits are scattered throughout the Lohnes soils, and a few of these are currently being used as sources of gravel and sand.

The soils of this association are fairly suitable for cultivated crops, hayland, and pasture. Droughtiness, susceptibility to wind erosion, and low inherent fertility are the main limitations for farming. Some of the poorly drained soils have a high lime zone near the surface that restricts the availability of phosphorus and potassium for plant growth.

This association is well suited to building site development. The gravel and sand content of these soils creates a hazard of cutbanks caving if the soils are excavated for basements and foundations. These soils are poorly suited to septic tank absorption fields because of the poor filtering capacity. Pollution of ground water supplies is a hazard.

The Lohnes soils provide only fair food, cover, and nesting habitat for openland and woodland wildlife. The droughty condition and low inherent fertility of these soils do not support the dense vegetation needed for ideal food, cover, and nesting habitat.

6. Rosewood-Ulen-Flaming Association

Poorly drained and moderately well drained, moderately coarse textured and coarse textured, dominantly calcareous soils

This association is on remnants of glacial lake shorelines, bars, flats, and deltas on glacial lake plains. These soils formed under prairie vegetation. Slopes range from 0 to 3 percent.

This association makes up about 4 percent of Pennington County. It is about 40 percent Rosewood soils, 20 percent Ulen soils, and 20 percent Flaming soils. The rest consists of soils of minor extent.

The poorly drained Rosewood soils are on plane or slightly concave positions on remnant shorelines, sandbars, and flats in glacial lake basins. Typically, the surface layer is black fine sandy loam about 8 inches thick. The underlying material to a depth of about 60 inches is gray and grayish brown, highly calcareous fine sandy loam in the upper part and light brownish gray and light gray, mottled, calcareous fine sand in the lower part.

The moderately well drained Ulen soils are on plane or slightly convex rises on remnant shorelines and sandbars on glacial lake plains. Typically, the surface layer is black, calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown, highly calcareous loamy fine sand in the upper part and light olive brown, pale brown, and light brownish gray, mottled, calcareous fine sand and very fine sand in the lower part.

The moderately well drained Flaming soils are on slightly convex rises on remnant shorelines and sandbars on glacial lake plains. Typically, the surface layer is black loamy fine sand about 13 inches thick. The subsoil is brown fine sand about 10 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, mottled fine sand.

Of minor extent in the association are the moderately well drained Grimstad and Poppleton soils and the poory drained Rockwell soils. Grimstad and Rockwell soils have a 20- to 40-inch, calcareous sandy mantle over loamy glacial till. Poppleton soils have a thin, dark surface layer over sandy sediment. Grimstad and Poppleton soils are in positions similar to those of the Ulen and Flaming soils, and Rockwell soils are usually in positions similar to and adjacent to those of the Rosewood soils.

About 80 percent of the soils in this associaton has been cleared or is being cleared for farming. Most of the acreage has networks of surface ditches to improve the drainage of the soil. Most areas are farmed to small grains, sunflowers, and hay. Wooded areas ranging from 5 to 200 acres are dominantly mixed bur oak and aspen.

These soils are fairly suited to cultivated crops, hayland, and pasture. The low available water capacity, below average inherent fertility, and the susceptibility to soil blowing are the main limitations for farming. Because the Rosewood soils tend to be wetter than the adjacent soils, spring planting could be delayed. The Ulen and Rosewood soils have a high lime zone near the surface that restricts the availability of potassium and phosphorus for plant growth.

The soils of this association are fairly suited to poorly suited to building site development. The main limitations on the poorly drained soils are the seasonal high water table and the hazard of cutbanks caving because of the sandy content of the soils. The standard septic tank absorption field does not function properly because of the seasonal high water table. Pollution of ground water supplies is a hazard.

7. Clearwater-Wyandotte-Thiefriver Association

Poorly drained, fine textured, moderately fine textured, and moderately coarse textured, calcareous soils

This association is on basins and flats on glacial lake plains. These soils formed under prairie vegetation. Slopes range from 0 to 2 percent.

This association makes up about 8 percent of Pennington County. It is about 50 percent Clearwater soils, 15 percent Wyandotte soils, and 10 percent Thiefriver soils. The rest of the area consists of soils of minor extent.

The poorly drained Clearwater soils are on plane or slightly concave basins on glacial lake plains. Typically, the surface layer is black clay about 8 inches thick. The subsoil is dark grayish brown, mottled, calcareous clay about 8 inches thick. The underlying material to a depth of about 60 inches is grayish brown and olive gray, mottled, calcareous clay.

The poorly drained Wyandotte soils are on plane or slightly concave basins and flats on glacial lake plains. These soils tend to lie adjacent to the smaller remnant beach ridges. Typically, the surface layer is black, calcareous clay loam about 8 inches thick. The underlying material to a depth of about 60 inches is dark gray, mottled, highly calcareous sandy clay loam in the upper part, dark grayish brown, grayish brown, and light brownish gray, mottled, calcareous very gravelly loamy coarse sand in the middle part, and olive gray, mottled, calcareous clay in the lower part.

The poorly drained Thiefriver soils are on nearly level or slightly concave remnants of beaches or bars on glacial lake plains. Typically, the surface layer is black, calcareous fine sandy loam about 10 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown and grayish brown, highly calcareous fine sandy loam in the upper part, light brownish gray and grayish brown, mottled, calcareous fine sand and very gravelly sand in the middle part, and grayish brown, mottled, calcareous clay in the lower part.

Of minor extent in this association are the poorly drained Espelie soils on plane or concave remnant shorelines and sandbars, the poorly drained Boash soils on plane or concave basins and flats, and the moderately well drained Hilaire soils on remnant beaches and bars.

About 90 percent of this association is used for farming. Small grains, sunflowers, and hay are the main crops. Most of the acreage has networks of surface ditches to improve the drainage of the soils. Small woodlots of bur oak and aspen are scattered throughout the association.

These soils are well suited to cultivated crops and to grasses and legumes for hay or pasture. Wetness is the main limitation for farming. Thiefriver and Wyandotte soils have a high lime zone near the surface that restricts the availability of potassium and phosphorus for plant growth. The Wyandotte soils tend to be droughty because of the gravelly strata. Soil blowing is a hazard in unprotected areas.

The soils of this association are poorly suited to building site development and septic tank absorption fields because of the seasonal high water table and the high shrink-swell potential of the clayey material.

8. Borup-Glyndon-Augsburg Association

Poorly drained and moderately well drained, medium textured, calcareous soils

This association is on basins and broad flats on glacial lake plains. These soils formed under prairie vegetation. Slopes range from 0 to 2 percent.

This association makes up about 3 percent of Pennington County. It is about 40 percent Borup soils, 30 percent Glyndon soils, and 10 percent Augsburg soils. The rest consists of soils of minor extent.

The poorly drained Borup soils are on plane to slightly concave basins and flats on glacial lake plains. Typically, the surface layer is black, calcareous loam about 8 inches thick. The subsurface layer is very dark gray, highly calcareous loam about 7 inches thick. The underlying material to a depth of about 60 inches is light brownish gray and light olive gray, mottled, highly calcareous very fine sandy loam in the upper part and light olive gray and light brownish gray, mottled, calcareous, stratified very fine sandy loam, loamy very fine sand, and very fine sand in the lower part.

The moderately well drained Glyndon soils are on slightly convex rises in basins and flats on glacial lake plains. Typically, the surface layer is black loam about 8 inches thick. The underlying material to a depth of about 60 inches is dark gray and pale brown, highly calcareous loam in the upper part and light yellowish brown, mottled, calcareous silt loam over light brownish gray, mottled, calcareous very fine sandy loam and loamy very fine sand in the lower part.

The poorly drained Augsburg soils are on plane to slightly concave basins and flats on glacial lake plains. Typically, the surface layer is black, calcareous loam about 8 inches thick. The subsurface layer is very dark gray, calcareous loam about 5 inches thick. The underlying material to a depth of about 60 inches is grayish brown, highly calcareous loam overlying light brownish gray, mottled, calcareous very fine sandy loam in the upper part and dark gray, mottled, calcareous clay in the lower part.

Of minor extent in the association are the moderately well drained Ulen and Flaming soils and the somewhat poorly drained Wheatville soils. The Wheatville soils are on slightly convex rises in glacial lake basins. The sandy Ulen and Flaming soils are on remnant shorelines and bars.

About 95 percent of the soils in this association has been cleared for farming. These soils are some of the best cropland in the county. Most of the acreage is farmed to small grains, sunflowers, and hay. A few small woodlots of mostly bur oak and aspen are throughout the association. Most of the acreage has a network of surface ditches to improve the drainage of the soils.

These soils are well suited to cultivated crops, hayland, and pasture. Wetness is the major limitation for farming. Most of the soils have a high lime zone near the surface that restricts the availability of potassium and phosphorus for plant growth. Soil blowing is a hazard in unprotected areas.

The soils of this association are poorly suited to fairly suited to building site development. The seasonal high water table is the main limitation, especially in the poorly drained soils. The standard septic tank absorption field does not function properly in most soils because of the seasonal high water table.

Areas Dominated by Level Soils that Formed in Organic Sediment Overlying Mineral Material

These are very poorly drained, level soils that formed in thin to moderately thick organic soil material and are underlain by mineral soil material. They formed under water-tolerant reeds, sedges, and grasses.

Two of the associations of Pennington County are in this group.

9. Deerwood-Hamre Association

Very poorly drained, mucky, mineral soils

This association is on glacial lake plains. These soils formed under wet prairie vegetation. This association is adjacent to the east side of the two main beach ridges in western Pennington County and formed as Glacial Lake Agassiz receded. Slopes range from 0 to 1 percent.

This association makes up about 2 percent of Pennington County. It is about 35 percent Deerwood soils and 30 percent Hamre soils. The rest consists of soils of minor extent.

The very poorly drained Deerwood soils are in small depressions and along the edges of larger bogs near the beach ridge shorelines. Typically, the surface layer is black muck about 9 inches thick. The next layer is black, mucky fine sandy loam about 5 inches thick. The underlying material to a depth of about 60 inches is light olive gray and light brownish gray, mottled loamy sand and loamy fine sand.

The very poorly drained Hamre soils are in small, closed depressions and along the edges of larger bogs. Typically, the surface layer is black muck about 13 inches thick underlain by black loam about 5 inches thick. The underlying material to a depth of about 60 inches is grayish brown and gray, mottled, calcareous clay loam and loam.

Of minor extent in the association are the very poorly drained Cathro and Markey soils in broad bogs and the poorly drained Rosewood and Mavie soils on slightly higher islands and along the edges of bogs.

Most of the acreage of the association supports a growth of willow brush and aspen. Some of the ponded areas support a growth of marsh vegetation. Drainage of these soils is not practical because there is usually no suitable outlet. A few small areas are used for pasture and hay.

These soils are generally unsuitable for cultivation, building site development, and sanitary facilities because of the high water table and susceptibility to ponding.

These soils are well suited to development of habitat for wetland wildlife. Water levels are generally easy to maintain to provide adequate vegetation for nesting, food, and cover. The poor trafficability of these soils limits the size of equipment needed to excavate wildlife ponds.

10. Markey-Cathro Association

Very poorly drained, mucky, organic soils

This association is on glacial lake plains. These soils formed under wet prairie vegetation. Slopes range from 0 to 1 percent.

This association makes up about 4 percent of Pennington County. It is about 30 percent Markey soils and 20 percent Cathro soils. The rest consists of soils of minor extent.

The very poorly drained Markey soils are in large, closed bogs and broad, glacial drainageways. Typically, the surface layer is black muck about 26 inches thick. The next layer is black fine sandy loam about 6 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled, calcareous very fine sandy loam and light brownish gray, mottled fine sand.

The very poorly drained Cathro soils are in large, closed bogs and broad, glacial drainageways. Typically, the surface layer is very dark brown and black muck about 16 inches thick. The subsurface layer is black muck about 20 inches thick. The next layer is black mucky silt loam about 6 inches thick. The underlying material to a depth of about 60 inches is light brownish gray, mottled, calcareous loam.

Of minor extent in the association are the very poorly drained Deerwood and Hamre soils along narrow drainageways and margins of large bogs; the very poorly drained Seelyeville soils, which are usually in the center of the larger bogs; and the poorly drained and moderately well drained Smiley and Reiner soils on small rises along the bog margins or islands within the larger bogs.

About 60 percent of the association is farmed to small grains, timothy, bromegrass hay, and pasture. The remaining acreage is grown over cropland and uncleared land that supports a growth of willow, alder, and aspen.

These soils are fairly suited to crops, hayland, and pasture. The seasonal high water table is the main limitation for farming. These soils are subject to frost during the growing season because of their low lying position. Unprotected topsoil in cultivated areas is very susceptible to soil blowing. Drainage of these soils is not practical because of the absence of suitable outlets for drainage. These soils are poorly suited to building site development and sanitary facilities because of the seasonal high water table and the hazard of ponding.

These soils are well suited to development of habitat for wetland wildlife. Water levels are generally easy to maintain to provide adequate vegetation for nesting, food, and cover. The poor trafficability of these soils limits the size of equipment needed to excavate wildlife ponds.

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, Reiner loamy fine sand is a phase of the Reiner 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. Fluvaquents-Haploborolls complex 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, gravel, 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.

Descriptions of the detailed soil map units follow.

46—Borup loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to several hundred acres.

Typically, the surface layer is black, calcareous loam about 8 inches thick, and the subsurface layer is very dark gray, highly calcareous loam about 7 inches thick. The underlying material to a depth of about 60 inches is light brownish gray and light olive gray, mottled, highly calcareous very fine sandy loam in the upper part and light olive gray and light brownish gray, mottled, calcareous, stratified very fine sandy loam, loamy very fine sand, and very fine sand in the lower part. Some areas are underlain by clay material within a depth of 40 inches, and other areas have a sandy upper mantle. Some small areas are not highly calcareous in the upper layers, and other small areas are better drained and are silty throughout.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of poorly drained Rosewood soils. Rosewood soils are sandy throughout and are in positions on the landscape similar to those of Borup soil.

The permeability of this Borup soil is moderately rapid. Available water capacity, natural fertility, and organic matter content are high. Surface runoff is very slow. Reaction is mildly alkaline or moderately alkaline throughout. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Barley is the small grain that is most tolerant of this condition. Flax is especially intolerant. The addition of organic matter can offset the limiting effect of carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements, and landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

52—Augsburg loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 200 acres.

Typically, the surface layer is black, calcareous loam about 8 inches thick. The subsurface layer is very dark gray, calcareous loam about 5 inches thick. The underlying material to a depth of about 60 inches is grayish brown, calcareous loam overlying light brownish gray, mottled, highly calcareous very fine sandy loam in the upper part and dark gray, mottled, calcareous clay in the lower part. Some areas have silty material to a depth of more than 40 inches, and other areas are clayey within 20 inches of the surface. Some small areas are not highly calcareous in the upper layers. Other small areas are sandy in the upper mantle. In some areas near St. Hilaire the surface layer is silty clay loam.

Included with this soil in mapping and making up 3 to 10 percent of the unit are small areas of poorly drained Clearwater soils and moderately well drained Glyndon soils. Clearwater soils are in positions on the landscape similar to those of Augsburg soil, and they are clayey throughout. Glyndon soils are on slightly convex rises and are silty throughout.

The permeability of this Augsburg soil is moderately rapid in the upper sediment and slow in the clayey material. The available water capacity, organic matter content, and natural fertility are high. Surface runoff is very slow. Reaction is mildly alkaline or moderately alkaline throughout. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland. The rest is in unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition of the upper layers of this soil. Barley is the small grain that is most tolerant of this condition. Flax is especially intolerant. The addition of organic matter can offset the limiting effects of carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

58—Kittson sandy clay loam. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains. Individual areas commonly are oblong, but some are irregular in shape. They range from 5 to about 60 acres.

Typically, the surface layer is black sandy clay loam about 9 inches thick. The subsoil is brown sandy clay loam about 8 inches thick. The underlying material to a depth of about 60 inches is brown and grayish brown, mottled, calcareous clay loam. Some areas are highly calcareous in the upper part, and other areas have a sand or gravelly sand mantle overlying the calcareous loam. In some small areas the clay content is higher than typical.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of poorly drained Kratka, Rockwell, Roliss, and Vallers soils in lower, concave positions and natural drainageways. Kratka and Rockwell soils have a sandy mantle overlying calcareous loam, and Rockwell and Vallers soils are strongly calcareous in the upper part.

The permeability of this Kittson soil is moderate, and available water capacity, organic matter content, and natural fertility are high. Surface runoff is slow. Reaction is neutral or mildly alkaline in the upper part and mildly alkaline or moderately alkaline in the lower part. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if correct planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable.

This soil is in capability subclass IIc.

59—Grimstad fine sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 100 acres.

Typically, the surface layer is black, calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown and grayish brown, highly calcareous loamy fine sand in the upper part; grayish brown and light olive brown, mottled, calcareous fine sand in the middle part; and grayish brown, mottled, calcareous loam in the lower part. Some areas have a 1- to 4-inch gravelly layer in the lower sandy mantle, and other areas have a sandy mantle more than 40 inches or less than 20 inches thick.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Kratka, Rockwell, and Vallers soils in lower, slightly concave positions. The Vallers soils are loamy throughout. Kratka soils are not highly calcareous in the upper layers.

The permeability of this Grimstad soil is moderately rapid in the upper sandy mantle and moderate in the underlying material. The available water capacity is moderate. Surface runoff is slow, and reaction is moderately alkaline in the upper 20 to 30 inches. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is very susceptible to soil blowing and droughty for shallow-rooted plants during dry periods because of low available water capacity in the upper sandy mantle. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Irrigation may be beneficial to specialized cash crops. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, and flax is especially intolerant. The addition of organic matter can offset the limiting effects caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including proper fertilization, pasture rotation, deferment of grazing during wet periods, and proper stocking rates, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and low available water capacity in the upper soil layers are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils, and Russian-olive is drought resistant. Seedling mortality is moderate, plant competition from herbaceous plants is severe, and the hazard of erosion is moderate. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland wildlife. The highly calcareous condition in the upper 30 inches and low available water capacity in the upper soil layers, however, are limitations. Grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIe.

60—Glyndon loam. This nearly level, moderately well drained soil is on slightly convex rises in glacial lake basins and plains. Individual areas are irregular in shape and range from 10 to about 100 acres.

Typically, the surface soil is black loam about 8 inches thick. The underlying material to a depth of about 60 inches is dark gray and pale brown, highly calcareous loam in the upper part, light yellowish brown, mottled, calcareous silt loam in the middle part, and light brownish gray, mottled, calcareous very fine sandy loam and loamy fine sand in the lower part. In some areas the soil is underlain by loam or clay within a depth of 40 inches, and in some areas the soil is sandy throughout.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of poorly drained Augsburg and Rosewood soils in lower, concave positions. Augsburg soils are underlain by clayey material within a depth of 40 inches, and Rosewood soils are sandy throughout.

The permeability of this Glyndon soil is moderately rapid, and available water capacity is high. Surface runoff is slow, and reaction is moderately alkaline in the upper 20 to 30 inches. Organic matter content and natural fertility are high. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland. The rest is in unimproved pasture and hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is restricted by the highly calcareous condition of this soil. The addition of organic matter can offset the limiting effect of carbonates on soil water and nutrient uptake. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to the development of habitat for openland wildlife. The highly calcareous condition in the upper 30 inches is the main limitation to plantings beneficial to wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants tolerant of carbonates in the soil can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIe.

64—Ulen fine sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 100 acres.

Typically, the surface layer is black, calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown, highly calcareous loamy fine sand in the upper part and light olive brown, pale brown, and light brownish gray, mottled, calcareous fine sand and very fine sand in the lower part. Some areas are not highly calcareous in the upper layers, and other areas are underlain by loamy or clayey material within a depth of 40 inches. In some small areas the soil is dominantly silty throughout.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Borup, Rockwell, and Thiefriver soils in lower, concave positions. Borup soils are silty throughout. Rockwell soils are underlain by loamy material, and Thiefriver soils are underlain by clayey sediment.

The permeability of this Ulen soil is rapid. Runoff is slow, and available water capacity is low. Reaction is mildly alkaline or moderately alkaline throughout. Organic matter content is moderate to high, and natural fertility is low to medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. This soil is very susceptible to soil blowing, and it is droughty for shallow-rooted plants during dry periods because of the low available water capacity. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Irrigation may be beneficial to specialized cash crops. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is restricted by the highly calcareous condition of this soil. Proper selection of crops helps to overcome this limitation. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil has fair suitability for windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and low available water capacity throughout are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils, and Russian-olive is drought resistant. Seedling mortality is moderate to severe, and the hazard of erosion is moderate. Plant competition from herbaceous plants, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows.

This soil has fair suitability for development of habitat for openland wildlife. The highly calcareous condition in the upper 30 inches and low available water capacity throughout are the main limitations of this soil. Grain and seed crops, grasses and legumes, and wild herbaceous plants tolerant of these limitations can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIe.

65—Foxhome sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are oblong and range from 5 to about 50 acres.

Typically, the surface soil is black sandy loam about 11 inches thick. The subsoil is dark brown loamy sand about 8 inches thick. The underlying material to a depth of about 60 inches is light olive brown, calcareous, mottled very gravelly coarse sand in the upper part and grayish brown, calcareous, mottled clay loam in the lower part. Some areas are underlain by loam at a depth of less than 20 inches or more than 40 inches, and other areas are highly calcareous in the upper layers. In some areas the soil is underlain by clay.

Included with this soil in mapping and making up 10 to 15 percent of most units are small areas of poorly drained Mavie, Roliss, Strandquist, and Wyandotte soils in lower, concave positions. Mavie and Wyandotte soils are strongly calcareous in the upper layers, and Roliss soils are loamy throughout.

The permeability of this Foxhome soil is moderately rapid in the sandy mantle and moderate in the underlying loamy material. Available water capacity is moderate, and surface runoff is slow. Reaction ranges from neutral to moderately alkaline. Organic matter content is moderate to high, and natural fertility is low to medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are farmed or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of low available water capacity in the upper mantle. Gravel and stones that were turned up during cultivation are in small areas. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is slight, but plant competition from herbaceous plants is severe. The hazard of erosion is slight. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to the development of habitat for openland wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIs.

66—Flaming loamy fine sand. This nearly level, moderately well drained soil is on slightly convex remnants of glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape or long and narrow and range from 5 to about 120 acres.

Typically, the surface layer is black loamy fine sand about 13 inches thick. The subsoil is brown fine sand about 10 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, mottled fine sand. Some areas are highly calcareous in the upper layers, and other areas are underlain by loam within a depth of 40 inches. In some small areas the black surface layer is more than 16 inches or less than 10 inches thick. In other areas thin, gravelly layers are in the profile.

Included with this soil in mapping and making up 3 to 10 percent of most areas are small areas of poorly drained Hamar, Kratka, Rockwell, and Rosewood soils in lower, concave positions and natural drainageways. Kratka and Rockwell soils are underlain by loamy material within a depth of 40 inches, and Rockwell and Rosewood soils are highly calcareous in the upper layers.

The permeability of this soil is rapid. Available water capacity is low, and surface runoff is slow. Organic matter content is moderate, and natural fertility is low to medium. Reaction ranges from slightly acid to moderately alkaline. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are in cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is fairly suited to small grains and grasses and legumes for hay or pasture. This soil is very susceptible to soil blowing and droughty for shallow-rooted plants during dry periods because of low available water capacity. Irrigation may be beneficial for specialized cash crops. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to fairly suited to windbreaks and environmental plantings. Low available water capacity is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Russian-olive, for example, is drought resistant. Seedling mortality is moderate to severe, and the hazard of erosion is moderate. Plant competition from herbaceous plants, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil has fair suitability for openland wildlife habitat. Low available water capacity is the main limitation for plantings that are beneficial to wildlife. Drought-tolerant grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IVe.

77—Garnes fine sandy loam. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains in the eastern part of Pennington County. Individual areas commonly are irregular in shape and range from 5 to about 60 acres.

Typically, the surface layer is very dark grayish brown fine sandy loam about 5 inches thick. The subsurface layer is grayish brown loamy fine sand about 6 inches thick. The subsoil is 9 inches thick. It is dark brown to brown clay loam. The underlying material to a depth of about 60 inches is grayish brown and light olive brown, mottled, calcareous loam. Some areas have a darker surface layer, and other areas have sandy or gravelly strata in the upper mantle.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Chilgren, Kratka, Roliss, and Smiley soils in lower, concave positions and natural drainageways. Kratka soils have a sandy mantle over calcareous loam, and Roliss soils do not have a clay enriched subsoil.

The permeability of this Garnes soil is moderate, and available water capacity is high. Surface runoff is slow. Reaction is neutral in the surface soil and upper part of the subsoil and mildly alkaline or moderately alkaline in the lower part of the subsoil and underlying material. Organic matter content is moderate, and natural fertility is medium. Depth to the seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture and hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. It generally has adequate available water for crops in most years. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks help to reduce soil blowing in areas where large tracts are open. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is slight, and the hazard of erosion is slight. Plant competition from herbaceous plants, however, is severe. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well. The edge habitat, which combines woodland and openland habitats, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIc.

148—Poppleton fine sand. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 120 acres.

Typically, the surface layer is very dark gray fine sand about 7 inches thick, and the subsurface layer is very dark grayish brown fine sand about 2 inches thick. The subsoil is brown to dark yellowish brown fine sand about

26 inches thick. The underlying material to a depth of about 60 inches is light brownish gray, mottled fine sand. Some areas have a thick, black surface layer, and other areas are underlain by loam within a depth of 40 inches. In some areas the soil is highly calcareous in the upper part of the profile.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Hamar and Rosewood soils. The poorly drained Hamar and Rosewood soils are in lower, concave positions. Rosewood soils are highly calcareous in the upper part.

The permeability of this Poppleton soil is rapid, and the surface runoff is slow. The available water capacity, natural fertility, and organic matter content are low. Reaction ranges from slightly acid to mildly alkaline. The depth to a seasonal high water table ranges from 2.5 to 5 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is fairly suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of low available water capacity. This soil is extremely susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil has fair suitability for windbreaks and environmental plantings. Low available water capacity is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Russian-olive, for example, is drought resistant. Seedling mortality is moderate to severe, and the hazard of erosion is moderate. Plant competition from herbaceous plants, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows.

This soil has fair suitability for openland wildlife habitat. Low available water capacity and low fertility are the main limitations for plantings that are beneficial to wildlife. Drought-tolerant plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable.

This soil is in capability subclass IVs.

184—Hamerly loam. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 50 acres.

Typically, the surface layer is black loam about 8 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, highly calcareous clay loam in the upper part and olive, pale olive, and olive gray, mottled, calcareous clay loam and loam in the lower part. Some areas are not highly calcareous in the upper layers, and some small areas have thin, sandy or sandy and gravelly layers in the upper part.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Mavie and Roliss soils in lower, concave positions. Mavie soils have a gravelly layer at least 6 inches thick in the upper part, and Roliss soils are not highly calcareous in the upper layers.

The permeability of this Hamerly soil is moderate, and available water capacity is high. Surface runoff is slow, and reaction is mildly alkaline or moderately alkaline in the upper 20 to 30 inches. Organic matter content and natural fertility are high. The depth to a seasonal high water table ranges from 2.5 to 5 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. The water supply is good during most seasons. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops help to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effects caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. This soil is well suited to use as pasture. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate, plant competition from herbaceous plants is severe, and the hazard of erosion is moderate. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to openland wildlife habitat. Grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIe.

205—Karlstad sandy loam. This nearly level, moderately well drained soil is in slightly concave swales on remnant glacial lake beach ridges on glacial lake plains. Individual areas are irregular in shape or long and narrow and range from 10 to about 80 acres.

Typically, the surface layer is very dark brown sandy loam about 3 inches thick, and the subsurface layer is grayish brown and brown loamy sand about 6 inches thick. The subsoil is about 10 inches thick. It is dark brown sandy loam in the upper part and dark brown, gravelly sandy loam in the lower part. The underlying material to a depth of about 60 inches is brown, light yellowish brown, and light brownish gray, mottled, calcareous sand and gravelly coarse sand. Some areas are mostly sandy, and other areas do not have a clay enriched subsoil. Some areas are underlain by loam within a depth of 40 inches, and other areas have a thick, black surface layer.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Strandquist and Syrene soils in lower, concave positions and natural drainageways. Strandquist soils have loamy material within a depth of 40 inches. Syrene soils are strongly calcareous in the upper layers.

The permeability of this Karlstad soil is moderately rapid in the upper sediment and very rapid in the underlying material. The available water capacity is low. Organic matter content is moderately low, and natural fertility is low. Reaction of the surface soil and upper part of the subsoil is slightly acid or neutral. Surface runoff is slow. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture and hayland. This soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty during dry periods because of low available water capacity. Gravel that was turned up during cultivation is on the surface in places. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil has fair suitability for windbreaks and environmental plantings. Low available water capacity is the main limitation to tree growth. Proper selection of trees can help to overcome this limitation. Russian-olive, for example, is drought resistant. Seedling mortality is moderate to severe, and the hazard of erosion is moderate. Plant competition from herbaceous plants, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows.

This soil has fair suitability for the development of habitat for openland and woodland wildlife. Low available water capacity is the main limitation for vegetation used for food, cover, and nesting. Drought resistant hardwoods, conifers, and associated grasses, legumes, and wild herbaceous plants should be planted. This soil and the associated soils are among the best areas supporting woodland wildlife in Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. This soil is suitable for road construction. It is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IVs.

236—Vallers loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 200 acres.

Typically, the surface layer is black loam about 8 inches thick, and the subsurface is very dark gray loam about 4 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, mottled, highly calcareous clay loam in the upper part and light brownish gray, mottled, calcareous loam in the lower part. Some areas are not highly calcareous in the upper layers. Some areas are sandy in the upper part, and other small areas are clayey in the lower part.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of moderately well drained Grimstad, Hamerly, and Kittson soils on slightly convex rises and very poorly drained Hamre soils in closed depressions. Grimstad soils formed in a sandy mantle over loamy sediment. Kittson soils do not have a highly calcareous upper layer. Hamre soils have a thin, mucky surface layer.

The permeability of this Vallers soil is moderately slow, and available water capacity is high. Organic matter content and natural fertility are high. Surface runoff is slow. Reaction is moderately alkaline in the upper 20 to 30 inches. The depth to a seasonal high water table ranges from 1 foot to 2.5 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface, and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effects caused by carbonates on soil water and nutrient uptake. A fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and wetness are the main limitations to tree growth. The proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. If buildings are constructed on this soil, they should be built without basements, and landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations can help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

245B—Lohnes loamy coarse sand, 0 to 6 percent slopes. This gently sloping, well drained or moderately well drained soil is on convex, remnant glacial lake beach ridges on glacial lake plains in the western part of Pennington County. Individual areas are long and narrow and are commonly oriented from north to south. They range from 10 to about 300 acres.

Typically, the surface layer is black loamy coarse sand about 9 inches thick. The next layer is very dark grayish brown loamy coarse sand about 5 inches thick. The underlying material to a depth of about 60 inches is stratified, brown coarse sand, very gravelly sand, and gravelly coarse sand. Some areas are very gravelly in the substratum, and other areas are highly calcareous in the upper layers. Some areas have a thin, black surface layer.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Flaming and Ulen soils, which are on lower, slightly concave positions, and poorly drained Rosewood and Syrene soils, which are in shallow depressions and on foot slopes of ridges. The Flaming soils have layers of subsoil, and the Rosewood, Syrene, and Ulen soils are highly calcareous in the upper layers.

The permeability of this Lohnes soil is rapid, and available water capacity is low. Surface runoff is very slow. Reaction is neutral or mildly alkaline in the upper part. Organic matter content is moderate or moderately low, and natural fertility is low. The depth to a seasonal high water table is more than 6 feet.

Most areas of this soil are used for cropland or are in pasture and hayland. Some tracts remain in woodland, however, or are used as a source of sand and gravel. This soil has fair suitability for small grains and grasses and legumes for hay or pasture. It is droughty during dry periods because of low available water capacity and is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing and retain soil moisture. Good pasture management, including a program of fertilization, pasture rotation, and proper stocking rates, helps to keep the pasture in good condition.

This soil has fair suitability for windbreaks and environmental plantings. Low available water capacity throughout is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Russian-olive, for example, is drought resistant. Seedling mortality is moderate to severe, and the hazard of erosion is moderate. Competition from herbaceous and woody plants, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grasses, weeds, and competing trees should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil has fair suitability for development of habitat for openland and woodland wildlife. Low available water capacity is the main limitation to vegetation used for food, cover, and nesting. Drought resistant hardwoods, conifers, and associated grasses, legumes, and wild herbaceous plants should be selected for planting. This soil provides good woodland habitat for numerous wildlife species common to Pennington County.

This soil is suitable for building sites and for local roads. It readily absorbs but does not adequately filter the effluent from septic tank absorption fields, and the poor filtering capacity may result in the pollution of ground water supplies. Installing distribution lines as close to the surface as possible lessens the severity of this hazard.

This soil is in capability subclass IVs.

280—Pelan sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 45 acres.

Typically, the surface layer is very dark grayish brown sandy loam about 6 inches thick, and the subsurface layer is dark brown loamy coarse sand about 4 inches thick. The subsoil is dark brown gravelly sandy clay loam about 5 inches thick. The underlying material to a depth of about 60 inches is grayish brown, calcareous, mottled gravelly loamy sand in the upper part and grayish brown, mottled, calcareous loam in the lower part. Some areas are underlain by loamy material within 20 inches of the surface or at a depth of more than 40 inches. Some small areas do not have a substantial clay increase in the subsoil. Some areas have less gravel than typical.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Chilgren, Kratka, and Smiley soils in lower, concave positions and natural drainageways. Chilgren and Smiley soils are loamy throughout. Kratka soils formed in a sandy mantle over loamy material.

Permeability of this Pelan soil is rapid in the upper sandy layer and moderate in the underlying material. Surface runoff is slow. Reaction is neutral in the surface soil and upper part of the subsoil. Organic matter content is moderate to high, and natural fertility is medium to low. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Many areas of this soil are farmed, and other areas are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of the moderately low available water capacity in the upper sandy layers. Gravel turned up during cultivation may be in places. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is moderate, and plant competition from herbaceous plants is moderate. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil has fair suitability for the development of openland and woodland wildlife habitat. Low available water capacity in the upper sandy layers is the main limitation for plantings beneficial to wildlife. Drought-tolerant woody and herbaceous species can be expected to grow well if proper planting and management practices are observed. The edge habitat, which combines woodland and openland habitats, provides adequate nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIs.

343—Wheatville loam. This nearly level, somewhat poorly drained soil is on slightly convex rises in glacial lake basins and on glacial lake plains. Individual areas are irregular in shape and range from about 5 to more than 200 acres.

Typically, the surface layer is black, calcareous loam about 10 inches thick. The underlying material to a depth of about 60 inches is gray, highly calcareous clay loam and loam in the upper part; olive yellow and light olive brown, calcareous very fine sandy loam in the middle part; and dark grayish brown, mottled, calcareous clay in the lower part. Some areas are not highly calcareous within 16 inches of the surface. Some areas do not have clayey material within a depth of 40 inches, and other small areas have clayey material at a depth of less than 20 inches.

Included with this soil in mapping and making up 3 to 10 percent of the unit are small areas of Clearwater and Ulen soils. The poorly drained Clearwater soils are in lower, concave positions and narrow, natural drainageways. The moderately well drained Ulen soils are on slightly convex rises and are sandy throughout.

The permeability of this Wheatville soil is moderately rapid in the upper mantle and slow in the underlying material. The available water capacity, organic matter content, and natural fertility are high. Surface runoff is very slow, and reaction is moderately alkaline in the upper 20 to 30 inches. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland. The rest is in pasture or hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. The soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effects caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate, plant competition from herbaceous plants is severe, and the hazard of erosion is moderate. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to openland wildlife habitat. The highly calcareous condition in the upper 30 inches of the soil is the main limitation for plantings beneficial to wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants tolerant of highly calcareous conditions can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse textured material provides added protection against structural damage. Constructing roads on well compacted, coarse textured fill material helps to protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable.

This soil is in capability subclass IIe.

372—Hamar loamy fine sand. This nearly level, poorly drained soil is in plane or slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. Individual areas are oblong and commonly parallel the remnant glacial lake beach ridges. They range from 5 to about 80 acres.

Typically, the surface layer is about 14 inches thick. It is very dark gray loamy fine sand in the upper part and very dark grayish brown loamy fine sand in the lower part. The underlying material to a depth of about 60 inches is dark grayish brown, mottled loamy fine sand in the upper part and brown and grayish brown, mottled, calcareous fine sand in the lower part. Some areas are highly calcareous in the upper part. Some areas have a thin, organic surface layer. Other small areas have thin layers that are high in gravel, silt, or very fine sand. In some small areas loam is within a depth of 40 inches.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of Foldahl, Grimstad, and Ulen soils. These soils are better drained than Hamar soil and are on convex rises. Foldahl and Grimstad soils are underlain by loamy material.

The permeability of this Hamar soil is rapid, and available water capacity is low. Runoff is slow. Reaction ranges from neutral in the upper layers to mildly alkaline in the underlying material. Natural fertility is low. Organic matter content is moderate to high. The depth to a seasonal high water table ranges from 1 foot to 2 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay and pasture. It is droughty for shallow-rooted plants during dry periods because of low available water capacity. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface reduce soil blowing and help to retain soil moisture by reducing evaporation during dry periods. Planting of windbreaks and growing grasses and legumes also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. A seasonal high water table 1 foot to 2 feet below the surface and low available water capacity are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Green ash and willow, for example, tolerate wet soil conditions. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements, and landscaping should be designed to drain surface water away from the buildings. Tile drains should be placed around the foundations to help remove excess subsurface water. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help overcome the wetness and protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IVw.

387—Roliss loam, depressional. This level, very poorly drained soil is in plane or slightly concave swales on glacial lake plains. Individual areas are irregular in shape and range from 5 to 20 acres. This soil is subject to ponding.

Typically, the surface layer is black loam about 7 inches thick. The subsoil is grayish brown, mottled loam about 3 inches thick. The underlying material to a depth of about 60 inches is brownish gray and olive, mottled, calcareous loam. Some areas have a thin upper mantle of sand, and other areas have a thin organic surface layer. In some small areas the subsoil has thin sandy layers.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Kratka soils. The Kratka soils formed in an upper sandy mantle.

The permeability of this Roliss soil is moderate. Available water capacity is high, and surface runoff is very slow or ponded. Organic matter content and natural fertility are high. Reaction ranges from neutral to moderately alkaline. The seasonal high water table ranges from 0.5 foot above the surface to 3 feet in depth.

Many areas of this soil are farmed, and other areas are being cleared for farming. The rest is in brush, woodland, and unimproved pasture and hayland. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay and pasture. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Onsite investigation usually is needed to determine soil needs and trees most suitable for planting.

This soil is generally unsuitable for building sites or septic tank absorption fields because of the hazard of ponding. Nearby soils are commonly better suited to these uses. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass IIIw.

404—Chilgren loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 160 acres.

Typically, the surface layer is very dark gray loam about 4 inches thick, and the subsurface layer is grayish brown, mottled fine sandy loam about 6 inches thick. The subsoil is about 8 inches thick. It is dark grayish brown, mottled clay loam. The underlying material to a depth of about 60 inches is olive gray, mottled, calcareous loam. Some areas have a thick, black surface layer, and other areas have a sandy mantle underlain by loam. Some areas do not have a substantial increase in clay in the subsoil.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of very poorly drained Hamre soils in shallow depressions and moderately well drained Linveldt and Reiner soils on slightly convex rises. Hamre soils have a thin mucky surface layer. Linveldt and Reiner soils have a black surface layer, and Linveldt soils have a layer of sand over a loamy substratum.

The permeability of this Chilgren soil is moderate, and available water capacity is high. Surface runoff is slow. Reaction is neutral or slightly acid in the surface soil and upper part of the subsoil and mildly alkaline in the lower part of the subsoil. Organic matter content is moderate, and natural fertility is medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses for hay or pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing in areas where large tracts are open. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wet soil conditions. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to the development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well. The edge habitat, which is a combination of woodland and openland habitats, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

412—Mavie fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 80 acres.

Typically, the surface layer is black fine sandy loam about 7 inches thick. The subsurface layer is olive gray, highly calcareous fine sandy loam about 7 inches thick. The underlying material to a depth of about 60 inches is light brownish gray and grayish brown, mottled, calcareous very gravelly sand and very gravelly coarse sand in the upper part and olive gray, mottled, calcareous loam in the lower part. Some areas have more sand in the upper mantle, and other areas have a gravelly sandy mantle to a depth of more than 40 inches. In some small areas the upper layers are not highly calcareous.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of moderately well drained Foxhome soils, very poorly drained Hamre soils, and poorly drained Roliss and Vallers soils. Foxhome soils are on convex rises. Hamre soils are in shallow depressions and have a mucky surface. Roliss and Vallers soils are loamy throughout and are in positions on the landscape similar to those of Mavie soils.

The permeability of this Mavie soil is rapid in the gravelly sand layer and moderate in the underlying loamy sediment. Available water capacity is moderate, and surface runoff is slow. The organic matter content is high, and natural fertility is low to medium. Reaction is mildly alkaline or moderately alkaline. Depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty during dry periods because of low available water capacity in the upper soil layers. Gravel and stones that were turned up during cultivation are in small areas. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIw.

426—Foldahl fine sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 100 acres.

Typically, the surface layer is black fine sandy loam about 9 inches thick. The subsoil is about 15 inches thick. It is very dark grayish brown fine sand in the upper part and yellowish brown, mottled fine sand in the lower part. The underlying material to a depth of about 60 inches is light brownish gray and grayish brown, calcareous, mottled loam. Some areas are highly calcareous in the upper part, and other areas are gravelly in the upper mantle. In some areas the sandy mantle is more than 40 inches thick, and in other areas it is less than 20 inches thick. In some areas the surface layer is fine sand.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Rockwell, Roliss, and Vallers soils in lower, concave positions. Roliss and Vallers soils are loamy throughout. Rockwell soils are highly calcareous in the upper part.

The permeability of this Foldahl soil is rapid in the sandy mantle and moderate in the underlying loamy material. Available water capacity is moderate, and surface runoff is slow. Reaction ranges from neutral to moderately alkaline. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of low availale water capacity in the upper sandy layers. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Low available water capacity in the upper sandy layers is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Seedling mortality is moderate to slight, and plant competition from herbaceous plants is moderate. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to the development of openland wildlife habitat. Low available water capacity in the upper sandy layers is the main limitation for plantings beneficial to wildlife. Drought-tolerant species of grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIs.

432—Strandquist sandy clay loam. This nearly level, poorly drained soil is in plane or slightly concave swales on glacial lake plains. Individual areas are irregular in shape and range from about 5 to about 80 acres.

Typically, the surface layer is black sandy clay loam and sandy loam about 11 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown, grayish brown, and light brownish gray, mottled very gravelly coarse sand in the upper part and olive gray, mottled, calcareous clay loam in the lower part. Some areas have more sand in the upper mantle than typical, and other areas have a gravelly sand mantle to a depth of more than 40 inches. In some small areas the upper layers are highly calcareous.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of moderately well drained Foxhome and Karlstad soils and very poorly drained Hamre soils. Foxhome and Karlstad soils are on convex rises, and Karlstad soils have a substantial increase in clay in the subsoil. Hamre soils are in shallow depressions and have a mucky surface.

The permeability of this Standquist soil is rapid in the sandy layers and moderate in the loamy underlying sediment. The available water capacity is moderate, and surface runoff is slow. The organic matter content is high, and natural fertility is low to medium. Reaction ranges from neutral to moderately alkaline. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods. Fertilization according to soil tests is desirable. Gravel that was turned up during cultivation is in places. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, rotation grazing, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. Low available water capacity in the upper sandy layers and wetness are the main limitations to tree growth. Proper selection of trees help to overcome these limitations. Green ash and willow, for example, tolerate wet soil conditions. Seedling mortality is moderate, and competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIw.

435—Syrene fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 80 acres.

Typically, the surface layer is about 13 inches thick. It is black, calcareous fine sandy loam in the upper part and very dark gray, calcareous fine sandy loam in the lower part. The underlying material to a depth of about 60 inches is light brownish gray, highly calcareous, mottled very gravelly loamy coarse sand in the upper part and light brownish gray, calcareous loamy fine sand and fine sand in the lower part. Some areas are not highly calcareous in the upper layers, and other areas are sandy and have very little gravel. In some areas loamy material is within a depth of 40 inches.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of moderately well drained Foxhome, Karlstad, and Ulen soils on convex rises and very poorly drained Deerwood soils in shallow depressions. Foxhome soils are underlain by loamy sediment within a depth of about 40 inches, and Karlstad soils have a substantial increase of clay in the subsoil. Ulen soils are sandy throughout. Deerwood soils have a thin, mucky surface.

The permeability of this Syrene soil is rapid, and available water capacity is low. Surface runoff is slow, and reaction is mildly alkaline or moderately alkaline throughout. The organic matter content is high, and natural fertility is low to medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are in cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty during dry periods because of low available water capacity. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is fairly suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches of the profile and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help overcome the wetness limitation and protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IVw.

439—Rockwell fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas commonly are irregular in shape and range from 5 to several hundred acres.

Typically, the surface layer is black, calcareous fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is dark gray and dark grayish brown, mottled, highly calcareous fine sandy loam and fine sand in the upper part; grayish brown and light brownish gray, mottled, calcareous fine sand and sand in the middle part; and light brownish gray, mottled, calcareous loam in the lower part. Some areas have a sandy mantle less than 20 inches thick. In other areas the sandy material is more than 40 inches thick. Some small areas are not highly calcareous in the upper part. Other areas have gravel in the underlying material.

Included with this soil in mapping and making up 5 to 15 percent of most areas are small areas of moderately well drained Foldahl and Ulen soils on slightly convex rises. Ulen soils are sandy throughout, and Foldahl soils are not highly calcareous in the upper layers.

The permeability of this Rockwell soil is moderately rapid in the sandy layers and moderate in the underlying loamy material. The available water capacity is moderate, and surface runoff is very slow. Reaction is mildly alkaline or moderately alkaline throughout. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are in cropland. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. It is droughty for shallow-rooted plants during dry periods because of moderately low available water capacity in the upper sandy layers. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches of the profile and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

481—Kratka fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 80 acres.

Typically, the surface layer is black fine sandy loam about 11 inches thick. The subsoil is dark grayish brown, mottled loamy fine sand about 7 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled sand in the upper part and olive gray, mottled, calcareous loam in the lower part. Some areas are highly calcareous in the upper layers, and other areas are clayey in the contrasting underlying material. Some small areas have a sandy mantle over loam that is more than 40 inches thick or less than 20 inches thick.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of Deerwood, Flaming, Grimstad, and Hamre soils. The very poorly drained Deerwood and Hamre soils are in shallow depressions and have a mucky surface. The moderately well drained Flaming and Grimstad soils are on slightly convex rises. Flaming soils are sandy throughout, and Grimstad soils are highly calcareous in the upper layers.

The permeability of this Kratka soil is moderately rapid in the sandy mantle and moderate in the loamy underlying material. Runoff is slow, and available water capacity is moderate. Reaction ranges from neutral to moderately alkaline. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods. A fertilization program according to soil tests is desirable. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisure by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, rotation grazing, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees can help to overcome this limitation. Green ash and willow, for example, tolerate wet soil conditions. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before the trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help overcome the wetness limitation and protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIw.

540—Seelyeville muck. This level, very poorly drained soil is in closed depressions on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 80 acres. This soil is subject to ponding.

Typically, this soil is highly decomposed, black organic material to a depth of about 60 inches. In some areas the organic layers are less than 51 inches thick.

The permeability of Seelyeville muck is moderate, and available water capacity and organic matter content are very high. Surface runoff is very slow, and the soil can be ponded for long periods. Natural fertility is low, and reaction is strongly acid to neutral. A seasonal high water table ranges from 2 feet above the surface to 1 foot in depth.

Most areas of this soil are idle and support growths of sedges and willow brush. A few small areas are used for hay or pasture. This soil has fair suitability for small grains, hayland, and pasture if properly drained and protected, but even if properly drained, it is subject to ponding for short periods. Because it is in low depressions, this soil is subject to frost damage during the growing season. During dry seasons, it is very susceptible to soil blowing and peat fires. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

This soil is well suited to the development of habitat for wetland wildlife. Because desired water levels can be maintained easily, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is generally unsuitable for building site development because of the hazards of ponding and structural damage resulting from low soil strength. It is generally unsuitable for septic tank absorption fields because of the ponding hazard. Soils that are better suited to these uses are commonly close by. Roads should be constructed on raised, coarse textured fill material and adquate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass IVw.

543—Markey muck. This level, very poorly drained organic soil is in closed depressions or broad, concave natural drainageways on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 200 acres. This soil is subject to ponding.

Typically, the surface layer is black muck about 26 inches thick. The next layer is black fine sandy loam about 6 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled, calcareous very fine sandy loam and light brownish gray, mottled fine sand. Some areas have an organic surface layer less than 16 inches thick or more than 51 inches thick. Other areas are underlain by loam.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Mavie and Syrene soils on slightly convex rises. These soils formed in mineral material throughout.

The permeability of this Markey soil is moderately rapid in the organic soil and rapid in the sandy sediment. The available water capacity and organic matter content are very high. Surface runoff is very slow, and the soil can be ponded for long periods. Natural fertility is low, and reaction ranges from slightly acid to mildly alkaline. A seasonal high water table ranges from 1 foot above the surface to 1 foot in depth.

Most areas of this soil are idle and support sedges, willow brush, and aspen. Small areas are used for hay or pasture. This soil is suitable for small grains, pasture, and hayland if properly drained and protected, but even if properly drained, it is subject to ponding for short periods. Because it is in low depressions, this soil is subject to frost damage during the growing season. During dry seasons, it is very susceptible to soil blowing and peat fires. This soil has fair suitability for grasses and selected legumes for hay and pasture. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

This soil is well suited to the development of habitat for wetland wildlife. Because desired water levels can be maintained easily, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is generally unsuitable for building site development because of the hazards of ponding and structural damage resulting from low soil strength. This soil is generally unsuitable for septic tank absorption fields because of the ponding hazard. Soils that are better suited to these uses are commonly close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass IVw.

544—Cathro muck. This level, very poorly drained organic soil is in closed depressions on broad, concave natural drainageways on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 200 acres. This soil is subject to ponding.

Typically, the surface layer is very dark brown and black muck about 16 inches thick, and the subsurface layer is black muck about 20 inches thick. The next layer is black, mucky silt loam about 6 inches thick. The underlying material to a depth of about 60 inches is light brownish gray, mottled, calcareous loam. Some areas have organic layers less than 16 inches thick or more than 51 inches thick. Some small areas are underlain by sand.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Chilgren, Roliss, and Smiley soils. These soils are on slightly convex rises and formed entirely in mineral material.

The permeability of this Cathro soil is moderately rapid in the upper organic layers and moderate in the underlying material. The available water capacity and organic matter content are very high. Surface runoff is very slow, and the soil can be ponded for long periods. Natural fertility is low, and reaction ranges from slightly acid to mildly alkaline. The depth to a seasonal high water table ranges from 1 foot above the surface to 1 foot in depth.

Most areas of this soil are idle and support sedges, willow brush, and aspen. Small areas are used for hay or pasture. This soil is suitable for small grains, hayland, and pasture if properly drained and protected, but even if properly drained, this soil is subject to ponding for short periods. Because it is in low depressions, this soil is subject to frost damage during the growing season. During dry seasons, it is very susceptible to soil blowing and peat fires. This soil is fairly suited to grasses and selected legumes for hay and pasture. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

This soil is well suited to the development of habitat for wetland wildlife. Because desired water levels can be easily maintained, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is generally unsuitable for building site development because of the hazards of ponding and structural damage resulting from low soil strength. This soil is generally unsuitable for septic tank absorption fields because of the ponding hazard. Soils that are better suited to these uses are commonly close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass IVw.

547—Deerwood muck. This level, very poorly drained soil is in closed depressions or slightly concave, narrow drainageways on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 200 acres. This soil is subject to ponding.

Typically, the surface layer is black muck about 9 inches thick. The next layer is black, mucky fine sandy loam about 5 inches thick. The underlying material to a depth of about 60 inches is light olive gray and light brownish gray, mottled loamy sand and loamy fine sand. Some areas have a thicker organic surface layer than typical. Other areas are underlain by loam.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Hamar, Mavie, and Syrene soils. These soils are on slightly convex rises and along the edges of bogs. They formed in mineral material throughout.

The permeability of this Deerwood soil is moderately rapid in the organic layer and rapid in the underlying material. The available water capacity is moderate, and surface runoff is very slow. Natural fertility is low. Reaction ranges from neutral to moderately alkaline. Organic matter content is very high. A seasonal high water table ranges from 1 foot above the surface to 1 foot in depth. Ponding is especially common in spring.

Most areas of this soil are idle and support sedges, willow brush, and aspen. Some areas have been drained, however, and are farmed as part of the cropland or are used for hayland and pasture. This soil is fairly suited to small grains, hayland, and pasture if drained and protected, but even if properly drained, this soil is subject to ponding for short periods. Because it is in low depressions, this soil is subject to frost damage during the growing season. During dry seasons, it is susceptible to peat fires and soil blowing. Returning crop residue, plowing down green manure crops, and applying barnyard manure help to maintain and improve fertility and tilth and reduce soil blowing. This soil is suited to grasses and selected legumes for hay and pasture. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

This soil is well suited to the development of habitat for wetland wildlife. Because desired water levels can be maintained fairly easily, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is generally unsuitable for building sites or septic tank absorption fields because of the hazard of ponding. Soils that are better suited to these uses are commonly close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against the damage caused by ponding.

This soil is in capability subclass IVw.

565—Eckvoll loamy sand. This nearly level, moderately well drained soil is on convex rises on glacial lake plains. Individual areas are irregular in shape and range from 5 to 80 acres.

Typically, the surface layer is black loamy sand about 9 inches thick, and the subsurface layer is brown and dark brown fine sand about 16 inches thick. The subsoil is brown sandy clay loam about 7 inches thick. The underlying material to a depth of about 60 inches is grayish brown, calcareous, mottled loam. Some areas have sandy sediment more than 40 inches thick or less than 20 inches thick. Other areas have a substantial increase in clay in the subsoil.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of poorly drained Kratka soils and moderately well drained Reiner soils. Kratka soils are in lower, concave positions. Reiner soils do not have the sandy sediment common to Eckvoll soil.

The permeability of this Eckvoll soil is moderately rapid in the upper sandy sediment and moderate in the underlying material. Available water capacity is moderate, and surface runoff is slow. Organic matter content is moderate, and natural fertility is medium. Reaction is neutral or mildly alkaline. The depth to a seasonal high water table ranges from 2.5 to 5 feet.

Figure 6.—Moderately well drained, light colored Eckvoll loamy fine sand and poorly drained, dark Kratka fine sandy loam. Minimum tillage practices and return of crop residue improve the organic matter content and reduce soil blowing on these soils.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. It is somewhat droughty during dry periods because of the moderate available water capacity. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and help to retain soil moisture by reducing evaporation during dry periods (fig. 6). Growing grasses and legumes and planting windbreaks help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Plant competition from herbaceous plants is moderate. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well. The edge habitat, a combination of woodland and openland habitats, provides adequate nesting, food, and cover for many of the wildlife common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIs.

582—Roliss loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 10 to several hundred acres.

Typically, the surface layer is black loam about 7 inches thick. The subsoil is dark gray, mottled, calcareous loam about 6 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled clay loam in the upper part and olive gray, mottled, calcareous loam and silt loam in the lower part. Some areas have a thin upper mantle of sand, and other areas are highly calcareous in the upper layers. Some small areas are clayey instead of loamy, and some areas have thin layers of gravelly sand in the subsoil.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of moderately well drained Foldahl, Grimstad, Hamerly, and Kittson soils and the very poorly drained Hamre soils. The Foldahl, Grimstad, Hamerly, and Kittson soils are on slightly convex rises. Hamre soils are in shallow depressions and natural drainageways and have a mucky surface.

The permeability of this Roliss soil is moderate. Available water capacity is high, and surface runoff is very slow. Organic matter content and natural fertility are high. Reaction ranges from neutral to moderately alkaline. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and legumes for hay and pasture. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to maintain good surface structure and reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wet soil conditions. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before the trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

This soil is poorly suited to use as building sites because of wetness. Buildings constructed on this soil should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

641—Clearwater clay. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to several hundred acres.

Typically, the surface layer is black clay about 8 inches thick. The subsoil is dark grayish brown, mottled, calcareous clay about 8 inches thick. The underlying material to a depth of about 60 inches is grayish brown and olive gray, mottled, calcareous clay. Some areas have a thin, sandy or silty mantle overlying the clay, and other areas are underlain by loam within a depth of 40 inches. In some small areas the upper layers are highly calcareous, and in other areas a gravelly or sandy layer more than 6 inches thick is between depths of 10 and 40 inches.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of moderately well drained Grimstad Variant, Hilaire, Reiner Variant, and Wheatville soils on slightly convex rises. Reiner Variant soils are underlain by loam within a depth of 40 inches. Grimstad Variant and Wheatville soils are strongly calcareous in the upper layers. Hilaire soils have a sandy upper mantle over clay, and Wheatville soils have a silty mantle over clay.

The permeability of this Clearwater soil is slow, and surface runoff is slow. Organic matter content and natural fertility are high. Reaction ranges from neutral to moderately alkaline. Available water capacity is moderate to high. This soil has high shrink-swell potential. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to maintain good surface structure and reduce soil blowing. This soil is well suited to pasture if it is adequately drained. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wetness. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from buildings, and foundations and footings designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material is added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against damage caused by frost action, low soil strength, and shrinking and swelling of the soil. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability of this soil restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

642—Clearwater loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 200 acres.

Typically, the surface layer is black loam about 7 inches thick. The subsoil is very dark grayish brown, mottled clay about 3 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown and olive gray, mottled, calcareous clay. Some areas have clayey surface layers, and other areas are underlain by loam within a depth of 40 inches. In some areas the upper layers are highly ca'careous, and in other areas a gravelly or sandy layeı more than 6 inches thick is between depths of 10 and 4() inches.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of moderately well drained Grimstad Variant, Hilaire, Reiner Variant, and Wheatville soils on slightly convex rises. Reiner Variant soils are underlain by loam within 40 inches of the surface. Grimstad Variant and Wheatville soils are highly calcareous in the upper layers. Hilaire soils have a sandy upper mantle over clay, and Wheatville soils have a silty mantle over clay.

The permeability of this Clearwater soil is slow, and available water capacity is moderate to high. Surface runoff is slow. Organic matter content and natural fertility are high. Reaction ranges from neutral to moderately alkaline. This soil has high shrink-swell potential. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are in cropland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to maintain good surface structure and reduce soil blowing. This soil is well suited to pasture if it is adequately drained. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods, helps to maintain the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wetness. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around foundations help to remove the excess subsurface water. Landscaping should be designed to drain surface water away from buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against damage caused by frost action, low soil strength, and shrinking and swelling of the soil. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability of this soil restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

643—Grimstad Variant fine sandy loam. This nearly level, moderately well drained soil is on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 100 acres.

Typically, the surface layer is black, calcareous fine sandy loam about 13 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown, highly calcareous fine sandy loam and loamy fine sand in the upper part; light olive brown, mottled, calcareous fine sand in the middle part; and grayish brown, mottled, calcareous clay in the lower part. Some areas have a sandy mantle more than 40 inches thick overlying the clay. Other small areas are not highly calcareous in the upper layers.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Clearwater and Espelie soils on lower, concave positions and natural drainageways. Clearwater soils are clayey throughout. Espelie soils are leached in the upper sandy mantle.

The permeability of this Grimstad Variant soil is moderately rapid in the upper mantle and slow in the underlying material. The available water capacity is moderate, and surface runoff is slow. Reaction is moderately alkaline in the upper 20 to 30 inches. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. This soil is very susceptible to soil blowing. It is droughty during dry periods because of low available water capacity in the sandy mantle. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals are reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a tolerant small grain, but flax is especially intolerant of carbonates in the soil. The addition of organic matter can offset the limiting effects caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of openland wildlife habitat. The highly calcareous condition in the upper 30 inches is the main limitation to plantings beneficial to wildlife. Grain and seed crops, grasses and legumes, and wild herbaceous plants tolerant of calcareous soils can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability in the lower part of this soil restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIe.

644—Boash clay loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 160 acres.

Typically, the surface layer is black clay loam about 7 inches thick. The subsoil is dark gray, mottled clay about 3 inches thick. The underlying material to a depth of about 60 inches is dark gray and olive gray, mottled, calcareous clay in the upper part and grayish brown, mottled, calcareous loam in the lower part. Some areas have a thin, sandy or silty mantle overlying the clay, and other areas are clayey to a depth of more than 40 inches. In some small areas the upper layers are highly calcareous, and in other areas a gravelly or sandy layer more than 6 inches thick is between a depth of 10 and 40 inches. In some areas all of the layers between a depth of 10 and 20 inches are not calcareous.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Kittson, Reiner Variant, and Roliss soils. The moderately well drained Kittson soils and the moderately well drained Reiner Variant soils are on slightly convex rises. Roliss soils are loamy throughout and are in positions on the landscape similar to those of Boash soils.

The permeability of this Boash soil is slow in the clayey material and moderate in the underlying loamy material. Available water capacity is moderate to high. Organic matter content and natural fertility are high. Reaction is neutral or mildly alkaline. Surface runoff is slow. This soil has high shrink-swell potential. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to maintain good surface structure and reduce soil blowing. This soil is well suited to pasture if it is adequately drained. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing during wet periods helps to maintain the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wetness. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the permeability of this soil restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

645—Espelie fine sandy loam. This nearly level, poorly drained soil is on linear or slightly concave, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are commonly irregular in shape and range from 5 to about 180 acres.

Typically, the surface layer is black fine sandy loam about 9 inches thick. The subsoil is dark grayish brown loamy fine sand about 4 inches thick. The underlying material to a depth of about 60 inches is grayish brown, mottled fine sand in the upper part and dark gray and gray, mottled, calcareous clay in the lower part. Some areas are highly calcareous or gravelly in the upper layers, and other small areas have sandy layers more than 40 inches thick or less than 20 inches thick.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of Deerwood, Flaming, and Grimstad Variant soils. The very poorly drained Deerwood soils are in shallow depressions and have a mucky surface. Flaming soils are sandy throughout. The moderately well drained Grimstad Variant and Flaming soils are on slightly convex rises.

The permeability of this Espelie soil is moderately rapid in the sandy upper material and slow in the underlying clayey material. Runoff is slow, and available water capacity is moderate. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods. Fertilization according to soil tests is desirable. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Stubble mulching, growing grasses and legumes, and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, rotation grazing, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition .

If properly drained, this soil is fairly suited to windbreaks and environmental plantings. The low available water capacity in the upper 20 to 40 inches and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Green ash and willow, for example, tolerate wetness. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against damage caused by frost action, low soil strength, and shrinking and swelling of the soil. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

647—Hilaire very fine sandy loam. This nearly level, moderately well drained soil is in plane or slightly convex, remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 10 to about 100 acres.

Typically, the surface layer and subsurface layer are black very fine sandy loam about 10 inches thick. The subsoil is dark grayish brown loamy fine sand about 5 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown, grayish brown, and light olive brown, mottled loamy fine sand and fine sand in the upper part and olive gray, mottled, calcareous clay in the lower part. Some areas are highly calcareous in the upper part, and other areas are gravelly in the upper mantle. Some areas have sandy layers that are more than 40 inches thick or less than 20 inches thick.

Included with this soil in mapping and making up 5 to 15 percent of most units are small areas of poorly drained Clearwater, Espelie, Thiefriver, and Wyandotte soils in lower, concave positions. Clearwater soils are clayey throughout. Thiefriver and Wyandotte soils are highly calcareous in the upper part.

The permeability of this Hilaire soil is moderately rapid in the upper sandy layers and slow in the underlying material. Available water capacity is moderate, and surface runoff is slow. Reaction is neutral in the upper layers. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of low available water capacity in the upper sandy layers. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Low available water capacity in the upper sandy layers is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Seedling mortality is moderate, and plant competition from herbaceous plants is moderate. The hazard of erosion is slight to moderate. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland wildlife. Low available water capacity in the upper sandy layers is the main limitation for plantings beneficial to wildlife. Drought-tolerant grain and seed crops, grasses and legumes, and wild herbaceous plants can be expected to grow well if proper planting and management practices are observed.

If buildings are constructed on this soil, foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIs.

648—Reiner Variant sandy clay loam. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains. Individual areas are irregular in shape and border parts of the Thief and Red Lake Rivers. They range from 10 to about 100 acres.

Typically, the surface layer is very dark gray sandy clay loam about 7 inches thick. The subsoil is about 9 inches thick. The upper part is dark grayish brown clay, and the lower part is very dark grayish brown clay. The underlying material to a depth of about 60 inches is dark gray, calcareous clay in the upper part and grayish brown, mottled, calcareous loam in the lower part. Some areas have a loamy subsoil, and other areas have a lighter colored surface layer than typical. In some areas the surface layer is sandy.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Boash, Clearwater, and Smiley soils. These poorly drained soils are on lower, concave positions and in natural drainageways.

The permeability of this Reiner Variant soil is slow in the clayey subsoil and moderate in the loamy underlying material. Available water capacity is moderate to high. Surface runoff is slow. Reaction is neutral or mildly alkaline in the surface layer and subsoil and mildly alkaline or moderately alkaline in the underlying material. Organic matter content and natural fertility are high. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. Adequate water is generally available for crops during most years. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is slight, and the hazard of erosion is slight. Plant competition from herbaceous plants, however, is severe. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well if proper planting and management practices are observed. The edge habitat, which combines woodland and openland habitats, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the permeability of this soil restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIc.

649—Reiner loamy fine sand. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 60 acres.

Typically, the surface layer is very dark gray loamy fine sand about 10 inches thick. The subsoil is about 12 inches thick. The upper part is dark brown clay loam, and the lower part is dark grayish brown, mottled loam. The underlying material to a depth of about 60 inches is grayish brown, mottled, calcareous loam. In some areas the soil has a sandy layer below the subsoil, and in other areas the soil has a loamy surface layer. Some areas have a lighter colored surface soil than typical, and some areas have a clayey layer in the upper part.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Kratka and Roliss soils. The poorly drained Kratka and Roliss soils are in lower, concave positions and natural drainageways. Kratka soils formed in a sandy mantle over loamy sediment.

The permeability of this Reiner soil is moderate, and available water capacity is high. Surface runoff is slow. Reaction ranges from neutral to moderately alkaline. Organic matter content is moderate, and natural fertility is high. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. Crops may be difficult to establish during dry years because of the droughtiness of the surface soil. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks help to reduce soil blowing in areas where large tracts are open. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is moderate, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well if proper planting and management practices are observed. The edge habitat, which combines woodland and openland habitat, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be constructed above the seasonal high water table. Tile drains placed around foundations help to remove the excess subsurface water. Landscaping should be designed to drain surface water away from buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIs.

650—Reiner fine sandy loam. This nearly level, moderately well drained soil is on slightly convex rises on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 200 acres.

Typically, the surface layer is black fine sandy loam about 7 inches thick. The next layer is olive brown loam and grayish brown silt loam about 2 inches thick. The subsoil is olive brown clay loam about 8 inches thick. The underlying material to a depth of about 60 inches is brown, grayish brown, and light olive brown, mottled, calcareous loam. Some areas have a sandy layer in the underlying material, and other areas have a lighter colored surface layer than typical. In some areas a clayey layer is in the upper part of the profile.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Kratka and Roliss soils. The poorly drained Kratka and Roliss soils are in lower, concave positions and natural drainageways. Kratka soils have a sandy mantle over loam.

The permeability of this Reiner soil is moderate, and available water capacity is high. Surface runoff is slow. Reaction ranges from neutral to moderately alkaline. Organic matter content and natural fertility are high. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. Adequate water is generally available for crops during most years. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks help to reduce soil blowing in areas where large tracts are open. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is slight, and the hazard of erosion is slight. Plant competition from herbaceous plants, however, is severe. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well if correct planting and management practices are observed. The edge habitat, which combines woodland and openland habitat, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIc.

651—Thiefriver fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 80 acres.

Typically, the surface layer is black, calcareous fine sandy loam about 10 inches thick. The underlying material to a depth of about 60 inches is dark grayish brown and grayish brown, highly calcareous fine sandy loam in the upper part; light brownish gray and grayish brown, mottled, calcareous fine sand and very gravelly sand in the middle part; and grayish brown, mottled, calcareous clay in the lower part. Some areas have a sandy mantle more than 40 inches thick overlying the clay, and other areas have sandy layers less than 20 inches thick. Some small areas have gravelly layers that are not highly calcareous in the upper part of the profile.

Included with this soil in mapping and making up 5 to 15 percent of most areas are small areas of Clearwater and Hilaire soils. Clearwater soils are clayey throughout and are in positions on the landscape similar to those of

Thiefriver soils. Hilaire soils are moderately well drained and are on convex rises.

The permeability of this Thiefriver soil is moderately rapid in the sandy mantle and slow in the underlying material. The available water capacity is moderate, and surface runoff is slow. Reaction is mildly alkaline or moderately alkaline throughout. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are in cropland. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of moderate available water capacity in the upper sandy layers. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of plants helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. Addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches of the profile and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be constructed above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

652—Wyandotte clay loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 300 acres.

Typically, the surface layer is black, calcareous clay loam about 8 inches thick. The underlying material to a depth of about 60 inches is dark gray, mottled, highly calcareous sandy clay loam in the upper part; dark grayish brown, grayish brown, and light brownish gray, mottled, calcareous very gravelly loamy coarse sand in the middle part; and olive gray, mottled, calcareous clay in the lower part. Some areas have more sand in the upper mantle than typical. Other areas have a sandy mantle more than 40 inches thick or sandy layers less than 20 inches thick. In some small areas the upper layers are not highly calcareous.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of poorly drained Clearwater soils and moderately well drained Foxhome soils. Clearwater soils are clayey throughout and are in positions on the landscape similar to those of Wyandotte soils. Foxhome soils are on convex rises and formed in sandy material over loamy sediment.

The permeability of this Wyandotte soil is rapid in the sandy layer and slow in the underlying clayey sediment. The available water capacity is moderate, and surface runoff is slow. The organic matter content is high, and natural fertility is low to medium. Reaction is mildly alkaline or moderately alkaline throughout. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty during dry periods because of low available water capacity in the upper sandy layers. Gravel and stones turned up during cultivation may be in some small areas. This soil is susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing.

The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil has fair suitability for windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches of the profile and wetness are the main limitations to tree growth. Proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

If buildings are constructed on this soil, the lower or basement level should be constructed above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings, and foundations and footings should be designed to prevent structural damage caused by shrinking and swelling of the soil. Backfilling around the foundations with suitable coarse material provides added protection against structural damage. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the slow permeability in the underlying material restricts it from readily accepting effluent. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIw.

712—Rosewood fine sandy loam. This nearly level, poorly drained soil is in plane or slightly concave basins on remnant glacial lake beaches and bars on glacial lake plains. Individual areas are irregular in shape and range from 10 to several hundred acres.

Typically, the surface layer is black fine sandy loam about 8 inches thick. The underlying material to a depth of about 60 inches is gray and grayish brown, highly calcareous, mottled fine sandy loam in the upper part and light brownish gray and light gray, mottled, calcareous fine sand in the lower part. Some areas are not highly calcareous in the upper layers. Some areas have thin, gravelly sandy strata, and other small areas are underlain by loamy or clayey material within a depth of 40 inches.

Included with this soil in mapping and making up 3 to 10 percent of most units are small areas of Grimstad and Grimstad Variant soils. These soils are on better drained, convex rises. Grimstad soils are underlain by loamy sediment, and Grimstad Variant soils are underlain by clayey sediment.

The permeability of this Rosewood soil is moderately rapid over rapid, and available water capacity is low. Surface runoff is slow. Organic matter content is moderate to high, and natural fertility is low to medium. Reaction is mildly alkaline or moderately alkaline throughout. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is in brush, woodland, and unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is droughty for shallow-rooted plants during dry periods because of low available water capacity. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. The availability of phosphorus, potassium, and certain trace minerals is reduced by the highly calcareous condition in the upper part of this soil. Proper selection of crops helps to overcome this limitation. Barley, for example, is a small grain that is tolerant of this condition, but flax is especially intolerant. The addition of organic matter can offset the limiting effect caused by carbonates on soil water and nutrient uptake. A well balanced fertilization program based on soil tests is desirable. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. The highly calcareous condition in the upper 30 inches of the profile and wetness are the main limitations to tree growth. The proper selection of trees helps to overcome these limitations. Conifers, for example, are especially intolerant of highly calcareous soils. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is poorly suited to use as building sites because of wetness. If buildings are constructed on this soil, they should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help overcome wetness and protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIw.

713—Linveldt fine sandy loam. This nearly level, moderately well drained soil is on slighty convex rises on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 200 acres.

Typically, the surface layer is black fine sandy loam about 10 inches thick. The subsoil is about 9 inches thick. The upper part is dark brown sandy loam, and the lower part is dark brown and brown loam. The underlying material to a depth of about 60 inches is yellowish brown and light olive brown, mottled sand in the upper part and dark grayish brown and grayish brown, mottled, calcareous loam in the lower part. Some areas are loamy throughout or have a sandy layer below the subsoil that is less than 6 inches thick. Other small areas are very gravelly in the upper mantle.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Kratka, Roliss, and Smiley soils in lower, concave positions. Roliss and Smiley soils are loamy throughout.

The permeability of this Linveldt soil is moderate. The available water capacity is moderate, and surface runoff is slow. Reaction ranges from neutral to moderately alkaline. Organic matter content is moderate to high, and natural fertility is medium. The depth to a seasonal high water table ranges from 2.5 to 6 feet.

Most areas of this soil are used for cropland or are being cleared for farming. This soil is well suited to small grains, sunflowers, and grasses and legumes for hay or pasture. It is somewhat droughty during dry periods because of the moderate available water capacity. This soil is very susceptible to soil blowing. Conservation tillage practices that leave part or all of the previous crop residue on the surface help to maintain organic matter content, reduce soil blowing, and retain soil moisture by reducing evaporation during dry periods. Growing grasses and legumes and planting windbreaks also help to reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

This soil is well suited to windbreaks and environmental plantings. Seedling mortality is slight, and the hazard of erosion is slight. Plant competition from herbaceous plants, however, is severe. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well if proper planting and management practices are observed. The edge habitat, which combines woodland and openland habitat, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

If buildings are constructed on this soil, the lower or basement level should be built above the seasonal high water table. Tile drains placed around the foundations help to remove excess subsurface water. Landscaping should be designed to drain surface water away from the buildings. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIIs.

765—Smiley sandy clay loam. This nearly level, poorly drained soil is in plane or slightly concave basins on glacial lake plains. Individual areas are irregular in shape and range from 5 to about 300 acres.

Typically, the surface layer is black sandy clay loam about 12 inches thick. The subsoil is olive gray, mottled clay loam about 7 inches thick. The mottled underlying material to a depth of about 60 inches is olive gray, calcareous clay loam in the upper part and olive gray, calcareous loam in the lower part. Some areas are light colored and have more sand in the surface layer than typical. Other areas have a 20- to 40-inch sandy mantle. Some areas are lower lying and do not have a substantial increase of clay in the subsoil.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of very poorly drained Hamre soils and moderately well drained Linveldt soils. Hamre soils are in shallow depressions and have a mucky surface. Linveldt soils are on slightly convex rises and have a sandy mantle overlying loamy sediment.

The permeability of this Smiley soil is moderate, and available water capacity is high. Surface runoff is slow. Reaction is neutral in the surface soil and subsoil and mildly alkaline or moderately alkaline in the underlying material. Organic matter content and natural fertility are high. The depth to a seasonal high water table ranges from 1 foot to 3 feet.

Most areas of this soil are used for cropland or are being cleared for farming. The rest is idle and supports brush or woodland. Some areas are in unimproved pasture or hayland. If properly drained, this soil is well suited to small grains, sunflowers, and grasses and legumes for hay and pasture. Conservation tillage practices that leave part or all of the previous crop residue on the surface and restricting cultivation when the soil is wet help to maintain organic matter content and reduce soil blowing. Good pasture management, including a program of fertilization, pasture rotation, proper stocking rates, and deferment of grazing during wet periods, helps to keep the pasture in good condition.

If properly drained, this soil is well suited to windbreaks and environmental plantings. Wetness is the main limitation to tree growth. Proper selection of trees helps to overcome this limitation. Green ash and willow, for example, tolerate wetness. Seedling mortality is moderate to severe, and plant competition from herbaceous plants is severe. The hazard of erosion, however, is slight. Seedling mortality can be reduced by careful seedbed preparation and maintenance of the windbreak rows. Grass and weeds should be removed before trees are planted and regrowth of competing vegetation controlled for the life of the windbreak.

This soil is well suited to development of habitat for openland and woodland wildlife. Woody and herbaceous species can be expected to grow well. The edge habitat, which combines woodland and openland habitats, provides adequate vegetation for nesting, food, and cover for many wildlife species common to Pennington County.

This soil is poorly suited to use as building sites because of wetness. If buildings are constructed on this soil, they should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove excess subsurface water. Roads should be constructed on well compacted, coarse textured fill material to help protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass IIw.

1006—Fluvaquents-Haploborolls complex. These nearly level to sloping soils are adjacent to the larger rivers in the county. The Fluvaquents are on nearly level flood plains. The Haploborolls are on short, steep slopes and river escarpments. These soils are so intermixed that separation in mapping is not practical. Individual areas are irregular in shape and range from 5 to about 50 acres. This map unit is 40 to 60 percent Fluvaquents and 40 to 60 percent Haploborolls.

The poorly drained or very poorly drained Fluvaquents are subject to occasional or frequent flooding. The soils commonly are stratified silt, very fine sand, and loam. The surface layer is black or very dark brown. Thin, dark buried layers are common. In some areas, a zone of calcium carbonate accumulation may be near the surface. Reaction is neutral through moderately alkaline. Inherent fertility is generally high. Many areas of Fluvaquents are farmed or used for hay and pasture. Some areas support the growth of grasses and trees. A seasonal high water table and flooding are hazards to the use of these soils. Most areas are subject to flooding every 2 to 5 years. When flooding occurs, some or all of the crops may drown (fig. 7).

The moderately well drained Haploborolls commonly are moderately coarse textured or medium textured. The surface layer is black except where eroded. Areas of Haploborolls are generally woodland and are seldom cultivated. Hardwood trees, such as quaking aspen and bur oak, are the common vegetative cover. Some areas of Haploborolls are used for hay and pasture. Susceptibility to water erosion is a limitation for use of this soil.

This complex is in capability subclass IVw.

1029—Pits, gravel. This map unit consists of areas where gravelly material has been excavated. These pits are generally associated with areas of Lohnes soils that occupy the remnant beach ridges in the western part of the county. The surface layer has been stripped from these soils and deposited around the edges of the gravel pits, and the coarser, gravelly material has been removed, leaving an open pit. The size and shape of pits is determined by the quality and quantity of gravel obtained from each site. Many of the gravel pits, especially the deeper abandoned ones, are ponded. Wetland wildlife habitat development is feasible in these ponded areas.

Various introduced and native grasses grow in and around the pits. This vegetation provides limited grazing for livestock, and the deeper, ponded pits provide a water supply. Many of the abandoned pits are being reclaimed by replacing the topsoil and reseeding. Gravel removed from these pits is used for road surfacing for industrial and construction purposes, and as concrete aggregate.

This map unit is not assigned to a capability subclass.

1804—Hamre muck, ponded. This level, very poorly drained soil is in closed depressions or in naturally dammed glacial drainageways on glacial lake plains. These soils are generally ponded year-round, but parts of some areas dry out during extended dry periods. Individual areas are irregular in shape and range from 5 to about 50 acres.

Typically, the surface layer is black muck about 11 inches thick. The underlying material to a depth of about

Figure 7.—Sloping Haploborolls and flooded Fluvaquents are typical of the Fluvaquents-Haploborolls complex during spring snowmelt on the Red Lake River flood plain. The river and the town of St. Hilaire are in the background.

60 inches is grayish brown and light brownish gray, mottled, calcareous loam. Some areas have organic layers more than 16 inches thick or less than 8 inches thick. Other areas have sandy layers in the underlying material.

The permeability of this Hamre soil is moderate. The available water capacity is very high, and surface runoff is ponded. Natural fertility is low, and reaction ranges from neutral to moderately alkaline. Organic matter content is very high. The seasonal high water table ranges from 2 feet above the surface to 1 foot in depth.

Most areas of this soil are idle and support a growth of water-tolerant vegetation. The soil is generally unsuitable for cropland, hayland, pasture, and windbreaks because it is subject to ponding and lacks suitable outlets. Considerable effort and costly management practices would be needed to use this soil effectively for crop production.

This soil is well suited to use as habitat for wetland wildlife. It provides nesting, mating, and escape areas for waterfowl, furbearers, and numerous upland animals and birds. Many of these areas can be improved by increasing the open water areas, fencing out livestock, and controlling the water level where feasible.

This soil is generally unsuitable for building sites or septic tank absorption fields because of the hazard of ponding. Soils that are better suited to these uses are usually close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass VIIIw.

1808—Markey muck, ponded. This level, very poorly drained soil is in closed depressions or in naturally dammed glacial drainageways on glacial lake plains. These soils are generally ponded year-round, but parts of some areas dry out during extended dry periods. Individual areas are irregular in shape and range from 5 to about 100 acres.

Typically, an organic surface mantle is black muck about 19 inches thick. The underlying material to a depth of about 60 inches is light brownish gray, mottled sand. Some areas have organic layers less than 16 inches thick, and other areas have loamy layers in the underlying material.

The permeability of this Markey soil is moderately rapid in the organic soil and rapid in the underlying material. The available water capacity is very high, and surface runoff is ponded. Natural fertility is low, and reaction ranges from neutral to moderately alkaline. Organic matter content is very high. The depth to a seasonal high water table ranges from 2 feet above the surface to 1 foot in depth.

Most areas of this soil are idle and support a growth of water-tolerant vegetation. This soil is poorly suited to cropland, hayland, pasture, and windbreaks because it is subject to ponding and generally lacks suitable outlets. Considerable effort and costly management practices would be needed to use this soil productively.

This soil is well suited to use as habitat for wetland wildlife. It provides nesting, mating, and escape areas for waterfowl, furbearers, and numerous upland animals and birds. Many of these areas can be improved by increasing the open water areas, fencing out livestock, and controlling the water level where feasible.

This soil is generally unsuitable for building site development because of the hazard of ponding and the structural damage that may result because of low soil strength. It generally is not suited to septic tank absorption fields because of the ponding hazard. Soils that are better suited to these uses are usually close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass VIIIw.

1878—Hamre muck. This level, very poorly drained soil is in closed depressions or slightly concave, narrow drainageways on glacial lake plains. This soil is subject to ponding. Individual areas are irregular in shape and range from 5 to about 200 acres.

Typically, the surface layer is black muck about 13 inches thick underlain by about 5 inches of black loam. The underlying material to a depth of about 60 inches is grayish brown and gray, mottled, calcareous clay loam and loam. Some areas have a muck surface layer more than 16 inches thick, and other areas have thin mucky layers or do not have muck at the surface.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of poorly drained Chilgren, Smiley, and Vallers soils on slightly convex rises and around the edges of bogs. These soils formed in mineral material throughout.

The permeability of this Hamre soil is moderate. The available water capacity is high, and surface runoff is very slow to ponded. Natural fertility is low, and reaction ranges from neutral to moderately alkaline. Organic matter content is very high. The depth to a seasonal high water table ranges from 1 foot above the surface to 1 foot in depth. Ponding on the surface is especially common in spring.

Most areas of this soil are idle and support sedges, willow brush, and aspen. Some areas have been drained and are used as part of the cropland, hayland, or pasture. If properly drained, this soil has fair suitability for small grains, sunflowers, and grasses for hay, pasture, and green manure crops. Even if proper drainage is provided, however, this soil can pond water during wet seasons. This soil is very susceptible to soil blowing. Returning crop residue, plowing down green manure crops, and adding barnyard manure help to maintain and improve fertility and soil tilth and reduce soil blowing. This soil is suited to pasture if it is adequately drained. Good pasture management, including a program of fertilization, proper stocking rates, pasture rotation, and deferment of grazing when the soil is wet, helps to maintain the pasture in good condition.

This soil is well suited to the development of habitat for wetland wildlife. Suitable water habitat is generally easy to develop. Because desired water levels can be maintained fairly easily, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is generally unsuitable for building sites or septic tank absorption fields because of the hazard of ponding. Soils that are better suited to these uses are usually close by. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help protect against damage caused by ponding and frost action.

This soil is in capability subclass IIIw.

1882—Rosewood fine sandy loam, seepy. This gently sloping, very poorly drained soil is on side slopes of remnant glacial lake beach ridges on glacial lake plains. This soil is commonly on the western sides of the remnant glacial lake beach ridges. Individual areas are long and narrow and range from 10 to about 200 acres.

Typically, the surface layer is black and very dark gray fine sandy loam about 9 inches thick. The underlying material to a depth of about 60 inches is grayish brown and light brownish gray, strongly calcareous fine sandy loam in the upper part and grayish brown and light brownish gray, mottled sand in the lower part. Some areas are not highly calcareous in the upper layers. Other areas have thin, gravelly, sandy strata. Some small areas are underlain by loamy material within 40 inches of the surface. Other areas have a surface layer of thin muck.

Included with this soil in mapping and making up 3 to 15 percent of most units are small areas of well drained and moderately well drained Lohnes soils and moderately well drained Karlstad soils on convex rises.

The permeability of this Rosewood soil is moderately rapid, and available water capacity is low. Surface runoff is very slow. Organic matter content is high, and natural fertility is low to medium. Reaction is mildly alkaline or moderately alkaline throughout. The depth to a seasonal high water table ranges from 0 to 3 feet.

Most areas of this soil are idle and support stands of willow brush and aspen, but some areas are used for pasture. Because of the difficulty in draining these areas, this soil is poorly suited to small grains, hayland, and pasture.

This soil is well suited to the development of habitat for wetland wildlife. Because desired water levels can be maintained easily, areas of wetland vegetation that is good for food and cover are plentiful.

This soil is poorly suited to use as building sites because of wetness. If buildings are constructed on this soil, they should be built without basements. Landscaping should be designed to drain surface water away from the buildings. Tile drains placed around the foundations help to remove the excess subsurface water. Roads should be constructed on raised, coarse textured fill material and adequate side ditches and culverts provided to help overcome the wetness and protect against frost damage. This soil is poorly suited to use as septic tank absorption fields because of the seasonal high water table and because the soil does not adequately filter the effluent. The poor filtering capacity may result in the pollution of ground water supplies. A mound type of absorption field may be suitable in some places.

This soil is in capability subclass VIw.

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Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in providing the nation's short- and long-range needs for food and fiber. The acreage of high quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, feed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. The moisture supply, of course, must be adequate, and the growing season has to be sufficiently long. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources, and farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food or fiber or are available for these uses. Urban or built-up land and water areas cannot be considered prime farmland.

Prime farmland soils usually have an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The acidity or alkalinity level of the soils is acceptable. The soils have few or no rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent.

Soils that have a high water table, are subject to flooding, or are droughty may qualify as prime farmland if the limitations are overcome by drainage, flood control, or irrigation. Onsite evaluation is needed to determine the effectiveness of corrective measures. More information on the criteria of prime farmland soils can be obtained at the local office of the Soil Conservation Service.

About 248,000 acres, or nearly 63 percent of Pennington County, meets the soil requirements for prime farmland. Most of these 248,000 acres of prime farmland soils is presently used as cropland, but some areas remain wooded or are used for pasture. Crops grown on this land, mainly small grains and sunflowers, account for most of the county's agricultural income each year.

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

The soils that make up prime farmland in Pennington County are listed in table 5. The location of each map unit is shown on the detailed soil maps at the back of this publication. The extent of each unit is given in table 4. The soil qualities that affect use and management are described in the section "Detailed Soil Map Units." The list in table 5 does not constitute a recommendation for a particular land use.

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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 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 sites for buildings, sanitary facilities, highways, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the 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 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

Dwayne Breyer, conservation agronomist, Soil Conservation Service, assisted in the preparation of this section.

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained (*7*); 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.

Pennington County is mainly a grain farming area, although some farmers raise beef cattle or hogs or manage dairy operations (fig. 8). Wheat, oats, barley, alfalfa, and sunflowers are the main crops (fig. 9). The acreage planted to corn is increasing yearly. It is generally marketed locally and used as feed grain or corn silage. Small acreages of buckwheat and flax are also grown. Approximately 75 percent of the land area is used for crops and 8 percent for pasture. The soils range from marginal to highly productive cropland. Good management practices can increase the yields of the soils within the county.

Soil blowing is a hazard throughout Pennington County because the nearly level topography makes the soils more susceptible to wind action. Most soil blowing occurs in areas where the soils are left bare in winter and spring. Fields plowed in the fall should be left rough and cloddy to expose the crop residue and protect the soil. Plowing in the fall is more frequently practiced on the poorly drained soils because these soils are difficult to work in spring when they are wet. Stripcropping, conservation tillage, stubble mulching, the use of field shelterbelts, and crop residue management help to control soil blowing.

Conservation tillage systems that have potential in the county include reduced tillage (use of chisel plows, disks, and field cultivators); till-planting on the ridges for row crops, such as corn and sunflowers; and no-till systems for planting small grains.

Wetness is a problem on many of the soils throughout Pennington County. Open ditches are commonly used to remove surface water. Field ditches are needed to remove excess water from the fields in spring to allow for better seedbed preparation and more timely planting. Adequately drained soils encourage root development because the movement of air and water in the soil is not restricted. In addition, soils that are adequately drained generally warm up earlier in the spring.

Tilling too frequently or when soils are wet or dry damages the soil structure. Frequent tillage makes the surface layer powdery, and water is not readily absorbed.

Figure 8.—Holstein dairy cows on Kratka fine sandy loam. Dairy operations are prevalent in the eastern part of Pennington County. Kratka fine sandy loam supports good forage for hay and pasture.

Tilling when the soil does not contain the proper amount of moisture makes the surface layer cloddy and unsuitable as a seedbed. The soils should be tilled only enough to prepare a good seedbed and control the growth of weeds. Fields plowed in the fall should be left rough in order to reduce soil erosion.

The application of fertilizer increases the crop yields of most of the soils in Pennington County. The amount of fertilizer needed should be based on soil tests. Applications vary, depending upon the type of soil, past management, and the nutrient demands of the crop to be grown.

Good pasture management is needed to establish highly productive forage grasses and legumes on the suitable soils. Poorly drained soils support moisture-tolerant grasses, such as reed canarygrass, timothy, and creeping foxtail, and legumes, such as birdsfoot trefoil, red clover, Ladino clover, and alsike clover. Better drained soils will support a wider range of forage species, including alfalfa, crownvetch, orchardgrass, and Kentucky bluegrass as well as those plants that grow on the poorly drained soils.

Good pasture management also includes a fertilization program, rotation grazing, proper stocking rates, deferred grazing during wet periods, brush and weed control, and providing for a full-season grazing system.

Full-season grazing systems generally combine cool-season grasses for early season and late season grazing and warm-season grasses for grazing during the warmer, drier summer months. Planting the cool- and warm-season grasses in different pastures and using a rotation grazing system allows for maximum utilization of the forage produced. Suitable warm-season grasses include big bluestem, indiangrass, switchgrass, little bluestem, and sideoats grama.

Applications of fertilizer should be based on soil test results. Fertilizer should be applied to cool-season grasses in spring and late in summer to promote vigorous growth during the period when the grasses are most used for grazing. Rotation grazing and proper

Figure 9.—Barley swathes and sunflowers on nearly level, poorly drained Clearwater clay. Barley is a common small grain, and sunflowers are an important row crop in Pennington County. Clearwater clay is in the Clearwater-Wyandotte-Thiefriver soil association.

stocking rates combined with the harvesting of excess forage maximizes pasture use. Deferred grazing is needed to maintain stands of legumes and warm-season grasses. It is also needed to reduce soil compaction and damage to growing plants when the soils are wet.

Yields Per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 6. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The 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 6 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the 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."

Windbreaks and Environmental Plantings

Windbreaks are an effective method of reducing soil blowing in Pennington County. Many soils have surface textures, such as sand, loamy fine sand, and fine sandy loam, that erode easily. Clay, loam, and silt loam are less affected by wind action, but unless properly managed and protected all soils are subject to blowing. The nearly level topography of Pennington County also contributes to wind erosion.

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 plantings at northern and western field borders at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, hold snow on the fields, and provide food and cover for wildlife.

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

Table 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

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.

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

Wildlife Habitat

George Pollard, biologist, Soil Conservation Service, and Terry Wolfe, wildlife manager, Minnesota Department of Natural Resources, assisted in the preparation of this section.

The conditions of wildlife habitat are related to soil, climate, and land use. Because farming is the major land use of Pennington County, wildlife habitat is mainly limited to the hardwood forested beach ridges and marshes, the scattered hardwood forests on the interbeach areas, and the organic soils in the eastern part of the county.

The soils of the beach ridges are nearly level to gently rolling, and some areas of these soils are marshland. Waterfowl and furbearers live mostly around the larger marshes, and deer and moose mainly inhabit the wooded beach ridges and scattered hardwood forests.

The soils of the interbeach areas are nearly level. Scattered hardwood forests support ruffed grouse, squirrels, sharp-tailed grouse, Hungarian partridge, red fox, and small numbers of deer and moose.

The wetter organic soils in the eastern part of Pennington County support waterfowl, furbearers, and small populations of deer and moose. Limited vegetative material for nesting and feeding is available to waterfowl on the soils in farm use.

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.

Many of the soils in Pennington County are rated "good" for potential development of wetland wildlife, but development of these soils for wetland wildlife habitat is limited because of the extensive network of drainage ditches throughout the county. In addition, the emphasis on agriculture as the major land use in the county greatly restricts the quality and quantity of the land that can be used to develop habitat for wetland wildlife.

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

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

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, wheatgrass, 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 soil reaction. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, prairie sandreed, leadplant, prairie-clover, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, browse, 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, poplar, plum, apple, cranberry, dogwood, and sumac. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, honeysuckle, caragana, 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, soil reaction, available water capacity, and wetness. Few conifers are native. Most of these trees are planted. Examples of coniferous plants are spruce, cedar, and juniper.

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

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

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

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include Hungarian partridge, dove, sharp-tailed grouse, meadowlark, field sparrow, jackrabbit, 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, ruffed grouse, woodcock, thrushes, woodpeckers, snowshoe hare, squirrels, gray fox, raccoon, deer, moose, and bear.

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

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. 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, 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, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and 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 or to a cemented pan, 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 or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

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

Sanitary Facilities

Table 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 or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

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

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 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 or to a cemented pan, 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, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

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

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation 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 or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

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

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

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

Construction Materials

Table 12 gives information about the soils as a source of roadfill, sand, gravel, and topsoil (fig. 10). 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

Figure 10.—Area of Lohnes soil that was excavated for sand and gravel. The Lohnes soil before excavation is in the background. This area has been excavated to a depth of 8 to 10 feet.

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; embankments, dikes, and levees; and aquifer-fed ponds. 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.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

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

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

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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.

This publication does not contain engineering test data, but some tests were made by the Minnesota State Department of Transportation. Data from these tests were considered in estimating the engineering index properties in table 14.

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 earthmoving operations.

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

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

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

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

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In table 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 (*6*). 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. The first letter is for drained areas, and the second is for undrained areas.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. 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, artesian, or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 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.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

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 (*8*). 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 Aquoll (*Aqu*, meaning water, 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 Haplaquolls (*Hapl*, meaning minimal horizonation, plus *aquoll*, the suborder of the Mollisols that have an aquic moisture regime).

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

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

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 (*8*). 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."

Augsburg Series

The Augsburg series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in calcareous, lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Augsburg soils are similar to Wheatville soils and commonly adjacent to Borup, Glyndon, Rosewood, Thiefriver, and Wheatville soils. Borup and Glyndon soils are silty through a depth of 40 inches. Borup soils are slightly higher on the landscape than Augsburg soils.

Rosewood soils are sandy throughout, and Thiefriver soils are sandy above the clayey 2C horizon. Glyndon, Rosewood, and Thiefriver soils are in positions on the landscape similar to those of Augsburg soils. Wheatville soils are slightly better drained than Augsburg soils and are higher on the landscape.

Typical pedon of Augsburg loam, 2,200 feet south and 600 feet west of the NE corner of sec. 1, T. 152 N., R. 44 W.

Ap—0 to 8 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine granular structure; very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

A—8 to 13 inches; very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure; very friable; slight effervescence; moderately alkaline; clear wavy boundary.

Ck—13 to 19 inches; grayish brown (2.5Y 5/2) loam; weak thin platy structure; very friable; violent effervescence; moderately alkaline; clear smooth boundary.

Cg1—19 to 28 inches; light brownish gray (2.5Y 6/2) very fine sandy loam; many medium and coarse distinct yellowish brown (10YR 5/6) mottles; single grain; loose; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg2—28 to 36 inches; light brownish gray (2.5Y 6/2) very fine sandy loam; many medium and coarse distinct yellowish brown (10YR 5/6) mottles; single grain; loose; slight effervescence; moderately alkaline; abrupt smooth boundary.

2C—36 to 60 inches; dark gray (5Y 4/1) clay; common medium distinct light olive brown (2.5Y 5/4) and few fine faint dark olive gray (5Y 3/2) mottles; weak fine angular blocky structure; firm; slight effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 16 inches. Depth to the 2C horizon ranges from 20 to 40 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1, or it is neutral and has value of 2 or 3. It is loam, silt loam, or very fine sandy loam.

The matrix of the Ck horizon has hue of 10YR through 5Y, value of 4 or 5, and chroma of 1 or 2. The Ck horizon is loam, very fine sandy loam, silt loam, or loamy very fine sand. The matrix of the Cg horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 through 3. The Cg horizon is loamy very fine sand, very fine sandy loam, silt loam, or very fine sand. Mottles are faint or distinct. The matrix of the 2C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2. The upper part commonly has lower value. The 2C horizon is silty clay, silty clay loam, or clay. Mottles are distinct or prominent. Reaction is mildly alkaline or moderately alkaline.

Boash Series

The Boash series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in lacustrine sediment. Permeability is slow in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Boash soils are similar to Clearwater soils and commonly adjacent to Reiner Variant, Reiner, Roliss, and Smiley soils. Clearwater soils are clayey throughout. Reiner Variant and Reiner soils have argillic horizons. They are better drained and are slightly higher on the landscape than Boash soils. Roliss and Smiley soils formed in loamy glacial till and are in positions on the landscape similar to those of Boash soils.

Typical pedon of Boash clay loam, 120 feet west and 240 feet north of the SE corner of sec. 5, T. 153 N., R. 43 W.

Ap—0 to 7 inches; black (N 2/0) clay loam; black (10YR 2/1) dry; weak medium subangular blocky structure; friable; common very fine and fine roots; mildly alkaline; abrupt smooth boundary.

Bg—7 to 10 inches; dark gray (5Y 4/1) clay; common medium faint dark olive gray (5Y 3/2) mottles; moderate medium subangular blocky structure; firm; few very fine roots; mildly alkaline; clear smooth boundary.

Cg1—10 to 13 inches; dark gray (5Y 4/1) clay; moderate medium angular blocky structure parting to moderate fine subangular blocky; firm; few very fine roots; slight effervescence; moderately alkaline; clear smooth boundary.

Cg2—13 to 27 inches; olive gray (5Y 4/2) clay; moderate medium angular blocky structure parting to moderate fine subangular blocky; firm; strong effervescence; moderately alkaline; abrupt wavy boundary.

2Cg3—27 to 34 inches; grayish brown (2.5Y 5/2) loam; common medium distinct light olive brown (2.5Y 5/4) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; common medium irregular soft lime filaments and threads; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.

2Cg4—34 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/4) and common fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; few fine irregular soft lime filaments and threads; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The mollic epipedon is 7 to 12 inches thick. The thickness of the solum ranges from 7 to 18 inches.

The A horizon has hue of 10YR and chroma of 1 or 2, or it is neutral and has value of 2. It is clay, silty clay, silty clay loam, or clay loam.

The B horizon has hue of 2.5Y or 5Y, value of 3 or 4, and chroma of 1 or 2. It is clay or silty clay.

The C horizon has value of 4 or 5 and chroma of 1 or 2. It is clay, silty clay, or silty clay loam. Common fine and medium mottles are in some pedons. The 2C horizon has value of 4 through 6 and chroma of 1 or 2. It is loam or clay loam and has common fine and medium mottles.

Borup Series

The Borup series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid. Slopes range from 0 to 2 percent.

Borup soils are similar to Glyndon soils and commonly adjacent to Augsburg, Glyndon, and Rosewood soils. Augsburg soils have a clayey 2C horizon. Glyndon soils are better drained than Borup soils and are slightly higher on the landscape. Rosewood soils formed in sandy sediment. Augsburg and Rosewood soils are in positions on the landscape similar to those of Borup soils.

Typical pedon of Borup loam, 1,650 feet south and 75 feet east of the NW corner of sec. 31, T. 153 N., R. 43 W.

Ap—0 to 8 inches; black (10YR 2/1) loam; very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak fine granular; very friable; common very fine and fine roots; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ak—8 to 15 inches; very dark gray (10YR 3/1) loam; gray (10YR 5/1) dry; weak fine granular structure; very friable; few very fine and fine roots; violent effervescence; moderately alkaline; clear smooth boundary.

Ck—15 to 18 inches; light brownish gray (2.5Y 6/2) very fine sandy loam; few fine distinct olive yellow (2.5Y 6/6) mottles; weak very fine granular structure; very friable; violent effervescence; moderately alkaline; clear wavy boundary.

Cg1—18 to 23 inches; light olive gray (5Y 6/2) very fine sandy loam; many coarse distinct light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6) mottles; weak very fine granular structure; very friable; strong effervescence; mildly alkaline; gradual wavy boundary.

Cg2—23 to 30 inches; light olive gray (5Y 5/2) loamy very fine sand; many coarse distinct olive yellow (2.5Y 6/6 and 2.5Y 6/8) mottles; weak very fine granular structure parting to single grain; very friable; strong effervescence; mildly alkaline; gradual wavy boundary.

C—30 to 60 inches; stratified light brownish gray (2.5Y 6/2) loamy fine sand and very fine sand with thin strata of dark grayish brown (2.5Y 4/2) fine sand; common medium distinct light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6) mottles; single grain; loose; slight effervescence; mildly alkaline.

The mollic epipedon is 7 to 16 inches thick. The upper boundary of the calcic horizon is within 16 inches of the surface.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam, silt loam, or very fine sandy loam.

The C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2. It is very fine sandy loam, loamy very fine sand, or loam but ranges to silt loam in the upper part of the C horizon and to very fine sand in the lower part.

Cathro Series

The Cathro series consists of very poorly drained soils in closed bog depressions. These soils formed in highly decomposed organic material underlain by glacial till. Permeability is moderately rapid in the organic soil and moderate in the underlying material. Slopes range from 0 to 1 percent.

Cathro soils are similar to Hamre and Markey soils and commonly adjacent to Hamre, Markey, and Seelyeville soils. Hamre soils have a layer of organic material less than 16 inches thick. They are around the periphery of bogs. Markey soils are underlain by sandy sediment. Seelyeville soils are decomposed organic material throughout. Markey and Seelyeville soils are in positions on the landscape similar to those of Cathro soils.

Typical pedon of Cathro muck, 1,600 feet east and 1,500 feet north of the center of sec. 2, T. 152 N., R. 39 W.

Oa1—0 to 16 inches; very dark brown (10YR 2/2) on broken face and black (10YR 2/1) rubbed sapric material; 30 to 40 percent fibers, about 15 percent rubbed; weak very fine to medium granular structure; very friable; many fine roots; mostly herbaceous fibers; neutral; clear smooth boundary.

Oa2—16 to 36 inches; black (10YR 2/1) broken face and rubbed sapric material; 20 to 30 percent fiber, about 10 percent rubbed; massive; nonsticky; few fine roots; primarily herbaceous fibers; neutral; clear smooth boundary.

2Ab—36 to 42 inches; black (10YR 2/1) mucky silt loam; weak medium subangular blocky structure parting to weak fine granular; friable; neutral; abrupt smooth boundary.

2Cg—42 to 60 inches; light brownish gray (2.5Y 6/2) loam; common medium distinct pale olive (5Y 6/4) and grayish brown (10YR 5/2) mottles; weak fine and medium subangular blocky structure; sticky; slight effervescence; mildly alkaline.

The depth to mineral material ranges from 16 to 50 inches. Fibers are dominantly herbaceous, but thin layers of woody fiber may be present.

The organic material has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. The surface tier is sapric or hemic material (muck, peaty muck, or mucky peat). In the subsurface tier, sapric material makes up more than 50 percent of the organic material, but combined with hemic material it may make up to as much as 10 inches of the horizon. The organic material has an unrubbed fiber content of less than 50 percent. The rubbed fiber content is usually less than 20 percent in the surface tier and less than 16 percent in the subsurface tier.

The 2Ab horizon may be absent in some pedons. The 2C horizon has hue of 10YR, 2.5Y, and 5Y, value of 4 through 6, and chroma of 1 or 2. It is sandy loam, loam, silt loam, or clay loam. Free carbonates may be absent in the 2C horizon in some pedons.

Chilgren Series

The Chilgren series consists of poorly drained, moderately permeable soils in plane or slightly concave basins on glacial lake plains. These soils formed in glacial till. Slopes range from 0 to 2 percent.

Chilgren soils are similar to Garnes and Smiley soils and commonly adjacent to Garnes, Hamre, and Kratka soils. Hamre soils are in adjacent bogs. Garnes soils are better drained than Chilgren soils, and they are higher on the landscape. Kratka soils have a 20- to 40-inch sandy mantle over loamy glacial till. They are in positions on the landscape similar to those of Chilgren soils. Smiley soils have a darker surface layer.

Typical pedon of Chilgren loam, 1,500 feet south and 700 feet east of the NW corner of sec. 26, T. 152 N., R. 39 W.

A—0 to 4 inches; very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) dry; weak fine and medium granular structure; very friable; many very fine and fine and few medium roots; slightly acid; abrupt smooth boundary.

E—4 to 10 inches; grayish brown (10YR 5/2) fine sandy loam; light brownish gray (10YR 6/2) dry; few medium faint pale brown (10YR 6/3) mottles; weak moderately thick platy structure parting to weak fine granular; very friable; common very fine and fine roots; about 8 percent coarse fragments; slightly acid; clear smooth boundary.

Btg—10 to 18 inches; dark grayish brown (2.5Y 4/2) clay loam; common fine faint light olive brown (2.5Y 5/4) and common fine distinct yellowish brown (10YR 5/6) mottles; moderate medium prismatic structure parting to moderate fine and medium subangular blocky; firm; common thin continuous very dark grayish brown (10YR 3/2) clay films on faces of peds; common very fine and fine and few medium roots; about 5 percent coarse fragments; slightly acid; abrupt smooth boundary.

Cg1—18 to 29 inches; olive gray (5Y 5/2) clay loam; common fine distinct light brownish gray (2.5Y 6/2) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; few very fine and fine roots; common irregular soft lime filaments and threads; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.

Cg2—29 to 60 inches; olive gray (5Y 5/2) loam; few fine prominent yellowish brown (10YR 5/6) and common medium faint light olive gray (5Y 6/2) and many medium distinct light olive brown (2.5Y 5/4) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; few fine prominent dark brown (7.5YR 4/4) iron concretions; about 5 percent coarse fragments; slight effervescence; moderately alkaline.

The solum ranges from 12 to 24 inches in thickness. Coarse fragments of gravel size range from 0 to 10 percent throughout the profile.

The A horizon is 1 to 5 inches thick. It has value of 2 or 3 and chroma of 1 or 2. The A or Ap horizon is loam or fine sandy loam.

The E horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 or 2. It is loamy fine sand, fine sandy loam, or loam.

The Btg horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 1 or 2. It is loam, sandy clay loam, or clay loam.

The C horizon has matrix hue of 2.5Y or 5Y, value of 5 through 6, and chroma of 2 or 3. It is clay loam, loam, or fine sandy loam. A Ck horizon of clay loam is in some pedons.

Clearwater Series

The Clearwater series consists of poorly drained, slowly permeable soils in plane or slightly concave basins on glacial lake plains. These soils formed in glacial till or lacustrine sediment. Slopes range from 0 to 2 percent.

Clearwater soils are commonly adjacent to Augsburg, Espelie, Hilaire, and Thiefriver soils. Augsburg soils have a coarse silty mantle over clayey underlying material, and Espelie and Thiefriver soils have a sandy mantle over clayey underlying material. All of these soils are in positions on the landscape similar to those of Clearwater soils. Hilaire soils also have a sandy mantle over clayey underlying material. They are better drained than Clearwater soils and are higher on the landscape.

Typical pedon of Clearwater clay, 1,750 feet east and 325 feet north of the SW corner of sec. 24, T. 152 N., R. 45 W.

Ap—0 to 8 inches; black (N 2/0) clay; black (N 2/0) dry; moderate very fine granular structure; firm; about 5 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

Bg—8 to 16 inches; dark grayish brown (2.5Y 4/2) clay; few fine distinct light olive brown (2.5Y 5/6) mottles; moderate fine angular blocky structure; firm; about 5 percent coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

Ck—16 to 35 inches; grayish brown (2.5Y 5/2) clay; few fine faint light olive brown (2.5Y 5/4) mottles; moderate very fine angular blocky structure; firm; about 3 percent coarse fragments; few masses or threads of segregated lime; strong effervescence; moderately alkaline; clear smooth boundary.

Cg—35 to 60 inches; olive gray (5Y 4/2) clay; common fine distinct light olive brown (2.5Y 5/4) and common medium distinct olive yellow (2.5Y 6/6) mottles; massive; very firm; strong effervescence; moderately alkaline.

The mollic epipedon is 7 to 11 inches thick. The solum ranges from 12 to 24 inches in thickness. Coarse fragments of gravel size range from 0 to 5 percent throughout the solum.

The A horizon has hue of 10YR, value of 2, and chroma of 1 or 2, or it is neutral and has value of 2. It is silty clay, silty clay loam, clay, clay loam, loam, or fine sandy loam.

The Bg horizon has hue of 2.5Y or 5Y, value of 3 or 4, and chroma of 1 or 2. It is clay or silty clay.

The C horizon has common fine and medium mottles. It is clay, silty clay, or silty clay loam.

Deerwood Series

The Deerwood series consists of very poorly drained soils in closed depressions or slightly concave, narrow drainageways on glacial lake plains. These soils formed in highly decomposed sapric material underlain by lacustrine sediment. Permeability is moderately rapid in the organic material and rapid in the underlying material. Slopes range from 0 to 1 percent.

Deerwood soils are similar to Hamre and Markey soils and commonly adjacent to Lohnes, Markey, and Kratka soils. Hamre soils are underlain by loamy glacial till. Markey soils have a layer of organic soil material that is thicker than that of Deerwood soils. Lohnes soils have a mollic epipedon. They are better drained and have more gravel than Deerwood soils. Kratka soils have a 20- to 40-inch sandy mantle overlying loamy glacial till. Markey soils are in positions on the landscape similar to those of Deerwood soils. Lohnes soils are higher on the landscape, and Kratka soils are slightly higher on the landscape.

Typical pedon of Deerwood muck, 2,530 feet south and 925 feet west of the NE corner of sec. 17, T. 154 N., R. 39 W.

Oa1—0 to 9 inches; black (10YR 2/1) broken face and rubbed sapric material; weak very fine granular structure; very friable; many very fine and common medium roots; mostly herbaceous fiber; slightly acid; clear smooth boundary.

2Ab—9 to 14 inches; black (N 2/0) mucky fine sandy loam; weak fine and medium subangular blocky structure; friable; common very fine and fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

2Cg1—14 to 20 inches; light olive gray (5Y 6/2) loamy sand; common medium distinct light yellowish brown (2.5Y 6/4) mottles; weak fine and medium granular structure parting to single grain; friable; strong effervescence; moderately alkaline; clear wavy boundary.

2Cg2—20 to 31 inches; light brownish gray (2.5Y 6/2) loamy fine sand; common coarse distinct olive (5Y 5/3) and common medium prominent dark yellowish brown (10YR 4/6) mottles; single grain; loose; slight effervescence; mildly alkaline; gradual wavy boundary.

2Cg3—31 to 60 inches; light brownish gray (2.5Y 6/2) loamy fine sand; common coarse distinct light yellowish brown (2.5Y 6/4) and few medium prominent light olive brown (2.5Y 5/6) mottles; single grain; loose; slight effervescence; mildly alkaline.

The O horizon is typically sapric material but may be stratified with hemic material. The O horizon, rubbed, has hue of 5YR through 10YR, value of 2 or 3, and chroma of 1 or 2. Fiber is typically herbaceous but may be partly woody.

The 2Ab horizon has hue of 10YR through 5Y, value of 2 or 3, and chroma of 1, or it is neutral and has value of 2. It is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, loamy fine sand, or fine sandy loam.

The 2C horizon has hue of 2.5Y or 5Y, value of 4 through 7, and chroma of 1 or 2. It is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand.

Eckvoll Series

The Eckvoll series consists of moderately well drained soils on convex rises on glacial lake plains. These soils formed in lacustrine or aeolian sediment and glacial till. Permeability is moderately rapid in the sediment on the upper part of the soils and moderate in the underlying material. Slopes range from 0 to 3 percent.

Eckvoll soils are similar to Linveldt soils and commonly adjacent to Linveldt, Kratka, and Reiner soils. Linveldt soils have a coarse-loamy argillic horizon. Kratka soils are poorly drained. Reiner soils are loamy throughout. Linveldt and Reiner soils are in positions on the landscape similar to those of Eckvoll soils, and Kratka soils are lower on the landscape.

Typical pedon of Eckvoll loamy sand, 1,520 feet west and 230 feet north of the SE corner of sec. 4, T. 153 N., R. 41 W.

Ap—0 to 9 inches; black (10YR 2/1) loamy sand; dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; very friable; common very fine and fine roots; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

E1—9 to 17 inches; brown (10YR 4/3) fine sand; brown (10YR 5/3) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; single grain; loose; few very fine and fine roots; about 2 percent coarse fragments; medium acid; clear wavy boundary.

E2—17 to 25 inches; dark brown (10YR 3/3) fine sand; brown (10YR 4/3) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; single grain; loose; few very fine and fine roots; about 2 percent coarse fragments; slightly acid; neutral; clear wavy boundary.

2Bt—25 to 32 inches; brown (10YR 4/3) sandy clay loam; common medium distinct dark grayish brown (2.5Y 4/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak medium angular blocky structure parting to weak fine subangular blocky; friable; common thin continuous very dark gray (10YR 3/1) clay films on faces of peds and in pores; about 5 percent coarse fragments; slightly acid; clear wavy boundary.

2C1—32 to 50 inches; grayish brown (2.5Y 5/2) loam; common medium distinct yellowish brown (10YR 5/6) and few fine distinct yellowish brown (10YR 5/8) mottles; moderate medium angular blocky structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline; gradual wavy boundary.

2C2—50 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/6) and common medium prominent yellowish brown (10YR 5/8) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline.

The thickness of the solum and depth to free carbonates range from 20 to 40 inches. The thickness of the sandy mantle ranges from 16 to 36 inches. Coarse fragments are sometimes absent in the upper part of the profile, and a gravelly lag line, at the place of contact between the two kinds of sediment, is in some pedons. The sediment in the lower part of the profile is 0 to 10 percent gravel size coarse fragments.

The A or Ap horizon has value of 2 or 3 and chroma of 1 through 3. It is loamy fine sand or loamy sand.

The E horizon has value of 4 through 6 and chroma of 2 through 4. It is fine sand, sand, or loamy sand.

The 2Bt horizon has hue of 10YR or 2.5Y, value of 3 through 6, and chroma of 2 through 4. It is sandy clay loam, loam, and clay loam.

The 2C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 through 4. It is loam, clay loam, or silt loam.

Espelie Series

The Espelie series consists of poorly drained soils in concave swales on remnant glacial lake beaches and bars of glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Espelie soils are commonly adjacent to Clearwater, Grimstad Variant, Hilaire, Thiefriver, and Wyandotte soils. Hilaire and Grimstad Variant soils are better drained than Espelie soils and are higher on the landscape. Thiefriver and Wyandotte soils have a calcic horizon beginning within a depth of 16 inches, and, in addition, Wyandotte soils have gravelly strata. Clearwater soils are clayey throughout. Thiefriver, Wyandotte, and Clearwater soils are in positions on the landscape similar to those of Espelie soils.

Typical pedon of Espelie fine sandy loam, 100 feet north and 1,700 feet east of the SW corner of sec. 18, T. 152 N., R. 44 W.

Ap—0 to 9 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine granular structure; very friable; about 3 percent coarse fragments; neutral; abrupt smooth boundary.

Bg—9 to 13 inches; dark grayish brown (10YR 4/2) loamy fine sand; common medium distinct dark yellowish brown (10YR 4/6) mottles; weak fine granular stucture; very friable; about 2 percent coarse fragments; neutral; clear wavy boundary.

Cg1—13 to 24 inches; grayish brown (2.5Y 5/2) fine sand; common medium distinct light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6) and few fine faint gray (10YR 6/1) mottles; single grain; loose; about 3 percent coarse fragments; neutral; clear smooth boundary.

2Cg2—24 to 37 inches; dark gray (5Y 4/1) clay; common fine distinct light olive brown (2.5Y 5/4 and 2.5Y 5/6) mottles; moderate medium prismatic structure parting to moderate medium angular blocky; firm; about 5 percent coarse fragments;

slight effervescence; mildly alkaline; abrupt wavy boundary.

2Cg3—37 to 60 inches; gray (5Y 5/1) clay; common fine distinct olive (5Y 5/4 and 5Y 6/4) mottles; moderate coarse prismatic structure parting to medium angular blocky; firm; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 14 inches. Coarse fragments of gravel size range from 2 to 5 percent. Depth to the clayey material ranges from 20 to 40 inches. A gravelly lag line as much as 6 inches thick may be at the base of the sandy material.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is typically fine sandy loam but ranges to sandy loam.

The B horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 or 2. It is loamy fine sand, fine sand, loamy sand, or sand. Mottles are distinct or prominent.

The C horizon is fine sand, sand, loamy fine sand, or loamy sand. It has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. The 2C horizon has hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 or 2. The 2C horizon is typically clay or silty clay but ranges to silty clay loam.

Flaming Series

The Flaming series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Slopes range from 0 to 3 percent.

Flaming soils are similar to Poppleton soils and commonly adjacent to Foldahl, Grimstad, Hamar, Kratka, Lohnes, Rosewood, and Ulen soils. Foldahl and Grimstad soils have loamy IIC horizons. They are in positions on the landscape similar to those of Flaming soils. Hamar, Kratka, and Rosewood soils are lower on the landscape and wetter. Lohnes soils have more gravel. They are higher on the landscape and better drained. Poppleton soils have a thinner, lighter colored surface layer. Ulen soils have a calcic horizon. They are slightly lower on the landscape than Flaming soils.

Typical pedon of Flaming loamy fine sand, 1,140 feet east and 190 feet north of the SW corner of sec. 14, T. 153 N., R. 44 W.

Ap—0 to 7 inches; black (10YR 2/1) loamy fine sand; very dark gray (10YR 3/1) dry; weak medium granular structure; very friable; few very fine and fine roots; neutral; abrupt smooth boundary.

A—7 to 13 inches; black (10YR 2/1) loamy fine sand; very dark gray (10YR 3/1) dry; weak medium granular structure; very friable; neutral; few very fine roots; clear smooth boundary.

BA—13 to 16 inches; very dark grayish brown (10YR 3/2) loamy fine sand; dark grayish brown (10YR 4/2) dry; weak fine granular structure; very friable; neutral; clear smooth boundary.

Bw—16 to 23 inches; brown (10YR 4/3) fine sand; very fine and fine granular structure; very friable; neutral; clear smooth boundary.

C1—23 to 32 inches; grayish brown (2.5Y 5/2) fine sand; common medium distinct olive yellow (2.5Y 6/6) and few fine faint light brownish gray (2.5Y 6/2) mottles; single grain; loose; neutral; clear wavy boundary.

C2—32 to 39 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct light yellowish brown (2.5Y 6/4) and olive yellow (2.5Y 6/6) and few fine prominent strong brown (7.5YR 5/6) mottles; single grain; loose; neutral; clear wavy boundary.

C3—39 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct light yellowish brown (2.5Y 6/4) and olive yellow (2.5Y 6/6) mottles; single grain; loose; slight effervescence; mildly alkaline.

The thickness of mollic epipedon ranges from 10 to 16 inches. Depth to free carbonates ranges from 30 to 60 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2.

The B horizon has hue of 10YR in the upper part and 10YR or 2.5Y in the lower part, value of 3 through 5, and chroma of 2 through 4. The value of 3 is in the upper part only. The B horizon is typically fine sand or loamy fine sand.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 through 3. It is fine sand or sand. Mottles that have chroma of 2 or less or a matrix that has chroma of 2 or less is within a depth of 40 inches.

Foldahl Series

The Foldahl series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Foldahl soils are similar to Foxhome and Hilaire soils and commonly adjacent to Flaming, Grimstad, Kratka, and Rockwell soils. Flaming soils are sandy throughout. Foxhome soils have more gravel. Hilaire soils have fine textured material within 40 inches of the surface. Flaming, Hilaire, and Grimstad soils are in positions on the landscape similar to those of Foldahl soils. Kratka and Rockwell soils are poorly drained and are lower on the landscape than Foldahl soils.

Typical pedon of Foldahl fine sandy loam, 450 feet west and 200 feet south of the NE corner of sec. 36, T. 153 N., R. 45 W.

Ap—0 to 9 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine granular structure; very friable; few very fine and fine roots; neutral; abrupt smooth boundary.

BA—9 to 18 inches; very dark grayish brown (10YR 3/2) fine sand; single grain; loose; neutral; gradual smooth boundary.

Bw—18 to 24 inches; yellowish brown (10YR 5/4) fine sand; few medium faint yellowish brown (10YR 5/6) and many medium faint dark yellowish brown (10YR 4/4) mottles; single grain; loose; neutral; abrupt smooth boundary.

2C1—24 to 28 inches; light brownish gray (2.5Y 6/2) loam; few fine faint light gray (2.5Y 7/2) and few fine distinct strong brown (7.5YR 5/8) mottles; weak coarse prismatic structure parting to weak very fine subangular blocky; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline; gradual wavy boundary.

2C2—28 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium distinct olive brown (2.5Y 4/4) and yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak very fine subangular blocky; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline.

The thickness of the mollic epipedon ranges from 7 to 18 inches. The thickness of the sandy sediment ranges from 20 to 40 inches. A thin gravelly layer may be below the sandy sediment. The glacial till is 5 to 20 percent coarse fragments. Mottles that have chroma of 2 or less are within a depth of 40 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is fine sandy loam, sandy loam, or loamy fine sand.

The B horizon has value of 3 or 4 and chroma of 2 through 4. It is sand, loamy sand, fine sand, or loamy fine sand.

The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 4. Mottles may be absent in some pedons. The C horizon is sand, loamy sand, fine sand, or loamy fine sand. The 2C horizon has hue of 2.5Y or 10YR, value of 5 through 7, and chroma of 2 through 4. It is loam, silt loam, or clay loam.

Foxhome Sèries

The Foxhome series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Foxhome soils are similar to Foldahl soils and commonly adjacent to Mavie and Roliss soils. Foldahl soils have fewer coarse fragments than Foxhome soils. Mavie soils have a calcic horizon beginning within a depth of 16 inches. Roliss soils are loamy throughout. Both Mavie and Roliss soils are lower on the landscape and wetter than Foxhome soils.

Typical pedon of Foxhome sandy loam, 650 feet west and 100 feet south of the NE corner of sec. 28, T. 154 N., R. 44 W.

Ap—0 to 5 inches; black (10YR 2/1) sandy loam; very dark gray (10YR 3/1) dry; weak moderate subangular blocky structure parting to weak fine and medium granular; friable; common very fine and fine roots; about 5 percent coarse fragments; neutral; abrupt smooth boundary.

A—5 to 11 inches; black (10YR 2/1) sandy loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine granular; friable; common very fine and fine roots; about 5 percent coarse fragments; neutral; abrupt wavy boundary.

Bw—11 to 19 inches; dark brown (10YR 4/3) loamy sand; weak fine and medium subangular blocky structure parting to single grain; very friable; few very fine and fine roots; about 15 percent coarse fragments; neutral; clear wavy boundary.

2C1—19 to 29 inches; light olive brown (2.5Y 5/4) very gravelly coarse sand; common medium distinct grayish brown (2.5Y 5/2) and few fine prominent yellowish brown (10YR 5/6) mottles; single grain; loose; about 55 percent coarse fragments; slight effervescence; mildly alkaline; abrupt wavy boundary.

3C2—29 to 36 inches; grayish brown (2.5Y 5/2) clay loam; common medium distinct light olive brown (2.5Y 5/4) and common fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; common fine irregular lime filaments and threads; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

3C3—36 to 60 inches; grayish brown (2.5Y 5/2) clay loam; common medium distinct light olive brown (2.5Y 5/4) and common fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 10 to 14 inches. Gravel-size coarse fragments occur throughout the profile. The A and B horizons are less than 15 percent; the 2C horizon is 35 to 75 percent; and the 3C horizons are less than 15 percent.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is sandy loam or loam.

The B horizon has hue of 10YR, value of 3 or 4, and chroma of 2 or 3. It is loamy sand, sandy loam, or loam. The lower part of the B horizon is gravelly loamy sand or gravelly sand in some pedons.

The 2C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 or 4. The 3C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 or 3. It is loam, clay loam, or silt loam. Mottles that have chroma of 2 or less or a matrix that has chroma of 2 or less or mottles of higher chroma are within a depth of 40 inches.

Garnes Series

The Garnes series consists of moderately well drained, moderately permeable soils on slightly convex rises on glacial lake plains. These soils formed in glacial till. Slopes range from 0 to 3 percent.

Garnes soils are similar to Reiner soils and commonly adjacent to Chilgren and Kratka soils. Chilgren soils are lower on the landscape and wetter than Garnes soils. Kratka soils have a 20- to 40-inch sandy mantle underlain with loam till. They also are lower on the landscape and wetter than Garnes soils. Reiner soils have a mollic epipedon.

Typical pedon of Garnes fine sandy loam, 2,200 feet south and 700 feet east of the NW corner of sec. 13, T. 153 N., R. 41 W.

Ap—0 to 5 inches; very dark grayish brown (10YR 3/2) fine sandy loam; gray (10YR 6/1) dry; weak fine granular structure; very friable; common very fine and fine roots; neutral; abrupt smooth boundary.

E—5 to 11 inches; grayish brown (10YR 5/2) loamy fine sand; few fine distinct yellowish brown (10YR 5/4) mottles; weak thin platy structure; very friable; common very fine and fine roots; slightly acid; abrupt wavy boundary.

Bt1—11 to 15 inches; dark brown (10YR 3/3) clay loam; moderate medium angular blocky structure parting to moderate fine subangular blocky; firm; common thin very dark grayish brown (10YR 3/2) clay films on faces of peds; about 5 percent coarse fragments; neutral; gradual wavy boundary.

Bt2—15 to 20 inches; brown (10YR 4/3) clay loam; few fine faint dark grayish brown (10YR 4/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak moderate angular blocky structure parting to weak fine subangular blocky; firm; common thin very dark grayish brown (10YR 3/2) clay films on faces of peds; about 5 percent coarse fragments; neutral; clear wavy boundary.

C1—20 to 26 inches; grayish brown (2.5Y 5/2) loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak fine and medium subangular blocky structure; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

C2—26 to 43 inches; grayish brown (2.5Y 5/2) loam; common fine distinct yellowish brown (10YR 5/6) and common fine faint gray (10YR 5/1) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

C3—43 to 60 inches; light olive brown (2.5Y 5/4) loam; common medium distinct yellowish brown (10YR 5/6) and gray (10YR 6/1) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 10 to 20 inches. Coarse fragments of gravel size range from 0 to 5 percent throughout.

An A horizon, as much as 3 inches thick, is in uncultivated areas. The Ap horizon has value of 3 or 4 and chroma of 1 or 2. The A or Ap horizon is loam, fine sandy loam, or sandy loam.

The E horizon has value of 4 through 6 and chroma of 1 or 2. It is loamy sand, loamy fine sand, sandy loam, fine sandy loam, or loam. The E horizon interfingers into the Bt horizon in some pedons.

The B horizon has value of 3 or 4 in the upper part and 4 in the lower part and chroma of 3 in the upper part and 2 or 3 in the lower part. Mottles that have chroma of 2 or less are in the lower part of the B horizon or are within 10 inches of the top of the B horizon. The B horizon is loam, sandy clay loam, or clay loam. It has common to many, thin to moderately thick clay films on faces of peds.

The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 4. It is loam, fine sandy loam, or sandy loam.

Glyndon Series

The Glyndon series consists of moderately well drained soils on slightly convex rises in glacial lake basins and on plains. These soils formed in lacustrine sediment. Permeability is moderately rapid. Slopes range from 0 to 2 percent.

Glyndon soils are similar to Borup soils and commonly adjacent to Augsburg, Borup, Rosewood, Ulen, and Wheatville soils. Borup and Rosewood soils are poorly drained, and, in addition, Rosewood soils are sandy. Augsburg and Wheatville soils are underlain by clay within 40 inches of the surface. Borup, Rosewood, and Augsburg soils are lower on the landscape than Glyndon soils. Ulen soils are sandy. They are in positions on the landscape similar to those of Glyndon soils.

Typical pedon of Glyndon loam, 150 feet west and 20 feet south of the NE corner of sec. 36, T. 153 N., R. 44 W.

Ap—0 to 8 inches; black (10YR 2/1) loam; weak medium granular structure; friable; few medium roots; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—8 to 14 inches; dark gray (10YR 4/1) loam; weak very fine subangular blocky structure; friable; few fine roots; violent effervescence; moderately alkaline; clear wavy boundary.

Ck2—14 to 22 inches; pale brown (10YR 6/3) loam; few fine faint light yellowish brown (2.5Y 6/4) mottles; weak very fine subangular blocky structure; very friable; few fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

C1—22 to 28 inches; light yellowish brown (2.5Y 6/4) silt loam; common fine distinct yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) and olive yellow (2.5Y 6/6) mottles; weak very fine subangular blocky structure; very friable; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—28 to 33 inches; light brownish gray (2.5Y 6/2) very fine sandy loam; many fine distinct yellowish brown (10YR 5/6), light gray (10YR 7/2), and light yellowish brown (2.5Y 6/4) mottles; weak very fine subangular blocky structure; very friable; strong effervescence; moderately alkaline; gradual smooth boundary.

C3—33 to 60 inches; light brownish gray (2.5Y 6/2) loamy fine sand; many medium prominent dark brown to brown (7.5YR 4/4), strong brown (7.5YR 5/6), and yellowish brown (10YR 5/6) mottles; single grain; loose; slight effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 14 inches. The calcic horizon begins within 16 inches of the surface.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is very fine sandy loam, loam, or silt loam.

The Ck horizon has hue of 10YR, value of 4 through 6, and chroma of 1 or 2; or it has hue of 2.5Y, value 4 through 6, and chroma 2 or 3. It is very fine sandy loam, loam, or silt loam. Mottles are absent in some pedons. The rest of the C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 3 or 4 in the upper part and 2 through 4 in the lower part. It is very fine sand, loamy very fine sand, very fine sandy loam, or silt loam. Mottles occur in all or part of the C horizon.

Grimstad Series

The Grimstad series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Grimstad soils are similar to Foldahl soils and commonly adjacent to Foldahl, Rockwell, Roliss, and Ulen soils. Foldahl soils do not have a calcic horizon beginning within 16 inches of the surface. Rockwell and Roliss soils are poorly drained. Ulen soils are sandy throughout. Foldahl and Ulen soils are in positions on the landscape similar to those of Grimstad soils. Rockwell and Roliss soils are lower on the landscape and wetter.

Typical pedon of Grimstad fine sandy loam, 2,420 feet south and 140 feet east of the NW corner of sec. 12, T. 152 N., R. 45 W.

Ap—0 to 6 inches; black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; very friable; common very fine and fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

A—6 to 9 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak moderate subangular blocky structure parting to weak fine granular; very friable; common very fine and fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

Ck1—9 to 13 inches; dark grayish brown (10YR 4/2) loamy fine sand; weak fine and medium subangular blocky structure parting to single grain; loose; few very fine roots; violent effervescence; moderately alkaline; clear smooth boundary.

Ck2—13 to 17 inches; grayish brown (10YR 5/2) loamy fine sand; single grain; loose; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

C1—17 to 24 inches; grayish brown (2.5Y 5/2) fine sand; common medium faint light olive brown (2.5Y 5/4) mottles; single grain; loose; strong effervescence; mildly alkaline; clear wavy boundary.

C2—24 to 31 inches; light olive brown (2.5Y 5/4) fine sand; common medium faint grayish brown (2.5Y 5/2) mottles; single grain; loose; strong effervescence; mildly alkaline; abrupt wavy boundary.

2C3—31 to 37 inches; grayish brown (2.5Y 5/2) loam; common medium faint light olive brown (2.5Y 5/4) and light brownish gray (2.5Y 6/2) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; common medium irregular soft lime filaments and threads; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear smooth boundary.

2C4—37 to 60 inches; grayish brown (2.5Y 5/2) loam; few medium faint light olive brown (2.5Y 5/4) and light brownish gray (2.5Y 6/2) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; few medium irregular soft lime filaments and threads; about 5 percent coarse fragments; strong effervescence; mildly alkaline.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is typically fine sandy loam or sandy loam but may be loamy fine sand.

The Ck horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 through 3. It is typically loamy sand or loamy fine sand, but the upper part may be sandy loam or fine sandy loam. The rest of the C horizon that overlies the 2C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 4. It is sand, fine sand, loamy sand, or loamy fine sand. The 2C horizon has value of 5 or 6 and chroma of 2 through 4. It is loam, silt loam, or clay loam. Coarse fragments of gravel size range from 2 to 10 percent.

Grimstad Variant

The Grimstad Variant consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Grimstad Variant soils are similar to Thiefriver soils and commonly adjacent to Clearwater, Espelie, Hilaire, Thiefriver, and Ulen soils. Clearwater, Espelie, and Thiefriver soils are poorly drained, and, in addition, Clearwater soils are clayey throughout. These soils are lower on the landscape than Grimstad Variant soils. Hilaire soils do not have a calcic horizon. Ulen soils are sandy throughout. Hilaire and Ulen soils are in positions on the landscape similar to those of Grimstad Variant soils.

Typical pedon of Grimstad Variant fine sandy loam, 1,250 feet north and 950 feet west of the SE corner of sec. 12, T. 152 N., R. 45 W.

Ap—0 to 13 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine granular structure; very friable; common very fine and fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—13 to 21 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak fine granular structure; very friable; few very fine and fine roots; violent effervescence; moderately alkaline; clear smooth boundary.

Ck2—21 to 23 inches; dark grayish brown (10YR 4/2) loamy fine sand; weak fine subangular blocky structure; very friable; violent effervescence; moderately alkaline; clear smooth boundary.

C1—23 to 34 inches; light olive brown (2.5Y 5/4) fine sand; common medium faint light brownish gray (2.5Y 6/2) and few fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; slight effervescence; mildly alkaline; abrupt smooth boundary.

2C2—34 to 60 inches; grayish brown (2.5Y 5/2) clay; many medium faint light olive brown (2.5Y 5/4) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium angular blocky; firm; strong effervescence; mildly alkaline.

The thickness of the sandy mantle ranges from 20 to 40 inches. The thickness of the mollic epipedon ranges from 8 to 14 inches. The thickness of the calcic horizon ranges from 6 to 12 inches. A gravelly layer less than 3 inches thick may overlie the 2C horizon. Distinct or prominent mottles are absent at a depth of less than 20 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is dominantly fine sandy loam, but the range includes loamy fine sand or sandy loam. Reaction is mildly alkaline or moderately alkaline.

The Ck horizon has hue of 10YR or 2.5Y, value of 3 through 5, and chroma of 1 through 3. It is loamy fine sand, loamy sand, sandy loam, or fine sandy loam. The rest of the C horizon that overlies the 2C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 through 4. It is dominantly fine sand or sand but ranges to loamy sand or loamy fine sand. Reaction is mildly alkaline or moderately alkaline. The 2C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is silty clay loam, silty clay, or clay.

Hamar Series

The Hamar series consists of poorly drained soils in slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid. Slopes range from 0 to 2 percent.

Hamar soils are similar to Kratka and Rosewood soils and commonly adjacent to Poppleton, Kratka, and Rosewood soils. Poppleton soils are better drained than Hamar soils and are higher on the landscape. Kratka soils are underlain by loam within a depth of 20 to 40 inches. Rosewood soils have a calcic horizon beginning within 16 inches of the surface. Kratka and Rosewood soils are in positions on the landscape similar to those of Hamar soils.

Typical pedon of Hamar loamy fine sand, 1,300 feet north and 200 feet west of the center of sec. 34, T. 153 N., R. 44 W.

Ap—0 to 8 inches; very dark gray (10YR 3/1) loamy fine sand; dark gray (10YR 4/1) dry; weak fine granular structure; very friable; few very fine and fine roots; neutral; abrupt smooth boundary.

A—8 to 14 inches; very dark grayish brown (10YR 3/2) loamy fine sand; dark grayish brown (10YR 4/2) dry; single grain; loose; few very fine roots; neutral; clear smooth boundary.

Cg1—14 to 24 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; few fine distinct dark brown (10YR 4/3) mottles; single grain; loose; mildly alkaline; clear wavy boundary.
Cg2—24 to 31 inches; brown (10YR 5/3) fine sand; many medium distinct yellowish brown (10YR 5/8) mottles; single grain; loose; slight effervescence; mildly alkaline; clear wavy boundary.
Cg3—31 to 39 inches; grayish brown (2.5Y 5/2) fine sand; few fine distinct brownish yellow (10YR 6/6) mottles; single grain; loose; slight effervescence; mildly alkaline; clear wavy boundary.
Cg4—39 to 60 inches; grayish brown (2.5Y 5/2) fine sand; few coarse prominent yellowish red (5YR 4/8) and common medium distinct yellowish brown (10YR 5/6) mottles; single grain; loose; slight effervescence; mildly alkaline.

The thickness of the mollic epipedon ranges from 10 to 20 inches. Depth to free carbonates ranges from 22 to 30 inches.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is loamy fine sand, loamy sand, sandy loam, or fine sandy loam. Distinct or prominent mottles are in the lower part of the A horizon in some pedons. An AC horizon is in some pedons.

The C horizon has hue of 2.5Y, 10YR, or 5Y, value of 3 through 5, and chroma of 1 through 4. It is fine sand, loamy fine sand, or loamy sand.

Hamerly Series

The Hamerly series consists of moderately well drained soils on slightly convex rises on glacial lake plains. These soils formed in loamy glacial till. Permeability is moderate. Slopes range from 0 to 2 percent.

Hamerly soils are similar to Vallers soils and commonly adjacent to Kittson, Roliss, and Vallers soils. Kittson soils are better drained than Hamerly soils and are slightly higher on the landscape. Neither Kittson nor Roliss soils have a calcic horizon beginning within a depth of 16 inches of the surface. Roliss and Vallers soils are poorly drained. Both soils are lower on the landscape than Hamerly soils, and, in addition, Roliss soils are wetter.

Typical pedon of Hamerly loam, 350 feet east and 450 feet north of the SW corner of sec. 35, T. 154 N., R. 45 W.

Ap—0 to 8 inches; black (10YR 2/1) loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; friable; about 5 percent coarse fragments; common very fine and fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.
Ck1—8 to 14 inches; grayish brown (2.5Y 5/2) clay loam; weak fine and medium subangular blocky structure parting to weak fine granular; friable; about 5 percent coarse fragments; common very fine and fine roots; violent effervescence; moderately alkaline; clear smooth boundary.
Ck2—14 to 23 inches; light brownish gray (2.5Y 6/2) clay loam; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; violent effervescence; moderately alkaline; clear wavy boundary.
C1—23 to 29 inches; olive (5Y 5/3) clay loam; few fine prominent light olive brown (2.5Y 5/6) and common medium faint light olive gray (5Y 6/2) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.
C2—29 to 45 inches; pale olive (5Y 6/3) loam; common medium distinct grayish brown (2.5Y 5/2) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.
C3—45 to 60 inches; olive gray (5Y 5/2) clay loam; common medium faint pale olive (5Y 6/3) mottles; weak coarse prismatic structure parting to weak moderately thick platy; about 2 percent coarse fragments; friable; slight effervescence; mildly alkaline.

Coarse fragments of gravel size range from 1 to 10 percent by volume.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is loam, silt loam, or clay loam. The A horizon may not have free carbonates in some pedons.

The C horizon has hue of 10YR through 5Y, value of 4 through 6, and chroma of 1 through 4. It is loam or clay loam. The Ck horizon is faintly mottled in some pedons.

Hamre Series

The Hamre series consists of very poorly drained soils in closed depressions or slightly concave, narrow drainageways on glacial lake plains. These soils formed in highly decomposed sapric material underlain by glacial till. Permeability is moderate. Slopes range from 0 to 1 percent.

Hamre soils are similar to Cathro and Deerwood soils and commonly adjacent to Cathro, Chilgren, Roliss, and Smiley soils. Cathro soils have a thicker surface layer of organic material than Hamre soils. Deerwood soils are underlain with sandy sediment. Cathro and Deerwood soils are in positions on the landscape similar to those of Hamre soils. Chilgren, Roliss, and Smiley soils are better drained than Hamre soils. They are on slightly higher knobs and along the edges of bogs.

Typical pedon of Hamre muck, 2,400 feet south and 100 feet east of the NW corner of sec. 8, T. 152 N., R. 39 W.

Oa—0 to 13 inches; black (10YR 2/1) rubbed and broken face sapric material; about 10 percent unrubbed fibers and less than 5 percent rubbed; weak fine granular structure; very friable; many fine and medium roots; medium acid; clear smooth boundary.

2A—13 to 18 inches; black (10YR 2/1) loam; very dark gray (10YR 3/1) dry; common fine faint dark gray (10YR 4/1) mottles; weak fine subangular blocky structure; friable; many fine and medium roots; common reddish brown (5YR 4/4) organic stains along root channels; neutral; clear smooth boundary.

2Cg1—18 to 35 inches; grayish brown (2.5Y 5/2) clay loam; common medium distinct light olive brown (2.5Y 5/4) mottles; weak very fine subangular blocky structure; friable; few fine roots; few reddish brown (5YR 4/4) organic stains along root channels; strong effervescence; mildly alkaline; gradual wavy boundary.

2Cg2—35 to 60 inches; gray (5Y 5/1) loam; many coarse distinct light olive brown (2.5Y 5/6) and few medium prominent brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; very friable; few shale fragments; strong effervescence; mildly alkaline.

The organic layer is 8 to 16 inches of highly decomposed sapric material. Depth to free carbonates ranges from 12 to 25 inches. A few cobblestones and stones are on the surface of the organic material in some areas.

The Oa horizon is typically sapric material, but it may be partly hemic. It has rubbed hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2, or it is neutral and has value of 2 or 3. Fiber is typically herbaceous but may be partly woody.

The 2A horizon has hue of 10YR, 2.5Y, or 5Y, value of 2 or 3, and chroma of 1 or 2. It is loam or silt loam.

The 2C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2, and it has common fine and medium mottles. It is clay loam, loam, or silt loam.

Hilaire Series

The Hilaire series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 3 percent.

Hilaire soils are similar to Grimstad Variant soils and commonly adjacent to Grimstad Variant, Clearwater, Thiefriver, and Wyandotte soils. Grimstad Variant soils have a calcic horizon within 16 inches of the surface. They are slightly higher on the landscape than Hilaire soils. Clearwater, Thiefriver, and Wyandotte soils are poorly drained. They are lower on the landscape and wetter than Hilaire soils.

Typical pedon of Hilaire very fine sandy loam, 190 feet east and 2,540 feet north of the SW corner of sec. 8, T. 153 N., R. 43 W.

Ap—0 to 7 inches; black (10YR 2/1) very fine sandy loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; very friable; common very fine and fine roots; about 2 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

A—7 to 10 inches; black (10YR 2/1) very fine sandy loam; very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak fine granular; very friable; few very fine and fine roots; about 2 percent coarse fragments; neutral; clear smooth boundary.

Bw—10 to 15 inches; dark grayish brown (10YR 4/2) loamy fine sand; weak medium subangular blocky structure; very friable; few very fine and fine roots; about 5 percent coarse fragments; neutral; clear smooth boundary.

C1—15 to 19 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; common medium distinct light olive brown (2.5Y 5/4) mottles; single grain; loose; about 5 percent coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

C2—19 to 29 inches; light olive brown (2.5Y 5/4) fine sand; common medium faint yellowish brown (10YR 5/4) mottles; single grain; loose; about 5 percent coarse fragments; neutral; clear wavy boundary.

C3—29 to 34 inches; grayish brown (2.5Y 5/2) fine sand; common medium distinct light olive brown (2.5Y 5/6) mottles; single grain; loose; about 5 percent coarse fragments; neutral; abrupt wavy boundary.

2C4—34 to 60 inches; olive gray (5Y 4/2) clay; common medium distinct very dark gray (5Y 3/1) and common medium prominent light olive brown (2.5Y 5/4) mottles; weak fine and medium angular blocky structure; firm; common medium irregular soft lime masses and filaments; about 10 percent coarse fragments; slight effervescence; mildly alkaline.

The thickness of the solum ranges from 12 to 28 inches. Depth to free carbonates ranges from 6 to 40 inches. The thickness of the sandy mantle over the clayey underlying material ranges from 20 to 40 inches. A gravelly lag line as much as 6 inches thick may be at the base of the sandy material in some pedons. The solum and C horizons are 2 to 10 percent coarse gravel-size fragments. Mottles that have chroma of 2 or less are within a depth of 40 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loamy sand, loamy fine sand, sandy loam, or fine sandy loam.

The B horizon has value of 3 or 4 and chroma of 2 through 4. It is sand, fine sand, loamy sand, or loamy fine sand.

The C horizon in the sandy sediment has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 through 4. It is sand, fine sand, loamy sand, or loamy fine sand. The 2C horizon has matrix hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2, or it is neutral and has value of 4 or 5. It is clay, silty clay, or silty clay loam.

Karlstad Series

The Karlstad series consists of moderately well drained soils in swales or on remnant glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and very rapid in the underlying material. Slopes range from 0 to 2 percent.

Karlstad soils are similar to Lohnes soils and commonly adjacent to Flaming, Lohnes, and Syrene soils. Flaming soils are sandy and do not have an argillic horizon. They are in positions on the landscape similar to those of Karlstad soils. Syrene soils are poorly drained and are lower on the landscape. Lohnes soils are slightly better drained than Karlstad soils and are higher on the landscape.

Typical pedon of Karlstad sandy loam, 1,000 feet west and 50 feet south of the NE corner of sec. 8, T. 153 N., R. 44 W.

A—0 to 3 inches; very dark brown (10YR 2/2) sandy loam; very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; very friable; very strongly acid; abrupt smooth boundary.

E—3 to 9 inches; grayish brown (10YR 5/2) and brown (10YR 5/3) loamy sand; light brownish gray (10YR 6/2) dry; common fine distinct dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and light brownish gray (10YR 6/2) mottles; weak very fine subangular blocky structure; very friable; very strongly acid; abrupt wavy boundary.

Bt1—9 to 16 inches; dark brown (10YR 4/3) sandy loam; moderate fine subangular blocky structure; friable; common moderately thick very dark grayish brown (10YR 3/2) clay films and common clay bridges between sand grains; about 1 percent coarse fragments; slightly acid; clear smooth boundary.

2Bt2—16 to 19 inches; dark brown (10YR 4/3) gravelly sandy loam; few fine faint grayish brown (10YR 5/2) mottles; moderate fine subangular blocky structure; friable; few moderately thick very dark grayish brown (10YR 3/2) clay films and clay bridges between sand grains; about 16 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

3C1—19 to 26 inches; brown (10YR 5/3) sand; few fine faint yellowish brown (10YR 5/4 and 5/6) mottles; single grain; loose; about 8 percent coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

3C2—26 to 60 inches; light yellowish brown (2.5Y 6/4) and light brownish gray (2.5Y 6/2) gravelly coarse sand; common fine distinct multicolored mottles; single grain; loose; about 30 percent coarse fragments; slight effervescence; moderately alkaline.

The thickness of the solum, depth to free carbonates, and depth to gravelly material ranges from 8 to 20 inches. The content of gravel averages 0 to 5 percent in the A and B horizons; 15 to 80 percent in the 2B horizon; and 0 to 50 percent in the 3C horizon.

The A horizon has value of 2 or 3 and chroma of 1 or 2. The Ap horizon is 5 to 10 inches thick in cultivated pedons. The E horizon has value of 4 to 6 and chroma of 2 or 3. The A and E horizons are loamy sand, sandy loam, or fine sandy loam. Reaction is slightly acid or neutral.

The B and 2B horizons have value of 3 through 5 and chroma of 2 through 4. Mottles that have chroma of 2 or less are in all or part of these horizons. The fine earth fraction is typically coarse sandy loam, sandy loam, or fine sandy loam, but it is sandy clay loam in the subhorizons of some pedons. Reaction is neutral or mildly alkaline. The B horizons have few to common clay films on faces of peds and clay bridges between sand grains. Few to common thin coatings of E material are on the faces of peds in some pedons. The 2B horizon is absent in some pedons.

The 2C horizon has matrix hue of 10YR or 2.5Y, value of 5 through 7, and chroma of 2 through 4. Mottles that have chroma higher than the matrix are in part or all of these horizons. The C horizons typically have strata of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine earth fraction. They range from slightly effervescent through strongly effervescent and are mildly alkaline or moderately alkaline. A slight accumulation of lime is in the upper part of the 3Ck horizon in some pedons. A 2C horizon is in some pedons. The 3C horizon is absent in some pedons.

Kittson Series

The Kittson series consists of moderately well drained soils on slightly concave rises on glacial lake plains. These soils formed in local alluvium over glacial till. Permeability is moderate. Slopes range from 0 to 3 percent.

Kittson soils are similar to Hamerly soils and commonly adjacent to Hamerly, Roliss, and Vallers soils. Roliss and Vallers soils have free lime closer to the surface than Kittson soils. Hamerly soils have calcic horizons beginning within 16 inches of the surface. They are in positions on the landscape similar to those of Kittson soils.

Typical pedon of Kittson sandy clay loam, 200 feet south and 1,400 feet east of the center of sec. 14, T. 154 N., R. 45 W.

Ap—0 to 9 inches; black (10YR 2/1) sandy clay loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine granular; friable; few very fine and fine roots; neutral; clear smooth boundary.

Bw—9 to 17 inches; brown (10YR 4/3) sandy clay loam; weak fine and medium subangular blocky structure; friable; few very fine and fine roots; mildly alkaline; clear smooth boundary.

2C1—17 to 21 inches; brown (10YR 5/3) clay loam; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; strong effervescence; mildly alkaline; clear smooth boundary.

2C2—21 to 30 inches; brown (10YR 5/3) clay loam; few fine prominent yellowish brown (10YR 5/6) and common medium faint grayish brown (10YR 5/2) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; strong effervescence; mildly alkaline; clear wavy boundary.

2C3—30 to 50 inches; grayish brown (10YR 5/2) clay loam; common medium distinct light olive brown (2.5Y 5/4) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; strong effervescence; mildly alkaline; clear wavy boundary.

2C4—50 to 60 inches; grayish brown (2.5Y 5/2) clay loam; few medium prominent yellowish brown (10YR 5/6) and common medium distinct light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; strong effervescence; mildly alkaline.

The thickness of the water-sorted mantle over the glacial till and the depth to free carbonates range from 15 to 30 inches. The thickness of the mollic epipedon ranges from 9 to 16 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is sandy clay loam or loam.

The B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. It is dominantly loam or sandy clay loam, but the lower part of the B horizon may be loamy fine sand or coarser sand. The C horizon has value of 4 through 6 and chroma of 2 through 4. It is loam or clay loam.

Kratka Series

The Kratka series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Kratka soils are similar to Foldahl and Rockwell soils and commonly adjacent to Foldahl, Hamar, Rockwell, Roliss, and Rosewood soils. Rockwell soils have a calcic horizon beginning within a depth of 16 inches. Foldahl soils are moderately well drained. Roliss soils are loamy throughout. Hamar and Rosewood soils are sandy throughout. Rockwell, Roliss, Hamar, and Rosewood soils are in positions on the landscape similar to those of Kratka soils. Foldahl soils are higher on the landscape.

Typical pedon of Kratka fine sandy loam, 1,420 feet north and 250 feet east of the SW corner of sec. 12, T. 154 N., R. 45 W.

Ap—0 to 6 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine granular; friable; few medium and common very fine and fine roots; about 5 percent coarse fragments; neutral; abrupt smooth boundary.

A—6 to 11 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak moderate subangular blocky structure parting to weak fine granular; friable; few fine and common very fine roots; about 5 percent coarse fragments; neutral; clear smooth boundary.

Bg1—11 to 14 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; common medium distinct light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; very friable; few very fine and fine roots; about 5 percent coarse fragments; neutral; clear smooth boundary.

Bg2—14 to 18 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; common medium distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak fine and medium subangular blocky structure; very friable; about 8 percent coarse fragments; neutral; clear wavy boundary.

Cg1—18 to 25 inches; grayish brown (2.5Y 5/2) fine sand; many large distinct light olive brown (2.5Y 5/6) and common medium distinct light brownish gray (2.5Y 6/2) and few medium prominent yellowish brown (10YR 5/6) mottles; single grain; loose; about 10 percent coarse fragments; neutral; abrupt wavy boundary.

2Cg2—25 to 31 inches; olive gray (5Y 5/2) loam; common medium prominent light olive brown (2.5Y 5/4) mottles; weak fine and medium subangular blocky structure; friable; about 5 percent coarse fragments; slight effervescence; mildly alkaline; clear wavy boundary.

2Cg3—31 to 39 inches; olive gray (5Y 5/2) loam; common medium prominent light olive brown (2.5Y 5/4) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear smooth boundary.

2Cg4—39 to 60 inches; olive gray (5Y 5/2) loam; few medium prominent yellowish brown (10YR 5/6) and common medium prominent light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to fine subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; mildly alkaline.

The thickness of the sandy mantle over glacial till or loamy lacustrine sediment ranges from 20 to 40 inches. The thickness of the mollic epipedon ranges from 8 to 18 inches. Coarse, gravel size fragments range from 5 to 10 percent. A gravelly layer as much as 6 inches thick may be at the base of the sandy mantle in some pedons.

The A horizon has value of 2 or 3 and chroma of 1 or 2, or it is neutral. It is loamy sand, loamy fine sand, sandy loam, and fine sandy loam. The lower part of the A horizon is mottled in some pedons.

The B horizon, where present, has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 or 2. It is loamy fine sand, fine sand, loamy sand, or sand. Mottles are distinct or prominent. The C horizon is absent in the upper part of the profile in some pedons. Where present, it has hue of 2.5Y or 10YR, value of 4 through 6, and chroma of 2 through 4. It is fine sand, sand, loamy fine sand, or loamy sand. The 2C horizon has hue of 10YR, 2.5Y, or 5Y, value of 5 or 6, and chroma of 1 through 3. The 2C horizon is loam, clay loam, or silt loam.

Linveldt Series

The Linveldt series consists of moderately well drained soils on slightly convex rises on glacial lake plains. These soils formed in water modified glacial till. Permeability is moderate. Slopes range from 0 to 3 percent.

Linveldt soils are similar to Pelan soils and commonly adjacent to Kratka, Reiner, and Smiley soils. Pelan soils have a loamy-skeletal argillic horizon. Reiner soils are loamy throughout. They are in positions on the landscape similar to those of Linveldt soils. Kratka and Smiley soils are poorly drained, and, in addition, Smiley soils are loamy throughout the profile. Both soils are lower on the landscape than Linveldt soils.

Typical pedon of Linveldt fine sandy loam, 175 feet north and 1,280 feet west of the SE corner of sec. 35, T. 154 N., R. 42 W.

Ap—0 to 10 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; friable; few very fine and fine roots; about 5 percent coarse fragments; neutral; abrupt smooth boundary.

Bt1—10 to 13 inches; dark brown (10YR 4/3) sandy loam; weak medium subangular blocky structure; friable; few very fine roots; few thin dark grayish brown (10YR 4/2) clay films on the faces of peds; about 10 percent coarse fragments; neutral; clear smooth boundary.

Bt2—13 to 19 inches; dark brown to brown (10YR 4/3) loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; common thin dark grayish brown (10YR 4/2) clay films on faces of peds and in pores; about 12 percent coarse fragments; neutral; clear smooth boundary.

C1—19 to 23 inches; yellowish brown (10YR 5/4) sand; few medium distinct grayish brown (2.5Y 5/2) mottles; single grain; loose; about 5 percent coarse fragments; mildly alkaline; clear smooth boundary.

C2—23 to 28 inches; light olive brown (2.5Y 5/4) sand; common medium distinct grayish brown (10YR 5/2) and olive yellow (2.5Y 6/6) mottles; single grain; loose; about 5 percent coarse fragments; mildly alkaline; abrupt wavy boundary.

2C3—28 to 36 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/6) mottles; weak medium angular blocky structure parting to weak fine and medium subangular blocky; friable; many medium distinct light gray (10YR 7/1 and 7/2) masses of segregated lime; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear wavy boundary.

2C4—36 to 60 inches; dark grayish brown (2.5Y 4/2) loam; common medium prominent light olive brown (2.5Y 5/6) mottles; weak medium angular blocky structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; slight effervescence; moderately alkaline.

The solum thickness ranges from 10 to 22 inches. Free carbonates are typically below the Bt horizon but may be present in the lower part of the Bt horizon in some pedons. Depth to the loamy glacial till ranges from 20 to 40 inches. Coarse, gravel size fragments range from 2 to 15 percent.

The Ap or A horizon has value of 2 or 3 and chroma of 1 or 2. It is fine sandy loam, sandy loam, or loamy fine sand. Reaction is neutral or mildly alkaline.

The Bt horizon has value of 3 through 5 and chroma of 3 or 4. It is sandy clay loam, sandy loam, or loam and ranges to loamy sand in the lower part. It has common or many, thin through moderately thick clay films on faces of peds.

The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 4. It is sand, coarse sand, loamy coarse sand, or loamy sand. Reaction is mildly alkaline through moderately alkaline. A thin gravelly layer may be in some pedons. The 2C horizon has hue of 2.5Y or 5Y and value of 5 or 6. It is loam, clay loam, or silt loam. Mottles are distinct or prominent. Reaction is mildly alkaline through moderately alkaline.

Lohnes Series

The Lohnes series consists of well drained or moderately well drained soils on remnant glacial lake ridges on glacial lake plains (fig. 11). These soils formed in lacustrine sediment. Permeability is rapid. Slopes range from 0 to 6 percent.

Lohnes soils are similar to Karlstad soils and commonly adjacent to Flaming, Karlstad, and Syrene soils. Karlstad soils have argillic horizons. Flaming soils have mottles higher in the profile than Lohnes soils. Syrene soils have a calcic horizon with 16 inches of the surface. Karlstad and Flaming soils are slightly lower on the landscape than Lohnes soils. Syrene soils are lower on the landscape.

Typical pedon of Lohnes loamy coarse sand, 0 to 6 percent slopes, 500 feet north and 50 feet west of the center of sec. 9, T. 152 N., R. 44 W.

Ap—0 to 9 inches; black (10YR 2/1) loamy coarse sand; very dark gray (10YR 3/1) dry; weak very fine granular structure; very friable; mildly alkaline; abrupt smooth boundary.

AC—9 to 14 inches; very dark grayish brown (10YR 3/2) loamy coarse sand; single grain; loose; mildly alkaline; clear smooth boundary.

C1—14 to 26 inches; brown (10YR 4/3) coarse sand; single grain; loose; slight effervescence; moderately alkaline; clear smooth boundary.

C2—26 to 34 inches; brown (10YR 4/3) very gravelly sand; single grain; loose; about 55 percent coarse fragments; slight effervescence; moderately alkaline; clear smooth boundary.

C3—34 to 41 inches; brown (10YR 5/3) coarse sand; single grain; loose; mildly alkaline; clear smooth boundary.

C4—41 to 46 inches; brown (10YR 4/3) gravelly coarse sand; single grain; loose; about 20 percent coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

C5—46 to 60 inches; brown (10YR 5/3) coarse sand; few fine faint yellowish brown (10YR 5/6) mottles; single grain; loose; about 10 percent coarse fragments; slight effervescence; mildly alkaline.

The mollic epipedon ranges from 10 to 20 inches in thickness. The A horizon has value of 2 or 3 and chroma of 1. It is loamy sand, loamy coarse sand, coarse sandy loam, or sandy loam.

The C horizon has hue of 10YR or 2.5Y, value of 3 through 5, and chroma of 2 through 4. It is sand, coarse sand, loamy sand, loamy coarse sand, or their gravelly analogs. Coarse, gravel-size fragments range from 0 to 60 percent.

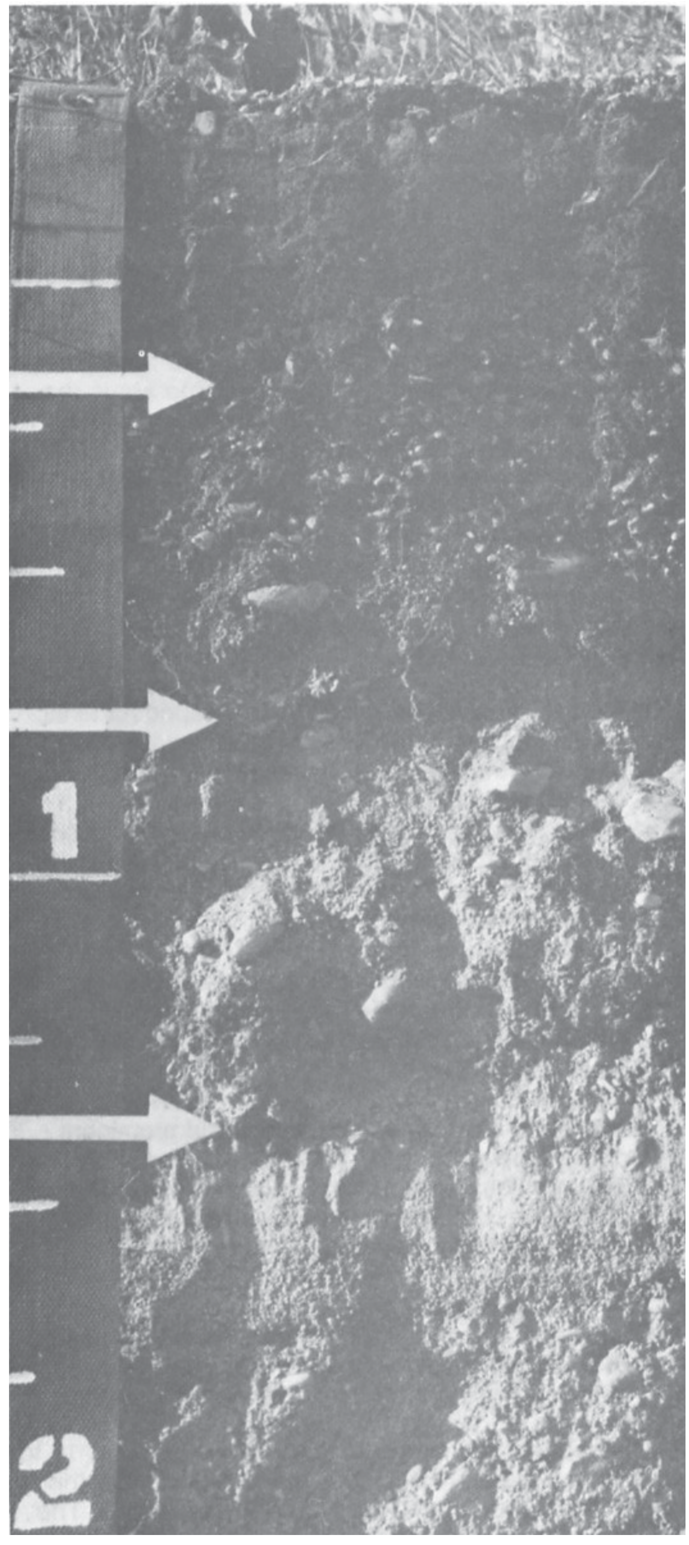

Figure 11.—Profile of Lohnes loamy coarse sand, 0 to 6 percent slopes. The thin surface layer overlies strata of sand and gravel. Lohnes soils make up the majority of the beach ridges in the western part of Pennington County. Depth is marked in feet.

Markey Series

The Markey series consists of very poorly drained soils in closed bog depressions or broad, concave natural drainageways on glacial lake plains. These soils formed in highly decomposed organic material underlain by lacustrine sediment. Permeability is moderately rapid in the organic soil and rapid in the underlying material. Slopes range from 0 to 1 percent.

Markey soils are similar to Cathro and Deerwood soils and commonly adjacent to Deerwood, Rosewood, Seelyeville, and Syrene soils. Cathro soils are underlain with loamy glacial till. Deerwood soils have an organic surface layer less than 16 inches thick and are in the shallower depressions or along the periphery of the deeper bogs. Rosewood and Syrene soils are poorly drained and do not have a histic epipedon. They are along the edges of bogs. Seelyeville soils have organic material more than 50 inches thick. They are in the larger, deeper bogs.

Typical pedon of Markey muck, 400 feet north and 75 feet east of the SW corner of sec. 22, T. 152 N., R. 40 W.

Oa1—0 to 9 inches; black (10YR 2/1) sapric material; very dark brown (10YR 2/2) rubbed; weak fine granular structure; very friable; medium acid; abrupt smooth boundary.

Oa2—9 to 26 inches; black (10YR 2/1) sapric material; very dark brown (10YR 2/2) rubbed; weak very fine and fine granular structure; very friable; medium acid; clear smooth boundary.

2Ab—26 to 32 inches; black (10YR 2/1) fine sandy loam; weak fine subangular blocky structure parting to weak very fine and fine granular; slight effervescence; mildly alkaline; abrupt smooth boundary.

2Cg1—32 to 36 inches; grayish brown (2.5Y 5/2) very fine sandy loam; few fine distinct and prominent olive yellow (2.5Y 6/6) and strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure parting to weak very fine granular; loose; slight effervescence; mildly alkaline; clear smooth boundary.

2Cg2—36 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6) mottles; single grain; loose; slight effervescence; mildly alkaline.

The depth to the sandy 2C horizon ranges from 16 to 50 inches. Fibers are dominantly herbaceous, but thin layers of woody material may be in some pedons. The organic material has hue of 10YR through 5YR, value of 2 or 3, and chroma of 1 or 2. The surface tier is sapric or hemic material, such as muck, peaty muck, or mucky peat, in some pedons. Sapric material makes up more than 50 percent of the material in the subsurface tier, but hemic material may make up a combined thickness of as much as 10 inches in some pedons.

The 2Cg horizons have hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 1 or 2. They are fine sand, sand, or loamy sand.

Mavie Series

The Mavie series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Mavie soils are similar to Rockwell and Wyandotte soils and commonly adjacent to Foxhome, Rockwell, and Roliss soils. Rockwell soils do not have a horizon that is 6 inches or more in thickness and more than 35 percent coarse fragments. Foxhome soils are better drained than Mavie soils and do not have a calcic horizon beginning within a depth of 16 inches. Roliss soils are loamy throughout. Wyandotte soils have clayey 2C horizons. Rockwell and Roliss soils are in positions on the landscape similar to those of Mavie soils. Foxhome soils are higher on the landscape.

Typical pedon of Mavie fine sandy loam, 740 feet east and 160 feet south of the NW corner of sec. 21, T. 154 N., R. 45 W.

Ap—0 to 7 inches; black (N 2/0) fine sandy loam; very dark gray (N 3/0) dry; weak fine and medium subangular blocky structure; friable; few very fine and fine roots; about 5 percent coarse fragments; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ckg—7 to 14 inches; olive gray (5Y 5/2) fine sandy loam; common medium distinct gray (N 6/0) and few medium faint light olive gray (5Y 6/2) mottles; weak fine and medium subangular blocky structure; friable; few very fine roots; about 10 percent coarse fragments; violent effervescence; moderately alkaline; clear smooth boundary.

2Cg1—14 to 21 inches; light brownish gray (2.5Y 6/2) very gravelly sand; common fine distinct light olive brown (2.5Y 5/4) mottles; single grain; loose; about 45 percent coarse fragments; slight effervescence; moderately alkaline; gradual wavy boundary.

2Cg2—21 to 30 inches; grayish brown (2.5Y 5/2) very gravelly coarse sand; common fine distinct light olive brown (2.5Y 5/4) and common fine prominent yellowish brown (10YR 5/6) mottles; single grain; loose; about 55 percent coarse fragments; slight effervescence; moderately alkaline; abrupt wavy boundary.

3Cg3—30 to 60 inches; olive gray (5Y 4/2) loam; common medium distinct grayish brown (2.5Y 5/2) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; common medium prominent dark brown (7.5YR 4/4) iron stains; about 10 percent coarse fragments; slight effervescence; moderately alkaline.

The mollic epipedon ranges from 7 to 16 inches in thickness. The 2C ranges from 6 to 24 inches in thickness. Depth to the 2C horizon ranges from 10 to 24 inches, and depth to the 3C horizon ranges from 20 to 40 inches.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1, or it is neutral and has value of 2 or 3. Coarse, gravel-size fragments range from 0 to 5 percent. The A horizon is fine sandy loam, loam, or sandy clay loam.

The Ck, 2C, and 3C horizons have hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2, or they are neutral and have value of 4 through 6. Distinct or prominent mottles are in the upper part of the Ck horizons. These mottles have chroma of 2. Coarse, gravel-size fragments range from 10 to 60 percent. The Ck horizon has a texture range similar to that of the A horizon. The 2Ck or 2C horizons are coarse sand, sand, loamy coarse sand, or loamy sand in the fine earth fraction. The 3C horizon is loam, silt loam, or clay loam.

Pelan Series

The Pelan series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in water modified glacial till. Permeability is rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 3 percent.

Pelan soils are similar to Foxhome and Linveldt soils and commonly adjacent to Chilgren, Linveldt, Kratka, Reiner, and Smiley soils. Foxhome soils have a mollic epipedon and do not have an argillic horizon. Chilgren and Smiley soils are poorly drained and are loamy throughout. Linveldt soils have less gravel than Pelan soils. Kratka soils have less gravel in the upper part of the sediment. Reiner soils are loamy throughout the profile. Linveldt and Reiner soils are in positions on the landscape similar to those of Pelan soils. Chilgren, Smiley, and Kratka soils are lower on the landscape than Pelan soils.

Typical pedon of Pelan sandy loam, 150 feet west and 450 feet north of the SE corner of sec. 1, T. 152 N., R. 42 W.

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) sandy loam; grayish brown (10YR 5/2) dry; weak coarse subangular blocky structure parting to weak fine and medium granular; friable; many very fine and common medium roots; less than 5 percent coarse fragments; neutral; abrupt smooth boundary.

E—6 to 10 inches; dark brown (10YR 4/3) loamy coarse sand; light brownish gray (10YR 6/2) dry; weak fine and medium subangular blocky structure parting to weak fine granular; friable; many very fine and fine roots; about 12 percent coarse fragments; slightly acid; clear smooth boundary.

Bt—10 to 15 inches; dark brown (10YR 4/3) gravelly sandy clay loam; weak moderate subangular blocky structure; friable; common thin discontinuous very dark grayish brown (10YR 3/2) clay films on faces of peds; common very fine and fine roots; about 35 percent coarse fragments; neutral; clear smooth boundary.

C1—15 to 26 inches; grayish brown (10YR 5/2) gravelly loamy sand, common medium distinct light brownish gray (10YR 6/2) and dark yellowish brown (10YR 4/6) mottles; single grain; loose; few very fine and fine roots; about 45 percent coarse fragments; slight effervescence; mildly alkaline; abrupt wavy boundary.

2C2—26 to 37 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/6) and few medium prominent dark brown (7.5YR 4/4) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

2C3—37 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/6 and 5/4) and few coarse prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; common fine irregular lime filaments and threads; about 5 percent coarse fragments; strong effervescence; mildly alkaline.

The thickness of the solum and depth to free carbonates range from 10 to 24 inches. In the upper part of the sediment the A horizon is 0 to 25 percent coarse fragments, the B horizon is 35 to 65 percent, and the C horizons are 20 to 60 percent. The 2C horizon is 5 to 15 percent content of gravel.

Where present, the Ap or A horizon has value of 2 or 3 and chroma of 1 or 2. The fine earth fraction is loamy sand, loamy fine sand, sandy loam, or fine sandy loam. The E horizon has value of 4 or 5 and chroma of 2 or 3. The fine earth fraction is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand.

The B horizon has value of 3 or 4 and chroma of 2 through 4. The fine earth fraction is coarse sandy loam, sandy loam, or sandy clay loam.

The sediment in the upper part of the C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 4. The fine earth fraction is coarse sand, sand, loamy coarse sand, and loamy sand. The 2C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 or 3. It is sandy loam, fine sandy loam, or loam.

Poppleton Series

The Poppleton series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid. Slopes range from 0 to 2 percent.

Poppleton soils are similar to Flaming soils and commonly adjacent to Foldahl, Hamar, Rosewood, and Ulen soils. Flaming, Foldahl, and Ulen soils have mollic epipedons. They are in positions on the landscape similar to those of Poppleton soils. Foldahl soils have loamy material within 40 inches of the surface. Hamar and Rosewood soils are poorly drained. They are lower on the landscape than Poppleton soils.

Typical pedon of Poppleton fine sand, 700 feet south and 200 feet west of the NE corner of sec. 15, T. 154 N., R. 45 W.

Ap—0 to 7 inches; very dark gray (10YR 3/1) fine sand; dark gray (10YR 4/1) dry; single grain; loose; neutral; abrupt smooth boundary.

A—7 to 9 inches; very dark grayish brown (10YR 3/2) fine sand; dark grayish brown (10YR 4/2) dry; single grain; loose; neutral; clear smooth boundary.

Bw1—9 to 17 inches; brown (10YR 4/3) fine sand; few fine faint dark yellowish brown (10YR 4/4) mottles; single grain; loose; mildly alkaline; clear smooth boundary.

Bw2—17 to 35 inches; dark yellowish brown (10YR 4/4) fine sand; few fine distinct strong brown (7.5YR 5/6) mottles; single grain; loose; neutral; clear wavy boundary.

C1—35 to 55 inches; light brownish gray (10YR 6/2) fine sand; many medium distinct yellowish brown (10YR 5/6) mottles; single grain; loose; mildly alkaline; clear wavy boundary.

C2—55 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct olive yellow (2.5Y 6/6) mottles; single grain; loose; neutral.

The solum thickness ranges from 24 to 36 inches. Depth to free carbonates ranges from 30 to 70 inches. The A horizon is 4 to 10 inches thick.

The A or Ap horizon has value of 2 or 3 and chroma of 1 or 2. It is fine sand, loamy fine sand, sand, or loamy sand. An E horizon is present in some pedons.

The B horizon has value of 4 through 6 and chroma of 3 or 4. It is fine sand or sand.

The C horizon has hue of 10YR or 2.5Y and value of 5 through 7. It is fine sand or sand.

Reiner Series

The Reiner series consists of moderately well drained soils on slightly convex rises on glacial lake plains. These soils formed in glacial till. Permeability is moderate. Slopes range from 0 to 3 percent.

Reiner soils are similar to Garnes and Smiley soils and commonly adjacent to Kratka, Linveldt, Roliss, and Smiley soils. Garnes soils have a lighter colored surface soil than Reiner soils. Linveldt soils have more sand in the subsoil. They are in positions on the landscape similar to those of Reiner soils. Kratka soils have sandy sediment 20 to 40 inches thick. Roliss soils do not have argillic horizons. The poorly drained Smiley soils are in the lower landscape positions.

Typical pedon of Reiner fine sandy loam, 1,050 feet west and 1,250 feet south of the center of sec. 11, T. 153 N., R. 43 W.

Ap—0 to 7 inches; black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) dry; weak medium subangular blocky structure parting to weak fine granular; friable; common very fine and fine roots; about 2 percent coarse fragments; slightly acid; abrupt smooth boundary.

B/E—7 to 9 inches; olive brown (2.5Y 4/3) loam (Bt) and grayish brown (10YR 5/2) silt loam (E); moderate fine medium prismatic structure parting to moderate fine and medium subangular blocky; firm (Bt) and friable (E); common thin discontinuous very dark grayish brown (10YR 3/2) clay films on faces of secondary peds; common very fine and fine roots; about 2 percent coarse fragments; neutral; abrupt wavy boundary.

Bt—9 to 17 inches; olive brown (2.5Y 4/4) clay loam; strong coarse prismatic structure parting to strong fine subangular blocky; firm; many moderately thick continuous very dark grayish brown (10YR 3/2) clay films on faces of peds; many very fine and few fine roots; about 2 percent coarse fragments; mildly alkaline; gradual smooth boundary.

C—17 to 21 inches; brown (10YR 5/3) loam; common medium distinct dark grayish brown (10YR 4/2) and few fine prominent yellowish brown (10YR 5/4) mottles; weak coarse subangular blocky structure parting to moderate very fine subangular blocky; friable; common very fine roots; about 2 percent coarse fragments; slight effervescence; moderately alkaline; gradual smooth boundary.

Ck1—21 to 29 inches; grayish brown (2.5Y 5/2) loam; common fine distinct light olive brown (2.5Y 5/4) and few fine distinct dark grayish brown (2.5Y 4/2) mottles; weak medium subangular blocky structure parting to weak thin platy; friable; few fine irregular soft masses of lime; few very fine and fine roots; about 2 percent coarse fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

Ck2—29 to 35 inches; light olive brown (2.5Y 5/4) loam; few fine prominent yellowish brown (10YR 5/6) and many medium distinct grayish brown (2.5Y 5/2) mottles and coatings on faces of peds; weak coarse prismatic stucture parting to weak medium platy;

friable; common fine irregular lime filaments and threads; few fine roots; about 2 percent coarse fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

Ck3—35 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine prominent yellowish brown (10YR 5/6) and many medium prominent gray (5Y 5/1) mottles and coatings on faces of plates; weak coarse prismatic structure parting to weak thin and moderately thick platy; friable; hard when dry; common fine irregular soft masses of lime; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The solum thickness and depth to free carbonates typically ranges from 13 to 22 inches. The mollic epipedon ranges from 7 to 16 inches in thickness. Coarse fragments of gravel size typically average less than 15 percent in the profile. A layer that is less than 2 inches thick and 25 to 50 percent coarse fragments is at a depth of less than 30 inches in some pedons.

The Ap or A horizon where present has value of 2 or 3 and chroma of 1 or 2. It is loamy fine sand, loam, sandy clay loam, or fine sandy loam. The A horizon is neutral or mildly alkaline.

The BA horizon is absent in some places. The B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4. It is mottled in some pedons. The B horizon typically is clay loam or loam but is sandy clay loam in some parts. Reaction ranges from neutral to mildly alkaline in the lower part.

The C horizon has value of 5 or 6 and chroma of 2 through 4. Mottles are distinct or prominent. The C horizon is loam, clay loam, or fine sandy loam.

Reiner Variant

The Reiner Variant consists of moderately well drained soils on slightly convex rises on glacial lake plains. These soils formed in lacustrine sediment. Permeability is slow in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 3 percent.

Reiner Variant soils are similar to Reiner soils and commonly adjacent to Clearwater, Reiner, and Smiley soils. Clearwater and Smiley soils are poorly drained. They are lower on the landscape than Reiner Variant soils. Reiner soils have less clay in the subsoil than Reiner Variant soils. They are lower on the landscape.

Typical pedon of Reiner Variant sandy clay loam, 2,300 feet west and 1,400 feet north of the SE corner of sec. 9, T. 153 N., R. 43 W.

Ap—0 to 7 inches; very dark gray (10YR 3/1) sandy clay loam; dark gray (10YR 4/1) dry; weak fine granular structure; very friable; neutral; abrupt smooth boundary.

Bt1—7 to 12 inches; dark grayish brown (10YR 4/2) clay; moderate fine and medium prismatic structure parting to moderate fine angular blocky; firm; few fine roots; many moderately thick very dark grayish brown (10YR 3/2) clay films on faces of peds; mildly alkaline; clear smooth boundary.

Bt2—12 to 16 inches; very dark grayish brown (2.5Y 3/2) clay; moderate fine and medium prismatic structure parting to moderate fine subangular blocky; firm; mildly alkaline; clear smooth boundary.

C1—16 to 36 inches; dark gray (5Y 4/1) clay; weak fine prismatic structure parting to weak fine angular blocky; firm; slight effervescence; mildly alkaline; clear wavy boundary.

2C2—36 to 60 inches; grayish brown (2.5Y 5/2) loam; common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky structure; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The solum thickness typically ranges from 12 to 24 inches. The mollic epipedon ranges from 7 to 16 inches in thickness.

The Ap horizon has value of 2 or 3 and chroma of 1 or 2; dry value ranges from 3 to 5. It is typically loam, clay loam, or sandy clay loam. Reaction is neutral or mildly alkaline.

The B horizon has hue of 10YR or 2.5Y, value of 2 through 4, and chroma of 2 or 3. Faint or distinct mottles are in some pedons. The B horizon is clay, silty clay, silty clay loam, or clay loam. Clay films have value of 2 or 3 and chroma of 1 or 2.

The C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2 in the upper part and typically has chroma of 2 in the lower part. Distinct or prominent mottles are in some pedons. The C horizon is clay, silty clay, or silty clay loam. Reaction is mildly alkaline or moderately alkaline.

The 2C horizon has hue of 2.5Y, value of 5 or 6, and chroma of 2 or 3. Mottles are distinct or prominent. The C horizon is silt loam, loam, or clay loam. Reaction is mildly alkaline or moderately alkaline.

Rockwell Series

The Rockwell series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Rockwell soils are similar to Grimstad and Thiefriver soils and commonly adjacent to Grimstad, Roliss, and Rosewood soils. Grimstad soils are better drained than Rockwell soils and are higher on the landscape. Roliss soils are loamy throughout and do not have a calcic horizon beginning within a depth of 16 inches.

Rosewood soils are sandy throughout the profile. Roliss and Rosewood soils are in positions on the landscape similar to those of Rockwell soils. Thiefriver soils have a clayey 2C horizon.

Typical pedon of Rockwell fine sandy loam, 700 feet west and 300 feet south of the NE corner of sec. 32, T. 153 N., R. 45 W.

Ap—0 to 9 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak fine granular structure; friable; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—9 to 17 inches; dark gray (N 4/0) fine sandy loam; weak fine subangular blocky structure; friable; violent effervescence; moderately alkaline; clear smooth boundary.

Ck2—17 to 22 inches; dark grayish brown (2.5Y 4/2) fine sand; few fine faint dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundry.

Cg1—22 to 30 inches; grayish brown (2.5Y 5/2) fine sand; many medium distinct olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) mottles; single grain; loose; about 4 percent coarse fragments; slight effervescence; mildly alkaline; abrupt smooth boundary.

Cg2—30 to 33 inches; light brownish gray (2.5Y 6/2) sand; few medium prominent light olive brown (2.5Y 5/6) mottles; single grain; loose; about 8 percent coarse fragments; slight effervescence; mildly alkaline; abrupt smooth boundary.

2Cg3—33 to 42 inches; light brownish gray (2.5Y 6/2) loam; common medium distinct light olive brown (2.5Y 5/6) mottles; weak fine subangular blocky structure; friable; about 4 percent coarse fragments; strong effervescence; mildly alkaline; clear smooth boundary.

2Cg4—42 to 60 inches; light brownish gray (2.5Y 6/2) loam; few medium prominent yellowish brown (10YR 5/6) and common medium distinct light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 8 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 18 inches. Depth to the loamy 2C horizon ranges from 20 to 40 inches. Coarse fragments in the 2C horizon range from 0 to 8 percent. A thin gravelly layer is at the place of contact of the C and 2C horizons in some pedons.

The A horizon has hue of 10YR or 2.5Y and value of 2 or 3. It is sandy loam, fine sandy loam, or loam. An Ak horizon may be present.

The Ck horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2, or it is neutral and ranges to hue of 10YR and chroma of 1. It is sandy loam, fine sandy loam, fine sand, loamy sand, or loam. The C and 2C horizons have hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. The C horizon is sand, fine sand, loamy sand, or loamy fine sand. The 2C horizon is loam or silt loam, but clay loam is within the range.

Roliss Series

The Roliss series consists of poorly drained and very poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in glacial till. Permeability is moderate. Slopes range from 0 to 2 percent.

Roliss soils are similar to Smiley and Vallers soils and commonly adjacent to Hamerly, Hamre, Kittson, and Vallers soils. Hamerly and Kittson soils are better drained than Roliss soils and are higher on the landscape. Hamre soils are very poorly drained. They have an organic surface layer and are lower on the landscape than Roliss soils. Vallers soils have a calcic horizon, the upper boundary of which is within a depth of 16 inches. Smiley soils have an argillic horizon. Vallers and Smiley soils are in positions on the landscape similar to those of Roliss soils.

Typical pedon of Roliss loam, 150 feet west and 1,300 feet south of the center of sec. 11, T. 153 N., R. 43 W.

Ap—0 to 7 inches; black (N 2/0) loam; weak coarse subangular blocky structure parting to weak fine and medium subangular blocky; friable; about 2 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

Bg—7 to 13 inches; dark gray (5Y 4/1) loam; few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure parting to weak fine and medium subangular blocky; friable; about 2 percent coarse fragments; slight effervescence; mildly alkaline; clear wavy boundary in places; irregular boundary in places.

Cg1—13 to 21 inches; grayish brown (2.5Y 5/2) clay loam; common fine prominent strong brown (7.5YR 5/6) and common medium distinct olive gray (5Y 5/2) mottles; weak fine and medium subangular blocky structure; friable; about 2 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

Cg2—21 to 29 inches; olive gray (5Y 5/2) loam; many medium prominent dark yellowish brown (10YR 4/4) mottles and few fine prominent dark reddish brown (5YR 3/4) coatings around root channels; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 2 percent coarse fragments; slight effervescence; moderately alkaline; gradual wavy boundary.

Cg3—29 to 36 inches; olive gray (5Y 5/2) loam; many medium and coarse prominent dark yellowish brown

(10YR 3/4) mottles; weak coarse prismatic structure parting to weak thick platy; friable; few fine very dark brown (10YR 2/2) coatings around root channels; about 2 percent coarse fragments; slight effervescence; moderately alkaline; clear wavy boundary.

Cg4—36 to 43 inches; olive gray (5Y 5/2) silt loam; many fine prominent reddish brown (5YR 4/4) and common medium distinct dark olive gray (5Y 3/2) mottles; weak fine and medium angular blocky; friable; about 2 percent coarse fragments; slight effervescence; moderately alkaline; clear wavy boundary.

Cg5—43 to 60 inches; olive gray (5Y 5/2) loam; olive gray (5Y 5/2) prism faces and matrix that have many coarse prominent dark yellowish brown (10YR 4/4) mottles; weak very coarse prismatic structure parting to moderate thick platy; friable to firm; few fine prominent very dark gray (10YR 3/1) iron and manganese masses and coatings; about 2 percent coarse fragments; slight effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 18 inches. Coarse fragments of gravel size range from 0 to 10 percent. A gravel layer as much as 5 inches thick may be in or at the base of the B horizon in some pedons.

The A horizon has hue of 10YR or is neutral. An AB horizon as much as 8 inches thick may be in some pedons. Mottles may be present in the A horizon in some pedons. The A horizon is typically loam, sandy clay loam, or clay loam but ranges to fine sandy loam.

The Bg horizon has hue of 2.5Y or 5Y, value of 3 through 5, and chroma of 1 or 2. It has textures similar to those of the A horizon.

The C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 through 4. It is loam, silt loam, or clay loam.

Rosewood Series

The Rosewood series consists of poorly drained and very poorly drained soils in plane or slightly concave basins on remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid over rapid. Slopes range from 0 to 2 percent.

Rosewood soils are similar to Ulen soils and commonly adjacent to Borup, Flaming, Hamar, Rockwell, Thiefriver, and Ulen soils. Borup soils have more silt than Rosewood soils. Flaming and Ulen soils are moderately well drained. Hamar soils do not have a calcic horizon. Rockwell and Thiefriver soils have finer textured 2C horizons than Rosewood soils. Borup, Rockwell, and Thiefriver soils are in positions on the landscape similar to those of Rosewood soils. Flaming and Ulen soils are higher on the landscape than Rosewood soils, and Hamar soils are slightly lower on the landscape than Rosewood soils.

Typical pedon of Rosewood fine sandy loam, 350 feet north and 1,100 feet west of the SE corner of sec. 27, T. 153 N., R. 44 W.

Ap—0 to 8 inches; black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; very friable; few very fine roots; about 2 percent coarse fragments; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—8 to 11 inches; gray (5Y 5/1) fine sandy loam; common medium prominent light brownish gray (2.5Y 6/2) and common medium distinct dark grayish brown (2.5Y 4/2) mottles; weak medium subangular blocky structure; very friable; few very fine roots; about 2 percent coarse fragments; violent effervescence; moderately alkaline; abrupt wavy boundary.

Ck2—11 to 18 inches; grayish brown (2.5Y 5/2) fine sandy loam; few medium distinct light yellowish brown (2.5Y 6/4) mottles; weak fine and medium subangular blocky structure; very friable; about 2 percent coarse fragments; violent effervescence; moderately alkaline; clear smooth boundary.

Cg1—18 to 23 inches; light brownish gray (2.5Y 6/2) fine sand; many medium distinct olive yellow (2.5Y 6/6) mottles; single grain; loose; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear smooth boundary.

Cg2—23 to 47 inches; light gray (2.5Y 7/2) fine sand; common coarse distinct olive yellow (2.5Y 6/6) and yellowish brown (10YR 5/6) mottles; single grain; loose; about 2 percent coarse fragments; strong effervescence; mildly alkaline; clear wavy boundary.

Cg3—47 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; common medium prominent yellowish brown (10YR 5/6) and many coarse distinct olive yellow (2.5Y 6/6) mottles; single grain; loose; about 5 percent coarse fragments; slight effervescence; mildly alkaline.

The mollic epipedon is 8 to 16 inches thick. The thickness of the coarse, loamy sediment is less than 20 inches. Coarse fragments of gravel size range from 2 to 10 percent. Reaction is mildly alkaline or moderately alkaline throughout.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is fine sandy loam, loamy fine sand, or sandy loam.

The Ck horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 or 2. It is fine sandy loam, sandy loam, loamy fine sand, or loamy sand. The lower part of the C horizon is sand, loamy fine sand, loamy sand, and fine sand, and some horizons are coarse sand as much as 6 inches thick. These horizons have hue of

2.5Y or 5Y, value of 4 through 7, and chroma of 2 to 4. Most or all parts of the C horizon are mottled.

Seelyeville Series

The Seelyeville series consists of very poorly drained soils in closed bog depressions or broad, concave natural drainageways on glacial lake plains. These soils formed in highly decomposed organic matter. Permeability is moderate. Slopes range from 0 to 1 percent.

Seelyeville soils are similar to Cathro and Markey soils and commonly adjacent to Cathro, Deerwood, Hamre, and Markey soils. Cathro soils are underlain by loamy material within a depth of 50 inches. Markey soils are underlain by sandy material. Cathro and Markey soils are on the shallower marginal areas of the deeper bogs. Hamre and Deerwood soils have an organic surface layer less than 16 inches thick. They are around the margins of the deep bogs.

Typical pedon of Seelyeville muck, 2,500 feet south and 100 feet east of the NW corner of sec. 14, T. 152 N., R. 39 W.

Oa1—0 to 8 inches; black (10YR 2/1) broken face and rubbed sapric material; about 50 percent fiber, about 2 percent rubbed; weak very fine granular structure; very friable; mostly herbaceous fibers; many fine roots; medium acid; clear smooth boundary.

Oa2—8 to 18 inches; black (10YR 2/1) broken face and rubbed sapric material; about 70 percent fiber, about 8 percent rubbed; weak very fine granular structure; very friable; mostly herbaceous fibers; few fine roots; strongly acid; gradual smooth boundary.

Oa3—18 to 26 inches; black (10YR 2/1) broken face and rubbed sapric material; about 80 percent fiber, 2 percent rubbed; massive; very friable; mostly herbaceous fibers; very strongly acid; gradual smooth boundary.

Oa4—26 to 51 inches; black (10YR 2/1) broken face and black (N 2/0) rubbed sapric material; massive; very friable; mostly herbaceous fibers; very strongly acid; clear wavy boundary.

Oa5—51 to 60 inches; very dark gray (10YR 3/1) broken face and very dark gray (10YR 3/1) rubbed sapric material; massive; friable; mostly herbaceous fibers; very strongly acid.

Mineral material is below a depth of 51 inches. Fibers are dominantly herbaceous, but thin layers of woody fibers may be present.

The organic material has hue of 10YR, 7.5YR or 5YR, value of 2 or 3, and chroma of 1 or 2. After rubbing, the subsurface tier usually has chroma of 1. The surface tier is sapric or hemic material, such as muck, peaty muck, or mucky peat. Sapric material makes up more than 50 percent of the material in the subsurface tier, but hemic material may make up a combined thickness of as much as 10 inches.

Smiley Series

The Smiley series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in glacial till. Permeability is moderate. Slopes range from 0 to 2 percent.

Smiley soils are similar to Chilgren, Reiner, and Roliss soils and commonly adjacent to Kratka, Reiner, and Roliss soils. Chilgren soils have a lighter colored surface soil than Smiley soils. Kratka soils have 20 to 40 inches of sandy sediment. Reiner soils are better drained than Smiley soils. Roliss soils do not have argillic horizons. Chilgren and Kratka soils are in positions on the landscape similar to those of Smiley soils. Reiner soils are higher on the landscape, and Roliss soils are lower on the landscape.

Typical pedon of Smiley sandy clay loam, 1,000 feet south and 400 feet west of the center of sec. 11, T. 153 N., R. 43 W.

Ap—0 to 12 inches; black (10YR 2/1) sandy clay loam; very dark gray (10YR 3/1) dry; weak coarse subangular blocky structure parting to moderate very fine and fine subangular blocky; friable; about 2 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

Btg—12 to 19 inches; olive gray (5Y 4/2) clay loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate fine prismatic structure parting to moderate fine and medium subangular blocky; friable; common thin and medium black (10YR 2/1) clay films on faces of peds; about 5 percent coarse fragments; moderately alkaline; clear wavy boundary.

Cg1—19 to 24 inches; olive gray (5Y 4/2) clay loam; few fine prominent dark yellowish brown (10YR 4/4) mottles; weak medium and coarse subangular blocky structure; friable; few fine irregular soft masses of lime; about 2 percent coarse fragments; strong effervescence; moderately alkaline; clear wavy boundary.

Cg2—24 to 35 inches; olive gray (5Y 4/2) clay loam; few fine prominent dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; common fine irregular soft masses of lime; about 2 percent coarse fragments; strong effervescence; moderately alkaline; clear wavy boundary.

Cg3—35 to 42 inches; olive gray (5Y 5/2) loam; common fine prominent dark yellowish brown (10YR 4/4) mottles; weak very coarse angular blocky structure parting to weak thick platy; friable; few fine irregular soft masses of lime; about 2 percent coarse fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg4—42 to 60 inches; olive gray (5Y 5/2) loam; many medium prominent olive brown (2.5Y 4/4) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak thick platy and weak medium subangular blocky; friable; about 2 percent coarse fragments; strong effervescence; moderately alkaline.

The solum thickness ranges from 10 to 26 inches. The mollic epipedon ranges from 7 to 14 inches in thickness. Coarse fragments of gravel size range from 2 to 10 percent in the solum and C horizon. Layers less than 2 inches thick are in the upper part of the C horizon in some pedons. These layers are as much as 35 percent coarse fragments.

The Ap horizon has value of 2 or 3 and chroma of 1 or 2. It is loam, sandy clay loam, or fine sandy loam. An A horizon is in some pedons.

The B horizon has hue of 2.5Y or 5Y, value of 3 through 5, and chroma of 1 through 3. It is clay loam, sandy clay loam, or loam. Reaction is neutral to moderately alkaline. Clay films have hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2.

The C horizon has hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 or 2. Mottles are common or many distinct or prominent. The C horizon typically is loam but ranges to include clay loam and fine sandy loam. Reaction is mildly alkaline or moderately alkaline.

Strandquist Series

The Strandquist series consists of poorly drained soils in plane or slightly concave swales on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid in the sediment in the upper part of the profile and moderate in the underlying material. Slopes range from 0 to 2 percent.

Strandquist soils are similar to Kratka and Mavie soils and commonly adjacent to Kratka, Mavie, and Roliss soils. Kratka soils have sandy sediment in the upper part of the profile. Mavie soils have a calcic horizon beginning within a depth of 16 inches. Roliss soils are loamy throughout. All of these soils are in positions on the landscape similar to those of Strandquist soils.

Typical pedon of Strandquist sandy clay loam, 1,450 feet east and 300 feet south of the NW corner of sec. 18, T. 153 N., R. 44 W.

Ap—0 to 7 inches; black (10YR 2/1) sandy clay loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; friable; common very fine and fine roots; mildly alkaline; abrupt smooth boundary.

A—7 to 11 inches; black (10YR 2/1) sandy loam; very dark gray (10YR 3/1) dry; weak medium and coarse subangular blocky structure parting to weak fine granular; friable; common very fine and fine roots; slight effervescence; moderately alkaline; clear smooth boundary.

Cg1—11 to 15 inches; dark grayish brown (2.5Y 4/2) very gravelly loamy coarse sand; few medium distinct light olive brown (2.5Y 5/6) mottles; single grain; loose; about 55 percent coarse fragments; slight effervescence; moderately alkaline; clear wavy boundary.

Cg2—15 to 23 inches; grayish brown (2.5Y 5/2) very gravelly coarse sand; common medium distinct light olive brown (2.5Y 5/6) mottles; single grain; loose; about 50 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.

Cg3—23 to 29 inches; light brownish gray (2.5Y 6/2) very gravelly coarse sand; few fine prominent yellowish brown (10YR 5/6) and common medium distinct light olive brown (2.5Y 5/6) mottles; single grain; loose; about 35 percent coarse fragments; strong effervescence; moderately alkaline; abrupt wavy boundary.

2Cg4—29 to 42 inches; olive gray (5Y 5/2) clay loam; common medium prominent yellowish brown (10YR 5/6) and many medium prominent light olive brown (2.5Y 5/6) mottles; weak fine and medium subangular blocky structure; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear smooth boundary.

2Cg5—42 to 60 inches; olive gray (5Y 5/2) clay loam; few medium prominent yellowish brown (10YR 5/6) and common medium prominent light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The upper, water-sorted mantle ranges in thickness from 20 to 40 inches over loamy material. The thickness of the solum ranges from 7 to 16 inches. The average content of gravel in the underlying material ranges from 35 to 75 percent below a depth of 10 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is sandy clay loam, sandy loam, fine sandy loam, or loam. A B horizon as much as 6 inches thick is in some pedons.

The C horizon has hue of 2.5Y, value of 4 to 6, and chroma of 1 or 2. Texture of the fine earth fraction is coarse sand, sand, loamy coarse sand, or loamy sand. The 2C horizon has hue of 2.5Y or 5Y, value of 5 to 6, and chroma of 1 or 2. It is loam, silt loam, or clay loam.

Syrene Series

The Syrene series consists of poorly drained soils in slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid. Slopes range from 0 to 2 percent.

Syrene soils are similar to Rosewood soils and commonly adjacent to Lohnes, Mavie, and Rosewood soils. Rosewood soils are mostly fine sand in the control section and less than 10 percent gravel. Lohnes soils do not have carbonates in the upper part of the profile and are better drained than Syrene soils. Mavie soils have more gravel in the upper mantle and are underlain by loamy material between depths of 20 and 40 inches. Rosewood and Mavie soils are in positions on the landscape similar to those of Syrene soils. Lohnes soils are on the higher beach ridges.

Typical pedon of Syrene fine sandy loam, 175 feet west and 1,700 feet north of the SE corner of sec. 9, T. 152 N., R. 44 W.

A1—0 to 7 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak fine granular; friable; common very fine and fine roots; neutral; clear smooth boundary.

A2—7 to 13 inches; very dark gray (2.5Y 3/1) fine sandy loam; weak medium subangular blocky structure parting to weak fine granular; friable; few very fine roots; strong effervescence; mildly alkaline; clear wavy boundary.

2Ck—13 to 30 inches; light brownish gray (2.5Y 6/2) very gravelly loamy coarse sand; few fine distinct olive yellow (2.5Y 6/6) and common medium distinct light yellowish brown (2.5Y 6/4) mottles; single grain; loose; about 40 percent coarse fragments; violent effervescence; mildly alkaline; clear smooth boundary.

2Cg1—30 to 36 inches; light brownish gray (2.5Y 6/2) loamy fine sand; common medium distinct light yellowish brown (2.5Y 6/4) mottles; single grain; loose; about 5 percent coarse fragments; strong effervescence; mildly alkaline; clear smooth boundary.

2Cg2—36 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; common medium prominent olive yellow (2.5Y 6/6) mottles; single grain; loose; about 5 percent coarse fragments; strong effervescence; mildly alkaline.

The thickness of the mollic epipedon ranges from 8 to 16 inches. The thickness of the loamy upper sediment ranges from 12 to 24 inches. The 2C horizon averages 10 to 35 percent coarse fragments.

The A horizon as hue of 10YR through 5Y, value of 2 or 3, and chroma of 1, or it is neutral and has value of 2 or 3. The A horizon is sandy loam, fine sandy loam, or loam.

A C horizon is in the upper part of the sediment in some pedons. The 2C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. The material making up the 2C horizon is commonly stratified with coarse sand, sand, fine sand, loamy coarse sand, loamy sand, and loamy fine sand in the fine earth fraction.

Thiefriver Series

The Thiefriver series consists of poorly drained soils in slightly concave swales on remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Thiefriver soils are similar to Grimstad Variant and Rockwell soils and commonly adjacent to Clearwater, Espelie, Hilaire, Grimstad Variant, Rosewood, and Wyandotte soils. Clearwater soils are clayey throughout. Espelie and Hilaire soils do not have calcic horizons within 16 inches of the surface. Hilaire and Grimstad Variant soils are better drained than Thiefriver soils and are higher on the landscape. Rosewood soils are sandy throughout. Wyandotte soils have more than 6 inches of gravel above the clayey material. Clearwater, Espelie, Rosewood, and Wyandotte soils are in positions on the landscape similar to those of Thiefriver soils.

Typical pedon of Thiefriver fine sandy loam, 2,500 feet west and 2,000 feet south of the NE corner of sec. 12, T. 153 N., R. 44 W.

Ap—0 to 10 inches; black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) dry; weak medium angular blocky structure; friable; many fine roots; about 2 percent coarse fragments; slight effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—10 to 14 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak medium and fine subangular blocky structure; very friable; common very fine and fine roots; about 2 percent coarse fragments; violent effervescence; moderately alkaline; clear wavy boundary.

Ck2—14 to 18 inches; grayish brown (2.5Y 5/2) fine sandy loam; few fine distinct light olive brown (2.5Y 5/4) mottles; weak fine and medium subangular blocky structure; very friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; clear wavy boundary.

Cg1—18 to 28 inches; light brownish gray (2.5Y 6/2) fine sand; common medium distinct light olive brown (2.5Y 5/4) mottles; single grain; loose; about 5 percent fragments; strong effervescence; moderately alkaline; clear wavy boundary.

Cg2—28 to 33 inches; grayish brown (2.5Y 5/2) very gravelly sand; few fine prominent yellowish brown (10YR 5/6) mottles; single grain; loose; about 45 percent coarse fragments; strong effervescence; moderately alkaline; abrupt wavy boundary.

2Cg3—33 to 52 inches; grayish brown (2.5Y 5/2) clay; few medium faint light olive brown (2.5Y 5/4) and common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; firm; about 5 percent coarse fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg4—52 to 60 inches; grayish brown (2.5Y 5/2) clay; common medium distinct yellowish brown (10YR 5/6) and common medium faint light olive brown (2.5Y 5/4) mottles; weak coarse prismatic structure parting to weak fine subangular blocky; firm; about 5 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the sandy mantle ranges from 20 to 40 inches. The thickness of the mollic epipedon ranges from 8 to 14 inches. The thickness of the calcic horizon ranges from 6 to 12 inches. The gravelly layer above the 2C horizon is absent in some pedons. Reaction is mildly alkaline or moderately alkaline throughout the profile.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is dominantly fine sandy loam but ranges to loam or sandy loam.

The Ck horizon has hue of 10YR or 2.5Y, value of 3 through 5, and chroma of 1 or 2. Coarse fragments of gravel size range from 2 to 10 percent. The Ck horizon is loamy fine sand, sandy loam, or fine sandy loam. The rest of the C horizon above the 2C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 or 2. It is dominantly fine sand or sand but ranges to loamy sand and loamy fine sand. This horizon is 5 to 50 percent coarse fragments of gravel size. Mottles are distinct or prominent. The 2C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. Coarse fragments of gravel size range from 2 to 10 percent. The 2C horizon is silty clay loam, silty clay, or clay.

Ulen Series

The Ulen series consists of moderately well drained soils on slightly convex, remnant glacial lake beaches and bars on glacial lake plains. These soils formed in lacustrine sediment. Permeability is rapid. Slopes range from 0 to 2 percent.

Ulen soils are similar to Flaming and Rosewood soils and commonly adjacent to Flaming, Glyndon, and Grimstad soils. Flaming soils do not have a calcic horizon. Glyndon soils are coarse-silty. Grimstad soils have loamy 2C horizons. Rosewood soils are poorly drained. Flaming, Glyndon, and Grimstad soils are in positions on the landscape similar to those of Ulen soils. Rosewood soils are lower on the landscape.

Typical pedon of Ulen fine sandy loam, 150 feet west and 150 feet north of the SE corner of sec. 21, T. 152 N., R. 45 W.

Ap—0 to 8 inches; black (10YR 2/1) fine sandy loam; weak very fine and fine granular structure; friable; common very fine and fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—8 to 16 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; weak very fine subangular blocky structure; very friable; few very fine and fine roots; violent effervescence; moderately alkaline; gradual wavy boundary.

Ck2—16 to 19 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; weak very fine subangular blocky structure; very friable; strong effervescence; moderately alkaline; clear wavy boundary.

C1—19 to 25 inches; light olive brown (2.5Y 5/4) fine sand; few fine faint light olive brown (2.5Y 5/6) mottles; single grain; loose; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—25 to 29 inches; pale brown (10YR 6/3) very fine sand; common to many medium distinct yellowish brown (10YR 5/6), light olive brown (2.5Y 5/6 and 5/8), and light brownish gray (2.5Y 6/2) mottles; single grain; loose; strong effervescence; moderately alkaline; clear smooth boundary.

Cg—29 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; many medium distinct and prominent strong brown (7.5YR 5/6) and dark brown to brown (7.5YR 4/4) mottles; single grain; loose; few small iron and manganese stains and concretions; slight effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 8 to 14 inches. Depth to loamy fine sand or coarser material is less than 20 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loamy fine sand, loamy sand, fine sandy loam, or sandy loam.

The Ck horizon has hue of 10YR, value of 4 or 5, and chroma of 1 through 3, or it has hue of 2.5YR, value of 4 or 5, and chroma of 2 or 3. It is loamy sand, loamy fine sand, sandy loam, or fine sandy loam. The rest of the C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 through 6. Chroma of 2 is mostly in the lower part. This horizon is very fine sand, fine sand, or loamy fine sand. Sand subhorizons are in some pedons.

Vallers Series

The Vallers series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains. These soils formed in glacial till. Permeability is moderately slow. Slope ranges from 0 to 2 percent.

Vallers soils are similar to Roliss soils and commonly adjacent to Hamerly, Kittson, Mavie, and Roliss soils. Hamerly and Kittson soils are better drained than Vallers soils and are higher on the landscape. Mavie soils have gravelly C horizons. Roliss soils do not have a calcic horizon beginning within a depth of 16 inches. Mavie and Roliss soils are in positions on the landscape similar to those of Vallers soils.

Typical pedon of Vallers loam, 120 feet east and 170 feet south of the NW corner of sec. 13, T. 154 N., R. 45 W.

Ap—0 to 8 inches; black (10YR 2/1) loam; very dark gray (10YR 3/1) dry; weak to moderate fine granular structure; friable; about 2 percent coarse fragments; common fine roots; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ak—8 to 12 inches; very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; about 5 percent coarse fragments; common fine and few medium roots; strong effervescence; moderately alkaline; clear smooth boundary.

Ck1—12 to 20 inches; grayish brown (2.5Y 5/2) clay loam; few fine distinct brown (10YR 5/3) and pale brown (10YR 6/3) mottles; weak very fine subangular blocky structure; friable; about 4 percent coarse fragments; few to common fine roots; violent effervescence; moderately alkaline; gradual wavy boundary.

Ck2—20 to 25 inches; light brownish gray (2.5Y 6/2) clay loam; common fine distinct yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/6) mottles; weak very fine subangular blocky structure; friable; about 8 percent coarse fragments; few fine roots; violent effervescence; moderately alkaline; gradual wavy boundary.

C1—25 to 30 inches; light brownish gray (2.5Y 6/2) loam; many fine distinct yellowish brown (10YR 5/6), light olive brown (2.5Y 5/6), and gray to light gray (10YR 6/1) mottles; weak very fine subangular blocky structure; friable; about 5 percent coarse fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—30 to 60 inches; light brownish gray (2.5Y 6/2) loam; many medium distinct and prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; moderate very fine and fine subangular blocky structure; friable; about 8 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 8 to 16 inches. The upper boundary of the calcic horizon is within a depth of 16 inches. The percentage of coarse fragments in the calcic horizon ranges from 2 to 8, but coarse fragments may be absent in the upper part of this horizon in some pedons.

The A horizon has value of 2 or 3. The lower part may be mottled in some pedons. The A horizon is clay loam, loam, or silt loam.

The Ck horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2. Mottles are absent in some pedons. The Ck horizon is clay loam, silty clay loam, or loam. The C horizon has hue of 2.5Y or 5Y, value of 4 through 7, and chroma of 1 through 3. It is loam or clay loam.

Wheatville Series

The Wheatville series consists of somewhat poorly drained soils on slightly convex rises in glacial lake basins and plains. These soils formed in lacustrine sediment. Permeability is moderately rapid in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Wheatville soils are similar to Augsburg soils and commonly adjacent to Augsburg, Borup, and Glyndon soils. Augsburg and Borup soils are poorly drained. They are lower on the landscape than Wheatville soils. Glyndon soils do not have the clayey underlying material common to Wheatville soils. They are at slight elevations.

Typical pedon of Wheatville loam, 1,750 feet south and 275 feet west of the NE corner of sec. 1, T. 152 N., R. 44 W.

Ap—0 to 7 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; strong effervescence; mildly alkaline; abrupt smooth boundary.

A—7 to 10 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak very fine granular structure; friable; strong effervescence; mildly alkaline; abrupt smooth boundary.

Ck1—10 to 16 inches; gray (10YR 5/1) clay loam; weak very fine granular structure; friable; violent effervescence; mildly alkaline; clear wavy boundary.

Ck2—16 to 21 inches; gray (10YR 5/1) loam; common fine distinct light brownish gray (2.5Y 6/2) mottles; weak very fine granular structure; friable; violent effervescence; mildly alkaline; abrupt wavy boundary.

C1—21 to 27 inches; olive yellow (2.5Y 6/6) very fine sandy loam; few fine faint yellowish brown (10YR 5/6) mottles; weak very fine granular structure; very friable; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—27 to 33 inches; light olive brown (2.5Y 5/6) very fine sandy loam; few fine distinct strong brown (7.5YR 5/8) mottles; weak very fine granular structure; very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

2C3—33 to 44 inches; dark grayish brown (2.5Y 4/2) clay; common medium distinct light brownish gray (2.5Y 6/2) mottles; moderate medium angular blocky structure; firm; strong effervescence; mildly alkaline; gradual wavy boundary.

2C4—44 to 60 inches; dark grayish brown (2.5Y 4/2) clay; common medium distinct light brownish gray

(2.5Y 6/2) and few medium prominent strong brown (7.5YR 5/8) mottles; moderate medium angular blocky structure; firm; strong effervescence; mildly alkaline.

The thickness of the mollic epipedon ranges from 7 to 14 inches. Depth to the 2C horizon ranges from 20 to 40 inches.

The A horizon has value of 2 or 3. It is loam, silt loam, or very fine sandy loam.

The Ck horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 or 2. It is very fine sandy loam, loam, silt loam, or loamy very fine sand. The rest of the C horizon in the upper part of the sediment has hue of 2.5Y or 10YR, value of 5 or 6, and chroma of 3 to 6. It is loamy very fine sand, very fine sandy loam, silt loam, sand, or loam. The 2C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 through 3. It is silty clay, clay, or silty clay loam.

Wyandotte Series

The Wyandotte series consists of poorly drained soils in plane or slightly concave basins on glacial lake plains (fig. 12). These soils formed in lacustrine sediment. Permeability is moderate in the sediment in the upper part of the profile and slow in the underlying material. Slopes range from 0 to 2 percent.

Wyandotte soils are similar to Thiefriver soils and commonly adjacent to Clearwater, Lohnes, Syrene, and Thiefriver soils. Clearwater soils are clayey throughout. Lohnes soils are better drained than Wyandotte soils and do not have a calcic horizon beginning within a depth of 16 inches. Thiefriver soils do not have a horizon that is 6 inches or more in thickness and more than 35 percent coarse fragments. Syrene soils are gravelly throughout. Clearwater, Syrene, and Thiefriver soils are in positions on the landscape similar to those of Wyandotte soils. Lohnes soils are higher on the landscape.

Typical pedon of Wyandotte clay loam, 2,100 feet east and 50 feet south of the NW corner of sec. 13, T. 154 N., R. 44 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam; very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; friable; many very fine and fine roots; about 5 percent coarse fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

Ck—8 to 15 inches; dark gray (10YR 4/1) sandy clay loam; weak fine and medium subangular blocky structure; friable; few very fine and fine roots; about 5 percent coarse fragments; violent effervescence; moderately alkaline; clear wavy boundary.

2C1—15 to 21 inches; dark grayish brown (2.5Y 4/2) very gravelly loamy coarse sand; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; single grain; loose; common very fine and fine roots; about 55 percent coarse fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

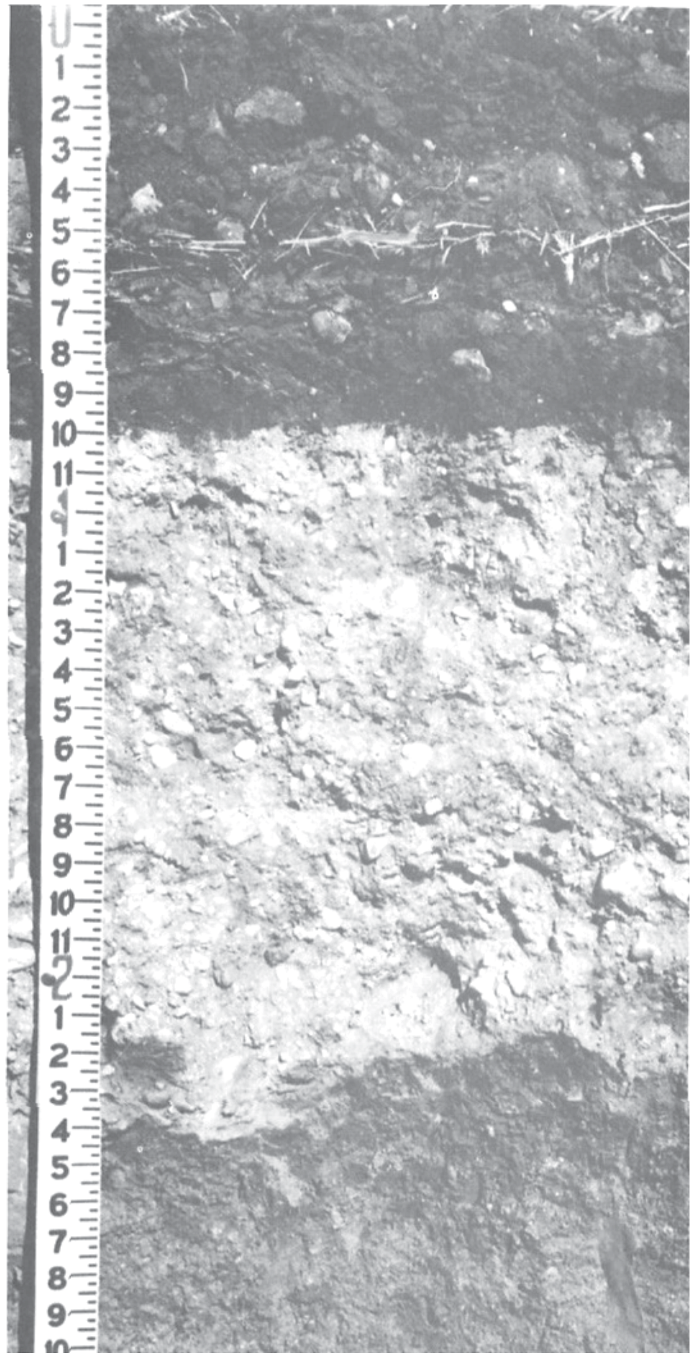

Figure 12.—Profile of Wyandotte clay loam. The gravelly layer between a depth of 10 to about 28 inches has low water holding capacity and limits rooting depth. The clay substratum is below the gravel layer. Although this soil is poorly drained, it may become droughty late in the growing season. Depth is marked in inches.

2C2—21 to 28 inches; grayish brown (2.5Y 5/2) very gravelly loamy coarse sand; few fine distinct gray (10YR 6/1) mottles; single grain; loose; about 45 percent coarse fragments; strong effervescence; mildly alkaline; gradual wavy boundary.

2C3—28 to 34 inches; light brownish gray (2.5Y 6/2) very gravelly loamy coarse sand; few fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; about 60 percent coarse fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

3Cg—34 to 60 inches; olive gray (5Y 4/2) clay; common fine distinct gray (5Y 6/1) and light olive brown (2.5Y 5/6) and brown (7.5YR 4/4) mottles; weak fine and medium angular blocky structure; firm; about 5 percent coarse fragments; few fine irregular soft lime filaments; strong effervescence; moderately alkaline.

The thickness of the mollic epipedon ranges from 7 to 14 inches. Depth to the 3C horizon ranges from 20 to 40 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. Coarse fragments of gravel size range from 2 to 10 percent. The A horizon is fine sandy loam, loam, or sandy clay loam.

The Ck horizon has hue of 10YR through 5Y, value of 4 or 5, and chroma of 1 or 2. Coarse fragments of gravel size range from 2 to 10 percent. The Ck horizon is loam or sandy clay. The 2C horizon has value of 4 through 6 and chroma of 0 through 2. Mottles are distinct or prominent. Coarse fragments of gravel size range from 45 to 70 percent. The 2C horizon is very gravelly loamy sand, very gravelly loamy coarse sand, very gravelly sand, or very gravelly coarse sand. The 3Cg horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 1 or 2. It is clay, silty clay, or clay loam.

Formation of the Soils

This section discusses the factors of soil formation and relates these factors to the soils in the survey area. It also explains the processes of soil formation.

Factors of Soil Formation

Soils formed as a result of the interaction of five factors—parent material, climate, plants and animals, relief, and time. Climate and plants and animals are the active factors of soil genesis. Their effect is conditioned by relief and time as they act on parent material. These factors slowly change the parent material into a natural body that has genetically related horizons. This natural body is known as soil.

Parent Material

The parent material in most of Pennington County was derived from the calcareous, loamy glacial till deposited during the last glaciation. This glacial till was later modified and reworked by Glacial Lake Agassiz, which covered the county after the glacier receded. Loamy glacial till underlies all of the present glacial lake sediment, and it is at or near the surface over much of the county. The differences in the depth of these glacial deposits account for many of the differences in the soils.

The eastern two-thirds of the county is a nearly level glacial plain. The calcareous till is commonly loam and clay loam. Pebbles and small stones are scattered over the surface of the area and throughout the till. Most of the soils are poorly drained. The topography is nearly level, but there are many shallow depressions and narrow drainageways.

The soils in the western one-third of Pennington County formed in material deposited by Glacial Lake Agassiz. Lacustrine sediment of silt and clay was deposited in lake basins, and lacustrine sand was deposited in sandbars, deltas, and interbeach areas. Gently sloping beach ridges and sandbars were formed when Glacial Lake Agassiz receded. These parent materials are commonly sand and loamy sand interspersed with gravel, small stones, and a few boulders on the surface and throughout the sediment.

Climate

Climate has affected the formation of soils in Pennington County. The parent material of these soils originated in a climate that produced continental glaciers. When the climate warmed and the glaciers receded and melted, the area was covered by Glacial Lake Agassiz. Eventually, as the climate stabilized to its present temperatures, the glacial lake drained.

As a soil forming factor, climate affects the physical, chemical, and biological characteristics of the soil. Pennington County has a cool, subhumid climate that has wide variations in temperature from summer to winter. During the long winter, when the soil is frozen to a depth of 3 to 5 feet for 6 months of the year, the soil forming processes are dormant except for the effects of frost action.

The influences of climate on the soil forming processes are most pronounced during the growing season. There is slightly more precipitation in the eastern part of the county than in the western part, and this difference has produced different kinds of native vegetation in the two areas. The soils in the eastern part of Pennington County developed under savanna or forest vegetation, and those in the western part developed under prairie vegetation. The lower rainfall influences the lime content in the soils in the western part of the county. Lower amounts of rainfall result in less effective removal of the soluble and colloidal materials in the upper part of the soil. The dominance of soils that have high lime content in the western part of Pennington County is the result of lower precipitation and lower water tables than in the eastern part.

Plants and Animals

The native vegetation of Pennington County is divided into two types—that which developed under tall grass prairie and that which developed under mixed hardwood forests.

West of the Red Lake and Thief Rivers, the soils developed under tall grass prairie and, in places, wetland reeds and sedges. Big bluestem, little bluestem, Canada wildrye, prairie cordgrass, needleandthread, indiangrass, and porcupinegrass are common kinds of vegetation. In addition, several species of wild flowers grew in the native prairie.

The prairie vegetation produces organic matter, and the bacteria that act upon the decaying plant remains create nitrogen for more vigorous plant growth. This process becomes a nutrient cycle. The organic matter stains the soil surface layer, and the soils become progressively darker as the content of organic matter increases. Soils that contain high amounts of lime at or near the surface, however, become grayish. These soils can be easily seen in cultivated fields.

East of the Red Lake and Thief Rivers and on the beach ridges in the western part of the county, the soils developed under mixed hardwood forests. Bur oak and quaking aspen are examples of this kind of native vegetation.

The hardwood forests aided in stabilizing the soil in these areas, but other effects on soil formation have been minimal. Soluble nutrients and clay particles were transported down into the soil profile by further precipitation. This movement is shown by the accumulation of clay in most of the soil profiles in the eastern part of Pennington County.

The activities of animals in the formation of soils in the county are of small importance as compared to the influence of plants. Earthworms and rodents, however, perform an important function in the transportation and translocation of organic material. They mix the surface soil, subsoil, and parent material.

The activities of man have altered most of the soils in Pennington County. In tilling the soils, man has partially altered the original structure of the surface soil and has mixed the darker surface layer with the lighter colored subsoil. By applying fertilizer and manure, he has increased the fertility of the soils.

Relief

Relief influences soil formation through its effect on temperature, drainage, erosion, and vegetation. Relief or topography is the most important factor in the differentiation of soils in similar parent material.

Because Pennington County has level to gently sloping topography, many of the soils are poorly drained, have high content of organic matter, and are mottled in degrees of varying intensity. The slightly deeper, concave areas frequently have organic surface layers and higher water tables than the other soils. In these areas the soils appear gleyed.

In the western part of Pennington County the relief of the beach ridges and sandbars is more pronounced than in the rest of the county. These gently sloping, gravelly and sandy soils commonly have better drainage, less organic matter, less clay, and fewer mottles than the soils of the nearly level glacial lake plain. The relief of these beach ridges is the result of the wave action of Glacial Lake Agassiz.

Time

Geographically, all of the soils in Pennington County are young. The soil forming process has been active for 9,000 to 12,000 years. The parent material was deposited by the most recent glacier and subsequent stages of Glacial Lake Agassiz.

This relatively short length of time for soil development has caused the soils in the county to have thinner profiles than soils that have developed over a longer period. The amount of soil development is determined by other soil forming factors, but without time none of the other factors would be able to influence soil development.

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Glossary

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

Ablation till. Loose, permeable till deposited during the final downwasting of glacial ice. Lenses of crudely sorted sand and gravel are common.

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

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

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

Alkali (sodic) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

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

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

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

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

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

Basal till. Compact glacial till deposited beneath the ice.

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

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

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

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

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

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

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

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

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

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

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

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

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

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

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

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

Coarse textured soil. Sand or loamy sand.

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.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

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

Congeliturbate. Soil material disturbed by frost action.

Conservation tillage. A tillage system that does not invert the soil and that leaves all or part of the crop residue on the surface throughout the year.

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

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

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

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

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

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

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

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

Cemented.—Hard; little affected by moistening.

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.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms.

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

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

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

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

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

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

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

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

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

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

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

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

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

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

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

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

Edge habitat. The junction where one major land use cover type ends and another begins. It is of prime importance for birds and animals. Most of the plants and animals that inhabit both openland and woodland are also in the edge habitat. A good example of edge habitat is the outside edge of a thick woodland that parallels the outside edge of a no-till field of corn.

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

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

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

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

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

Erosion pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Excess alkali (in tables). Excess exchangeable sodium in the soil. The resulting poor physical properties restrict the growth of plants.

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

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

Excess salts (in tables). Excess water-soluble salts in the soil that restrict the growth of most plants.

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

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

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

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

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

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

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

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

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

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

Fragile (in tables). A soil that is easily damaged by use or disturbance.

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

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

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

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

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

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

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

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

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

Graded stripcropping. Growing crops in strips that grade toward a protected waterway.

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.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter.

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

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

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

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

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

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

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

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

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

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic, granular, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

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

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

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

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

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

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

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

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

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

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

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

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

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

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

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

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

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

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

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

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

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

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

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

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

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

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

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

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

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

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

Moderately coarse textured soil. Coarse sandy loam, sandy loam, and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

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

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

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

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting (in tables). Pits caused by melting ground ice. They form on the soil after plant cover is removed.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

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

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

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

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH

7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

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

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

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

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

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.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

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

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

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

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

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

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

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded and 6 to 15 inches (15 to 38 centimeters) in length if flat.

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

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

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

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

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

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface soil. The A, E, AB, and EB horizons. Includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

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.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

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

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

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve. A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by melt water streams, in a glacial lake or other body of still water in front of a glacier.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

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

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

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Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1951-72 at Thief River Falls, Minnesota]

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 number of growing degree days[1]	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	10.1	-10.5	-.2	38	-40	0	0.92	0.32	1.39	4	10.8
February---	18.2	-3.4	7.4	42	-35	0	.47	.18	.69	2	5.2
March------	30.8	9.8	20.3	60	-26	22	.98	.24	1.56	3	8.9
April------	49.7	28.9	39.3	78	2	114	2.09	.55	3.31	5	3.2
May--------	65.9	39.9	52.9	89	21	405	2.55	1.12	3.70	6	.1
June-------	74.7	50.9	62.8	93	34	684	3.73	1.92	5.20	8	.0
July-------	79.6	55.2	67.4	95	40	849	3.66	1.70	5.25	6	.0
August-----	79.0	53.4	66.2	95	37	812	3.01	1.45	4.28	6	.0
September--	67.1	43.1	55.1	89	24	453	2.62	1.02	3.92	6	.0
October----	55.3	33.3	44.3	81	13	209	1.73	.51	2.71	4	.6
November---	34.4	17.5	26.0	61	-15	22	.85	.32	1.27	2	5.9
December---	19.4	1.4	10.4	43	-31	0	.94	.33	1.42	4	10.6
Yearly:											
Average--	48.7	27.8	37.7	---	---	---	---	---	---	---	---
Extreme--	---	---	---	97	-41	---	---	---	---	---	---
Total----	---	---	---	---	---	3,570	23.55	18.85	28.60	56	45.3

[1]A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (40° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-72 at Thief River Falls, Minnesota]

Probability	Temperature		
	24^{o} F or lower	28^{o} F or lower	32^{o} F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	May 13	May 27	June 9
2 years in 10 later than--	May 7	May 23	June 3
5 years in 10 later than--	April 26	May 15	May 23
First freezing temperature in fall:			
1 year in 10 earlier than--	September 22	September 12	September 13
2 years in 10 earlier than--	September 28	September 17	September 16
5 years in 10 earlier than--	October 9	September 27	September 22

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-72 at Thief River Falls, Minnesota]

Probability	Length of growing season if daily minimum temperature is--		
	Higher than 24^{o} F	Higher than 28^{o} F	Higher than 32^{o} F
	Days	Days	Days
9 years in 10	137	118	102
8 years in 10	147	123	109
5 years in 10	165	134	121
2 years in 10	183	145	134
1 year in 10	192	150	140

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

Map symbol	Soil name	Acres	Percent
46	Borup loam	5,145	1.3
52	Augsburg loam	1,308	0.3
58	Kittson sandy clay loam	949	0.2
59	Grimstad fine sandy loam	2,098	0.5
60	Glyndon loam	3,821	1.0
64	Ulen fine sandy loam	4,438	1.1
65	Foxhome sandy loam	859	0.2
66	Flaming loamy fine sand	5,695	1.4
77	Garnes fine sandy loam	1,847	0.5
148	Poppleton fine sand	2,086	0.5
184	Hamerly loam	758	0.2
205	Karlstad sandy loam	4,162	1.0
236	Vallers loam	7,857	2.0
245B	Lohnes loamy coarse sand, 0 to 6 percent slopes	13,810	3.5
280	Pelan sandy loam	1,643	0.4
343	Wheatville loam	736	0.2
372	Hamar loamy fine sand	928	0.2
387	Roliss loam, depressional	728	0.2
404	Chilgren loam	1,659	0.4
412	Mavie fine sandy loam	2,642	0.7
426	Foldahl fine sandy loam	1,993	0.5
432	Strandquist sandy clay loam	351	0.1
435	Syrene fine sandy loam	1,955	0.5
439	Rockwell fine sandy loam	9,860	2.5
481	Kratka fine sandy loam	41,467	10.5
540	Seelyeville muck	614	0.2
543	Markey muck	7,840	1.9
544	Cathro muck	4,104	1.0
547	Deerwood muck	10,478	2.7
565	Eckvoll loamy sand	2,673	0.7
582	Roliss loam	22,887	5.8
641	Clearwater clay	14,336	3.6
642	Clearwater loam	3,942	1.0
643	Grimstad Variant fine sandy loam	938	0.2
644	Boash clay loam	2,442	0.6
645	Espelie fine sandy loam	2,835	0.7
647	Hilaire very fine sandy loam	1,776	0.5
648	Reiner Variant sandy clay loam	1,971	0.5
649	Reiner loamy fine sand	1,516	0.3
650	Reiner fine sandy loam	49,041	12.3
651	Thiefriver fine sandy loam	3,107	0.8
652	Wyandotte clay loam	5,825	1.5
712	Rosewood fine sandy loam	10,619	2.7
713	Linveldt fine sandy loam	7,516	1.9
765	Smiley sandy clay loam	104,262	26.2
1006	Fluvaquents-Haploborolls complex	3,778	0.9
1029	Pits, gravel	1,889	0.5
1804	Hamre muck, ponded	605	0.1
1808	Markey muck, ponded	1,119	0.3
1878	Hamre muck	10,489	2.6
1882	Rosewood fine sandy loam, seepy	1,583	0.4
	Water	1,100	0.2
	Total	398,080	100.0

TABLE 5.--PRIME FARMLAND

[Only the soils considered prime farmland are listed. Urban or built-up areas of the soils are not considered prime farmland. If a soil is prime farmland under certain conditions, the conditions are specified in parentheses after the soil name]

Map symbol	Soil name
46	Borup loam (where drained)
52	Augsburg loam (where drained)
58	Kittson sandy clay loam
59	Grimstad fine sandy loam[1]
60	Glyndon loam[1]
77	Garnes fine sandy loam
184	Hamerly loam[1]
236	Vallers loam (where drained)
343	Wheatville loam[1]
404	Chilgren loam (where drained)
426	Foldahl fine sandy loam
439	Rockwell fine sandy loam (where drained)
582	Roliss loam (where drained)
641	Clearwater clay (where drained)
642	Clearwater loam (where drained)
643	Grimstad Variant fine sandy loam[1]
644	Boash clay loam (where drained)
645	Espelie fine sandy loam (where drained)
647	Hilaire very fine sandy loam
648	Reiner Variant sandy clay loam
649	Reiner loamy fine sand
650	Reiner fine sandy loam
651	Thiefriver fine sandy loam (where drained)
765	Smiley sandy clay loam (where drained)

[1]These soils are classified as wet soils but do not require drainage to grow the common crops of this county.

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield figure 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	Spring wheat	Oats	Barley	Sunflowers	Bromegrass-alfalfa	Grass-legume hay	Corn silage
	Bu	Bu	Bu	Lb	AUM*	Ton	Ton
46 Borup	48	80	60	2,000	5.5	4.0	12.0
52 Augsburg	48	80	60	2,000	5.5	4.0	12.0
58 Kittson	48	80	60	2,000	5.5	4.0	12.0
59 Grimstad	40	70	50	1,800	5.0	3.5	9.0
60 Glyndon	48	80	60	2,000	5.5	4.0	12.0
64 Ulen	35	65	45	1,500	3.7	2.5	8.0
65 Foxhome	35	60	45	1,400	4.0	2.7	8.0
66 Flaming	23	50	35	950	3.7	2.5	6.0
77 Garnes	45	80	55	2,000	5.5	4.0	12.0
148 Poppleton	20	50	35	950	3.5	2.3	6.0
184 Hamerly	45	75	55	1,900	5.5	3.7	11.0
255 Karlstad	25	55	35	950	3.5	2.5	6.5
236 Vallers	45	75	55	1,900	5.5	3.7	11.0
245B Lohnes	20	40	30	950	3.3	2.0	6.0
280 Pelan	35	60	45	1,400	4.0	3.0	8.0
343 Wheatville	48	80	60	2,000	5.5	4.0	12.0
372 Hamar	25	55	35	950	3.5	2.5	6.5
387 Roliss	30	60	40	1,300	4.2	3.0	7.0
404 Chilgren	45	75	55	1,800	5.5	4.0	9.0
412 Mavie	35	70	50	1,800	4.0	3.0	8.0
426 Foldahl	40	70	50	1,800	5.0	3.5	9.0

See footnote at end of table.

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Spring wheat	Oats	Barley	Sunflowers	Bromegrass-alfalfa	Grass-legume hay	Corn silage
	Bu	Bu	Bu	Lb	AUM*	Ton	Ton
432 Strandquist	35	60	45	1,400	4.0	3.0	7.0
435 Syrene	35	60	45	1,400	4.0	3.0	7.0
439 Rockwell	40	70	50	1,800	4.5	3.5	9.0
481 Kratka	35	60	45	1,500	4.2	3.0	8.0
540 Seelyeville	30	60	40	1,000	3.5	2.5	---
543 Markey	30	60	40	1,000	3.5	2.5	---
544 Cathro	30	60	40	1,000	3.5	2.5	---
547 Deerwood	30	60	40	1,000	3.5	2.5	---
565 Eckvoll	30	65	45	1,500	4.0	2.5	8.0
582 Roliss	45	80	55	1,950	5.5	3.7	11.0
641 Clearwater	41	75	55	1,800	5.0	3.5	11.0
642 Clearwater	44	75	60	1,900	5.3	3.7	11.0
643 Grimstad Variant	40	70	50	1,800	5.0	3.4	9.0
644 Boash	41	75	55	1,800	5.0	3.5	11.0
645 Espelie	35	65	40	1,600	4.5	3.0	9.0
647 Hilaire	40	75	50	1,800	5.0	3.5	9.0
648 Reiner Variant	45	80	58	2,000	5.5	4.0	12.0
649 Reiner	43	75	55	1,850	4.5	3.0	10.0
650 Reiner	48	80	60	2,000	5.0	3.5	12.0
651 Thiefriver	35	70	50	1,800	4.5	3.5	9.0
652 Wyandotte	35	70	50	1,750	4.2	3.0	8.0
712 Rosewood	35	65	45	1,400	3.7	2.5	8.0

See footnote at end of table.

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Spring wheat	Oats	Barley	Sunflowers	Bromegrass-alfalfa	Grass-legume hay	Corn silage
	Bu	Bu	Bu	Lb	AUM*	Ton	Ton
713------------------------ Linveldt	43	75	55	1,800	5.0	3.5	10.0
765------------------------ Smiley	45	80	55	1,950	5.5	4.0	11.0
1006**: Fluvaquents.							
Haploborolls.							
1029**. Pits							
1804----------------------- Hamre	---	---	---	---	---	---	---
1808----------------------- Markey	---	---	---	---	---	---	---
1078----------------------- Hamre	30	60	40	1,000	3.5	2.5	---
1882----------------------- Rosewood	---	---	---	---	---	---	---

* 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.
** 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 heights, in feet, of-- <8	8-15	16-25	26-35	>35
46. Borup	---	Tatarian honeysuckle, common chokecherry, Siberian peashrub, eastern redcedar, lilac.	Russian-olive, blue spruce, white spruce, bur oak.	Golden willow, Siberian elm.	Eastern cottonwood.
52. Augsburg	---	Common chokecherry, Tatarian honeysuckle, Siberian peashrub, eastern redcedar, lilac.	Russian-olive, bur oak, white spruce, blue spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
58. Kittson	---	Tatarian honeysuckle, common chokecherry, Siberian peashrub, Peking cotoneaster, lilac, Amur maple, American plum.	Blue spruce, Manchurian crabapple, Black Hills spruce.	Golden willow.	Eastern cottonwood.
59. Grimstad	Lilac.	Eastern redcedar, common chokecherry, Tatarian honeysuckle, Siberian peashrub.	Blue spruce, Russian-olive, white spruce, bur oak.	Golden willow, Siberian elm.	Eastern cottonwood.
60. Glyndon	Lilac.	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, common chokecherry.	Blue spruce, white spruce, bur oak, Russian-olive.	Golden willow, Siberian elm.	Eastern cottonwood.
64. Ulen	Lilac.	Eastern redcedar, common chokecherry, Tatarian honeysuckle, Siberian peashrub.	Russian-olive, white spruce, blue spruce, bur oak.	Siberian elm, golden willow.	Eastern cottonwood.
65. Foxhome	Silver buffaloberry, Siberian peashrub, Tatarian honeysuckle, lilac.	Green ash, Manchurian crabapple, common chokecherry, eastern redcedar, Russian-olive, Siberian crabapple.	Ponderosa pine, Siberian elm.	---	---
66. Flaming	---	Eastern redcedar, common chokecherry, American plum, Siberian peashrub, Peking cotoneaster, Tatarian honeysuckle, redosier dogwood.	Manchurian crabapple, blue spruce, white spruce.	Golden willow.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
77----------------- Garnes	Lilac	Common chokecherry, Siberian peashrub, Tatarian honeysuckle, eastern redcedar.	Bur oak, blue spruce, white spruce, Russian-olive.	Golden willow, Siberian elm.	Eastern cottonwood.
148----------------- Poppleton	---	Eastern redcedar, common chokecherry, American plum, redosier dogwood, Tatarian honeysuckle, Siberian peashrub, Peking cotoneaster.	Blue spruce, white spruce, Manchurian crabapple.	Golden willow	Eastern cottonwood.
184----------------- Hamerly	---	Siberian peashrub, American plum, lilac.	Ponderosa pine, blue spruce, Siberian crabapple, eastern redcedar.	Golden willow, green ash, hackberry.	Eastern cottonwood, Siberian elm.
205----------------- Karlstad	Lilac	Eastern redcedar, common chokecherry, Tatarian honeysuckle, Siberian peashrub.	Blue spruce, white spruce, bur oak, Russian-olive.	Golden willow, Siberian elm.	Eastern cottonwood.
236----------------- Vallers	---	Tatarian honeysuckle, Siberian peashrub, common chokecherry, eastern redcedar, lilac.	White spruce, bur oak, Russian-olive, blue spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
245B---------------- Lohnes	---	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, lilac, American plum.	Green ash, hackberry, ponderosa pine, Russian-olive, Siberian crabapple.	Siberian elm, honeylocust.	---
280----------------- Pelan	Tatarian honeysuckle, Siberian peashrub, lilac, silver buffaloberry.	Green ash, Russian-olive, Manchurian crabapple, Siberian crabapple, eastern redcedar, common chokecherry.	Siberian elm, ponderosa pine.	---	---
343----------------- Wheatville	Lilac	Common chokecherry, eastern redcedar, Siberian peashrub, Tatarian honeysuckle.	Blue spruce, white spruce, Russian-olive, bur oak.	Golden willow, Siberian elm.	Eastern cottonwood.
372----------------- Hamar	Silver buffaloberry, lilac.	Siberian peashrub, Tatarian honeysuckle.	Hackberry, blue spruce, ponderosa pine, Siberian crabapple, eastern redcedar.	Golden willow, green ash.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of-- <8	8-15	16-25	26-35	>35
387 Roliss	---	Siberian peashrub, lilac, Tatarian honeysuckle, eastern redcedar, common chokecherry.	Blue spruce, white spruce, bur oak, Russian-olive.	Golden willow, Siberian elm.	Eastern cottonwood.
404 Chilgren	---	Eastern redcedar, Siberian peashrub, Tatarian honeysuckle, lilac, common chokecherry.	White spruce, Russian-olive, bur oak, blue spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
412 Mavie	---	Siberian peashrub, eastern redcedar, common chokecherry, lilac, Tatarian honeysuckle.	Russian-olive, white spruce, bur oak, blue spruce.	Siberian elm, golden willow.	Eastern cottonwood.
426 Foldahl	---	Eastern redcedar, American plum, common chokecherry, Tatarian honeysuckle, Peking cotoneaster, Siberian peashrub.	Blue spruce, Manchurian crabapple, white spruce.	Golden willow	Eastern cottonwood.
432 Strandquist	---	Eastern redcedar, common chokecherry, Tatarian honeysuckle, lilac, Siberian peashrub.	Russian-olive, white spruce, bur oak, blue spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
435 Syrene	---	Common chokecherry, Siberian peashrub, Tatarian honeysuckle, eastern redcedar, lilac.	Blue spruce, white spruce, Russian-olive, bur oak.	Siberian elm, golden willow.	Eastern cottonwood.
439 Rockwell	---	Tatarian honeysuckle, Siberian peashrub, lilac, eastern redcedar, common chokecherry.	Bur oak, Russian-olive, white spruce, blue spruce.	Siberian elm, golden willow.	Eastern cottonwood.
481 Kratka	---	Eastern redcedar, Siberian peashrub, lilac, common chokecherry, Tatarian honeysuckle.	Russian-olive, bur oak, blue spruce, white spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
540 Seelyeville	---	Tatarian honeysuckle.	---	Golden willow, white willow.	Imperial Carolina poplar.
543 Markey	Common ninebark	Tatarian honeysuckle.	---	Golden willow, white willow.	Imperial Carolina poplar.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
544. Cathro	Common ninebark	Tatarian honeysuckle.	---	Golden willow, white willow.	Imperial Carolina poplar.
547. Deerwood	---	Tatarian honeysuckle.	---	White willow, golden willow.	Imperial Carolina poplar.
565. Eckvoll	---	American plum, Peking cotoneaster, Siberian peashrub, eastern redcedar, Tatarian honeysuckle, common chokecherry, redosier dogwood.	Manchurian crabapple, blue spruce, white spruce.	Golden willow	Eastern cottonwood.
582. Roliss	---	Tatarian honeysuckle, lilac, eastern redcedar, common chokecherry.	White spruce, blue spruce, bur oak, Russian-olive.	Golden willow, American elm, Siberian elm.	Eastern cottonwood.
641, 642. Clearwater	---	Lilac, Tatarian honeysuckle, eastern redcedar, Siberian peashrub, common chokecherry.	White spruce, bur oak, blue spruce, Russian-olive.	Golden willow, Siberian elm.	Eastern cottonwood.
643. Grimstad Variant	Lilac	Eastern redcedar, common chokecherry, Siberian peashrub, Tatarian honeysuckle.	Blue spruce, Russian-olive, bur oak, white spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
644. Boash	---	Siberian peashrub, American plum, lilac, common chokecherry, Tatarian honeysuckle, redosier dogwood.	Blue spruce, white spruce, Manchurian crabapple.	Golden willow	Carolina poplar, eastern cottonwood.
645. Espelie	---	Tatarian honeysuckle, Siberian peashrub, lilac, American plum, redosier dogwood, common chokecherry.	White spruce, Manchurian crabapple, blue spruce.	Golden willow	Eastern cottonwood, Carolina poplar.
647. Hilaire	---	Redosier dogwood, eastern redcedar, Tatarian honeysuckle, American plum, Peking cotoneaster, common chokecherry, Siberian peashrub.	Blue spruce, Manchurian crabapple, white spruce.	Golden willow	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
648. Reiner Variant	Lilac	Siberian peashrub, common chokecherry, Tatarian honeysuckle, eastern redcedar.	Blue spruce, Russian-olive, white spruce, bur oak.	Siberian elm, golden willow.	Eastern cottonwood.
649, 650. Reiner	Lilac	Siberian peashrub, common chokecherry, Tatarian honeysuckle, eastern redcedar.	Russian-olive, blue spruce, white spruce, bur oak.	Golden willow, Siberian elm.	Eastern cottonwood.
651. Thiefriver	---	Tatarian honeysuckle, Siberian peashrub, lilac, eastern redcedar, common chokecherry.	Russian-olive, bur oak, white spruce, blue spruce.	Siberian elm, golden willow.	Eastern cottonwood.
652. Wyandotte	---	Siberian peashrub, Tatarian honeysuckle, lilac, common chokecherry, eastern redcedar.	Blue spruce, white spruce, Russian-olive, bur oak.	Golden willow, Siberian elm.	Eastern cottonwood.
712. Rosewood	---	Common chokecherry, Tatarian honeysuckle, Siberian peashrub, eastern redcedar, lilac.	Blue spruce, Russian-olive, bur oak, white spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
713. Linveldt	Lilac	Siberian peashrub, eastern redcedar, common chokecherry, Tatarian honeysuckle.	Russian-olive, bur oak, blue spruce, white spruce.	Siberian elm, golden willow.	Eastern cottonwood.
765. Smiley	---	Tatarian honeysuckle, common chokecherry, Siberian peashrub, eastern redcedar, lilac.	Russian-olive, white spruce, bur oak, blue spruce.	Golden willow, Siberian elm.	Eastern cottonwood.
1006*: Fluvaquents.					
Haploborolls.					
1029*. Pits					
1804. Hamre					
1808. Markey					
1878. Hamre	---	Tatarian honeysuckle.	---	Golden willow, white willow.	Imperial Carolina poplar.
1882. Rosewood					

* 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	Golf fairways
46 Borup	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
52 Augsburg	Severe: wetness.	Moderate: percs slowly, wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
58 Kittson	Slight	Slight	Slight	Slight	Slight.
59 Grimstad	Slight	Slight	Slight	Slight	Slight.
60 Glyndon	Slight	Slight	Slight	Slight	Slight.
64 Ulen	Slight	Slight	Slight	Slight	Slight.
65 Foxhome	Slight	Slight	Slight	Slight	Slight.
66 Flaming	Slight	Slight	Slight	Slight	Moderate: droughty.
77 Garnes	Slight	Slight	Slight	Slight	Slight.
148 Poppleton	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Moderate: droughty.
184 Hamerly	Slight	Slight	Slight	Slight	Slight.
205 Karlstad	Slight	Slight	Slight	Slight	Moderate: droughty.
236 Vallers	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
245B Lohnes	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
280 Pelan	Slight	Slight	Moderate: small stones.	Slight	Moderate: droughty.
343 Wheatville	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight	Slight.
372 Hamar	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
387 Roliss	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
404 Chilgren	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
412 Mavie	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
426: Foldahl	Slight	Slight	Slight	Slight	Slight.
432: Strandquist	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
435: Syrene	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
439: Rockwell	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
481: Kratka	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
540: Seelyeville	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
543: Markey	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
544: Cathro	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
547: Deerwood	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
565: Eckvoll	Slight	Slight	Slight	Slight	Slight.
582: Roliss	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
641: Clearwater	Severe: wetness, too clayey.	Severe: too clayey.	Severe: too clayey, wetness.	Severe: too clayey.	Severe: too clayey.
642: Clearwater	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
643: Grimstad Variant	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight	Moderate: droughty.
644: Boash	Severe: wetness, too clayey.	Severe: too clayey.	Severe: too clayey, wetness.	Severe: too clayey.	Severe: too clayey.
645: Espelie	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, droughty.
647: Hilaire	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight	Moderate: droughty.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
648 Reiner Variant	Slight	Slight	Slight	Slight	Slight.
649, 650 Reiner	Slight	Slight	Slight	Slight	Slight.
651 Thiefriver	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, droughty.
652 Wyandotte	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, droughty.
712 Rosewood	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, droughty.
713 Linveldt	Slight	Slight	Slight	Slight	Slight.
765 Smiley	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
1006*: Fluvaquents.					
Haploborolls.					
1029*. Pits					
1804 Hamre	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
1808 Markey	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
1878 Hamre	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
1882 Rosewood	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.

* 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
46 Borup	Good	Good	Fair	Fair	Poor	Good	Good	Good	Fair	Good.
52 Augsburg	Good	Good	Fair	Fair	Poor	Good	Good	Good	Fair	Good.
58 Kittson	Good	Good	Good	Fair	Fair	Poor	Poor	Good	Fair	Poor.
59 Grimstad	Fair	Good	Fair	Fair	Poor	Poor	Poor	Good	Fair	Poor.
60 Glyndon	Good	Good	Good	Fair	Poor	Poor	Poor	Good	Fair	Poor.
64 Ulen	Fair	Good	Fair	Fair	Poor	Poor	Poor	Fair	Fair	Poor.
65 Foxhome	Fair	Good	Good	Fair	Fair	Poor	Poor	Good	Fair	Poor.
66 Flaming	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
77 Garnes	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
148 Poppleton	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
184 Hamerly	Good	Good	Good	Fair	Poor	Fair	Fair	Good	Fair	Fair.
205 Karlstad	Fair	Good	Fair	Fair	Fair	Poor	Very poor.	Fair	Fair	Very poor.
236 Vallers	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
245B Lohnes	Fair	Good	Fair	Fair	Fair	Poor	Very poor.	Fair	Fair	Very poor.
280 Pelan	Fair	Good	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
343 Wheatville	Good	Good	Good	Fair	Poor	Poor	Poor	Good	Fair	Poor.
372 Hamar	Fair	Fair	Fair	Fair	Poor	Fair	Fair	Fair	Poor	Fair.
387 Roliss	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
404 Chilgren	Good	Good	Good	Good	Good	Good	Fair	Good	Good	Fair.
412 Mavie	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
426 Foldahl	Fair	Good	Good	Fair	Fair	Poor	Poor	Good	Fair	Poor.

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 herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
432------------------ Strandquist	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
435------------------ Syrene	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
439------------------ Rockwell	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
481------------------ Kratka	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
540------------------ Seelyeville	Fair	Poor	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
543------------------ Markey	Fair	Poor	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
544------------------ Cathro	Fair	Poor	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
547------------------ Deerwood	Fair	Poor	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
565------------------ Eckvoll	Fair	Fair	Good	Good	Fair	Poor	Poor	Fair	Good	Poor.
582------------------ Roliss	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
641, 642------------ Clearwater	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
643------------------ Grimstad Variant	Fair	Good	Fair	Fair	Poor	Poor	Poor	Fair	Fair	Poor.
644------------------ Boash	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
645------------------ Espelie	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
647------------------ Hilaire	Fair	Good	Good	Fair	Fair	Poor	Poor	Good	Fair	Poor.
648------------------ Reiner Variant	Good	Good	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
649, 650------------ Reiner	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
651------------------ Thiefriver	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
652------------------ Wyandotte	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
712------------------ Rosewood	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
713------------------ Linveldt	Good	Good	Good	Good	Fair	Poor	Poor	Good	Good	Poor.
765------------------ Smiley	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.

TABLE 9.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
1006*:										
Fluvaquents.										
Haploborolls.										
1029*. Pits										
1804 Hamre	Very poor.	Very poor.	Poor	Poor	Poor	Good	Good	Very poor.	Poor	Good.
1808 Markey	Very poor.	Very poor.	Poor	Poor	Poor	Good	Good	Very poor.	Poor	Good.
1878 Hamre	Fair	Poor	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
1882 Rosewood	Very poor.	Very poor.	Fair	Poor	Poor	Good	Good	Poor	Poor	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	Lawns and landscaping
46----------------- Borup	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
52----------------- Augsburg	Severe: wetness.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
58----------------- Kittson	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action.	Slight.
59----------------- Grimstad	Moderate: wetness.	Slight----------	Moderate: wetness.	Slight----------	Moderate: frost action.	Slight.
60----------------- Glyndon	Severe: cutbanks cave.	Slight----------	Moderate: wetness.	Slight----------	Severe: frost action.	Slight.
64----------------- Ulen	Severe: cutbanks cave.	Slight----------	Moderate: wetness.	Slight----------	Moderate: frost action.	Slight.
65----------------- Foxhome	Moderate: wetness.	Slight----------	Moderate: wetness.	Slight----------	Severe: frost action.	Slight.
66----------------- Flaming	Severe: cutbanks cave.	Slight----------	Moderate: wetness.	Slight----------	Moderate: frost action.	Moderate: droughty.
77----------------- Garnes	Moderate: wetness.	Slight----------	Moderate: wetness.	Slight----------	Severe: frost action.	Slight.
148---------------- Poppleton	Severe: cutbanks cave.	Slight----------	Moderate: wetness.	Slight----------	Moderate: frost action.	Moderate: droughty.
184---------------- Hamerly	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: frost action.	Slight.
205---------------- Karlstad	Severe: cutbanks cave.	Slight----------	Moderate: wetness.	Slight----------	Slight----------	Moderate: droughty.
236---------------- Vallers	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
245B--------------- Lohnes	Severe: cutbanks cave.	Slight----------	Slight----------	Slight----------	Slight----------	Moderate: droughty.
280---------------- Pelan	Moderate: wetness.	Slight----------	Moderate: wetness.	Slight----------	Moderate: frost action.	Moderate: droughty.
343---------------- Wheatville	Moderate: too clayey, wetness.	Slight----------	Severe: shrink-swell.	Slight----------	Severe: frost action.	Slight.
372---------------- Hamar	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness, frost action.	Severe: wetness.
387---------------- Roliss	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, frost action.	Severe: ponding.
404---------------- Chilgren	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.

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	Lawns and landscaping
412: Mavie	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Severe: wetness.
426: Foldahl	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
432: Strandquist	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Severe: wetness.
435: Syrene	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness, frost action.	Moderate: wetness.
439: Rockwell	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
481: Kratka	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness, frost action.	Severe: wetness.
540: Seelyeville	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
543: Markey	Severe: cutbanks cave, excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus, flooding.
544: Cathro	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
547: Deerwood	Severe: cutbanks cave, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.
565: Eckvoll	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
582: Roliss	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
641: Clearwater	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.	Severe: too clayey.
642: Clearwater	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.	Moderate: wetness.
643: Grimstad Variant	Moderate: wetness.	Slight	Severe: shrink-swell.	Slight	Severe: frost action.	Moderate: droughty.
644: Boash	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Severe: too clayey.

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	Lawns and landscaping
645: Espelie	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.	Moderate: wetness, droughty.
647: Hilaire	Moderate: wetness.	Slight	Severe: shrink-swell.	Slight	Severe: frost action.	Moderate: droughty.
648: Reiner Variant	Moderate: wetness.	Severe: shrink-swell.	Moderate: wetness.	Severe: shrink-swell.	Severe: low strength, frost action, shrink-swell.	Slight.
649, 650: Reiner	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
651: Thiefriver	Severe: wetness.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: frost action.	Moderate: wetness, droughty.
652: Wyandotte	Severe: wetness.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: frost action.	Moderate: wetness, droughty.
712: Rosewood	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness, frost action.	Moderate: wetness, droughty.
713: Linveldt	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
765: Smiley	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
1006*: Fluvaquents.						
Haploborolls.						
1029*. Pits						
1804: Hamre	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, frost action.	Severe: ponding, excess humus.
1808: Markey	Severe: cutbanks cave, excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
1878: Hamre	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, frost action.	Severe: ponding, excess humus.
1882: Rosewood	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action.	Severe: wetness.

* 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
46-------------------- Borup	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness, seepage, too sandy.	Severe: seepage, wetness.	Poor: wetness.
52-------------------- Augsburg	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: wetness, seepage.	Poor: wetness, too clayey, hard to pack.
58-------------------- Kittson	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
59-------------------- Grimstad	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Fair: wetness.
60-------------------- Glyndon	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Fair: wetness.
64-------------------- Ulen	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy.
65-------------------- Foxhome	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Fair: wetness.
66-------------------- Flaming	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy.
77-------------------- Garnes	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
148------------------- Poppleton	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy.
184------------------- Hamerly	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
205------------------- Karlstad	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy.
236------------------- Vallers	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
245B------------------ Lohnes	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.

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
280------------------ Pelan	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Fair: wetness.
343------------------ Wheatville	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack.
372------------------ Hamar	Severe: wetness, poor filter.	Severe: wetness, seepage.	Severe: wetness, seepage, too sandy.	Severe: wetness, seepage.	Poor: wetness, too sandy, seepage.
387------------------ Roliss	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
404------------------ Chilgren	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
412------------------ Mavie	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
426------------------ Foldahl	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Fair: wetness.
432------------------ Strandquist	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
435------------------ Syrene	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: wetness, seepage, too sandy.	Severe: wetness, seepage.	Poor: seepage, too sandy, wetness.
439------------------ Rockwell	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
481------------------ Kratka	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
540------------------ Seelyeville	Severe: ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: seepage, ponding.	Poor: ponding, excess humus.
543------------------ Markey	Severe: ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: seepage, ponding.	Severe: seepage, ponding.	Poor: seepage, too sandy, ponding.
544------------------ Cathro	Severe: ponding.	Severe: seepage, excess humus, ponding.	Severe: ponding.	Severe: seepage, ponding.	Poor: ponding.
547------------------ Deerwood	Severe: ponding, poor filter.	Severe: seepage, excess humus, ponding.	Severe: seepage, ponding, too sandy.	Severe: seepage, ponding.	Poor: seepage, too sandy, ponding.

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
565----------------- Eckvoll	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Fair: wetness.
582----------------- Roliss	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
641, 642------------ Clearwater	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
643----------------- Grimstad Variant	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack.
644----------------- Boash	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
645----------------- Espelie	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack, wetness.
647----------------- Hilaire	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack.
648----------------- Reiner Variant	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: too clayey, wetness.
649, 650------------ Reiner	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
651----------------- Thiefriver	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack, wetness.
652----------------- Wyandotte	Severe: wetness, percs slowly.	Severe: seepage, wetness.	Severe: wetness, too clayey.	Severe: seepage, wetness.	Poor: too clayey, hard to pack, wetness.
712----------------- Rosewood	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
713----------------- Linveldt	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Fair: wetness.
765----------------- Smiley	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.

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
1006*:					
Fluvaquents.					
Haploborolls.					
1029*. Pits					
1804 Hamre	Severe: ponding, percs slowly.	Severe: excess humus, ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
1808 Markey	Severe: ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: seepage, ponding.	Severe: seepage, ponding.	Poor: seepage, too sandy, ponding.
1878 Hamre	Severe: ponding, percs slowly.	Severe: excess humus, ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
1882 Rosewood	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, 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
46 Borup	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
52 Augsburg	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
58 Kittson	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
59 Grimstad	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: too sandy.
60 Glyndon	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
64 Ulen	Fair: wetness.	Probable	Improbable: too sandy.	Fair: too sandy.
65 Foxhome	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Poor: small stones.
66 Flaming	Fair: wetness.	Probable	Improbable: too sandy.	Fair: too sandy.
77 Garnes	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
148 Poppleton	Fair: wetness.	Probable	Improbable: too sandy.	Poor: too sandy.
184 Hamerly	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
205 Karlstad	Fair: wetness.	Probable	Improbable: too sandy.	Fair: area reclaim, small stones.
236 Vallers	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
245B Lohnes	Good	Probable	Improbable: too sandy.	Fair: small stones, area reclaim.
280 Pelan	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Poor: area reclaim, small stones.
343 Wheatville	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
372 Hamar	Fair: wetness.	Probable	Improbable: too sandy.	Fair: too sandy.
387 Roliss	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
404: Chilgren	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
412: Mavie	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Poor: small stones.
426: Foldahl	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
432: Strandquist	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Poor: small stones, area reclaim.
435: Syrene	Fair: wetness.	Probable	Improbable: too sandy.	Poor: small stones.
439: Rockwell	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
481: Kratka	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
540: Seelyeville	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
543: Markey	Poor: wetness.	Probable	Improbable: too sandy.	Poor: excess humus, wetness.
544: Cathro	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
547: Deerwood	Poor: wetness.	Probable	Improbable: too sandy.	Poor: excess humus, wetness.
565: Eckvoll	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
582: Roliss	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
641: Clearwater	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
642: Clearwater	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
643: Grimstad Variant	Poor: low strength, shrink-swell.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
644: Boash	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
645 Espelie	Poor: low strength, shrink-swell.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
647 Hilaire	Poor: low strength, shrink-swell.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
648 Reiner Variant	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
649, 650 Reiner	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
651 Thiefriver	Poor: low strength, shrink-swell.	Improbable: thin layer.	Improbable: excess fines.	Fair: thin layer.
652 Wyandotte	Poor: low strength, shrink-swell.	Improbable: thin layer.	Improbable: excess fines.	Poor: small stones.
712 Rosewood	Fair: wetness.	Probable	Improbable: too sandy.	Poor: thin layer.
713 Linveldt	Fair: wetness.	Improbable: thin layer.	Improbable: excess fines.	Fair: small stones.
765 Smiley	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
1006*: Fluvaquents.				
Haploborolls.				
1029*. Pits				
1804 Hamre	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
1808 Markey	Poor: wetness.	Probable	Improbable: too sandy.	Poor: excess humus, wetness.
1878 Hamre	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
1882 Rosewood	Poor: wetness.	Probable	Improbable: too sandy.	Poor: thin layer, 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-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Irrigation
46 Borup	Severe: seepage.	Severe: piping, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness.
52 Augsburg	Severe: seepage.	Severe: wetness, hard to pack.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.
58 Kittson	Moderate: seepage.	Moderate: piping, wetness.	Moderate: slow refill.	Frost action	Wetness.
59 Grimstad	Severe: seepage.	Severe: piping.	Moderate: slow refill, deep to water.	Favorable	Wetness.
60 Glyndon	Severe: seepage.	Severe: piping.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness.
64 Ulen	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Cutbanks cave	Wetness, soil blowing.
65 Foxhome	Severe: seepage.	Severe: piping.	Severe: slow refill, deep to water.	Frost action	Wetness, soil blowing.
66 Flaming	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Cutbanks cave	Wetness, droughty, fast intake.
77 Garnes	Moderate: seepage.	Severe: piping.	Moderate: deep to water, slow refill.	Frost action	Wetness, soil blowing.
148 Poppleton	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Cutbanks cave	Wetness, droughty, fast intake.
184 Hamerly	Moderate: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Frost action	Wetness.
205 Karlstad	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Cutbanks cave	Wetness, droughty.
236 Vallers	Slight	Severe: wetness.	Severe: slow refill.	Frost action	Wetness.
245B Lohnes	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Droughty, fast intake, soil blowing.
280 Pelan	Severe: seepage.	Severe: piping.	Moderate: deep to water, slow refill.	Favorable	Wetness, droughty, soil blowing.
343 Wheatville	Severe: seepage.	Severe: hard to pack.	Severe: slow refill.	Frost action, percs slowly.	Wetness, percs slowly.
372 Hamar	Severe: seepage.	Severe: seepage, piping, wetness.	Severe: cutbanks cave.	Cutbanks cave	Wetness, fast intake, soil blowing.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Irrigation
387 Roliss	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, frost action.	Ponding.
404 Chilgren	Moderate: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Frost action	Wetness.
412 Mavie	Severe: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Frost action	Wetness, droughty, soil blowing.
426 Foldahl	Severe: seepage.	Severe: piping.	Moderate: slow refill, deep to water.	Frost action	Soil blowing, wetness.
432 Strandquist	Moderate: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Frost action	Wetness, erodes easily.
435 Syrene	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Cutbanks cave	Wetness, soil blowing, droughty.
439 Rockwell	Severe: seepage.	Severe: wetness, piping.	Moderate: slow refill.	Frost action	Wetness, soil blowing.
481 Kratka	Severe: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Favorable	Wetness, droughty, soil blowing.
540 Seelyeville	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Ponding, subsides.	Ponding, soil blowing.
543 Markey	Severe: seepage.	Severe: seepage, piping, ponding.	Severe: cutbanks cave.	Ponding, subsides, frost action.	Ponding, soil blowing.
544 Cathro	Severe: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, subsides, frost action.	Ponding, soil blowing.
547 Deerwood	Severe: seepage.	Severe: seepage, piping, ponding.	Severe: cutbanks cave.	Ponding, subsides, cutbanks cave.	Ponding, soil blowing.
565 Eckvoll	Severe: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Frost action	Wetness, fast intake, soil blowing.
582 Roliss	Moderate: seepage.	Severe: wetness, piping.	Moderate: slow refill.	Frost action	Wetness.
641 Clearwater	Slight	Severe: hard to pack, wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, slow intake, percs slowly.
642 Clearwater	Slight	Severe: hard to pack, wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.
643 Grimstad Variant	Severe: seepage.	Severe: hard to pack.	Severe: slow refill.	Percs slowly, frost action.	Wetness, droughty, soil blowing.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Irrigation
644 Boash	Moderate: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.
645 Espelie	Severe: seepage.	Severe: wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, droughty.
647 Hilaire	Severe: seepage.	Severe: hard to pack.	Severe: slow refill.	Percs slowly, frost action.	Wetness, droughty, soil blowing.
648 Reiner Variant	Moderate: seepage.	Severe: piping.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.
649 Reiner	Moderate: seepage.	Moderate: piping.	Moderate: deep to water, slow refill.	Frost action	Wetness, fast intake, soil blowing.
650 Reiner	Moderate: seepage.	Moderate: piping.	Moderate: deep to water, slow refill.	Frost action	Wetness.
651 Thiefriver	Severe: seepage.	Severe: wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, droughty, soil blowing.
652 Wyandotte	Severe: seepage.	Severe: hard to pack, wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, droughty.
712 Rosewood	Severe: seepage.	Severe: seepage, piping, wetness.	Severe: cutbanks cave.	Cutbanks cave	Wetness, droughty, soil blowing.
713 Linveldt	Severe: seepage.	Moderate: piping.	Moderate: slow refill, deep to water.	Frost action	Wetness, soil blowing.
765 Smiley	Moderate: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Frost action	Wetness.
1006*: Fluvaquents.					
Haploborolls.					
1029*. Pits					
1804 Hamre	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, frost action, subsides.	Ponding, soil blowing.
1808 Markey	Severe: seepage.	Severe: seepage, piping, ponding.	Severe: cutbanks cave.	Ponding, subsides, frost action.	Ponding, soil blowing.
1878 Hamre	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, frost action, subsides.	Ponding, soil blowing.
1882 Rosewood	Severe: seepage.	Severe: seepage, piping, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, droughty.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

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

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
46----------------- Borup	0-15	Loam----------------	OL, ML	A-4	0	100	100	95-100	70-95	20-34	NP-7
	15-30	Very fine sandy loam, loamy very fine sand, silt loam.	ML	A-4	0	100	100	90-100	60-95	<30	NP-5
	30-60	Loamy fine sand, very fine sand, very fine sandy loam.	ML	A-4	0	100	100	85-100	50-90	<30	NP-5
52----------------- Augsburg	0-13	Loam, very fine sandy loam.	ML, CL, OL, CL-ML	A-4, A-6	0	100	100	95-100	50-90	15-40	NP-15
	13-19	Loam, very fine sandy loam, loamy very fine sand.	ML	A-4	0	100	100	95-100	50-90	20-40	NP-10
	19-36	Loamy very fine sand, very fine sandy loam, very fine sand.	ML	A-4	0	100	100	95-100	50-85	20-40	NP-10
	36-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	50-90	35-55
58----------------- Kittson	0-9	Sandy clay loam	CL, CL-ML	A-6, A-4	0	100	95-100	85-95	50-75	20-40	5-20
	9-17	Loam, fine sandy loam, sandy clay loam.	CL, SC	A-6	0-5	90-100	65-100	60-90	40-75	20-40	10-20
	17-60	Loam, clay loam	CL	A-6	0-2	95-100	85-98	80-90	50-75	20-40	10-20
59----------------- Grimstad	0-9	Fine sandy loam	SM, SM-SC	A-4, A-2	0	100	100	80-100	15-50	15-30	NP-7
	9-31	Loamy sand, loamy fine sand, fine sand.	SM, SP-SM	A-2, A-3	0	100	90-100	80-90	5-35	<25	NP-4
	31-60	Sandy loam, fine sandy loam, loam.	SC, CL, SM-SC, CL-ML	A-4, A-6	0-3	95-100	90-100	70-90	40-85	15-40	5-20
60----------------- Glyndon	0-22	Loam----------------	OL, ML	A-4	0	100	100	95-100	70-95	20-40	NP-10
	22-28	Silt loam, very fine sandy loam, loam.	ML, CL-ML, CL	A-4	0	100	100	90-100	60-95	20-30	NP-10
	28-60	Loamy very fine sand, very fine sand, very fine sandy loam.	ML, SM, SC, CL	A-4	0	100	100	85-100	35-75	10-30	NP-10
64----------------- Ulen	0-8	Fine sandy loam---	SM	A-4, A-2	0	100	100	80-100	20-50	<20	NP-4
	8-25	Loamy fine sand, fine sand.	SM	A-2	0	100	95-100	70-95	12-35	---	NP
	25-60	Fine sand, very fine sand.	SP-SM, SM	A-3, A-2	0	100	95-100	80-100	5-35	---	NP
65----------------- Foxhome	0-11	Sandy loam---------	SM	A-4	0-2	95-100	90-100	75-90	35-50	<30	NP-5
	11-19	Loamy sand, sandy loam, loam.	SM, SP-SM	A-2, A-4	0-2	95-100	85-100	55-80	10-50	20-30	NP-5
	19-29	Gravelly sand, very gravelly coarse sand, gravelly loamy sand.	SP, SP-SM, GP, GP-GM	A-1	2-5	50-75	40-60	20-50	0-10	---	NP
	29-60	Loam, clay loam, silt loam.	ML, CL, CL-ML	A-4, A-6	1-5	90-100	85-100	75-90	50-80	20-40	1-15
66----------------- Flaming	0-16	Loamy fine sand	SM, SP-SM	A-2, A-3	0	100	100	75-90	5-30	---	NP
	16-60	Fine sand, loamy fine sand, loamy sand.	SM, SP-SM	A-2, A-3	0	100	100	75-90	5-30	---	NP

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	
77---------------- Garnes	0-11	Fine sandy loam, loamy fine sand.	SM	A-4	0-3	95-100	85-100	55-75	35-50	20-30	1-5
	11-20	Clay loam, sandy clay loam, loam.	CL, SC	A-6, A-4	2-5	95-100	80-100	70-100	45-80	20-40	7-20
	20-60	Sandy loam, loam, fine sandy loam.	SM, ML, CL, SC	A-4, A-6	1-5	95-100	75-95	60-90	35-65	15-40	1-15
148-------------- Poppleton	0-9	Fine sand--------	SP-SM, SM	A-3, A-2	0	100	100	80-95	5-25	---	NP
	9-60	Fine sand, sand	SM, SP	A-3, A-2	0	100	100	80-95	3-15	---	NP
184-------------- Hamerly	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	90-100	80-95	60-90	20-40	5-20
	8-23	Loam, clay loam	CL, CL-ML	A-4, A-6,	0-5	95-100	90-100	80-95	60-75	20-40	5-20
	23-60	Loam, clay loam	CL, CL-ML	A-4, A-6,	0-5	95-100	90-100	80-95	60-75	20-40	5-20
205-------------- Karlstad	0-9	Sandy loam, loamy sand.	SM, SM-SC, SC	A-2, A-4	0-2	95-100	95-100	75-95	12-50	10-25	NP-10
	9-16	Coarse sandy loam, sandy loam, fine sandy loam.	SM, SM-SC, SC	A-2, A-4	0-2	95-100	95-100	75-95	12-50	10-25	NP-10
	16-19	Gravelly coarse sandy loam, gravelly sandy loam, gravelly fine sandy loam.	SC, SM, SM-SC	A-2, A-4	0-2	65-95	20-85	15-70	5-35	10-25	NP-10
	19-60	Stratified gravelly coarse sand to loamy fine sand.	SP, SP-SM	A-1, A-2, A-3	0	60-90	50-100	20-80	2-12	---	NP
236-------------- Vallers	0-12	Loam-------------	OL, ML	A-4	0	95-100	90-100	80-90	50-80	30-40	4-10
	12-25	Clay loam, silty clay loam, sandy clay loam.	CL	A-6	0	95-100	90-97	80-95	50-80	30-40	10-20
	25-60	Loam, clay loam	CL, CL-ML	A-4, A-6	0	95-100	90-97	85-95	60-75	20-40	5-20
245B------------- Lohnes	0-9	Loamy coarse sand	SM, SP-SM	A-2, A-1	0	100	90-100	45-65	10-25	---	NP
	9-60	Coarse sand, very gravelly sand, gravelly coarse sand.	SM, SP-SM, SP	A-2, A-1, A-3	0	80-100	65-100	35-60	2-20	---	NP
280-------------- Pelan	0-10	Sandy loam, loamy coarse sand.	SM, SC	A-2, A-4	2-4	95-100	75-100	60-90	30-50	<20	3-15
	10-15	Gravelly sandy loam, gravelly sandy clay loam.	SM, GM, SC, GC	A-2, A-1	2-4	45-85	35-65	20-45	12-35	10-30	NP-10
	15-26	Stratified gravelly coarse sand to fine sandy loam.	SP-SM, SP, GP, GP-GM	A-1, A-3, A-2	2-4	40-85	40-80	20-60	1-10	---	NP
	26-60	Fine sandy loam, sandy loam, loam.	SM, ML, CL, SC	A-4, A-6	1-5	90-100	85-95	60-90	40-65	10-30	1-15
343-------------- Wheatville	0-21	Loam, clay loam--	OL, ML, CL, CL-ML	A-4	0	100	100	90-100	50-95	15-35	NP-10
	21-33	Very fine sandy loam, silt loam, loamy very fine sand.	ML, CL, CL-ML	A-4	0	100	100	85-100	50-95	15-35	NP-10
	33-60	Clay, silty clay, silty clay loam.	CH, CL	A-7, A-6	0	100	100	95-100	90-100	35-80	15-45
372-------------- Hamar	0-14	Loamy fine sand	SM, SM-SC	A-2, A-4	0	100	100	85-100	15-40	<25	NP-5
	14-24	Loamy fine sand, loamy sand.	SM, SM-SC	A-2, A-4	0	100	100	85-100	15-40	<25	NP-5
	24-60	Fine sand, loamy sand, loamy fine sand.	SM, SM-SC, SP-SM	A-2	0	100	100	70-100	10-35	<25	NP-5

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	
387 Roliss	0-7	Loam	CL, CL-ML	A-4, A-6	0	95-100	80-100	80-100	60-90	20-40	5-20
	7-13	Loam, clay loam, silty clay loam.	CL	A-6	0	94-100	80-100	80-90	60-80	20-40	10-20
	13-60	Loam, clay loam, silt loam.	CL, CL-ML	A-6, A-4	0	95-100	80-98	80-95	60-80	20-40	5-20
404 Chilgren	0-4	Loam	SM, SM-SC, ML, CL-ML	A-4, A-2	0-3	90-100	85-100	60-85	25-55	15-35	NP-10
	4-10	Loamy sand, loamy fine sand, fine sandy loam.	SM, ML, SM-SC, CL-ML	A-2, A-4	0-3	75-100	70-100	50-85	15-55	15-35	NP-10
	10-29	Clay loam, loam, sandy clay loam.	CL, ML, SM, SC	A-6, A-4	1-5	75-100	70-100	60-95	35-85	25-40	7-20
	29-60	Loam, sandy loam, fine sandy loam.	CL, SM, ML, SC	A-4, A-2	2-5	75-100	70-100	50-90	30-70	20-30	3-10
412 Mavie	0-7	Fine sandy loam	CL, CL-ML	A-4, A-6	0-3	95-100	85-100	70-95	50-80	20-40	5-15
	7-14	Loam, fine sandy loam, sandy loam.	CL-ML, CL, SM-SC, SC	A-4, A-6	2-5	95-100	85-100	70-95	40-75	20-35	5-15
	14-30	Very gravelly coarse sand, very gravelly sand, very gravelly loamy sand.	SP-SM, SP, GP, GP-GM	A-1	2-5	30-65	15-55	10-30	1-10	---	NP
	30-60	Loam, silt loam, clay loam.	ML, CL, CL-ML	A-4, A-6	1-5	95-100	75-90	70-85	50-75	20-40	2-15
426 Foldahl	0-9	Fine sandy loam	SM	A-4	0	100	95-100	70-85	35-50	<20	NP-4
	9-24	Fine sand, loamy fine sand, sand.	SP-SM, SM	A-2, A-3	0-3	95-100	90-100	70-85	5-35	---	NP
	24-60	Loam, clay loam, sandy loam.	CL-ML, CL, SM-SC, SC	A-4, A-6	1-5	95-100	70-95	70-90	40-85	15-40	5-20
432 Strandquist	0-11	Sandy clay loam, sandy loam.	CL-ML, CL, ML	A-4, A-6	1-2	95-100	95-100	75-90	55-70	20-40	5-20
	11-29	Very gravelly coarse sand, gravelly coarse sand, very gravelly loamy coarse sand.	SP, GP, GP-GM, SP-SM	A-1	2-5	40-75	25-65	15-50	0-5	---	NP
	29-60	Silty clay loam, loam, sandy loam.	CL-ML, CL, SC, SM-SC	A-4, A-6	1-2	95-100	80-100	65-90	35-80	20-40	5-20
435 Syrene	0-13	Fine sandy loam	SM, SC, SM-SC	A-4	0-3	95-100	85-100	55-70	35-50	15-35	NP-10
	13-60	Stratified loamy fine sand to gravelly coarse sand.	SP-SM, SP	A-3, A-1, A-2	2-5	75-95	55-85	30-60	0-10	---	NP
439 Rockwell	0-9	Fine sandy loam	ML, SM, SM-SC, CL-ML	A-4	0	100	95-100	70-85	40-55	15-25	1-7
	9-17	Fine sandy loam, sandy loam, loam.	SM, ML, SM-SC, CL-ML	A-4	0	100	95-100	60-85	35-55	15-25	1-7
	17-33	Fine sand, sand, loamy fine sand.	SM	A-2	0	100	95-100	65-80	20-35	---	NP
	33-60	Silt loam, loam, clay loam.	CL, CL-ML, SC, SM-SC	A-6, A-4	0-1	95-100	90-100	70-90	40-85	15-40	5-20
481 Kratka	0-11	Fine sandy loam	SM, SM-SC	A-4	0	95-100	90-100	50-80	36-50	<25	2-6
	11-25	Loamy sand, loamy fine sand, loamy fine sand.	SP-SM	A-3, A-2	0	95-100	90-100	50-80	5-10	---	NP
	25-60	Loam, clay loam, sandy loam.	SM-SC, SC, CL-ML, CL	A-4, A-6	0	95-100	90-100	70-90	40-60	15-40	5-20

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	
540----------- Seelyeville	0-60	Sapric material--	PT	A-8	0	---	---	---	---	---	---
543----------- Markey	0-26	Sapric material	PT	A-8	---	---	---	---	---	---	---
	26-60	Fine sand, fine sandy loam, very fine sandy loam.	SP, SM, SP-SM	A-2, A-3	0	100	90-100	60-75	0-20	---	NP
544----------- Cathro	0-16	Sapric material	PT	A-8	0	---	---	---	---	---	---
	16-36	Sapric material	PT	A-8	0	---	---	---	---	---	---
	36-60	Sandy loam, loam, silt loam.	SM, ML, SC, CL	A-4	0	100	95-100	60-100	35-90	15-26	3-10
547----------- Deerwood	0-9	Sapric material	PT	A-8	0	---	---	---	---	---	---
	9-14	Fine sand, loamy sand, fine sandy loam.	SM, SP-SM	A-2, A-4	0-5	95-100	90-100	50-75	12-50	<20	NP-4
	14-60	Loamy fine sand, loamy sand.	SM, SP, SP-SM	A-2, A-3, A-1	0-5	75-100	55-100	35-70	1-35	---	NP
565----------- Eckvoll	0-9	Loamy fine sand	SM, SM-SC	A-4, A-2	0-2	90-100	85-100	45-80	25-50	<20	NP-7
	9-25	Fine sand, sand, loamy sand.	SM, SP-SM	A-1, A-2, A-3	0-2	90-100	85-100	45-75	5-30	<20	NP-4
	25-32	Clay loam, sandy clay loam, loam.	SC, CL	A-4, A-6, A-7	0-5	90-100	85-97	65-95	45-75	25-45	10-25
	32-60	Loam, clay loam	CL	A-4, A-6	0-5	90-100	85-97	70-95	55-80	20-40	7-20
582----------- Roliss	0-7	Loam-------------	CL, CL-ML	A-4, A-6	0	95-100	80-100	80-100	60-90	20-40	5-20
	7-13	Loam, clay loam, silty clay loam.	CL	A-6	0	95-100	80-100	80-90	60-80	20-40	10-20
	13-60	Loam, clay loam	CL, CL-ML	A-6, A-4	0	95-100	80-100	80-95	60-80	20-40	5-20
641----------- Clearwater	0-8	Clay-------------	CL, CH	A-7	0	95-100	90-97	80-95	70-95	45-80	20-50
	8-16	Clay, silty clay, silty clay loam.	CL, CH	A-7	0	95-100	90-97	80-95	70-95	40-80	20-50
	16-60	Clay, silty clay, silty clay loam.	CH, CL	A-7	0	95-100	90-100	80-97	75-95	40-80	20-50
642----------- Clearwater	0-8	Loam-------------	SM-SC, SM, ML, CL-ML	A-4	0	95-100	90-97	65-85	45-65	20-35	NP-11
	8-16	Clay, silty clay, silty clay loam.	CL, CH	A-7	0	95-100	90-97	80-95	70-95	40-80	20-50
	16-60	Clay, silty clay, silty clay loam.	CH, CL	A-7	0	95-100	90-100	80-97	75-95	40-80	20-50
643----------- Grimstad Variant	0-13	Fine sandy loam	SM, SM-SC	A-4	0	100	100	75-95	35-50	15-30	NP-8
	13-23	Loamy fine sand, fine sandy loam.	SM, SM-SC	A-4, A-2	0	100	100	75-100	15-40	15-30	NP-8
	23-34	Loamy fine sand, fine sand.	SM, SP-SM	A-3, A-2	0	95-100	95-100	75-100	5-35	<20	NP
	34-60	Clay loam, silty clay loam, clay.	CH	A-7	0	95-100	95-100	95-100	70-100	60-80	35-50
644----------- Boash	0-7	Clay loam--------	CH, CL	A-7	0-2	95-100	90-100	80-100	70-95	40-60	17-30
	7-27	Clay, silty clay loam, silty clay.	CH	A-7	0-2	95-100	90-100	80-100	70-95	50-80	25-50
	27-60	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6	1-3	95-100	88-97	75-95	55-80	24-35	6-20

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
645----------------- Espelie	0-9	Fine sandy loam	SM, ML, SC, CL	A-4, A-2	0	95-100	85-100	60-85	30-65	<25	NP-8
	9-24	Loamy sand, loamy fine sand, fine sand.	SM, SP-SM	A-2, A-4	0-5	85-100	60-100	30-80	10-40	<20	NP-4
	24-60	Clay, silty clay, clay loam.	CH, CL	A-7	1-3	90-100	85-100	80-100	70-100	40-65	20-40
647----------------- Hilaire	0-10	Very fine sandy loam.	SM, ML, SC, CL	A-4, A-2	0	90-100	75-100	50-85	30-55	<25	NP-8
	10-15	Loamy sand, loamy fine sand, sand.	SM, SP-SM	A-1, A-2, A-4	0-2	85-100	75-100	45-85	10-40	<20	NP-4
	15-34	Gravelly loamy sand, fine sand, sand.	SM, SP-SM	A-1, A-2	0-5	85-100	65-100	30-70	10-30	<20	NP-4
	34-60	Clay, silty clay, silty clay loam.	CH, CL	A-7	1-3	95-100	85-100	75-95	65-90	40-70	20-45
648----------------- Reiner Variant	0-7	Sandy clay loam--	CH, CL	A-6, A-7	0	100	100	95-100	65-95	25-60	11-35
	7-36	Clay, clay loam	CH, CL	A-7, A-6	0	100	95-100	90-100	70-95	25-75	11-50
	36-60	Loam--------------	CL, CL-ML	A-6	0-3	100	95-100	85-100	70-80	20-40	5-20
649----------------- Reiner	0-7	Loamy fine sand	SM	A-2, A-4	0-5	85-100	75-100	60-90	30-45	<20	NP-4
	7-17	Clay loam, loam, sandy clay loam.	CL	A-6, A-7, A-4	0-3	85-100	75-100	60-95	55-80	25-50	7-30
	17-60	Loam, clay loam, fine sandy loam.	CL, ML, SM, SC	A-4, A-6	0-3	85-100	75-100	55-100	35-80	20-40	3-20
650----------------- Reiner	0-7	Fine sandy loam--	CL, CL-ML, ML	A-4, A-6	0-5	85-100	75-100	65-95	50-70	20-40	3-20
	7-17	Clay loam, loam, sandy clay loam.	CL	A-6, A-7, A-4	0-3	85-100	75-100	60-95	55-80	25-50	7-30
	17-60	Loam, clay loam, fine sandy loam.	CL, ML, SM, SC	A-4, A-6	0-3	85-100	75-100	55-100	35-80	20-40	3-20
651----------------- Thiefriver	0-10	Fine sandy loam	ML, SM, SM-SC, CL-ML	A-4	0	95-100	75-100	70-90	35-55	<20	NP-5
	10-33	Very gravelly sand, fine sand, fine sandy loam.	SM, SP-SM	A-2, A-3	0-3	90-100	75-100	50-80	5-35	---	NP
	33-60	Clay, silty clay, silty clay loam.	CH, CL	A-7	1-3	100	95-100	95-100	90-100	40-65	20-40
652----------------- Wyandotte	0-8	Clay loam--------	CL-ML, CL	A-4, A-6	0-3	95-100	85-100	70-95	50-70	25-40	6-15
	8-15	Loam, sandy clay loam.	CL-ML, CL	A-4, A-6	0-3	95-100	80-95	60-95	50-65	25-40	6-16
	15-34	Gravelly loamy coarse sand, very gravelly sand, gravelly coarse sand.	SM, SP, GP, GM	A-1	2-5	20-60	15-50	10-30	0-15	---	NP
	34-60	Clay, silty clay loam, silty clay.	CH, CL	A-7	1-3	85-100	80-100	75-100	65-95	40-90	20-60
712----------------- Rosewood	0-8	Fine sandy loam	SM, SC, SM-SC	A-2, A-4	0	100	97-100	65-90	30-50	<30	NP-10
	8-18	Fine sandy loam, loamy fine sand, sandy loam.	SM, SC, SM-SC	A-2, A-4	0	100	95-100	60-85	25-45	<30	NP-10
	18-60	Fine sand, sand, coarse sand.	SM, SP-SM	A-1, A-2, A-3	0	85-100	75-95	45-75	5-25	---	NP
713----------------- Linveldt	0-10	Fine sandy loam	SM-SC, SM	A-2, A-4	0-5	95-100	80-100	55-90	20-50	15-25	2-7
	10-19	Sandy clay loam, loam, sandy loam.	SM-SC, CL-ML, CL, SC	A-2, A-6, A-4	0-5	95-100	80-100	50-90	25-75	25-40	6-15
	19-28	Loamy sand, sand, coarse sand.	SM, SP-SM, SM-SC	A-2, A-1, A-3	0-5	65-100	55-100	30-80	5-30	<20	NP-5
	28-60	Loam, clay loam, fine sandy loam.	CL, CL-ML, SC, SM-SC	A-4, A-6	0-3	90-100	80-100	60-90	40-70	25-40	6-20

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	
765-------------- Smiley	0-12	Sandy clay loam--	ML, CL, CL-ML	A-4, A-6	0-2	95-100	85-100	75-95	50-80	<35	2-12
	12-19	Clay loam, sandy clay loam, loam.	CL	A-6, A-7	0-2	95-100	85-100	70-95	50-80	25-50	10-25
	19-60	Loam, fine sandy loam, clay loam.	CL, CL-ML, SC, SM-SC	A-4, A-6	0-2	95-100	85-100	70-95	40-80	25-40	6-18
1006*: Fluvaquents.											
Haploborolls.											
1029*. Pits											
1804-------------- Hamre	0-13	Sapric material--	PT	A-8	---	---	---	---	---	---	---
	13-18	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6, A-7	0-3	90-100	80-100	70-100	50-90	25-45	6-20
	18-60	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6, A-7	0-3	80-100	75-100	65-95	50-85	25-45	6-20
1808-------------- Markey	0-26	Sapric material	PT	A-8	---	---	---	---	---	---	---
	26-60	Sand, loamy sand	SP, SM, SP-SM	A-2, A-3	0	100	90-100	60-75	0-20	---	NP
1878-------------- Hamre	0-13	Muck--------------	PT	A-8	---	---	---	---	---	---	---
	13-18	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6, A-7	0-3	90-100	80-100	70-100	50-90	25-45	6-20
	18-60	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6, A-7	0-3	80-100	75-100	65-95	50-85	25-45	6-20
1882-------------- Rosewood	0-8	Fine sandy loam	SM, SC, SM-SC	A-2, A-4	0	100	95-100	65-90	30-50	<30	NP-10
	8-18	Fine sandy loam, loamy fine sand, sandy loam.	SM, SC, SM-SC	A-2, A-4	0	100	95-100	60-85	25-45	<30	NP-10
	18-60	Fine sand, sand	SM, SP-SM	A-1, A-2, A-3	0	85-100	75-95	45-75	5-25	---	NP

* 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	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH	Mmhos/cm					Pct
46----------------- Borup	0-15	15-27	1.20-1.40	2.0-6.0	0.20-0.23	7.4-8.4	<2	Low--------	0.28	5	4L	4-8
	15-30	10-18	1.30-1.50	2.0-6.0	0.17-0.20	7.4-8.4	<2	Low--------	0.28			
	30-60	5-18	1.35-1.65	2.0-6.0	0.15-0.19	7.9-8.4	<2	Low--------	0.28			
52----------------- Augsburg	0-13	10-27	1.20-1.40	0.6-6.0	0.20-0.23	7.4-8.4	<2	Low--------	0.28	5	4L	4-6
	13-19	5-18	1.30-1.50	2.0-6.0	0.20-0.23	7.9-8.4	<2	Low--------	0.28			
	19-36	5-18	1.40-1.60	2.0-6.0	0.17-0.22	7.9-8.4	<2	Low--------	0.28			
	36-60	35-85	1.10-1.40	0.06-0.2	0.10-0.14	7.4-8.4	<2	High-------	0.28			
58----------------- Kittson	0-9	10-27	1.30-1.45	0.6-2.0	0.20-0.22	6.6-7.8	<2	Low--------	0.24	5	5	4-6
	9-17	18-30	1.35-1.55	0.6-2.0	0.17-0.19	6.6-7.8	<2	Low--------	0.32			
	17-60	18-30	1.40-1.65	0.6-2.0	0.15-0.18	7.4-8.4	<2	Low--------	0.32			
59----------------- Grimstad	0-9	10-18	1.30-1.45	2.0-6.0	0.13-0.18	7.4-8.4	<2	Low--------	0.20	5	3	2-4
	9-31	2-15	1.45-1.60	6.0-20	0.08-0.14	7.4-9.0	<2	Low--------	0.20			
	31-60	10-30	1.50-1.65	0.6-2.0	0.11-0.19	7.4-9.0	<2	Low--------	0.37			
60----------------- Glyndon	0-22	15-27	1.20-1.40	0.6-2.0	0.20-0.23	7.4-9.0	<2	Low--------	0.28	4	4L	3-7
	22-28	10-18	1.30-1.50	0.6-6.0	0.17-0.20	7.9-9.0	<2	Low--------	0.28			
	28-60	5-18	1.35-1.65	2.0-20	0.15-0.19	7.4-8.4	<2	Low--------	0.28			
64----------------- Ulen	0-8	5-12	1.35-1.60	6.0-20	0.16-0.18	7.9-8.4	<2	Low--------	0.17	4	2	1-3
	8-25	5-12	1.45-1.65	6.0-20	0.10-0.12	7.9-8.4	<2	Low--------	0.17			
	25-60	1-7	1.50-1.70	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.17			
65----------------- Foxhome	0-11	10-20	1.35-1.50	2.0-6.0	0.14-0.18	6.6-7.3	<2	Low--------	0.20	3	3	3-7
	11-19	10-25	1.35-1.50	2.0-20	0.10-0.15	6.6-7.3	<2	Low--------	0.20			
	19-29	5-15	1.50-1.70	6.0-20	0.03-0.05	7.4-7.8	<2	Low--------	0.10			
	29-60	12-35	1.40-1.70	0.6-2.0	0.15-0.21	7.4-8.4	<2	Low--------	0.37			
66----------------- Flaming	0-16	2-10	1.40-1.55	6.0-20	0.11-0.13	5.6-7.3	<2	Low--------	0.17	5	2	2-4
	16-60	2-10	1.50-1.70	6.0-20	0.06-0.10	5.6-8.4	<2	Low--------	0.17			
77----------------- Garnes	0-11	5-20	1.40-1.60	2.0-6.0	0.14-0.18	6.6-7.8	<2	Low--------	0.32	5	3	.5-2
	11-20	18-30	1.50-1.65	0.6-2.0	0.17-0.20	6.6-7.8	<2	Moderate	0.32			
	20-60	10-27	1.60-1.75	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.32			
148---------------- Poppleton	0-9	2-10	1.45-1.65	6.0-20	0.08-0.10	5.6-7.3	<2	Low--------	0.15	5	1	1-3
	9-60	1-10	1.45-1.65	6.0-20	0.07-0.09	5.6-7.8	<2	Low--------	0.15			
184---------------- Hamerly	0-8	18-35	1.20-1.60	0.6-2.0	0.17-0.22	6.6-8.4	<2	Low--------	0.28	5	4L	4-7
	8-23	18-35	1.20-1.60	0.6-2.0	0.15-0.19	7.4-8.4	<2	Low--------	0.28			
	23-60	18-35	1.30-1.60	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.37			
205---------------- Karlstad	0-9	5-15	1.20-1.70	2.0-6.0	0.13-0.18	6.1-7.3	<2	Low--------	0.15	5	3	1-4
	9-16	5-18	1.20-1.70	2.0-6.0	0.13-0.18	6.1-7.3	<2	Low--------	0.15			
	16-19	5-18	1.80-2.00	2.0-6.0	0.12-0.16	6.6-7.8	<2	Low--------	0.15			
	19-60	1-5	1.80-2.00	>20	0.02-0.04	7.4-8.4	<2	Low--------	0.15			
236---------------- Vallers	0-12	18-28	1.20-1.35	0.6-2.0	0.22-0.24	7.4-8.4	<4	Low--------	0.28	5	4L	5-8
	12-25	18-35	1.40-1.55	0.2-0.6	0.15-0.19	7.9-8.4	<4	Low--------	0.28			
	25-60	18-35	1.50-1.70	0.2-0.6	0.17-0.19	7.4-8.4	<4	Low--------	0.28			
245B--------------- Lohnes	0-9	5-15	1.50-1.70	6.0-20	0.08-0.10	6.6-7.3	<2	Low--------	0.15	5	2	1-3
	9-60	0-10	1.50-1.70	6.0-20	0.03-0.07	6.6-8.4	<2	Low--------	0.15			
280---------------- Pelan	0-10	5-20	1.60-1.90	2.0-6.0	0.10-0.13	6.1-7.8	<2	Low--------	0.24	3	3	.5-3
	10-15	5-18	1.80-2.00	6.0-20	0.10-0.16	6.6-7.8	<2	Low--------	0.24			
	15-26	1-5	1.80-2.00	6.0-20	0.05-0.13	7.4-8.4	<2	Low--------	0.24			
	26-60	5-20	1.60-1.90	0.6-6.0	0.14-0.18	7.9-8.4	<2	Low--------	0.37			
343---------------- Wheatville	0-21	15-27	1.25-1.40	2.0-6.0	0.18-0.22	7.4-8.4	<2	Low--------	0.28	4	4L	3-7
	21-33	5-18	1.35-1.55	2.0-6.0	0.15-0.21	7.4-8.4	<2	Low--------	0.28			
	33-60	35-80	1.15-1.50	0.06-0.2	0.10-0.14	7.4-7.8	<2	High-------	0.28			

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	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH	Mmhos/cm					Pct
372-------------- Hamar	0-14	5-10	1.20-1.30	2.0-20	0.10-0.12	6.6-7.8	<2	Low--------	0.17	5	2	1-3
	14-24	0-7	1.35-1.55	2.0-20	0.10-0.12	6.6-8.4	<2	Low--------	0.17			
	24-60	0-7	1.45-1.65	2.0-20	0.6-0.8	7.4-8.4	<2	Low--------	0.17			
387-------------- Roliss	0-7	18-35	1.10-1.50	0.2-2.0	0.17-0.24	6.6-7.8	<2	Low--------	0.28	5	6	3-8
	7-13	18-35	1.30-1.70	0.2-0.6	0.15-0.19	6.6-7.8	<2	Low--------	0.28			
	13-60	18-35	1.30-1.70	0.6-2.0	0.15-0.19	7.9-8.4	<2	Low--------	0.28			
404-------------- Chilgren	0-4	5-18	1.20-1.7	2.0-6.0	0.16-0.18	6.1-7.3	<2	Low--------	0.28	5	3	1-3
	4-10	2-18	1.40-1.6	0.6-2.0	0.13-0.22	6.1-7.3	<2	Low--------	0.28			
	10-29	18-35	1.30-1.7	0.6-2.0	0.18-0.22	6.6-7.8	<2	Moderate	0.28			
	29-60	10-27	1.3-1.8	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.28			
412-------------- Mavie	0-7	18-35	1.30-1.45	0.6-2.0	0.18-0.22	7.4-8.4	<2	Low--------	0.28	5	4L	3-6
	7-14	10-27	1.35-1.55	0.6-2.0	0.12-0.19	7.9-8.4	<2	Low--------	0.28			
	14-30	2-10	1.40-1.65	6.0-20	0.03-0.05	7.4-8.4	<2	Low--------	0.10			
	30-60	18-35	1.40-1.70	0.6-2.0	0.15-0.21	7.4-8.4	<2	Low--------	0.37			
426-------------- Foldahl	0-9	4-15	1.30-1.50	2.0-6.0	0.14-0.18	6.1-7.8	<2	Low--------	0.20	5	3	2-5
	9-24	4-15	1.45-1.60	6.0-20	0.07-0.12	6.6-7.8	<2	Low--------	0.20			
	24-60	12-35	1.50-1.65	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.37			
432-------------- Strandquist	0-11	10-25	1.20-1.70	0.6-2.0	0.14-0.18	6.6-7.8	<2	Low--------	0.32	2	4L	2-6
	11-29	1-5	1.80-2.00	6.0-20	0.03-0.05	7.4-8.4	<2	Low--------	0.10			
	29-60	10-30	1.30-1.80	0.6-2.0	0.12-0.19	7.4-8.4	<2	Low--------	0.37			
435-------------- Syrene	0-13	8-18	1.25-1.45	2.0-6.0	0.13-0.18	7.4-8.4	<2	Low--------	0.28	2	3	3-8
	13-60	2-10	1.50-1.70	6.0-20	0.02-0.04	7.4-8.4	<2	Low--------	0.10			
439-------------- Rockwell	0-9	10-20	1.25-1.45	2.0-6.0	0.16-0.18	7.4-8.4	<2	Low--------	0.24	5	3	4-8
	9-17	5-30	1.35-1.50	2.0-6.0	0.15-0.17	7.9-8.4	<2	Low--------	0.24			
	17-33	3-10	1.40-1.60	6.0-20	0.05-0.07	7.4-7.8	<2	Low--------	0.24			
	33-60	15-30	1.40-1.60	0.6-2.0	0.18-0.22	7.4-7.8	<2	Low--------	0.24			
481-------------- Kratka	0-11	5-15	1.20-1.50	2.0-6.0	0.13-0.18	7.4-7.8	<2	Low--------	0.17	5	3	2-5
	11-25	2-10	1.30-1.60	6.0-20.	0.06-0.11	7.4-7.8	<2	Low--------	0.17			
	25-60	10-35	1.50-1.80	0.6-2.0	0.11-0.19	7.9-8.4	<2	Low--------	0.17			
540-------------- Seelyeville	0-60	---	0.10-0.25	0.2-6.0	0.35-0.45	5.6-7.3	<2	-----------	----	---	3	>25
543-------------- Markey	0-26	---	0.15-0.45	0.2-6.0	0.35-0.45	5.6-7.8	<2	-----------	----	---	3	55-85
	26-60	0-10	1.40-1.65	6.0-20	0.03-0.08	6.1-8.4	<2	Low--------	----			
544-------------- Cathro	0-16	---	0.28-0.45	2.0-6.0	0.45-0.55	5.6-7.8	<2	-----------	----	---	3	60-85
	16-36	---	0.15-0.30	2.0-6.0	0.35-0.45	5.6-7.8	<2	-----------	----			
	36-60	0-25	1.50-2.00	0.6-2.0	0.11-0.22	6.6-8.4	<2	Low--------	----			
547-------------- Deerwood	0-9	---	0.10-0.30	2.0-6.0	0.35-0.45	6.6-7.8	<2	-----------	----	5	3	50-90
	9-14	2-18	1.20-1.70	2.0-20	0.09-0.17	7.4-8.4	<2	Low--------	0.17			
	14-60	0-10	1.50-1.70	6.0-20	0.02-0.07	7.4-8.4	<2	Low--------	0.17			
565-------------- Eckvoll	0-9	5-15	1.30-1.70	2.0-6.0	0.10-0.12	6.1-7.3	<2	Low--------	0.17	5	2	1-3
	9-25	2-10	1.30-1.80	2.0-6.0	0.06-0.08	6.1-7.3	<2	Low--------	0.17			
	25-32	18-35	1.40-1.80	0.6-2.0	0.16-0.18	6.6-7.8	<2	Moderate	0.32			
	32-60	18-32	1.30-1.70	0.6-2.0	0.17-0.19	7.4-8.4	<2	Low--------	0.32			
582-------------- Roliss	0-7	18-35	1.10-1.50	0.6-2.0	0.17-0.24	6.6-7.8	<2	Low--------	0.28	5	6	3-7
	7-13	18-35	1.30-1.70	0.6-2.0	0.15-0.19	6.6-7.8	<2	Low--------	0.28			
	13-60	18-35	1.30-1.70	0.6-2.0	0.15-0.19	7.9-8.4	<2	Low--------	0.28			
641-------------- Clearwater	0-8	40-60	1.20-1.50	0.06-0.2	0.13-0.17	6.6-7.8	<2	High-------	0.32	5	4	3-6
	8-16	35-60	1.20-1.50	0.06-0.2	0.15-0.18	7.4-8.4	<2	High-------	0.32			
	16-60	35-60	1.20-1.60	0.06-0.2	0.15-0.18	7.4-8.4	<2	High-------	0.32			

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH	Mmhos/cm					Pct
642-------------- Clearwater	0-8	10-27	1.30-1.60	0.6-6.0	0.10-0.16	6.6-7.8	<2	Low--------	0.24	5	3	2-5
	8-16	35-60	1.20-1.50	0.06-0.2	0.15-0.18	7.4-8.4	<2	High-------	0.32			
	16-60	35-60	1.20-1.60	0.06-0.2	0.15-0.18	7.4-8.4	<2	High-------	0.32			
643-------------- Grimstad Variant	0-13	5-15	1.50-1.60	2.0-6.0	0.13-0.18	7.4-8.4	<2	Low--------	0.20	5	3	2-4
	13-23	8-15	1.55-1.65	2.0-6.0	0.09-0.17	7.9-8.4	<2	Low--------	0.20			
	23-34	3-8	1.55-1.70	6.0-20	0.06-0.11	7.9-8.4	<2	Low--------	0.20			
	34-60	35-80	1.35-1.60	0.06-0.2	0.09-0.16	7.9-8.4	<2	High-------	0.32			
644-------------- Boash	0-7	35-40	1.10-1.40	0.06-0.2	0.13-0.17	6.6-7.8	<2	High-------	0.32	5	4	3-6
	7-27	35-60	1.10-1.40	0.06-0.2	0.15-0.20	6.6-7.8	<2	High-------	0.32			
	27-60	16-35	1.20-1.60	0.6-2.0	0.12-0.18	7.4-8.4	<2	Low--------	0.32			
645-------------- Espelie	0-9	8-18	1.30-1.45	2.0-6.0	0.13-0.18	6.6-7.3	<2	Low--------	0.20	4	3	2-4
	9-24	3-10	1.35-1.60	2.0-20	0.06-0.11	6.6-7.8	<2	Low--------	0.17			
	24-60	35-60	1.35-1.60	0.06-0.2	0.09-0.19	7.4-8.4	<2	High-------	0.32			
647-------------- Hilaire	0-10	8-18	1.30-1.45	2.0-6.0	0.13-0.18	6.6-7.3	<2	Low--------	0.15	4	3	2-4
	10-15	3-10	1.25-1.40	6.0-20	0.07-0.14	6.6-7.8	<2	Low--------	0.15			
	15-34	1-10	1.20-1.40	6.0-20	0.07-0.12	6.6-7.8	<2	Low--------	0.10			
	34-60	35-60	1.35-1.55	0.06-0.2	0.09-0.19	7.4-8.4	<2	High-------	0.32			
648-------------- Reiner Variant	0-7	18-35	1.25-1.45	0.2-0.6	0.18-0.23	6.6-7.3	<2	Moderate	0.28	5	7	4-8
	7-36	35-50	1.30-1.60	0.06-0.6	0.15-0.19	6.6-7.8	<2	High-------	0.28			
	36-60	27-40	1.45-1.65	0.06-0.2	0.14-0.16	7.4-8.4	<2	Low--------	0.37			
649-------------- Reiner	0-7	5-12	1.30-1.70	6.0-20	0.10-0.12	6.6-7.3	<2	Low--------	0.17	5	2	3-5
	7-17	18-35	1.40-1.75	0.6-2.0	0.15-0.19	6.6-7.3	<2	Moderate	0.32			
	17-60	16-30	1.35-1.75	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.32			
650-------------- Reiner	0-7	10-25	1.30-1.60	0.6-2.0	0.20-0.22	6.6-7.3	<2	Low--------	0.32	5	5	4-6
	7-17	18-35	1.40-1.75	0.6-2.0	0.15-0.19	6.6-7.3	<2	Moderate	0.32			
	17-60	16-30	1.35-1.75	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.32			
651-------------- Thiefriver	0-10	8-18	1.30-1.45	2.0-6.0	0.13-0.18	7.4-8.4	<2	Low--------	0.24	5	3	2-4
	10-33	2-10	1.25-1.40	6.0-20	0.06-0.11	7.4-8.4	<2	Low--------	0.17			
	33-60	35-70	1.35-1.60	0.06-0.2	0.09-0.19	7.4-8.4	<2	High-------	0.32			
652-------------- Wyandotte	0-8	16-22	1.30-1.45	0.6-2.0	0.14-0.18	7.4-7.8	<2	Low--------	0.28	5	4L	4-8
	8-15	18-24	1.30-1.45	0.6-2.0	0.14-0.23	7.9-8.4	<2	Low--------	0.28			
	15-34	2-10	1.40-1.70	6.0-20	0.02-0.06	7.4-8.4	<2	Low--------	0.15			
	34-60	35-80	1.40-1.55	0.06-0.2	0.15-0.18	7.4-7.8	<2	High-------	0.32			
712-------------- Rosewood	0-8	8-18	1.20-1.40	2.0-6.0	0.13-0.18	7.8-184	<2	Low--------	0.24	3	3	4-7
	8-18	6-18	1.20-1.40	2.0-6.0	0.11-0.15	7.9-8.4	<2	Low--------	0.24			
	18-60	1-6	1.45-1.65	6.0-20	0.05-0.08	7.4-8.4	<2	Low--------	0.24			
713-------------- Linveldt	0-10	8-15	1.20-1.40	2.0-6.0	0.13-0.18	6.6-7.8	<2	Low--------	0.28	5	3	2-4
	10-19	12-18	1.25-1.50	0.6-6.0	0.12-0.18	6.6-7.8	<2	Low--------	0.28			
	19-28	2-10	1.45-1.70	6.0-20	0.06-0.11	7.4-8.4	<2	Low--------	0.17			
	28-60	16-30	1.35-1.70	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.32			
765-------------- Smiley	0-12	8-20	1.20-1.50	0.6-2.0	0.20-0.24	6.6-7.8	<2	Low--------	0.24	5	5	2-5
	12-19	18-35	1.35-1.60	0.6-2.0	0.15-0.19	6.6-7.8	<2	Moderate	0.24			
	19-60	16-32	1.40-1.70	0.6-2.0	0.14-0.19	7.4-8.4	<2	Low--------	0.24			
1006*: Fluvaquents.												
Haploborolls.												
1029*. Pits												
1804------------- Hamre	0-13	---	0.18-0.22	0.2-2.0	0.35-0.48	6.6-7.8	<2	Low--------	0.20	5	2	85-95
	13-18	18-35	1.30-1.70	0.2-2.0	0.17-0.19	6.6-7.8	<2	Low--------	0.32			
	18-60	18-35	1.40-1.70	0.2-2.0	0.17-0.19	7.4-8.4	<2	Low--------	0.32			

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	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors		Wind erodi- bility group	Organic matter
									K	T		
	In	Pct	G/cm^3	In/hr	In/in	pH	Mmhos/cm					Pct
1808--------------	0-26	---	0.15-0.45	0.2-6.0	0.35-0.45	5.6-7.8	<2	-----------	----	---	3	55-85
Markey	26-60	0-10	1.40-1.65	6.0-20	0.03-0.08	6.1-8.4	<2	Low--------	----			
1878--------------	0-13	---	0.18-0.22	0.2-2.0	0.35-0.48	6.6-7.8	<2	Low--------	0.20	5	2	85-95
Hamre	13-18	18-35	1.30-1.70	0.2-2.0	0.17-0.19	6.6-7.8	<2	Low--------	0.32			
	18-60	18-35	1.40-1.70	0.2-2.0	0.17-0.19	7.4-8.4	<2	Low--------	0.32			
1882--------------	0-8	8-18	1.20-1.40	2.0-6.0	0.13-0.18	7.9-8.4	<2	Low--------	0.24	3	3	4-7
Rosewood	8-18	6-18	1.20-1.40	2.0-6.0	0.11-0.15	7.9-8.4	<2	Low--------	0.24			
	18-60	1-6	1.45-1.65	6.0-20	0.05-0.08	7.4-8.4	<2	Low--------	0.24			

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--SOIL AND WATER FEATURES

["High water table" and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Soil name and map symbol	Hydrologic group[1]	High water table			Potential frost action	Risk of corrosion	
		Depth	Kind	Months		Uncoated steel	Concrete
		Ft					
46----------------- Borup	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
52----------------- Augsburg	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
58----------------- Kittson	C	2.5-6.0	Apparent	Nov-Jun	High------------	High-----------	Low.
59----------------- Grimstad	B	2.5-6.0	Apparent	Apr-Jul	Moderate--------	Moderate-------	Low.
60----------------- Glyndon	B	2.5-6.0	Apparent	Apr-Jul	High------------	High-----------	Low.
64----------------- Ulen	B	2.5-6.0	Apparent	Apr-Jul	Moderate--------	Low------------	Low.
65----------------- Foxhome	B	2.5-6.0	Apparent	Nov-Jun	High------------	Moderate-------	Low.
66----------------- Flaming	A	2.5-6.0	Apparent	Nov-Jun	Moderate--------	Low------------	Low.
77----------------- Garnes	B	2.5-6.0	Apparent	Apr-Jul	High------------	Moderate-------	Low.
148---------------- Poppleton	A	2.5-5.0	Apparent	Nov-Jun	Moderate--------	Low------------	Low.
184---------------- Hamerly	C	2.5-5.0	Apparent	Apr-Jun	High------------	High-----------	Low.
205---------------- Karlstad	A	2.5-6.0	Apparent	Apr-Jul	Low-------------	Low------------	Low.
236---------------- Vallers	C	1.0-2.5	Apparent	Nov-Jun	High------------	High-----------	Low.
245B--------------- Lohnes	A	>6.0	---	---	Low-------------	Moderate-------	Low.
280---------------- Pelan	B	2.5-6.0	Apparent	Apr-Jul	Moderate--------	Moderate-------	Low.
343---------------- Wheatville	B	2.5-6.0	Apparent	Apr-Jul	High------------	High-----------	Low.
372---------------- Hamar	A/D	1.0-2.0	Apparent	Oct-Jun	Moderate--------	High-----------	Low.
387*--------------- Roliss	B/D	+.5-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
404---------------- Chilgren	C	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
412---------------- Mavie	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
426---------------- Foldahl	B	2.5-6.0	Apparent	Nov-Jun	High------------	Moderate-------	Low.
432---------------- Strandquist	B/D	1.0-3.0	Apparent	Nov-Jun	High------------	High-----------	Low.

See footnotes at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	High water table[1]			Potential frost action	Risk of corrosion	
		Depth	Kind	Months		Uncoated steel	Concrete
		Ft					
435----------------- Syrene	B/D	1.0-3.0	Apparent	Apr-Jul	Moderate--------	High-----------	Low.
439----------------- Rockwell	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
481----------------- Kratka	B/D	1.0-3.0	Apparent	Apr-Jul	Moderate--------	High-----------	Low.
540*---------------- Seelyeville	A/D	+2-1.0	Apparent	Jan-Dec	High------------	High-----------	Moderate.
543*---------------- Markey	A/D	+1-1.0	Apparent	Nov-Jun	High------------	High-----------	Low.
544*---------------- Cathro	A/D	+1-1.0	Apparent	Nov-Jun	High------------	High-----------	Low.
547*---------------- Deerwood	B/D	+1-1.0	Apparent	Jan-Dec	Moderate--------	High-----------	Low.
565----------------- Eckvoll	B	2.5-5.0	Apparent	Apr-Jun	High------------	Moderate-------	Low.
582----------------- Roliss	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
641, 642------------ Clearwater	D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
643----------------- Grimstad Variant	B	2.5-6.0	Apparent	Apr-Jul	High------------	High-----------	Low.
644----------------- Boash	D	1.0-3.0	Apparent	Apr-Jun	High------------	High-----------	Low.
645----------------- Espelie	B/D	1.0-3.0	Apparent	Apr-Jun	High------------	High-----------	Low.
647----------------- Hilaire	B	2.5-6.0	Apparent	Apr-Jun	High------------	Moderate-------	Low.
648----------------- Reiner Variant	C	2.5-6.0	Apparent	Nov-Jun	High------------	Moderate-------	Low.
649, 650------------ Reiner	B	2.5-6.0	Apparent	Apr-Jul	High------------	Moderate-------	Low.
651----------------- Thiefriver	B/D	1.0-3.0	Apparent	Nov-Jun	High------------	High-----------	Low.
652----------------- Wyandotte	D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
712----------------- Rosewood	A/D	1.0-3.0	Apparent	Apr-Jun	Moderate--------	High-----------	Low.
713----------------- Linveldt	B	2.5-6.0	Apparent	Apr-Jul	High------------	Moderate-------	Low.
765----------------- Smiley	B/D	1.0-3.0	Apparent	Apr-Jul	High------------	High-----------	Low.
1006** Fluvaquents.							
Haploborolls.							

See footnotes at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	High water table			Potential frost action	Risk of corrosion	
		Depth	Kind	Months		Uncoated steel	Concrete
		Ft					
1029**. Pits							
1804*: Hamre	C/D	+2-1.0	Apparent	Jan-Dec	High	High	Low.
1808*: Markey	A/D	+2-1.0	Apparent	Nov-Jun	High	High	Low.
1878*: Hamre	C/D	+1-1.0	Apparent	Jan-Dec	High	High	Low.
1882: Rosewood	D	0-3.0	Apparent	Jan-Dec	High	High	Low.

* In the "High water table--Depth column, a plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

** 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
Augsburg	Coarse-silty over clayey, frigid Typic Calciaquolls
Boash	Clayey over loamy, montmorillonitic (calcareous), frigid Typic Haplaquolls
Borup	Coarse-silty, frigid Typic Calciaquolls
Cathro	Loamy, mixed, euic Terric Borosaprists
Chilgren	Fine-loamy, mixed, frigid Typic Ochraqualfs
Clearwater	Fine, montmorillonitic (calcareous), frigid Typic Haplaquolls
Deerwood	Sandy, mixed, frigid Histic Humaquepts
Eckvoll	Fine-loamy, mixed Aquic Eutroboralfs
Espelie	Sandy over clayey, mixed, frigid Typic Haplaquolls
Flaming	Sandy, mixed Aquic Haploborolls
Fluvaquents	Loamy, mixed, frigid Fluvaquents
Foldahl	Sandy over loamy, mixed Aquic Haploborolls
Foxhome	Sandy-skeletal over loamy, mixed Aquic Haploborolls
Garnes	Fine-loamy, mixed Aquic Eutroboralfs
Glyndon	Coarse-silty, frigid Aeric Calciaquolls
Grimstad	Sandy over loamy, frigid Aeric Calciaquolls
Grimstad Variant	Sandy over clayey, frigid Aeric Calciaquolls
Hamar	Sandy, mixed, frigid Typic Haplaquolls
Hamerly	Fine-loamy, frigid Aeric Calciaquolls
Hamre	Fine-loamy, mixed, nonacid, frigid Histic Humaquepts
Haploborolls	Loamy, mixed Haploborolls
Hilaire	Sandy over clayey, mixed Aquic Haploborolls
Karlstad	Coarse-loamy, mixed Aquic Eutroboralfs
Kittson	Fine-loamy, mixed Aquic Haploborolls
Kratka	Sandy over loamy, mixed, frigid Typic Haplaquolls
Linveldt	Coarse-loamy, mixed Aquic Argiborolls
Lohnes	Sandy, mixed Udorthentic Haploborolls
Markey	Sandy or sandy-skeletal, mixed, euic Terric Borosaprists
Mavie	Sandy-skeletal over loamy, frigid Typic Calciaquolls
Pelan	Loamy-skeletal, mixed Psammentic Eutroboralfs
Poppleton	Mixed, frigid Aquic Udipsamments
Reiner	Fine-loamy, mixed Abruptic Udic Argiborolls
Reiner Variant	Clayey over loamy, mixed Abruptic Udic Argiborolls
Rockwell	Coarse-loamy, frigid Typic Calciaquolls
Roliss	Fine-loamy, mixed (calcareous), frigid Typic Haplaquolls
Rosewood	Sandy, frigid Typic Calciaquolls
Seelyeville	Euic Typic Borosaprists
Smiley	Fine-loamy, mixed, frigid Typic Argiaquolls
Strandquist	Sandy-skeletal over loamy, mixed (calcareous), frigid Typic Haplaquolls
Syrene	Sandy, frigid Typic Calciaquolls
Thiefriver	Sandy over clayey, mixed, frigid Typic Calciaquolls
Ulen	Sandy, frigid Aeric Calciaquolls
Vallers	Fine-loamy, frigid Typic Calciaquolls
Wheatville	Coarse-silty over clayey, frigid Aeric Calciaquolls
Wyandotte	Sandy-skeletal over clayey, frigid Typic Calciaquolls

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