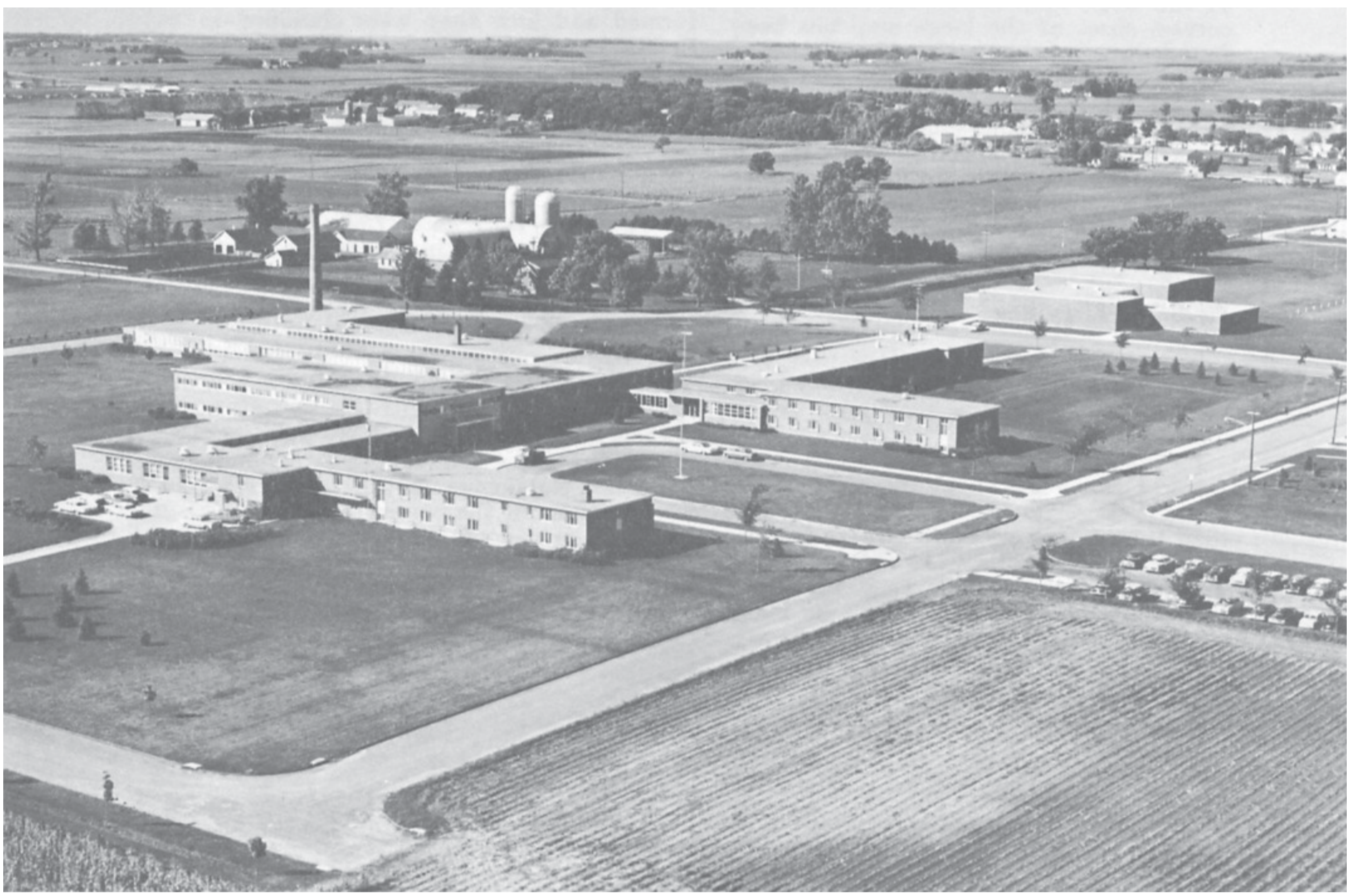
Series 1961, No. 24

ISSUED MAY 1965

SOIL SURVEY

WASECA COUNTY Minnesota



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
MINNESOTA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Waseca County, Minn., will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; and add to our knowledge of soil science.

Locating Soils

Use the index to map sheets at the back of this report to locate areas on the large map. The index is a small map of the county numbered to show where each sheet of the large map is located. When the correct sheet of the large map has been found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they occur on the map. The symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where the symbol belongs.

Finding Information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and Management of the Soils." In this way they first identify the soils on their farm and then learn how these soils can be managed and what yields can be expected. The "Guide to Mapping Units and Capability Units" at the back of the report will simplify use of the map and report. This guide lists each soil and land type mapped in the county, and the page where each is described. It also lists the capability unit for each soil and land type, and the pages where each is described.

Engineers and builders will want to refer to the section "Use of the Soils for Engineering." Tables in that section show characteristics of the soils that affect engineering.

Persons interested in science will find information about how the soils were formed and how they were classified in the section "Formation and Classification of Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in Waseca County will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

* * * * *

Fieldwork for this survey was completed in 1961. Unless otherwise indicated, all statements in the report refer to conditions in the county at that time. The soil survey of Waseca County was made as part of the technical assistance furnished by the Soil Conservation Service to the Waseca County Soil and Water Conservation District.

Cover picture: Southern School of Agriculture and Experiment Station at Waseca, Minn.

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SOIL SURVEY OF WASECA COUNTY, MINNESOTA

BY JOSEPH F. CUMMINS, SOIL CONSERVATION SERVICE

FIELD SURVEY BY CARROLL R. CARLSON, JOSEPH F. CUMMINS, RUSSELL J. EDWARDS, GRENFALL F. HARMS, GORDEN MACVEY, D. KIRK WOODWORTH, HALVOR RAVENHOLT, AND LEO G. SHIELDS, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

WASECA COUNTY is in the south-central part of Minnesota (fig. 1). The county seat is located at Waseca. The county has a total land area of 415 square miles, and most of the acreage is land in farms. In 1960 approximately 80 percent of the land in farms was cropland. Corn and soybeans are the principal grain crops, and hogs and dairy cattle are the principal kinds of livestock.

The soil survey was made cooperatively by the U.S. Department of Agriculture and the Minnesota Agricultural Experiment Station to provide a basis for determining uses of the land. In the preparation of the survey report, assistance was received from the Waseca County Extension Service, the U.S. Bureau of Public Roads, the Minnesota Department of Highways, and the U.S. Weather Bureau.

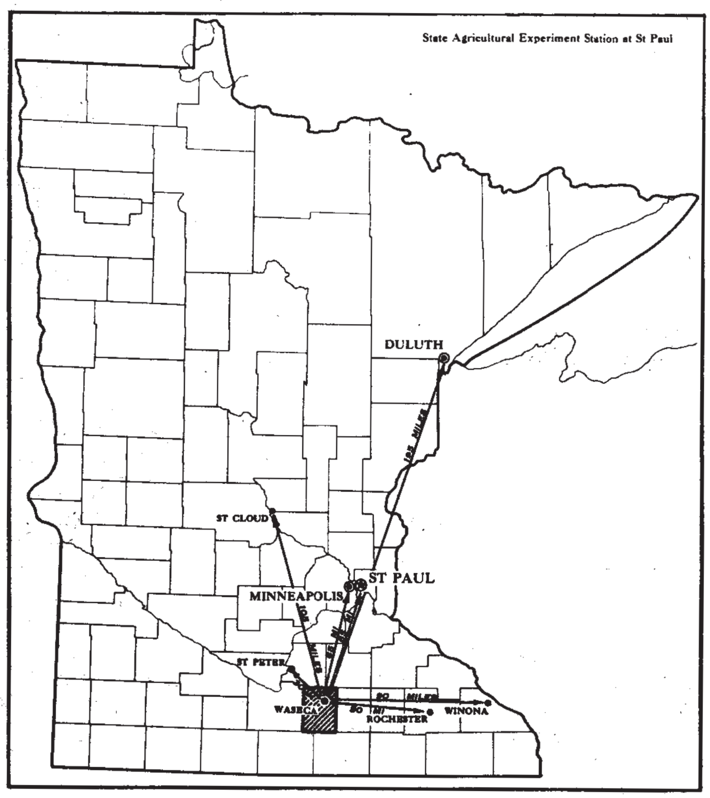

Figure 1.—Location of Waseca County in Minnesota.

General Nature of the County

This section describes the social and industrial development of the county and gives facts about agriculture. It also discusses the physiography, drainage, geology, water supply, and climate of the county.

Social and Industrial Development

The area that is now Waseca County was opened to legal settlement in 1851. In that year the Sioux Indians relinquished title to a large area of land west of the Mississippi River.

From 1855 to 1857, the area was a part of Steele County, but in 1857 Waseca County was organized. Most of the early settlers who came to this county were from the eastern part of the United States and from Canada, and they were mainly of Irish, German, and Scandinavian descent. Of the 13 original townsites that were established, 7 remain. They are Waseca, Janesville, New Richland, Waldorf, Matawan, Alma City, and Otisco. In 1960 Waseca had a population of 5,898; Janesville, 1,426; and New Richland, 1,046.

The first railroad in the county began service in 1867. Two railroads now serve the county, and buslines also provide transportation. Public highways have been well maintained. In 1960 there was a total of 754 miles of all-weather roads in the county. In many places the roads run along section lines.

Trading centers are conveniently located throughout the county. Marketing facilities are available for farm products, either within the county or in large centers nearby. Waseca, Janesville, Waldorf, New Richland, and Otisco provide outlets for milk. Packing plants at South St. Paul, in Dakota County, at Albert Lea in Freeborn County, and at Austin in Mower County provide markets for livestock products.

Grain elevators are located at Waseca, Janesville, Waldorf, Matawan, and New Richland. A plant where soybeans are processed is located in Mankato in Blue Earth County, and a second such plant is in Savage in Scott County. Corn and peas are frozen at a plant in Waseca.

Most of the one-room elementary schools in the county have been consolidated with elementary schools and high schools at Waseca, New Richland, Waldorf, and Janesville. There are several parochial elementary schools and one parochial high school in the county. Churches are numerous, both in urban and in rural areas.

Nearly all farms have electricity available, and most farms have telephone service. Natural gas is available to some parts of the county.

Agriculture

When this county was first settled, agricultural products were grown mainly for home use. Barley and corn were grown on a small acreage, but wheat and oats were the principal crops and the chief source of cash income. Only a few head of livestock were raised. About 55 percent of the total acreage in the county was wet and needed artificial drainage.

Among the most important factors that have influenced the development of agriculture in this county are improvements in artificial drainage. The improvement of drainage outlets was begun in the early 1880's, and farmers began to use tile drainage about 1910. In 1912 an experimental farm on the outskirts of Waseca was purchased to develop improved methods of draining the soils. Interest in the use of complete drainage systems also increased after farm machinery improved and more land was needed for crops. As a result, drainage was improved in many areas. A few outlets still need further development, but the chief need is to improve the present drainage systems and to reclaim odd areas. The use of most of the land that has been drained has shifted from pasture to the growing of corn and soybeans.

In the early 1880's, at about the time when improvements in drainage outlets were first made, a trend toward diversified farming began. Less wheat and more feed grains were grown, and the raising of livestock became more important. Dairy cattle were raised extensively, for those animals made the most profitable use of the forage that was available in wet areas. Dairying continues to be a significant farm enterprise, but there are now fewer small dairy farms and a greater number of larger ones than there formerly were. As the number of small dairy farms has decreased, farms have tended to become more specialized.

Hogs were of only minor importance in the early agriculture, but when the acreage of corn increased and the quality of the corn improved, hogs were raised more extensively. In 1959 nearly 19 percent of the total income derived from the sale of farm products was from the sale of hogs, and an additional 16 percent was from the sale of dairy products.

The raising of beef cattle was a minor enterprise in early agriculture. Feeder cattle have been fairly numerous at various times when prices were favorable, but they have been less important as a source of farm income than dairy cattle and hogs. Feeder cattle have become more numerous as the acreage in corn has increased and the number of dairy farms has decreased.

Chickens and other types of poultry were not raised extensively in this county until about 1930, when income from the sale of poultry and poultry products became important. In the 1950's poultry raising became more specialized, and in 1959 there were 15 poultry farms in the county.

A number of small flocks of sheep are in the county. However, sheep have not been important as a source of farm income. Table 1 shows the number of livestock and the principal kinds of livestock raised in the county in stated years.

TABLE 1.—*Number of livestock on farms*

Livestock	1945	1950	1959
	Number	*Number*	*Number*
Horses and mules	5, 300	2, 500	501
Cattle and calves	35, 500	32, 600	32, 288
Milk cows	18, 000	15, 100	11, 571
Hogs and pigs	54, 000	62, 300	75, 945
Sheep and lambs	8, 100	5, 700	4, 545
Chickens	[1] 366, 668	[1] 337, 850	[1] 380, 690

[1] Four months old or older.

Table 2 gives the acreage of the principal crops grown in the county in stated years. Corn was grown on only a small acreage in the early days of agriculture, and most of the early varieties of corn were not suited to the climate. The improvement in varieties of corn and in the marketing facilities for corn and soybeans have encouraged the recent shift from diversification of crops to specialization.

TABLE 2.—*Acreage of principal crops*

Crop	1945	1950	1960
	Acres	*Acres*	*Acres*
Corn for all purposes	72, 400	66, 400	100, 486
Small grains:			
Winter wheat	2, 500	1, 100	625
Spring wheat	2, 100	1, 500	12, 280
Oats	50, 900	50, 800	26, 652
Barley	400	8, 600	684
Rye	350	700	415
Flax	2, 500	4, 900	152
Soybeans	5, 200	23, 700	31, 162
All hay	34, 200	26, 200	21, 853

The acreage of soybeans has increased rapidly since 1935, and soybeans are now second only to corn in dollar value as a cash-grain crop. As a result of the increase in the acreage of soybeans, there has been a decrease in the acreage of small grains and meadow.

Oats were originally grown for livestock feed and for market. Now, this crop is used primarily as a specialized feed, for bedding, and as a companion crop for legumes.

Government agricultural programs have recently caused the acreage of wheat to be increased to some extent. Most of the wheat is planted in spring.

Because of the canning factories located at Waseca, at Wells in Faribault County, and at Le Sueur in Le Sueur County, a small acreage has been planted to sweet corn and peas. Hybrid corn is grown extensively for seed in Iosco and Blooming Grove Townships. A few farmers produce canarygrass seed in the undrained areas of organic soils.

In the early days of agriculture, native prairie grasses were cut for hay, but in the 1880's red clover and timothy became important for tame hay. Alfalfa and sweetclover were not grown extensively until about 1920. After that year, the acreage of alfalfa and sweetclover increased because methods of growing those crops successfully were better understood.

Physiography and Drainage

This county is in an area through which several ice sheets advanced and retreated during the glacial period. The complex, irregular morainic topography is typical of that in a till plain formed by the back wasting of the Late Wisconsin ice sheet. In places the end moraines and ground moraines, however, have a drumloid pattern that is characterized by short, circular hills that have smooth sides and nearly level tops.

The county can be divided into the following four physiographic areas: Strong end-moraine topography throughout the eastern and northern tier of townships; lacustrine sediments in the western part of Vivian, Freedom, and Alton Townships; transitional areas of ground moraines between the lacustrine sediments; and end moraines and outwash areas in the central part of Otisco Township and in section 1 in Janesville Township.

The Le Sueur River drains a large part of the county. It has a broad, shallow valley that is less than 50 feet deep. The bottom of this valley is generally less than 25 feet below the adjoining till plain. The southwestern part of the county drains to Bull Run Creek, the Cobb River, and the Little Cobb River. The Cannon River drains a small area of the northern edge of the county, and Crane Creek drains a part of Woodville and Blooming Grove Townships (fig. 2).

Lakes and marshes are common throughout the county. Lake Elysian at present drains into the Le Sueur River, but there is a well-defined channel that connects it with the Cannon River in the southern part of Le Sueur County. This channel developed when the ice sheet caused the water to pond and prevented the water from flowing westward to the Minnesota River.

Geology and Water Supply

All of this county is covered by a mantle of glacial drift, which ranges from 125 feet to more than 200 feet in thickness (*8*).[1] In the extreme northeastern, central, and southwestern parts of the county, the glacial drift is generally less than 150 feet thick, but it is thicker along the eastern border and toward the northwestern part. A belt of drift that appears to be more than 200 feet thick extends from the county line in Janesville Township eastward to a point beyond Janesville. This belt may have been caused by a buried channel that extends to the Minnesota Valley at Mankato in Blue Earth County.

Bedrock is not exposed anywhere in the county. The rocks that directly underlie the glacial drift are all of the Ordovician period, except that there is some white clay in the southeastern part of the county that may be of the Cretaceous period. This clay may be residual material derived from the weathering of Maquoketa shale and dolomitic limestone (fig. 3). The rocks of Ordovician age dip toward the southeast at a slight angle.

Buried deep beneath the county is Jordan sandstone, which is of Cambrian age. At Waseca, the top of the Jordan sandstone lies 670 feet below the surface (fig. 4). The top of the Jordan sandstone is 500 feet above sea level in the northwestern part of the county, but it is only about 350 feet above sea level in the southeastern part. The dip is toward the trough of a broad, synclinal basin. The axis of this basin extends from Waseca southeastward toward Albert Lea in Freeborn County and Austin in Mower County. The underground water supply in this basin is constantly recharged by the waters of the Mississippi River in the vicinity of St. Paul and Minneapolis.

In addition to the Jordan formation, the other members of the St. Croixan series are represented. The Oneota-Shakopee group, which has a total thickness of about 225 feet, separates the St. Peter and Jordan formations. The Oneota formation is about 150 feet thick. In places it is separated from the Shakopee formation by a thin bed of sandstone, which may represent the Root Valley formation. The Shakopee limestone in this area is reddish pink and is about 100 feet thick. The Oneota and Shakopee formations yield some water from joints, bedding planes, and solution passages, but no large supply of water can be expected.

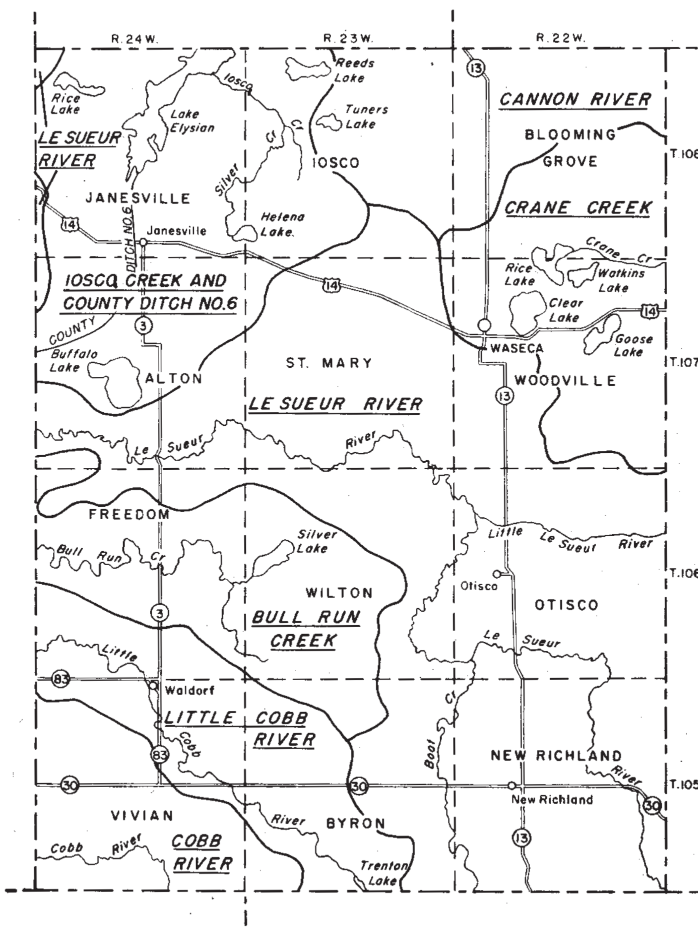

Figure 2.—Major watersheds in Waseca County.

[1] Italic numbers in parentheses refer to Literature Cited, p. 82.

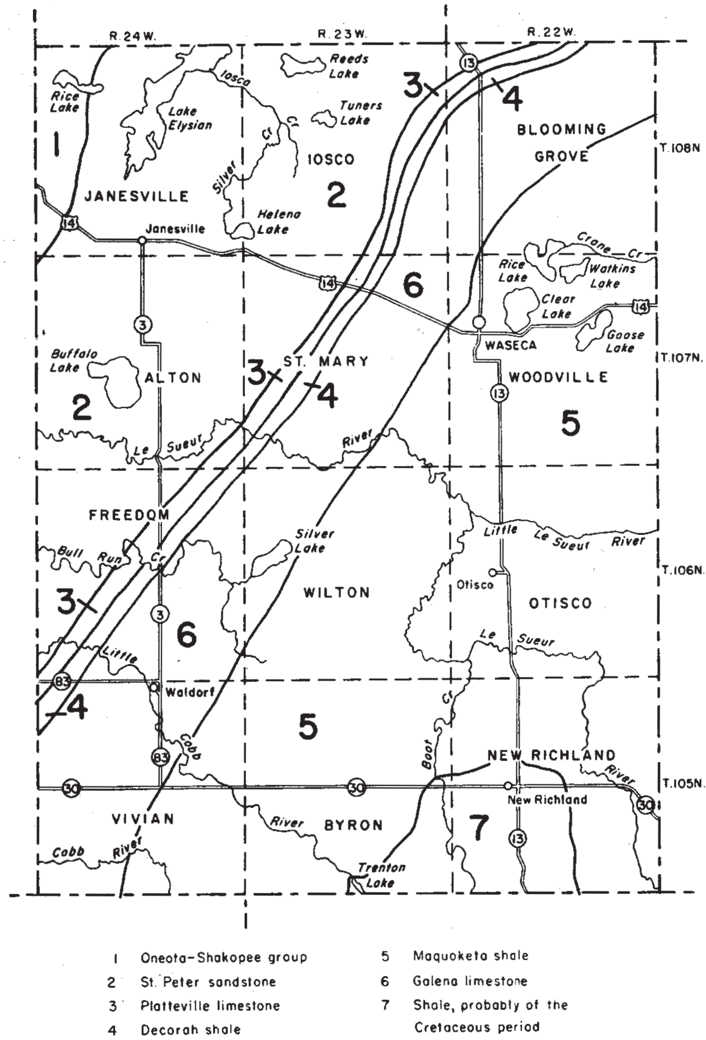

Figure 3.—Geologic formations in Waseca County.

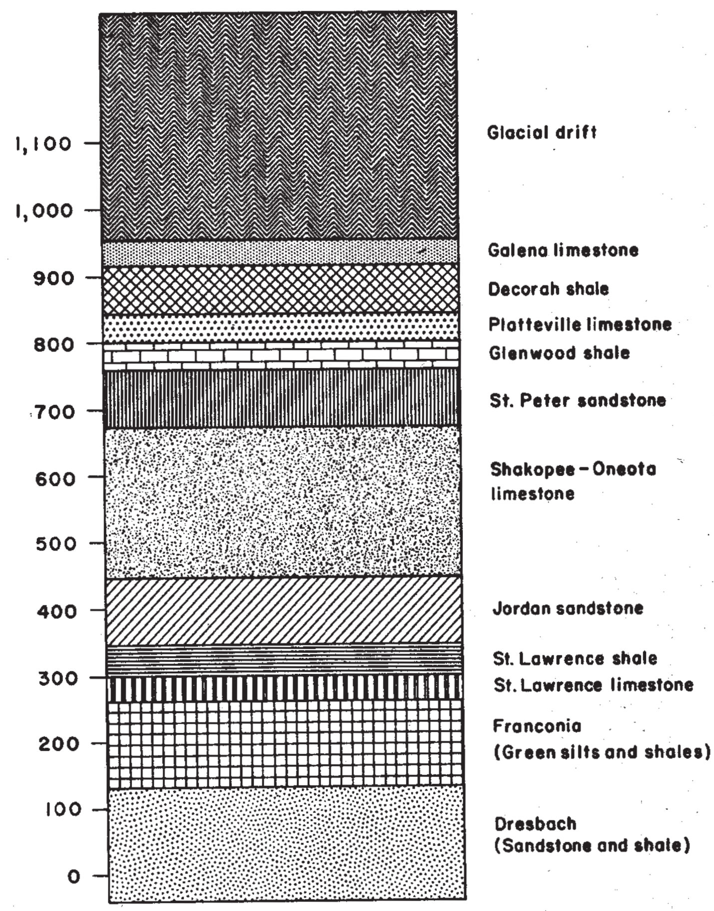

Figure 4.—Geologic cross section at Waseca. The numbers at the left give the elevation above sea level.

St. Peter sandstone lies beneath the drift in much of the northwestern half of the county. It is about 120 feet thick. To the south and east, it is overlain by the Platteville and Galena limestone formations and in places it is also overlain by Decorah and Glenwood shale.

The Maquoketa, Galena, and Platteville formations underlie the drift throughout most of the southeastern half of the county. A deep well drilled a few miles south of the county line, in Freeborn County, penetrated several hundred feet of limestone and shale that belong to those formations. At Waseca, where the underlying rocks dip toward the town of Freeborn, much of the upper part of these formations was removed by erosion prior to glaciation. The limestone and assorted shale are about 100 feet thick.

The major supply of water for the communities and larger industries of the county is obtained from the St. Peter and Jordan sandstone formations. St. Peter sandstone, which is 200 to 300 feet below the surface, carries a large amount of water under considerable hydrostatic pressure. The supply of water from this formation is adequate for most purposes, but the larger industries may need to rely on the Jordan sandstone formation for an increased supply of water. This formation is at a depth of 650 to 750 feet. An additional, but rarely used, source of water is the Dresbach formation, at a depth of about 1,000 feet. Occasionally, a supply of water may be obtained from the solution passages in the limestone.

The principal sources of water for farm and domestic use and for the many small industrial plants are the sandy and gravelly beds in the glacial drift. These deposits are 100 to 250 feet thick. Most farm wells are drilled, and they draw water from the lower part of the drift.

Unlike most regions where the drift is thick, this county has few bored, dug, or driven wells. There is little sand or gravel in the upper part of the drift, and as a result, little water is available in the upper drift in dry seasons.

Climate [2]

Waseca County is in the interior of the great land mass of North America. This land mass, heated in summer by a sun that is at a high altitude and that shines for long hours, makes the summers warm and pleasant. The average temperature for the months of June, July, and August is 70.8° F. Temperatures of 100° or higher have occurred only 27 times in the last 30 years and only 3 times in the last 20 years.

The temperature in winter is in sharp contrast to that in summer. In winter the land cools rapidly, and there is less effective solar heating because the days are short and the sun is low on the horizon. Northerly winds from Canada bring additional frigid air. As this air contains little moisture, it brings only a small amount of precipitation. This cold air causes the temperature to drop to zero or below about 33 days each year. A reading of 20 below zero occurs at least once in most winters. One of the coldest periods on record was that of December 1916 through February 1917 when the mean (average) temperature was 5.4° for a period of 3 months. The lowest temperature on record occurred in January 1924, when the temperature dropped to —37°. Tables 3 and 4 give facts about the temperature and precipitation in the county for a 30-year period beginning in 1930.

[2] By Joseph H. Strub, Jr., State climatologist, U.S. Weather Bureau.

Table 3.—*Temperature and precipitation at the Southern Experiment Station, Waseca, Minn.*

Month	Temperature: Average daily maximum	Temperature: Average daily minimum	Two years in 10 will have at least 4 days with—: Maximum temperature equal to or higher than—	Two years in 10 will have at least 4 days with—: Minimum temperature equal to or lower than—	Precipitation: Average total	One year in 10 will have—: Less than—	One year in 10 will have—: More than—	Days that have a snow cover of 1.0 inch or more	Average depth of snow on days that have a snow cover
	° F.	° F.	° F.	° F.	Inches	Inches	Inches		Inches
January	24	5	40	−19	0.9	0.3	1.6	22	5
February	28	9	45	−12	1.0	.2	1.8	20	5
March	39	21	62	0	1.8	.7	3.0	13	4
April	58	35	78	21	2.3	.9	3.7	1	1
May	71	47	87	32	3.6	1.5	5.6	(1)	0
June	80	57	92	44	4.7	1.8	7.2	0	0
July	85	61	95	50	3.4	1.2	7.0	0	0
August	83	59	93	48	3.5	1.3	5.1	0	0
September	74	50	90	35	2.9	.7	5.9	(1)	0
October	62	39	80	25	1.6	.4	3.0	(1)	0
November	42	24	64	4	1.6	.4	2.7	7	2
December	29	12	46	−12	.9	.3	1.7	17	3
Year	56	35	[2] 106	[3] −35	28.2	22.0	33.7	80	4

[1] Less than 0.5 day. [2] Average annual highest maximum. [3] Average annual lowest minimum.

TABLE 4.—*Averages and extremes of*

[Based on records kept at Waseca, Minn., from 1930 to 1959. Prepared by the U.S. Department of Commerce Weather Bureau

Month	Temperature							
	Averages			Extremes				Estimated growing degree days [1]
	Daily maximum	Daily minimum	Monthly	Highest on record	Year	Lowest on record	Year	
	° F.	° F.	° F.	° F.		° F.		
January	23.8	5.0	14.4	62	1944	−34	1935	----------
Febuary	28.4	8.9	18.7	63	1931	−33	1951	----------
March	39.3	20.7	30.0	77	1946	−27	1948	----------
April	57.6	34.6	46.1	90	1939 [2]	6	1954 [2]	69
May	70.7	46.8	58.8	106	1934	22	1946	310
June	79.7	56.9	68.3	105	1934	32	1945	549
July	85.1	61.0	73.1	106	1936	45	1958 [2]	716
August	82.8	59.1	71.0	101	1936	34	1950 [2]	651
September	74.1	49.8	62.0	100	1931	20	1939	360
October	62.1	39.0	50.6	91	1953	8	1936	143
November	42.1	23.6	32.9	77	1933	−16	1952	----------
December	28.9	11.7	20.3	60	1939	−29	1950	----------
Year	56.2	35.0	45.6	106	----------	−34	1935	2,798

[1] Based on a temperature of 50°. [2] Also on earlier dates. [3] Less than one-half day.

The latest date on record when the temperature dropped to 32° in spring is June 3, and the earliest date in fall is September 10. Table 5 shows probabilities that are representative for the entire county of the last freezing temperatures in spring and the first in fall. This table shows that 5 years in 10 there will be 227 days when the temperature does not drop as low as 16°, 188 days when it does not drop as low as 24°, 140 days when it does not drop as low as 32°, 100 days when it does not drop as low as 40°, and 28 days when it does not drop as low as 50°.

Table 6 gives the probabilities of receiving specified amounts of precipitation during the 1-week periods indicated, and table 7 gives the probabilities of receiving a specified amount of precipitation during the 3-week periods indicated. More than 70 percent of the annual precipitation falls during the period April through September. Precipitation of 0.01 inch or more can be expected on an average of 95 days per year, 5 of which will have 1 inch or more. Rainfall of an intensity of 1.10 inch per hour can be expected about once in 2 years. The greatest amount of precipitation that has fallen during any 1 month was 11.89 inches in August 1924. The heaviest rainfall occurs as a result of thunderstorms, and an average of 40 of these storms occur annually. Some thunderstorms are accompanied by hail and by damaging winds. Approximately eight hailstorms or storms with damaging winds occur each year. Tornadoes are rare; only two tornadoes were reported in this county during the period 1916 to 1961.

The first measurable snowfall generally occurs in November, and the last measurable snowfall comes early in April about 1 year in 2. Annual snowfall has ranged from 10.8 inches in 1930 to 88.2 inches in 1951. Snowfall is most important because it helps build up the reserves of moisture in the subsoil.

Long-term records of humidity, the amount of cloudiness, and wind direction are not available. Records at the Rochester weather station, 50 miles to the east, however, are considered representative for this county. The records at Rochester indicate that in summer the average humidity at noon ranges from 52 to 55 percent, and that in winter the average humidity at noon ranges from 72 to 79 percent. The prevailing wind direction is northwesterly from November to April and southeasterly during the other months. During a typical year, there are 78 days that are clear, 135 days that are partly cloudy, and 152 days that are cloudy.

temperature and precipitation

in cooperation with the Waseca Development Corporation, Waseca, Minn. Absence of data indicates no records available]

Precipitation								Precipitation of 0.10 inch or more	Average mean number of days with—			
			Snow						Temperature			
									Maximum		Minimum	
Average	Greatest daily	Year	Average	Maximum monthly	Year	Greatest daily	Year		90° and above	32° and below	32° and below	0° and below
Inches	*Inches*		*Inches*	*Inches*		*Inches*						
0.87	1.10	1949	7.0	24.1	1932	7.6	1935	3	0	23	31	12
.96	1.22	1948	7.4	24.6	1936	8.0	1939[2]	3	0	16	28	8
1.76	2.86	1956	10.3	41.0	1951	14.0	1952	4	0	9	27	2
2.25	2.0	1945	1.9	12.0	1945	9.0	1945	5	(3)	(3)	13	0
3.56	2.24	1956	.2	2.0	1954	1.5	1944	8	1	0	2	0
4.69	8.79	1956	0	0	--------	0	--------	8	4	0	(3)	0
3.43	4.08	1944	0	0	--------	0	--------	6	8	0	0	0
3.53	4.22	1935	0	0	--------	0	--------	6	6	0	0	0
2.93	2.70	1959	.2	4.0	1942	4.0	1942	5	2	0	1	0
1.59	2.90	1931	.1	1.5	1939	1.5	1939	4	(3)	(3)	8	0
1.57	1.70	1932	4.7	17.3	1940	11.0	1952	4	0	7	12	1
.91	1.34	1945	7.7	23.1	1950	13.0	1945[2]	3	0	19	30	7
28.05	8.79	1956	39.5	41.0	1951	14.0	1952	59	21	74	152	30

Effect of climate on crops.—Agriculture in this county is influenced by shifts from the modal climatic pattern. In some years, for example, warm air from the south encroaches for brief periods in winter and causes what is locally called January or February thaws. During these short periods, the snow cover melts and there are wide extremes between daytime and nighttime temperatures. Then, legumes, fruit trees, and other kinds of trees are sometimes injured.

Alternate freezing and thawing during the so-called spring breakup may damage legumes on fine-textured soils that have not been drained. Occasionally, a "late spring" affects the timeliness of field operations.

The pronounced increase in precipitation during May and June is characterized by rains of high intensity. Then, erosion is likely to be especially severe on exposed soils where moisture is at or near field capacity. The crop cover and the usual lower supply of moisture in July and August reduce the damage done by intense rains during that period. Occasionally, a prolonged rainy period in June delays spraying or the cultivation of corn and soybeans. It may also delay the harvesting of the first crop of hay.

In some seasons high temperatures and erratic rainfall during July and early in August reduce the bushel weight of small grains and adversely affect the pollination of corn. Sometimes persistent light rains in October and early in November hamper the harvesting of corn and soybeans. Frosts occasionally occur in the lower lying areas late in May and August and early in September. Infrequently—once in 20 years or more—climatic patterns that are typical of those in the Great Plains (*4*) drift into the county, and as a result, periods of drought stress occur. Drought occurs whenever the supply of moisture for crops, either the supply from rainfall or that stored in the soil, becomes inadequate for crops. Each day that there is inadequate moisture in the root zone is defined as a drought day. Table 8 gives probabilities of drought days on soils of different moisture-storing capacities.

Although adverse weather sometimes affects agriculture in this county, a crop failure has never occurred. The usual weather pattern is one especially adapted to the high production of corn, small grains, soybeans, and hay.

729-456—65——2

TABLE 5.—*Probabilities of critical temperatures in spring and fall*

[Based on records kept at the Southern Experiment Station, Waseca, Minn.]

Probability	Dates for given probability and temperature							
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower	36° F. or lower	40° F. or lower	50° F. or lower
Spring:								
1 year in 10, later than	April 10.	April 18.	May 2.	May 14.	May 27.	June 3.	June 13.	
2 years in 10, later than	April 5.	April 12.	April 26.	May 9.	May 21.	May 29.	June 8.	
5 years in 10 later than	March 26.	April 2.	April 17.	April 28.	May 10.	May 19.	May 30.	June 22.
Fall:								
1 year in 10, earlier than	October 23.	October 14.	October 7.	September 23.	September 19.	September 2.	August 18.	
2 years in 10, earlier than	October 28.	October 20.	October 12.	September 29.	September 25.	September 7.	August 25.	
5 years in 10, earlier than	November 8.	November 1.	October 22.	October 10.	September 27.	September 17.	September 7.	July 20.

TABLE 6.—*Amounts and probability of weekly precipitation*

[Based on records kept at Waseca, Minn. (*5*)]

Week beginning—	Amount of precipitation in inches							
	None or a trace [1]	0. 20	0. 40	0. 60	0. 80	1. 00	1. 40	2. 00
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
April 26 to May 2	13	77	63	49	38	29	15	6
May 3 to May 9	8	76	61	48	37	29	18	8
May 10 to May 16	8	66	43	27	17	11	5	1
May 17 to May 23	8	74	61	50	42	35	23	14
May 24 to May 30	18	73	63	53	45	37	26	15
May 31 to June 6	5	79	66	55	46	38	27	16
June 7 to June 13	0	90	78	66	56	46	30	18
June 14 to June 20	5	75	61	49	40	33	22	12
June 21 to June 27	5	80	68	58	49	42	31	19
June 28 to July 4	5	82	69	57	47	39	27	14
July 5 to July 11	8	71	56	45	36	28	19	9
July 12 to July 18	23	62	50	40	32	25	17	8
July 19 to July 25	13	61	45	34	26	20	12	5
July 26 to August 1	10	67	54	44	37	31	22	13
August 2 to August 8	15	69	58	49	42	36	27	17
August 9 to August 15	13	65	49	38	29	22	14	6
August 16 to August 22	15	71	57	46	37	29	19	9
August 23 to August 29	20	62	49	39	31	25	20	13
August 30 to September 5	13	71	56	45	36	28	18	9
September 6 to September 12	5	79	65	54	44	36	24	13
September 13 to September 19	10	72	58	46	37	29	19	9
September 20 to September 26	13	63	49	39	31	25	17	9
September 27 to October 3	28	51	38	28	22	16	10	4

[1] A trace of precipitation is an amount too small to measure.

TABLE 7.—*Amounts and probability of precipitation for 3-week periods*

[Based on records kept at Waseca, Minn. (*5*)]

Date	Amount of precipitation in inches							
	0 or trace [1]	0.20	0.40	0.60	0.80	1.00	1.40	2.00
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
March 1 to March 21	0	87	73	59	48	39	25	12
March 22 to April 11	0	96	89	80	70	61	44	26
April 12 to May 2	3	97	95	90	84	77	62	40
May 3 to May 23	0	100	98	95	90	84	70	48
May 24 to June 13	0	100	99	98	95	92	85	71
June 14 to July 4	0	100	99	98	95	92	84	69
July 5 to July 25	0	98	93	88	81	74	61	43
July 26 to August 15	0	94	88	81	75	70	60	47
August 16 to September 5	0	99	97	93	87	81	67	48
September 6 to September 26	0	99	97	93	88	82	70	53
September 27 to October 17	3	86	73	62	53	44	31	18
October 18 to November 7	5	83	70	58	48	39	26	14
November 8 to November 28	5	84	71	59	49	40	27	14
November 29 to December 19	3	78	54	36	23	14	5	1
December 20 to January 9	3	78	59	44	33	24	13	5
January 10 to January 30	5	81	57	36	22	12	4	1
January 31 to February 27	3	85	65	47	32	21	9	2

[1] A trace of precipitation is an amount too small to measure.

TABLE 8.—*Probabilities of drought days on soils of different moisture-storing capacities (3)* [1]

Probability	Minimum drought days if soil has total available moisture capacity of—				
	1 inch	3 inches	5 inches	7 inches	9 inches
Percent:					
10	87	63	49	46	37
20	78	53	39	33	28
30	74	47	32	26	22
40	68	41	27	18	16
50	64	35	21	12	0
60	60	30	15	5	0
70	55	24	8	0	0
80	49	17	2	0	0
90	42	8	0	0	0

[1] Inches of water a soil can hold and make available to the roots of the plant to be grown. For the estimated available water capacity of individual soils, by soil layers, see the column "Available Water Capacity" in table 11 of the section "Use of the soils for Engineering."

General Soil Map

After study of the soils in a locality and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations. Such a map is the colored soil map in the back of this report. Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ among themselves in some or in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows, not the kind of soil at any particular place, but several distinct patterns of soils.

Each soil association is named for the major soil series in it, but, as already noted, soils of other series may also be present. The major soils of one soil association may also be present in another association, but in a different pattern.

The general map is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

The general soil map in the back of the report shows the seven soil associations in Waseca County. Associations 2, 4, and 5, which make up roughly the southwestern quarter of the county, are for the most part nearly level. The others contain more slopes, ridges, and knolls, along with intervening swales. In the following pages these associations are described.

1. Lester-Kilkenny-Le Sueur-Cordova Association

Gently undulating to rolling soils on low, nearly circular hills that have smooth sides and nearly level tops

This association consists of soils on low, nearly circular, smooth-sided hills that are surrounded by swales. The hills are 40 to 640 acres in size. Their tops are nearly level and are 20 to 40 feet higher than the swales. In places narrow ridges, at a slightly lower elevation than the tops of the hills, connect the hills. This association occupies approximately 30 square miles. It is mainly in the northwestern part of the county.

The soils of this association have a dark to moderately dark surface layer, and they formed in calcareous glacial till. Well-drained Lester and Kilkenny soils are on the sides of the hills, and moderately well drained Le Sueur soils and poorly drained Cordova soils are on the nearly level hilltops. Small depressions, 15 to 20 feet across and about 1 foot deep, are common in the Cordova soils. In these depressions the color of the surface layer is gray. In some of the smaller depressions between the hills are bogs and marshes occupied by peat. An occasional lake occupies the larger depressions.

The soils of this association have a high yield potential, but they are subject to erosion, need tile drainage in places, and are difficult to keep in good tilth. The areas of peat are low in fertility.

2. Marna-Guckeen-Le Sueur-Cordova Association

Nearly level to gently undulating soils of the wooded lake plain

This association is made up of soils on the broad flats of the wooded lake plain and on gentle knolls. Drainageways that are bordered in places by steep slopes cut through the areas, and there are many slight depressions. There is generally no definite drainage pattern, but there are some major drainageways. This association is mainly in the west-central part of the county. It occupies about 25 square miles.

The soils of this association have a dark to moderately dark surface layer and range from well drained to very poorly drained. Some of them formed in deposits of calcareous sediment laid down by the waters of glacial lakes that occupied the depressions in the till plain. Others formed in islands of glacial till that were higher than the surrounding areas. These islands were not covered by the waters of the glacial lakes, and they now consist of low knolls on the lake plain, which is nearly flat except for slight depressions and drainageways.

On the broad flats within this association are the poorly drained Marna and Cordova soils. The areas of Marna soils are small and occur within areas of Cordova soils. The Cordova soils contain many small depressions, 15 to 20 feet across and about 1 foot deep, in which the soil material is gray. Moderately well drained Guckeen and Le Sueur soils are on the low knolls on the till plain. Peat and very poorly drained Glencoe and Lura soils are in the depressions and along drainageways, and a small acreage of steep, well-drained Lester soils occupies narrow belts adjacent to the major drainageways.

The soils in this association have a high yield potential, but they are poorly drained in many places. They are also difficult to keep in good tilth. The areas of peat are low in fertility.

3. Webster-Glencoe-Nicollet Association

Nearly level to gently undulating soils in slight depressions and on gentle rises and broad flats

This association consists mainly of soils in slight depressions, on gentle rises, and on broad flats. In places between the rises are swales that are only 3 to 4 feet below the tops of the rises. This association is mainly in the south-central part of the county. It occupies about 64 square miles.

The soils of this association are dark colored and are well drained to very poorly drained. They formed in calcareous glacial till. Poorly drained Webster soils are in the slight depressions and on the broad flats adjacent to the gentle rises; very poorly drained Glencoe soils are in the slight depressions and in the swales; and moderately well drained Nicollet soils are on the rises. Adjacent to and surrounding the Glencoe soils, is a small acreage of poorly drained or very poorly drained Canisteo soils, and Peat is in the larger depressions and drainageways. A minor part of the association is made up of well-drained Clarion soils.

The soils in this association have a high yield potential. They are difficult to keep in good tilth, however, and some of them are wet. Areas of Peat and of soils high in lime need special treatment to improve their fertility.

4. Clarion-Nicollet-Webster Association

Gently undulating to rolling soils on short, convex and concave slopes; and soils on low knolls and on low, nearly circular hills

In this association are two types of relief (fig. 5). Where the first type is dominant, some of the soils are on rather short, convex and concave slopes that rise 15 to 40 feet above the adjacent swales. Others are in gently undulating areas or on low knolls (fig. 6). The drainageways in these areas have no definite pattern.

The second type of relief is dominant in parts of Blooming Grove and New Richland Townships. Where that type of relief occurs, the topography is similar to that of the Lester-Kilkenny-Le Sueur-Cordova association. There are many nearly circular hills that have smooth sides, and in places there are narrow, slightly lower ridges that connect the hills. The tops of the hills are nearly level and rise 20 to 40 feet above the swales.

Figure 5.—An area of the Clarion-Nicollet-Webster association, showing the irregular topography.

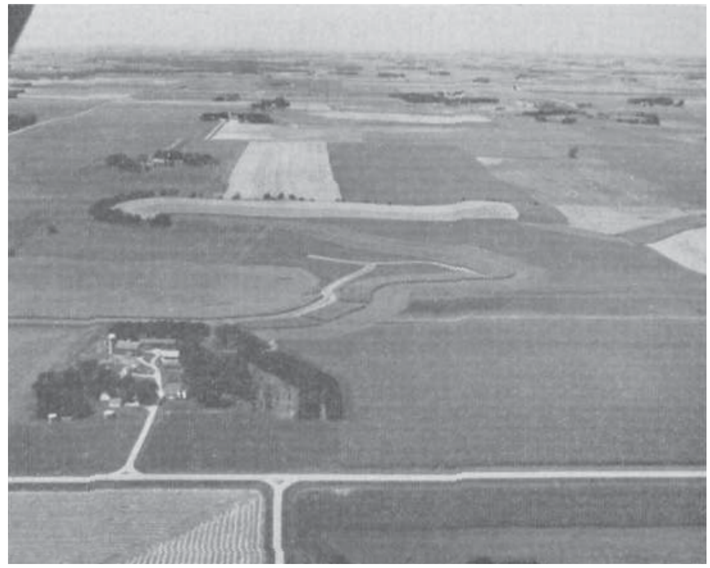

Figure 6.—A view of the Clarion-Nicollet-Webster association from the air.

This association occupies about 84 square miles. The soils in it have a dark to moderately dark surface layer and are well drained to very poorly drained. They formed in calcareous glacial till. Well drained Clarion soils are in the gently rolling to rolling areas, and moderately well drained Nicollet soils are on the nearly level hilltops, knolls, and gently undulating slopes. Poorly drained Webster soils are also on the nearly level hilltops and in other nearly level to slightly depressed areas within areas of undulating soils; between the hills, in depressions, are very poorly drained Glencoe soils; and associated with some of the steeper areas of Clarion soils are well-drained Storden soils.

The major soils of this association have a high yield potential. Most of these soils are subject to erosion and need tile drainage. Surface tilth is generally difficult to maintain, and the areas of peat are low in fertility.

5. Marna-Guckeen-Nicollet Association

Nearly level to gently undulating soils of the prairie lake plain

This association consists mainly of soils of the prairie lake plain (fig. 7). Within the areas the broad flats are broken by gentle rises, slight depressions, and drainageways. Except for the major drainageways, there is no definite drainage pattern. This association occupies one large area in the southwestern part of the county. It occupies about 42 square miles.

The soils of this association have a dark-colored surface layer, and they range from well drained to very poorly drained. Some of them formed in deposits of calcareous sediment laid down by the waters of glacial lakes that occupied the depressions in the till plain.

Figure 7.—**A field of wheat stubble on a nearly level area of the Marna-Guckeen-Nicollet association.**

Others developed in islands of glacial till that were higher than the surrounding areas. These islands were not covered by the waters of the glacial lakes, and they are now low knolls on the till plain.

The Marna soils are poorly drained and are on broad flats where small depressions, 15 to 20 feet across and 1 foot deep are common. Moderately well drained Guckeen and Nicollet soils are on the gentle rises. Very poorly drained Glencoe and Lura soils and Peat are in the depressions and drainageways, and steep, well-drained Clarion soils are in narrow belts adjacent to the major drainageways.

The soils of this association have high yield potential. They are difficult to keep in good tilth, however, and some of them need drainage. Peat is low in fertility.

6. Lester-Le Sueur-Cordova-Webster Association

Gently undulating to rolling soils that have short, concave and convex slopes that rise 15 to 40 feet above the swales; and soils on low knolls and low, nearly circular hills

This association is the most extensive in the county. It has two distinct kinds of relief. Where the first type is dominant, there are short, concave and convex, rolling slopes that rise 15 to 40 feet above the level of the swales. These areas are intermingled with areas of gently undulating slopes and low knolls.

The areas where the second type of relief is dominant are similar to those of the Lester-Kilkenny-Le Sueur-Cordova association, but a small area in the northern part of Iosco Township is more rolling. In most places the soils are on low, nearly circular hills that have smooth sides (fig. 8). The tops of these hills are nearly level and rise 20 to 40 feet above the swales.

This association has a poorly defined pattern of drainage. It occupies approximately 164 square miles.

The soils of this association have a dark to moderately dark surface layer and range from well drained to very poorly drained. They formed in calcareous glacial till. Well-drained Lester soils are in the gently rolling to rolling areas. Associated with the steeper areas of Lester soils are well-drained Storden soils. Moderately well drained Le Sueur soils are in areas where the slopes are between 1 and 3 percent. Poorly drained Cordova and Webster soils are on the nearly level hilltops and in the nearly level to slightly depressed areas of gently undulating soils. Small depressions, 15 to 20 feet across and about 1 foot deep, are common in areas of Cordova soils. In the depressions between the hills are very poorly drained Glencoe soils.

The major soils of this association have a high yield potential, but they are subject to erosion, need drainage in places, and are difficult to keep in good tilth. The areas of peat are low in fertility.

7. Wadena-Estherville-Webster-Biscay Association

Nearly level to strongly sloping soils of dissected outwash plains

This association consists of soils of outwash plains that are cut by drainageways. On the hilltops that rise above the level of the plain are nearly level to gently undulating soils that are 15 to 30 feet above the level of the swales. Drainageways that cut through the areas are bordered by strongly sloping soils (fig. 9). This association is in the east-central part of the county. It occupies only one area of about 6 square miles.

The soils of this association have a dark to moderately dark surface layer and range from somewhat excessively drained to very poorly drained. The soils on the hills formed in medium-textured to moderately coarse textured glacial drift. Those in the lower areas formed in medium-textured glacial drift over coarse-textured material.

Figure 8.—**Low, nearly circular hills on a farm in the Lester-Le Sueur-Cordova-Webster association. Contour stripcropping is practiced on this farm.**

Figure 9.—**An area of the Wadena-Estherville-Webster-Biscay association, which has irregular, sloping relief and is cut by many drainageways.**

Well-drained, nearly level to gently undulating Wadena soils and excessively drained, nearly level Estherville soils are on the tops of the hills. Steeper Estherville soils are on the side slopes. Poorly drained Webster soils and very poorly drained Biscay and Glencoe soils are in some of the depressions, and Peat is in the larger depressions and in drainageways. Occasional areas of Clarion and Storden soils occur among areas of the other well-drained and excessively drained soils.

The yield potential is low on the somewhat excessively drained soils of this association. It is moderate on the well-drained soils and high on the poorly drained soils. The soils are subject to erosion, and crops growing on them are likely to be damaged by drought. Drainage is needed in places. Peat is also low in fertility.

How Soils are Mapped and Classified

Soil scientists made this survey to learn what kinds of soils are in Waseca County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Lester and Nicollet, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Lester clay loam and Lester fine sandy loam are two soil types in the Lester series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Lester clay loam, 2 to 6 percent slopes, is one of several phases of Lester clay loam, a soil type that ranges from nearly level to steep.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodland, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not pratical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Lester-Storden complex. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Rough broken land or Marsh, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. Based on the yield and practice tables and other data, the soil scientists set up trial groups and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

Descriptions of the Soils

This section is provided for those who want information about the soils in the county. It describes the individual soils, or mapping units; that is, the areas on the detailed soil map that are bounded by lines and are identified by a symbol. For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. The acreage and proportionate extent of each soil mapped in the county are given in table 9. Their location is shown on the soil map at the back of the report.

In the descriptions that follow, each soil series is first described, and then the soils in the series. The series description mentions features that apply to all of the soils in that particular series. Following the name of each soil is a symbol that identifies that soil on the map at the back of the report. At the end of the soil description is a reference to the capability unit in which the soil has been placed.

As a general rule, only one soil profile is described for each series, and that profile is considered representative of all the soils in the series. The descriptions of the individual soils generally tell how their profiles differ from the one given as representative of the series. A more detailed description of a profile that is typical of the series is given in the section "Formation and Classification of Soils." Terms used to describe the soils are defined in the Glossary.

TABLE 9.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Alluvial land	1, 332	0. 5
Biscay loam	172	. 1
Canisteo clay loam	6, 591	2. 5
Canisteo clay loam, depressional	5, 602	2. 1
Clarion loam, 2 to 6 percent slopes	3, 974	1. 5
Clarion loam, 2 to 6 percent slopes, moderately eroded	6, 587	2. 5
Clarion loam, 6 to 12 percent slopes	148	. 1
Clarion loam, 6 to 12 percent slopes, moderately eroded	2, 830	1. 1
Clarion loam, 6 to 12 percent slopes, severely eroded	69	(1)
Clarion loam, 12 to 18 percent slopes, moderately eroded	285	. 1
Clarion-Estherville complex, 2 to 6 percent slopes, moderately eroded	110	(1)
Clarion-Storden complex, 2 to 6 percent slopes, moderately eroded	196	. 1
Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded	672	. 2
Clarion-Storden complex, 6 to 12 percent slopes, severely eroded	183	. 1
Clarion-Storden complex, 12 to 18 percent slopes, moderately eroded	215	. 1
Clarion-Storden complex, 12 to 18 percent slopes, severely eroded	214	. 1
Clarion-Storden complex, 18 to 24 percent slopes	121	(1)
Clarion-Storden complex, 18 to 24 percent slopes, severely eroded	54	(1)
Clarion-Storden complex, 24 to 35 percent slopes	161	. 1
Colo silty clay loam	743	. 3
Colo silty clay loam, frequent overflow	1, 201	. 4
Colo silty clay loam, very wet	588	0. 2
Cordova silty clay loam	3, 937	1. 5
Dickinson fine sandy loam, 2 to 6 percent slopes	195	. 1
Dickinson loam, 0 to 6 percent slopes	505	. 2
Dickinson loam, 6 to 12 percent slopes, moderately eroded	98	(1)
Dundas silt loam	809	. 3
Estherville sandy loam, 0 to 6 percent slopes	796	. 3
Estherville sandy loam, 6 to 12 percent slopes, moderately eroded	338	. 1
Estherville soils, 12 to 25 percent slopes, moderately eroded	165	. 1
Estherville, Lester, and Storden soils, 6 to 12 percent slopes, moderately eroded	353	. 1
Estherville, Lester, and Storden soils, 12 to 18 percent slopes, moderately eroded	95	(1)
Glencoe silty clay loam	17, 384	6. 5
Guckeen silty clay loam, 0 to 2 percent slopes	3, 784	1. 4
Guckeen silty clay loam, 2 to 6 percent slopes	1, 735	. 7
Huntsville loam, sand substratum	207	. 1
Huntsville silt loam	1, 564	. 6
Huntsville silt loam, frequent overflow	519	. 2
Kilkenny clay loam, 2 to 6 percent slopes	1, 471	. 6
Kilkenny clay loam, 2 to 6 percent slopes, moderately eroded	4, 982	1. 9
Kilkenny clay loam, 6 to 12 percent slopes	232	. 1
Kilkenny clay loam, 6 to 12 percent slopes, moderately eroded	4, 387	1. 7
Kilkenny clay loam, 6 to 12 percent slopes, severely eroded	54	(1)
Kilkenny clay loam, 12 to 18 percent slopes	113	(1)
Kilkenny clay loam, 12 to 18 percent slopes, moderately eroded	368	. 1

See footnote at end of table.

TABLE 9.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Kilkenny clay loam, 12 to 18 percent slopes, severely eroded	207	0.1	Lester-Storden complex, 12 to 18 percent slopes, moderately eroded	321	0.1
Kilkenny clay loam, 18 to 24 percent slopes	184	.1	Lester-Storden complex, 12 to 18 percent slopes, severely eroded	250	.1
Kilkenny clay loam, 18 to 24 percent slopes, moderately eroded	122	(1)	Lester-Storden complex, 18 to 24 percent slopes	198	.1
Kilkenny clay loam, 24 to 35 percent slopes	257	.1	Lester-Storden complex, 18 to 24 percent slopes, severely eroded	124	(1)
Lake beaches	1,115	.4	Lester-Storden complex, 24 to 35 percent slopes	301	.1
Lester clay loam, 2 to 6 percent slopes	18,461	6.9	Le Sueur clay loam, 0 to 2 percent slopes	9,598	3.6
Lester clay loam, 2 to 6 percent slopes, moderately eroded	16,886	6.4	Le Sueur clay loam, 2 to 6 percent slopes	6,674	2.5
Lester clay loam, 6 to 12 percent slopes	870	.3	Lura silty clay loam	248	.1
Lester clay loam, 6 to 12 percent slopes, moderately eroded	12,347	4.6	Marna silty clay loam	12,057	4.5
Lester clay loam, 12 to 18 percent slopes	238	.1	Marsh	2,165	.8
Lester clay loam, 12 to 18 percent slopes, moderately eroded	1,123	.4	Nicollet clay loam, 0 to 2 percent slopes	6,349	2.4
Lester clay loam, 12 to 18 percent slopes, severely eroded	224	.1	Nicollet clay loam, 2 to 6 percent slopes	4,076	1.5
Lester clay loam, 18 to 24 percent slopes	221	.1	Peat and muck, deep	11,064	4.2
Lester clay loam, 18 to 24 percent slopes, moderately eroded	162	.1	Peat and muck, deep and calcareous	104	(1)
Lester clay loam, 18 to 24 percent slopes, severely eroded	142	.1	Peat and muck, shallow	3,297	1.2
Lester clay loam, 24 to 35 percent slopes	151	.1	Peat and muck, shallow and calcareous	345	.1
Lester fine sandy loam, sandy variant, 2 to 6 percent slopes	214	.1	Rough broken land	164	.1
Lester-Estherville complex, 2 to 6 percent slopes, moderately eroded	148	.1	Talcot silty clay loam	118	(1)
Lester-Storden complex, 2 to 6 percent slopes, moderately eroded	131	(1)	Terril loam, 2 to 6 percent slopes	652	.2
Lester-Storden complex, 6 to 12 percent slopes, moderately eroded	650	.2	Truman silt loam, 2 to 6 percent slopes	187	.1
Lester-Storden complex, 6 to 12 percent slopes, severely eroded	170	.1	Truman silt loam, 2 to 6 percent slopes, moderately eroded	146	.1
			Truman silt loam, 6 to 12 percent slopes, moderately eroded	52	(1)
			Wadena loam, 2 to 6 percent slopes	285	.1
			Webster clay loam	76,627	29.0
			Gravel pits	36	(1)
			Total	265,600	100.0

[1] Less than 0.05 percent.

Alluvial Land (Ad)

This miscellaneous land type consists of moderately dark colored material that has been deposited recently by streams. The areas are nearly level to gently undulating and are adjacent to the major streams, where they are subject to frequent flooding, scouring, and stream cutting. In places there are remnants of old stream channels. Drainage is good to moderately good.

The texture in the upper part of the soil material is dominantly loam, but it is loamy sand, sandy loam, or silt loam in places. The underlying material is stratified loam, sandy loam, loamy sand, and silt loam that varies in thickness. Because of the hazard of flooding, this land is used almost entirely for undeveloped pasture. Capability unit VIw-1.

Biscay Series

The Biscay series consists of dark-colored, moderately deep, poorly drained soils of outwash plains and uplands. The soils are on slightly depressed flats. They developed under tall prairie grasses in glacial drift that is calcareous at a depth of 24 to 36 inches.

The surface layer of these soils is black, neutral to mildly alkaline loam that is about 16 inches thick. Their subsoil is dark-gray, neutral to mildly alkaline loam that is about 18 inches thick. The underlying material is calcareous, stratified coarse sand and gravel. In a few places where the outwash is thin, the coarse sand and gravel is underlain by glacial till at a depth of 42 to 48 inches.

These soils are moderately permeable. They are high in natural fertility and have good moisture-supplying capacity.

The Biscay soils are closely associated with the Wadena soils, but they are less well drained than those soils.

Biscay loam (0 to 2 percent slopes) (By).—This is the only Biscay soil mapped in the county. It is nearly level and is in slight depressions that in many places are adjacent to areas of sloping Wadena soils. In a few places the underlying material is coarse sand instead of stratified coarse sand and gravel.

This soil is well suited to row crops, but drainage is needed for high yields. Installing tile and open drains is difficult because of the underlying sandy material, which tends to cave or slough. Capability unit IIw-1.

Canisteo Series

The Canisteo series consists of dark-colored, deep, poorly drained or very poorly drained soils of the uplands. These soils are in depressions and swales, and they have a fluctuating water table near the surface. They developed under sedges in calcareous glacial till.

The surface layer of these soils is black, calcareous clay loam that is 12 to 24 inches thick. Their subsoil is very dark gray, calcareous clay loam that is 14 to 18 inches thick. The underlying material is olive-gray, calcareous clay loam till that is streaked with olive and very dark gray.

These soils have moderately slow permeability and moderate natural fertility. Their moisture-supplying capacity is high.

The Canisteo soils are closely associated with the moderately well drained Nicollet and poorly drained Webster soils. They are also in belts adjacent to areas of Peat and muck.

Canisteo clay loam (Ca).—This soil is on broad flats. It is associated with areas of Nicollet and Webster soils.

If maximum yields are to be obtained, tile drainage is needed. If drainage is provided and phosphorus and potassium are added, this soil is well suited to corn and soybeans. Capability unit IIw–1.

Canisteo clay loam, depressional (Cd).—This soil is in depressions and drainageways within areas of Nicollet and Webster soils. It also occurs in narrow belts surrounding areas of Peat. In places a thin layer of organic material is on the surface. In other places there is a high concentration of shells in the surface layer.

Water from higher areas is frequently ponded on this soil, and surface drains and tile drains are needed. If drainage is provided and phosphorus and potassium are added, good yields of corn and soybeans can be obtained. Capability unit IIIw–1.

Clarion Series

The Clarion series consists of deep, well-drained soils of the uplands. In many places the soils are on knolls that are 5 to 20 acres in size and have convex and concave relief. The slopes range from gently undulating to strongly rolling. The soils developed under tall prairie grasses in calcareous glacial till.

The surface layer of these soils is very dark brown, slightly acid to medium acid loam that is 8 to 12 inches thick. The subsoil is dark-brown to brown, slightly acid light clay loam to light silty clay loam that is about 20 inches thick. The underlying material is grayish-brown to light olive-brown, calcareous loam or light clay loam.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high.

The Clarion soils are similar to the Lester soils, but they have a thicker surface layer and are shallower over calcareous material. They are also less acid and have a lower content of clay in their subsoil. Some areas of Clarion soils are intricately mixed with areas of Storden or Estherville soils. In those areas it is impractical to map the soils of these series separately, and they are mapped as a complex.

Clarion loam, 2 to 6 percent slopes (ClB).—This soil is gently undulating and is on knolls that have convex and concave relief. The slopes are 75 to 150 feet long. The knolls range from 5 to 20 acres in size. The soil layers are thinner on the convex slopes than in other areas. In some places this soil is intermingled with areas of Nicollet and Webster soils. In other places it lies above areas of more sloping Clarion soils.

This soil is well suited to row crops, small grains, and meadow. There is a slight hazard of erosion. Capability unit IIe–1.

Clarion loam, 2 to 6 percent slopes, moderately eroded (ClB2).—This soil is gently undulating, and it lies on slopes that are 75 to 150 feet long. It is on knolls, 5 to 20 acres in size, where the relief is both convex and concave. In some places this soil is intermingled with areas of Nicollet or Webster soils. In other places it lies above areas of more sloping Clarion soils.

Erosion and deep tillage have mixed part of the subsoil with material in the surface layer. As a result, the present plow layer is more brownish and less friable than the original one, and it contains less organic matter. Erosion is greater on the convex slopes than in other areas.

This soil is well suited to row crops, small grains, and meadow, but practices are needed to control erosion. Runoff is medium. Capability unit IIe–1.

Clarion loam, 6 to 12 percent slopes (ClC).—This soil is on knolls, 5 to 20 acres in size, that have irregular convex and concave relief. It lies on slopes that are 75 to 150 feet long. In places moderately sloping strips of this soil occur below areas of gently undulating Clarion soils. The layers in the profile are slightly thinner than those in the less sloping Clarion soils. They are the thinnest where the slopes are convex.

In some places the areas mapped include strips of a Terril loam that are too narrow to be mapped separately. The Terril soil commonly occurs at the base of slopes. Its surface layer is generally thicker than that of the Clarion soil.

Erosion is more difficult to control on this Clarion soil than on the less sloping Clarion soils. Therefore, row crops should be grown less frequently, and practices to control erosion should be used more intensively. Runoff is medium to rapid. Capability unit IIIe–1.

Clarion loam, 6 to 12 percent slopes, moderately eroded (ClC2).—This soil is mainly on knolls, 5 to 20 acres in size, where there is irregular convex and concave relief, but some moderately sloping areas are in strips below areas of gently undulating Clarion soils. The slopes are 75 to 150 feet long. The layers in the profile of this soil are slightly thinner than those in less sloping Clarion soils. They are the thinnest where the slopes are convex. The plow layer is more brownish and less friable than that of the less eroded Clarion loams, and it contains less organic matter. Erosion is greater on the convex slopes than in other areas.

In a few places on the convex slopes, small areas of Storden soils are mapped with this soil. In other places the areas mapped include strips of Terril loam that are too narrow to be mapped separately. The Terril soil commonly occurs at the base of slopes. Its surface layer is thicker than that of the Clarion soil.

If erosion is controlled and proper management is used, cultivated crops, small grains, and meadow are well suited. Runoff is medium to rapid. Capability unit IIIe–1.

Clarion loam, 6 to 12 percent slopes, severely eroded (ClC3).—This soil occupies 3- to 5-acre areas on knolls that have irregular convex and concave relief, but some moderately sloping areas are in narrow strips below areas of gently undulating Clarion soils. The slopes are 75 to 150 feet long.

All or practically all of the original surface layer has been removed by erosion. The present surface layer consists mainly of material from the subsoil. It is less friable than the original one. In places shallow rills have developed in cultivated fields. Natural fertility, the content of organic matter, and the rate of infiltration have been severely reduced.

Even if practices to control erosion are used, row crops should be grown only occasionally. Runoff is medium to rapid, and the hazard of further erosion is severe. Capability unit IVe–1.

Clarion loam, 12 to 18 percent slopes, moderately eroded (ClD2).—This soil is in strips below areas of gently undulating Clarion soils and above areas of Webster and Glencoe soils. The remaining surface layer is only 3 to 6 inches thick. It is more brownish than that of the less eroded Clarion soils because plowing has mixed material from the subsoil with that in the surface layer. The subsoil is thinner than that of the less sloping Clarion soils.

Small areas of Storden soils on the upper parts of convex slopes are mapped with this soil. The areas mapped also include strips of Terril loam, too narrow to be mapped separately, that commonly occur at the base of slopes. The surface layer of the Terril soil is thicker than that of the Clarion soil.

This Clarion soil is better suited to small grains and meadow than to cultivated crops. Row crops can be grown occasionally if stripcropping is used to control erosion. Runoff is rapid, and the hazard of further erosion is severe. Capability unit IVe–1.

Clarion-Estherville complex, 2 to 6 percent slopes, moderately eroded (CrB2).—The soils of this complex occur in small, scattered areas. The surface is undulating. Clarion soils make up approximately 60 percent of the acreage, and Estherville soils make up 30 percent. The remaining 10 percent is Storden soils. These soils have a thinner surface layer and subsoil than the gently undulating Clarion and Estherville soils that are mapped separately. In some places coarse gravel is on the surface.

The Storden soils appear as light-colored bumps on convex slopes within the areas of darker colored Clarion soils. The Estherville soils are coarser textured and more droughty than the Clarion soils. In dry weather, crops on the Estherville soils may be damaged by lack of moisture. As a result, they turn yellow and give the field a spotty appearance.

Because the soils of this complex occur in small areas, they are generally farmed as parts of larger fields that take in adjacent soils. If practices to control erosion are used, these soils are suited to small grains and meadow, although a row crop can be grown occasionally. Runoff is medium. Capability unit IIIe–4.

Clarion-Storden complex, 2 to 6 percent slopes, moderately eroded (CsB2).—Approximately 80 percent of this complex is Clarion loam, and about 20 percent is Storden loam. The Clarion soil has thinner layers than Clarion loam, 2 to 6 percent slopes, moderately eroded. The Storden soil has a profile similar to the one described under the Storden series. This soil is on convex slopes and appears as light-colored bumps within areas of darker colored Clarion soils.

This complex is well suited to row crops, small grains, and meadow, but crops on the patches of Storden soil need extra phosphate and potash. Erosion is a hazard, but it can be easily controlled. Runoff is medium. Capability unit IIe–4.

Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded (CsC2).—About 70 percent of the acreage of this complex is Clarion loam, and 30 percent is Storden loam. The layers in the Clarion profile are thinner than those in the profile described for the Clarion series, but the profile of the Storden soil is similar to the one described for the Storden series. This soil is on convex rolling slopes and appears as lighter colored bumps surrounded by the darker Clarion soil.

If erosion is controlled, the soils of this complex can be used for row crops, small grains, and meadow. Crops on the patches of Storden soil respond to extra additions of phosphate and potash. Runoff is medium to rapid. Capability unit IIIe–1.

Clarion-Storden complex, 6 to 12 percent slopes, severely eroded (CsC3).—The soils of this complex are similar to those of Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded, but all or nearly all of the surface layer has been removed by erosion. About 70 percent of the acreage is Clarion loam, and about 30 percent is Storden loam. The Clarion soil is more brownish than the less eroded Clarion soils. The Storden soil is on convex rolling slopes and appears as lighter colored bumps within the areas of darker colored Clarion soils.

Because of the difficulty in controlling erosion, small grains and meadow are better suited to these soils than row crops, but a row crop can be grown occasionally. The soils need to be managed more carefully than those in less eroded Clarion-Storden complexes, and they need fertilizer for satisfactory yields. Crops may be damaged more severely by dry weather on these soils than crops grown on the less eroded Clarion and Storden soils. Runoff is medium to rapid. Capability unit IVe–2.

Clarion-Storden complex, 12 to 18 percent slopes, moderately eroded (CsD2).—About 70 percent of the acreage of this complex is Clarion loam, and 30 percent is Storden loam. The soils have thinner layers than those in the profiles described for the Clarion and Storden series. Mapped with these soils are small areas of only slightly eroded soils.

This complex is better suited to small grains and meadow than to tilled crops because the slopes are too steep and irregular for terracing. Runoff is rapid. Capability unit IVe–2.

Clarion-Storden complex, 12 to 18 percent slopes, severely eroded (CsD3).—In this complex about 70 percent of the acreage is Clarion soils and about 30 percent is Storden soils. All or nearly all of the original surface layer has been removed by erosion. The present surface layer consists mainly of material from the subsoil or from other underlying horizons. Shallow rills are common, and there are a few gullies.

These soils are better suited to improved pasture than to tilled crops because the slopes are too steep and irregular for terracing. Fertilizer is needed for satisfactory yields of forage. Capability unit VIe–1.

Clarion-Storden complex, 18 to 24 percent slopes (CsE).—About 70 percent of the acreage of this complex is Clarion soils, and 30 percent is Storden soils. The soils are probably best used for improved pasture because the moderately steep, irregular slopes make other uses impractical. Fertilizer is needed for satisfactory yields of forage. Capability unit VIe–1.

Clarion-Storden complex, 18 to 24 percent slopes, severely eroded (CsE3).—About 70 percent of this complex is Clarion soils, and 30 percent is Storden soils. All or nearly all of the original surface layer has been removed by erosion, and the present surface layer consists mainly of material from the subsoil or from other underlying horizons. Shallow rills are common, and there are a few gullies. The areas of this complex are small and adjoin areas of less eroded soils.

Most of the acreage is used for pasture, but fertilizer is needed to obtain satisfactory yields. Normal use of machinery is difficult because of the strong slopes. Capability unit VIIe-1.

Clarion-Storden complex, 24 to 35 percent slopes (CsF).—This complex is about 60 percent Clarion loam and 40 percent Storden loam. Mapped with these soils, however, are areas of more eroded and of coarser textured soils. In this complex the soils have slightly thinner layers than the soils of the other Clarion-Storden complexes that are only slightly eroded. Most of the acreage is in pasture or trees. Capability unit VIIe-1.

Colo Series

The Colo series consists of deep, poorly drained and very poorly drained soils of the bottom lands. The soils are in nearly level areas or on slopes that are slightly concave. They developed in moderately fine textured material under tall prairie grasses.

The surface layer is black, neutral silty clay loam that is 18 to 24 inches thick. The subsoil is olive-gray, neutral silty clay loam that is several feet thick. The Colo soils are generally calcareous at a depth of 42 to 60 inches, but some areas are calcareous at a depth of 24 to 42 inches.

These soils are moderately permeable. They are high in natural fertility and in moisture-supplying capacity.

The Colo soils are closely associated with the moderately well drained Huntsville soils.

Colo silty clay loam (Ct).—This soil is along the smaller drainageways and small streams. In some places it is adjacent to Huntsville soils. Mapped with it are small areas that are calcareous at the surface.

Colo silty clay loam is highly productive and is used intensively for growing row crops. In some of the broad areas along the Le Sueur River, pumping stations have been installed to provide an adequate outlet for tile drains. Capability unit IIw-2.

Colo silty clay loam, frequent overflow (Cu).—This soil is along the larger streams. Mapped with it are a few areas that are calcareous at the surface.

Because of the hazard of overflow, this Colo soil is better suited to pasture than to tilled crops. If pumps are installed, however, and if dikes are built to give protection from overflow, field crops can be grown. Capability unit VIw-1.

Colo silty clay loam, very wet (Cw).—This soil is in depressions and seep areas near the Huntsville soils. Some areas are also associated with Alluvial land, and those areas are subject to overflow. Mapped with this soil are a few areas that are calcareous at the surface.

If outlets are developed for tile drains or if pumps are installed, this soil is suited to intensive use for row crops. Capability unit IIIw-4.

Cordova Series

The Cordova series consists of black, deep, poorly drained soils of the uplands. These soils are nearly level and are on the tops of somewhat circular hills. They are also on broad flats and in small, shallow depressions. The water table was normally lower than in the associated Webster and Marna soils before artificial drainage was installed. These soils developed under hardwoods.

The surface layer is black, neutral to slightly acid silty clay loam or clay loam that is 6 to 10 inches thick. The subsoil is dark gray or very dark gray, medium acid to slightly acid silty clay loam, light silty clay, or clay loam that ranges from 15 to 30 inches in thickness. The underlying material is olive, firm, calcareous clay loam.

The Cordova soils are similar to the Webster soils, but they are deeper over calcareous material. They also have less clay in the surface layer, and they have a more clayey and more acid subsoil. The Cordova soils are somewhat similar to the Marna soils, but they have a thinner surface layer that contains less clay, and their subsoil is more acid.

Cordova silty clay loam (0 to 2 percent slopes) (Cy).—This is the only Cordova soil mapped in the county. It is surrounded by sloping Lester and Le Sueur soils, and in places small areas of Lester and Le Sueur, too small to be mapped separately, are mapped with it. Where this Cordova soil occurs in small, shallow depressions, the surface layer is gray when dry, rather than black like the surface layer in the higher areas. Ponding in these small depressions can be reduced if open intakes or French drains are installed.

If this soil is adequately drained, it is highly productive. After it is drained, row crops can be grown intensively. Capability unit IIw-1.

Dickinson Series

This series consists of dark-colored, deep, well-drained and somewhat excessively drained soils of the uplands. The soils are nearly level to moderately steep. They developed in sandy glacial drift under tall prairie grasses.

The plow layer is very dark brown, slightly acid to medium acid fine sandy loam or loam that is about 8 inches thick. The subsoil is dark yellowish-brown to very dark grayish-brown, medium acid sandy loam that is 14 to 30 inches thick. The underlying material is yellowish-brown, neutral to calcareous sand that contains some gravel.

The Dickinson soils in this county are less deeply leached than normal for the series, although a few areas are leached to a depth of 60 inches.

The Dickinson soils are closely associated with the Wadena and Estherville soils. They are somewhat similar to the Wadena soils, but they lack the coarse sand that is present in the solum of the Wadena soils, and they also lack gravel and sand in the substratum. Their solum is thicker than that of the Estherville soils, and the particles of sand in the solum are finer than those in the Estherville soils. In addition, the material underlying the Dickinson soils is sandy rather than gravelly like that underlying the Estherville soils.

Dickinson fine sandy loam, 2 to 6 percent slopes (DcB).—This soil is mainly nearly level and occurs in small areas. In most places it is adjacent to and above areas of more sloping Dickinson soils, but it also occurs near areas of the Estherville and Wadena soils. Mapped with this soil are a few acres of sandy soils that developed under timber and that have a lighter colored surface layer. The areas of included soils are too small to be mapped separately. Permeability is moderately rapid, and the moisture-supplying capacity is low.

Row crops, small grains, and meadow are suited. Crops are sometimes damaged, however, by lack of moisture. Erosion is a hazard. Capability unit IIIe-4.

Dickinson loam, 0 to 6 percent slopes (DkB).—This soil is nearly level to gently undulating. Its plow layer contains less sand than that of Dickinson fine sandy loam, 2 to 6 percent slopes, and this soil has higher available moisture capacity. In some places plowing has mixed material from the subsoil with the remaining material from the original surface layer, and as a result, the plow layer is lighter colored than the original one. Mapped with this soil are a few acres of sandy soils that have a lighter colored surface layer than this soil. These sandy soils are included because of their small extent.

In places this Dickinson soil is at a higher elevation than the more sloping Dickinson soils. It is also near areas of Estherville and Wadena soils. Permeability is moderate and the moisture-supplying capacity is moderate.

This soil is suited to row crops, small grains, and meadow. It is subject to erosion, however, and lack of moisture may damage crops that are grown on it. Capability unit IIe-3.

Dickinson loam, 6 to 12 percent slopes, moderately eroded (DkC2).—This soil is mainly moderately rolling to rolling, but a few areas are moderately steep. In most places this soil lies below areas of less sloping Dickinson soils, but in places it is near the Estherville and Wadena soils. Plowing has mixed material from the subsoil with that in the remaining original surface layer. As a result, the present surface layer is lighter colored than that of the slightly eroded Dickinson soils.

This soil is suited to row crops, small grains, and meadow. Permeability is moderate and moisture-supplying capacity is moderate. Erosion is more difficult to control, however, than on the less sloping Dickinson soils. Also, in some years crops may be damaged by lack of moisture. Capability unit IIIe-3.

Dundas Series

The Dundas series consists of deep, somewhat poorly drained soils of the uplands. The surface layer of these soils is dark when moist and is moderately dark when dry. The slopes are slightly convex to slightly depressed. These soils developed mainly in glacial till under a hardwood forest and grass. The upper horizons may have developed in more silty material than the lower ones.

The plow layer is black to very dark gray, slightly acid to medium acid silt loam that is about 7 inches thick. The subsurface layer is very dark gray to dark gray, medium acid silt loam that is 2 to 5 inches thick. The subsoil is mottled dark grayish-brown, medium acid to very strongly acid silty clay loam to heavy clay loam that is about 24 to 36 inches thick. The underlying material is variegated gray and olive-gray, neutral to slightly calcareous clay loam.

Permeability is moderately slow. The soils have moderate natural fertility and high moisture-supplying capacity.

The Dundas soils are closely associated with the poorly drained Cordova soils and the moderately well drained Le Sueur soils. Their profile is somewhat similar to that of the Cordova soils, but they have a thinner surface layer of lighter colored silt loam that directly overlies a distinct, gray-colored subsurface layer. They also have thicker clay films or films of organic matter on the surfaces of the peds, generally a more acid subsoil, and better surface drainage.

Dundas silt loam (Du).—This is the only Dundas soil mapped in the county. It is on slightly convex and depressional slopes within areas of Le Sueur soils.

Crops grown on this soil are affected by slight changes in the content of moisture in the soil. The surface layer tends to slake and crust if it becomes too wet or if this soil is tilled when wet. Grasses and legumes should be included in the cropping system to help maintain good tilth. Tile drains normally are not used, but drainage can be improved if tile are installed at a depth of 3 feet and at intervals of 80 feet. Runoff is slow to medium. Response to fertilizer is good, particularly response to nitrogen. Capability unit IIIw-2.

Estherville Series

The Estherville series consists of dark-colored, shallow, and excessively drained soils of the outwash plain. The soils are nearly level to steep. They developed under tall prairie grasses in medium-textured to moderately coarse textured glacial drift that overlies calcareous sand and gravel.

The surface layer is very dark brown to dark grayish-brown, slightly acid to medium acid sandy loam that is 6 to 10 inches thick. The subsoil is dark-brown to dark yellowish-brown, slightly acid to medium acid sandy loam that is between 10 and 15 inches thick. The underlying material is dark yellowish-brown and dark-brown, calcareous coarse sand and gravel.

These soils are rapidly permeable. They are low in natural fertility, however, and have low moisture-supplying capacity.

The Estherville soils are closely associated with the well-drained Wadena and Dickinson soils. They are also near the poorly drained Biscay soils.

Estherville sandy loam, 0 to 6 percent slopes (EaB).—This soil is above areas of more rolling and sloping Estherville soils. In places it is also near areas of Dickinson and Wadena soils. Mapped with it is a small acreage of lighter colored, sandy soils and a few small areas where gravel outcrops on the surface.

Row crops, small grains, and meadow are suited to this Estherville soil. Erosion needs to be controlled in the sloping areas. Drought is a hazard in the nearly level areas, and crops may be damaged by lack of moisture. Yields of small grains and meadow crops are more dependable than yields of row crops. Capability unit IIIe-4.

Estherville sandy loam, 6 to 12 percent slopes, moderately eroded (EaC2).—This soil generally lies below areas of gently sloping Estherville soils. In places it is near areas of Dickinson and Wadena soils. Because of erosion, the plow layer is a mixture of material from the subsoil and the remaining original surface layer. It is lighter colored than the plow layer of less eroded Estherville soils.

Mapped with this soil are a few small areas that are severely eroded. Also included are small spots of soils that have a surface layer of gravelly sandy loam or gravelly loamy sand.

Practices are needed to control erosion, and crops are likely to be damaged by lack of moisture. In some years only one kind of crop is affected by dry weather. Therefore, it is a good practice to diversify the crops by planting some areas to row crops, some to small grains, and others to meadow crops. Capability unit IVe–3.

Estherville soils, 12 to 25 percent slopes, moderately eroded (EoE2).—These soils generally lie below areas of less sloping Estherville soils. In places they are near areas of Dickinson and Wadena soils. Mapped with these soils are spots of gravelly material, which are more numerous than in other mapping units of Estherville soils. Also included are some areas in which the underlying material is medium sand rather than coarse sand and gravel.

Machinery is difficult to use on these soils because the slopes are steep. The soils should be kept in permanent vegetation to protect them from erosion. Improved pasture is probably the best use. Capability unit VIIe–2.

Estherville, Lester, and Storden soils, 6 to 12 percent slopes, moderately eroded (EsC2).—About 40 percent of this complex is Estherville soils, 40 percent is Lester soils, and 20 percent is Storden soils. These soils occur in too intricate a mixture for it to be practical to map them separately. They have thinner layers than the less sloping Estherville, Lester, and Storden soils. In places coarse gravel outcrops at the surface. The Estherville soils are coarser textured than the Lester and Storden soils. The Storden soils are on convex slopes and appear as lighter colored bumps within areas of darker colored Estherville and Lester soils.

The soils of this complex are suited to row crops, small grains, and meadow, but practices are needed to control erosion. Because the soils occur in small areas, they are generally farmed as parts of larger fields that consist mainly of other soils. Capability unit IVe–3.

Estherville, Lester, and Storden soils, 12 to 18 percent slopes, moderately eroded (EsD2).—About 40 percent of this undifferentiated unit is Estherville soils, 40 percent is Lester soils, and 20 percent is Storden soils. In the areas of Estherville soils, there are many small spots where gravel outcrops at the surface. The Estherville soils are coarser textured than the Lester and Storden soils. The Storden soils are on convex slopes and appear as lighter colored bumps surrounded by darker colored Estherville and Lester soils. Small areas of minor soils are included in the mapping.

The soils of this unit should be kept in permanent vegetation, and improved pasture is probably their best use. It is not generally practical to grow row crops or small grains, and the normal use of machinery is difficult because of the strong slopes. Practices are needed to control erosion. Capability unit VIe–2.

Glencoe Series

The Glencoe series consists of dark-colored, deep, very poorly drained soils in upland depressions and swales throughout the county. These soils developed in glacial till under a rank growth of sedges. They are calcareous at a depth of 24 to 42 inches.

The surface layer is black, neutral silty clay loam that is 14 to 20 inches thick. The subsurface layer is dark gray and very dark gray silty clay loam and is 3 to 8 inches thick. The underlying material is light olive-brown, calcareous clay loam till.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high.

The Glencoe soils are closely associated with the poorly drained Webster soils, the moderately well drained Nicollet and Le Sueur soils, and the well drained Clarion and Lester soils. They are similar to the Lura soils, but they are slightly coarser textured throughout the profile and they lack moderate to strong, blocky and prismatic structure in the subsoil.

Glencoe silty clay loam (Gc).—This is the only Glencoe soil mapped in the county. It is in depressions and drainageways throughout the county. In areas that have not been drained or that have been recently drained, there is generally a thin layer of organic material on the surface. Mapped with this soil are areas that have a surface layer of clay loam. Also included are small areas that are calcareous at the surface.

Tile drainage is needed to develop Glencoe soil into dependable cropland. In addition, shallow field ditches should be installed to prevent ponding during heavy rains. Deeper ditches are needed to provide outlets for tile drains. If this Glencoe soil is adequately drained, it is suited to intensive use for row crops. Capability unit IIIw–1.

Guckeen Series

The Guckeen series consists of dark-colored, deep, moderately well drained to somewhat poorly drained soils of the uplands. These soils are nearly level to gently undulating. They developed in lake-laid sediments over calcareous clay loam till. The native vegetation was tall prairie grasses.

The surface layer is black, slightly acid to medium acid heavy silty clay loam to silty clay that is 10 to 16 inches thick. The subsoil is dark grayish-brown, slightly acid to medium acid heavy clay loam to silty clay that is 15 to 24 inches thick. The underlying material is mottled, dark grayish-brown and light olive-brown, calcareous clay loam.

These soils are moderately permeable. They are high in natural fertility and in moisture-supplying capacity.

The Guckeen soils are closely associated with the poorly drained Marna soils. They are somewhat similar to the Nicollet soils, but they have a higher content of clay throughout the profile.

Guckeen silty clay loam, 0 to 2 percent slopes (GuA).—This soil is generally near areas of Marna, Lura, and Glencoe soils. Mapped with it are areas that have a surface layer of silty clay. The soil has few limitations for farming and is used intensively for row crops. Capability unit I–1.

Guckeen silty clay loam, 2 to 6 percent slopes (GuB).—This soil is generally near areas of Marna, Lura, and Glencoe soils. In most places the slopes are about 3 percent. Mapped with this soil are areas in which the surface layer is silty clay.

The hazard of erosion is slight. Only simple practices are needed to protect this soil. Capability unit IIe–1.

Huntsville Series

The Huntsville series consists of dark-colored, deep, well drained to moderately well drained soils of the bottom lands. These soils are nearly level and are adjacent to the major rivers and drainageways. They developed in medium-textured alluvium under tall prairie grasses. In recent times the soils have been covered by timber.

The plow layer is very dark gray to black, slightly acid loam to silt loam that is about 8 inches thick. The subsoil is very dark gray or very dark brown, slightly acid to neutral silt loam to loam. Below a depth of 42 inches, the soil material is coarser textured than in the upper part of the profile, and it is stratified in places.

These soils are moderately permeable. They are high in natural fertility and have a good moisture-supplying capacity.

The Huntsville soils are closely associated with the poorly drained Colo soils. They also occur near areas of Alluvial land.

Huntsville loam, sand substratum (Hm).—This soil is mainly on the flood plains of the Le Sueur River. It is slightly higher than the adjacent bottom lands and adjoins soils of the uplands.

This soil is well suited to corn and soybeans, and those crops are grown intensively. There is a slight hazard of erosion. In places diversions are needed to intercept runoff from the adjacent uplands. Capability unit IIw–3.

Huntsville silt loam (Hn).—This soil is generally in the smaller drainageways and is adjacent to the smaller streams. Some areas are near the upper ends of streams and are subject to only occasional overflow.

This soil is well suited to row crops. It can be farmed intensively to corn and soybeans. Capability unit IIw–3.

Huntsville silt loam, frequent overflow (Ho).—This soil generally occurs in fairly large areas near the major streams. It is subject to frequent overflow and to streambank cutting. Because of the hazard of flooding, most of the acreage is in undeveloped pasture, but some areas are in trees. A few areas are farmed, even though crops may be damaged by flooding. Capability unit VIw–1.

Kilkenny Series

The Kilkenny series consists of very dark gray, deep, well-drained, gently undulating to steep soils of the uplands. The soils are on somewhat circular hills throughout the county, but they are mainly in the northwestern corner and in a small area just north of Waseca. They developed under hardwoods.

The surface layer is very dark gray, slightly acid to medium acid clay loam that is 4 to 10 inches thick. The subsoil is very dark brown to dark grayish-brown, medium acid to very strongly acid heavy clay loam that is 35 to 40 inches thick. The underlying material is light olive-brown to olive, weakly calcareous to strongly calcareous clay loam.

These soils have moderately slow permeability. They are high in natural fertility and high in moisture-supplying capacity.

The Kilkenny soils are associated with the moderately well drained Le Sueur soils, the poorly drained Cordova soils, and the very poorly drained Glencoe soils. They are also closely associated with the Lester soils. The Kilkenny soils are more acid, contain more clay, and have stronger soil structure than the Lester soils. The layers in the profile are also generally thicker than those in the profile of the Lester soils.

Kilkenny clay loam, 2 to 6 percent slopes (KcB).—This soil is on knolls, 5 to 20 acres in size, that have convex and concave relief. It lies on slopes that are 75 to 150 feet long. On the complex slopes the layers in the profile are thinner than those in other areas. This soil occurs within areas of Le Sueur and Marna soils. In places it lies above areas of more sloping Kilkenny soils. Mapped with it are small areas of Le Sueur soils that are too small to be mapped separately.

This Kilkenny soil is suited to row crops, small grains, and meadow. Runoff is medium, and practices are needed to control erosion. Capability unit IIe–2.

Kilkenny clay loam, 2 to 6 percent slopes, moderately eroded (KcB2).—This gently undulating soil is on knolls, 5 to 20 acres in size, that have convex and concave relief. It lies on slopes that are 80 to 150 feet long. This soil is within areas of Le Sueur and Marna soils, and in many places it lies above areas of more sloping Kilkenny soils. Mapped with this soil are areas of Le Sueur soils that are too small to be mapped separately.

Erosion, deep tillage, and the removal of trees have caused part of the subsoil to be mixed with material from the surface layer. As a result, the plow layer is more brownish and less friable than that of the less eroded Kilkenny soil, and it contains less organic matter. Erosion is greatest on the convex slopes.

Row crops, small grains, and meadow are suited, but practices are needed to control further erosion. Runoff is medium. Capability unit IIe–2.

Kilkenny clay loam, 6 to 12 percent slopes (KcC).—This soil is on knolls, 5 to 20 acres in size, that have irregular, convex and concave relief. The areas are moderately rolling to rolling, and the slopes are 80 to 150 feet long. Strips of this soil also occur below areas of less sloping Kilkenny soils and above areas of steeper Kilkenny soils. In a few places this soil adjoins narrow strips of Marna soils and depressions occupied by Glencoe soils. The layers in the profile of this soil are slightly thinner than those in the less sloping Kilkenny soils. They are thinnest on the convex slopes and thickest on the concave slopes.

Mapped with this soil are strips of a Terril loam that are too narrow to be mapped separately. The included soil generally lies at the base of slopes. Its surface layer is thicker than that of this Kilkenny soil.

Row crops, small grains, and meadow are suited. Runoff is medium to rapid, and erosion is more difficult to control than on the less sloping Kilkenny soils. Capability unit IIIe–2.

Kilkenny clay loam, 6 to 12 percent slopes, moderately eroded (KcC2).—This soil is on knolls, 5 to 20 acres in size, that have irregular, convex and concave relief. It is on slopes that are 80 to 150 feet long. Narrow strips of this soil also lie below areas of Kilkenny or Le Sueur soils on the more gentle slopes. In places this soil adjoins narrow areas of Marna soils and depressions occupied by Glencoe soils.

The layers in the profile of this soil are slightly thinner than those in the gently sloping Kilkenny soils. They are thinnest on the convex slopes and thickest on the concave slopes. Erosion, deep tillage, and tree removal have caused material from the subsoil to be mixed with that in the surface layer. As a result, the plow layer is more brownish and less friable than that of the slightly eroded Kilkenny soils, and it contains less organic matter. Erosion is greatest on the convex slopes.

Mapped with this soil are strips of a Terril loam that are too narrow to be mapped separately. This included soil generally lies at the base of slopes and has a thicker surface layer than the Kilkenny soil.

Row crops, small grains, and meadow are suited. Runoff is medium to rapid, and measures are needed to control further erosion. Capability unit IIIe–2.

Kilkenny clay loam, 6 to 12 percent slopes, severely eroded (KcC3).—This soil is moderately rolling to rolling. It is generally in small, scattered patches below areas of less sloping Kilkenny soils, but in some places it lies above areas that are steeper.

All or nearly all of the original surface layer has been removed by erosion. As a result, the present surface layer is lighter colored than that of the Kilkenny soils that are only slightly eroded. Shallow rills are common, and there are a few gullies.

Practices to control further erosion are necessary on this soil. If erosion is controlled, small grains and meadow crops are suited, and row crops can be grown occasionally. Runoff is medium to rapid. Capability unit IVe–1.

Kilkenny clay loam, 12 to 18 percent slopes (KcD).—This moderately steep soil is generally in small, scattered areas below less steep soils. Mapped with it are a few spots of Kilkenny soils that are moderately eroded and lighter colored than this soil.

Row crops can be grown occasionally if stripcropping is practiced. Small grains and meadow crops are better suited, however, than row crops. Runoff is rapid. The slopes are too steep for terracing. Capability unit IVe–1.

Kilkenny clay loam, 12 to 18 percent slopes, moderately eroded (KcD2).—This moderately steep soil is mainly in small, scattered areas. In places it lies below areas of less steep Kilkenny soils.

The soil layers are thinner than those in the profile described for the series. Because of erosion, plowing has mixed material from the subsoil with that in the remaining surface layer. As a result, the present surface layer is lighter colored than that of the Kilkenny soils that are only slightly eroded.

Row crops can be grown occasionally if stripcropping is used to control erosion, but small grains and meadow crops are better suited than cultivated crops. Runoff is rapid, but the slopes are too steep for terracing. Capability unit IVe–1.

Kilkenny clay loam, 12 to 18 percent slopes, severely eroded (KcD3).—This moderately steep soil occurs mainly in small, scattered areas. It generally lies below areas of less steep Kilkenny soils.

All or nearly all of the original surface layer has been removed by erosion. As a result, the present surface layer is lighter colored than that of the slightly eroded Kilkenny soils. Shallow rills are common, and there are a few gullies.

Runoff is rapid, and the hazard of further erosion is severe. Therefore, this soil should be kept in permanent vegetation. Improved pasture is probably the best use. Capability unit VIe–1.

Kilkenny clay loam, 18 to 24 percent slopes (KcE).—This steep soil lies below areas of Kilkenny clay loams that are less steep. Most of the acreage is in timber or has been used for pasture. As a result, most of the original surface layer remains.

This soil should be kept in permanent vegetation to control erosion. Pastures should be improved and fertilizer added. Runoff is rapid. Capability unit VIe–1.

Kilkenny clay loam, 18 to 24 percent slopes, moderately eroded (KcE2).—This soil occupies small, scattered areas below Kilkenny clay loams that are less steep. The soil layers are thinner than those in the profile described for the series. Plowing has mixed material from the subsoil with that in the remaining surface layer. As a result, the present surface layer is lighter colored than that in the slightly eroded Kilkenny soils. In some places the surface layer consists mainly of material from the subsoil. Shallow rills are common, and there are a few gullies.

This steep soil should be kept in permanent vegetation to control further erosion. Improved pasture is probably the best use. Runoff is rapid. Capability unit VIe–1.

Kilkenny clay loam, 24 to 35 percent slopes (KcF).—This steep soil occurs in small, scattered areas below areas of less steep Kilkenny clay loams. The areas on the lower parts of slopes are generally adjacent to areas of Glencoe, Webster, or Marna soils.

Most of the acreage is in timber or is used for pasture. As a result, most of the original surface layer remains. This soil ought to be kept in permanent vegetation to control erosion. Permanent pastures should be improved. Runoff is rapid. Capability unit VIIe–1.

Lake Beaches (La)

This miscellaneous land type consists of dark-colored, very poorly drained, coarse-textured material deposited by the waters of lakes. In places it surrounds the larger peat bogs.

This land type is wet and droughty. Therefore, yields of crops grown on it are not dependable. The land is generally farmed as a part of larger fields and is used the same as the adjoining soils. Capability unit IVw–1.

Lester Series

The Lester series consists of very dark gray, deep, well-drained soils that are gently undulating to very steep. These soils are on uplands, and they developed under hardwoods.

Both Lester clay loams and Lester fine sandy loams are mapped in this county. The plow layer of the Lester clay loams is very dark gray, medium acid light clay loam that is about 4 to 9 inches thick. The subsoil is very dark brown to dark grayish-brown, medium acid to strongly acid clay loam that is 20 to 30 inches thick. The underlying material is light olive-brown, calcareous loam or clay loam. The plow layer of the Lester fine sandy loams is about 8 inches thick and consists of very dark grayish-brown, medium acid fine sandy loam. The upper part of the subsoil is dark grayish-brown fine sandy loam that grades to dark-brown clay loam in the lower part. The underlying material is similar to that underlying the Lester clay loams.

The Lester soils are moderately permeable. Their natural fertility is moderate to high, and their moisture-supplying capacity is medium to high.

The Lester soils occur throughout most of the county. They are associated with the moderately well drained Le Sueur soils, the poorly drained Webster and Cordova soils, and the very poorly drained Glencoe soils. They also lie above areas of Terril soils. In the northwestern and west-central parts of the county, the Lester soils are associated with the Kilkenny soils. They are similar to the Kilkenny soils, but they are less friable than those soils and have less structural development. Also their subsoil is less acid and contains less clay than that of the Kilkenny soils. The Lester soils are similar to the Clarion soils, but they are deeper over calcareous material. Their subsoil is also more clayey and more acid than the subsoil of the Clarion soils.

In some places the Lester soils are intermingled with areas of Storden and Estherville soils. In those areas it was impractical to map the soils separately, and they are therefore mapped as a complex.

Lester clay loam, 2 to 6 percent slopes (LcB).—This gently undulating soil is on knolls, 5 to 20 acres in size, that have convex and concave relief. It lies on slopes that are 80 to 150 feet long. The soil layers are thinner on the convex slopes than in other areas. This soil is surrounded by areas of Le Sueur and Webster soils. In many places it lies above areas of more sloping Lester soils. Mapped with this soil are areas of Le Sueur soils that are too small to be mapped separately.

Row crops, small grains, and meadow are well suited. Runoff is medium, however, and the soil is subject to erosion. Capability unit IIe–1.

Lester clay loam, 2 to 6 percent slopes, moderately eroded (LcB2).—This gently undulating soil is on knolls, 5 to 20 acres in size, that have convex and concave relief. It is surrounded by areas of Le Sueur and Webster soils, and in many places it lies above areas of more sloping Lester soils. Mapped with this soil are areas of Le Sueur soils that are too small to be mapped separately.

Erosion deep tillage, and the removal of trees have caused material from the subsoil to be mixed with that in the surface layer. As a result, the plow layer is more brownish and less friable than that of the slightly eroded Lester soils, and it contains less organic matter. Erosion is greatest on the convex slopes.

Row crops, small grains, and meadow are well suited, but practices are needed to control further erosion. Runoff is medium. Capability unit IIe–1.

Lester clay loam, 6 to 12 percent slopes (LcC).—This soil is on knolls, 5 to 20 acres in size, that have irregular, convex and concave relief. It is mainly moderately rolling to rolling and is on slopes that are 80 to 150 feet long. Some sloping or strongly sloping strips, however, lie below areas of less sloping Lester soils. Still other areas of this soil occupy the smooth side slopes of somewhat circular hills that have flat tops. In places this soil is surrounded by narrow strips of Webster soils or by depressions occupied by Glencoe soils.

This soil has slightly thinner layers than the less sloping Lester soils. The layers are thinnest on the convex slopes and thickest on the concave slopes.

Mapped with this soil are strips of a Terril loam, generally at the base of slopes, in areas too narrow to be mapped separately. The surface layer of this included soil is generally thicker than that of the Lester soil.

Row crops, small grains, and meadow are suited, but erosion is more difficult to control than on the less sloping Lester soils. Runoff is medium to rapid. Capability unit IIIe–1.

Lester clay loam, 6 to 12 percent slopes, moderately eroded (LcC2).—This soil is on knolls, 5 to 20 acres in size, that have irregular, convex and concave relief. It is mainly moderately rolling to rolling and is on slopes that are 80 to 150 feet long. In places, however, this soil is sloping or strongly sloping and occurs in strips below areas of less sloping Lester soils. In other places it lies above steeper areas. In still other places it is on the smooth sides of somewhat circular hills that have flat tops. In a few places this soil is surrounded by narrow strips of Webster soils or by depressions that are occupied by Glencoe soils.

This soil has thinner layers than the less sloping Lester soils. The soil layers are thinnest on the convex slopes and thickest on the concave slopes.

Erosion, deep tillage, and the removal of trees have caused material from the subsoil to be mixed with that in the surface layer. As a result, the plow layer is more brownish and less friable than that of the slightly eroded Lester soils, and it contains less organic matter.

Mapped with this soil are a few areas of Storden soils that are too small to be mapped separately. Also included are strips of a Terril loam that is generally at the base of slopes. The Terril soil has a thicker surface layer than the Lester soil. It is included because the areas are too narrow to be mapped separately.

Row crops, small grains, and meadow are suited, but erosion is more difficult to control than on the less sloping Lester soils. Runoff is medium to rapid. Capability unit IIIe–1.

Lester clay loam, 12 to 18 percent slopes (LcD).—Moderately steep areas of this soil are on hills, 5 to 20 acres in size, that have irregular convex and concave relief. The slopes in these areas are 80 to 120 feet long. Sloping and strongly sloping strips of this soil also occur below areas of less sloping Lester soils. Some areas of this soil are on the smooth side slopes of somewhat circular hills that have flat tops, and a few areas are surrounded by narrow strips of Webster soils. Other areas are surrounded by depressions occupied by Glencoe soils, and still other areas are adjacent to broad drainageways occupied by Glencoe soils and by areas of Peat and muck. The soil layers are thinner on the steeper slopes than in the less sloping areas and are the thinnest on the convex slopes.

Mapped with this soil are a few areas of Storden soils that are too small to be mapped separately. Also included are areas of a Terril loam, too narrow to be mapped separately, that are generally at the base of slopes. The surface layer of this included Terril soil is thicker than that of the Lester soil.

Most of the acreage is wooded or in permanent pasture. The slopes are too steep for terracing, but if stripcropping is used to control erosion, a row crop can be grown occasionally. Small grains and meadow crops are suitable in areas that have been cleared. Permanent pastures should be fertilized and improved to obtain the maximum yields of forage. Runoff is rapid. Capability unit IVe–1.

Lester clay loam, 12 to 18 percent slopes, moderately eroded (LcD2).—This moderately steep soil is on hills, 5 to 20 acres in size, that have irregular convex and concave relief. The slopes are 80 to 120 feet long. In some places this soil occurs in moderately steep strips below less sloping Lester soils. In other places it is on the smooth sides of somewhat circular hills that have flat tops. A few areas are surrounded by narrow strips of Webster soils or by depressions occupied by Glencoe soils. This soil is also adjacent to broad drainageways occupied by Glencoe soils and by areas of Peat and muck.

The soil layers are thinner on the steeper slopes than in the less sloping areas; they are the thinnest on the convex slopes. Erosion, deep tillage, and the removal of trees have caused material from the subsoil to be mixed with that in the surface layer. As a result, the surface layer is more brownish and less friable than that of the slightly eroded Lester soils, and it contains less organic matter.

Mapped with this soil are spots of Storden soils that are too small to be mapped separately. Also included are strips of a Terril loam, too narrow to be mapped separately, that are generally at the base of slopes. The surface layer of the Terril soil is thicker than that of the Lester soil.

Small grains and meadow are well suited. If strip-cropping is used to control erosion, a row crop can be grown occasionally. The slopes are too steep for terracing. Runoff is rapid. Capability unit IVe–1.

Lester clay loam, 12 to 18 percent slopes, severely eroded (LcD3).—This soil is moderately steep and occurs in strips, 3 to 8 acres in size, below areas of less sloping Lester soils. The slopes are 80 to 120 feet long. In many places this soil adjoins broad drainageways occupied by Glencoe soils and by areas of Peat and muck.

The soil layers become thinner as the slope increases and are the thinnest on the convex slopes. All or nearly all of the original surface layer has been removed by erosion. As a result, the present surface layer is browner and less friable than that of the less eroded Lester soils, and it contains less organic matter. Also the rate of infiltration is slower, and shallow rills are common in cultivated fields.

Mapped with this soil are a few areas of Storden soils that are too small to be mapped separately. Also included are areas of a Terril loam, too narrow to be mapped separately, that are generally at the base of slopes. The surface layer of the included Terril soil is thicker than that of the Lester soil.

This Lester soil should be kept in permanent vegetation that will control further erosion. Improved pasture is the best use. Runoff is rapid. Capability unit VIe–1.

Lester clay loam, 18 to 24 percent slopes (LcE).—This steep soil lies on convex and concave slopes that range from 80 to 300 feet in length. The slopes are dissected at frequent intervals by shallow draws. In some places they are cut by abrupt ravines that are deep and narrow.

Mapped with this soil are spots of Storden soils. These included areas are too small to be mapped separately.

Most of the acreage is wooded or in permanent pasture. Runoff is very rapid. Therefore, this soil should be kept in permanent vegetation to control erosion. Pastures should be improved. Capability unit VIe–1.

Lester clay loam, 18 to 24 percent slopes, moderately eroded (LcE2).—This steep soil occupies patches, 3 to 8 acres in size, within cultivated fields. It lies on slopes that are 80 to 100 feet long. Narrow strips of this soil are below more gently sloping Lester soils.

The soil layers become thinner as the slope increases and are thinnest on the convex slopes. Erosion, deep tillage, and the removal of trees have caused material from the subsoil to be mixed with that in the surface layer. As a result, the present surface layer is more brownish and less friable than that of the slightly eroded Lester soils, and it contains less organic matter.

Mapped with this soil are spots of Storden soils that are too small to be mapped separately. Also included are small areas of severely eroded Lester soils and strips of a Terril loam that are too narrow to be mapped separately. The Terril soil is generally at the base of slopes and has a thicker surface layer than the Lester soil.

Most of the acreage has been converted to permanent vegetation. For maximum yields of forage, permanent pastures should be renovated occasionally. Runoff is rapid. Capability unit VIe–1.

Lester clay loam, 18 to 24 percent slopes, severely eroded (LcE3).—This steep soil is in narrow strips, 3 to 8 acres in size, that lie below areas of less sloping Lester soils. It is on slopes that are 80 to 100 feet long.

This soil receives runoff from higher areas. As a result, all or nearly all of the original surface layer has been removed, and the present surface layer consists mainly of material from the subsoil. The surface layer is more brownish and less friable than that of less eroded Lester soils, and it has poorer tilth. Also, infiltration is slower. Because less water soaks into the soils, runoff is greater, less moisture is available to plants, and additional soil material is lost through erosion.

Mapped with this soil are spots of Storden soils that are too small to be mapped separately. Also included are strips of a Terril loam, too narrow to be mapped separately, that are generally at the base of slopes. The surface layer of the Terril soil is thicker than that of the Lester soil.

Runoff is rapid on this Lester soil. Therefore, all of the acreage should be kept in permanent vegetation. Improved pasture is the best use. For maximum yields of forage, fertilizer should be applied and grazing ought to be controlled. Capability unit VIIe–1.

Lester clay loam, 24 to 35 percent slopes (LcF).—This very steep soil is on convex and concave slopes that range from 80 to 300 feet in length. The slopes are dissected at frequent intervals by shallow draws. In some places they are cut by abrupt, deep and narrow ravines.

Mapped with this soil are spots of Storden soils that are too small to be mapped separately. Also included are small areas of moderately and severely eroded Lester soils.

Most of the acreage is wooded or in permanent pasture. Runoff is very rapid. Therefore, this soil should be kept in permanent vegetation that will control erosion. Pastures need to be renovated periodically to obtain maximum yields of forage. Capability unit VIIe–1.

Lester fine sandy loam, sandy variant, 2 to 6 percent slopes (LfB).—This gently undulating soil is on knolls 5 to 10 acres in size. It lies on slopes that are 80 to 150 feet long, and it is associated with the Lester clay loams.

In some areas erosion and deep tillage have caused material from the subsoil to be mixed with that in the surface layer. The texture in the surface layer and in the upper part of the subsoil is coarser than that described in the profile of the typical Lester soils.

Mapped with this soil are nearly level areas and areas that are moderately eroded. These included areas are too small to be mapped separately.

Row crops, small grains, and meadow are suited. Control of erosion is a major management problem, and there is a moderate hazard of drought. Capability unit IIe-3.

Lester-Estherville complex, 2 to 6 percent slopes, moderately eroded (LhB2).—The soils of this complex are rolling and occur in small, scattered areas. About 60 percent of the acreage is Lester soils, 30 percent is Estherville soils, and 10 percent is Storden soils. The layers in the profiles of these soils are thinner than those of the gently undulating Lester clay loams. In some places coarse gravel crops out on the surface.

Row crops, small grains, and meadow are well suited, but the Estherville soils are droughty. Runoff is medium, and measures are needed to control further erosion. Capability unit IIIe-4.

Lester-Storden complex, 2 to 6 percent slopes, moderately eroded (LsB2).—About 80 percent of this complex is Lester loam, and about 20 percent is Storden loam. The Storden soil is on convex slopes and appears as lighter colored bumps within areas of darker colored Lester soils. The Lester soil generally has thinner layers than Lester clay loam, 2 to 6 percent slopes, moderately eroded. The profile of the Storden soil is similar to the one described under the Storden series.

This complex is well suited to row crops, small grains, and meadow. Crops grown on the spots of Storden soil respond to additions of phosphate and potash. Further erosion is a hazard, but it can be easily controlled. Runoff is medium. Capability unit IIe-4.

Lester-Storden complex, 6 to 12 percent slopes, moderately eroded (LsC2).—About 70 percent of this complex is Lester loam, and about 30 percent is Storden loam. The layers in the Lester soil are thinner than those in the profile described for the Lester series. The Storden soil has a profile similar to the one described for the Storden series.

Row crops, small grains, and meadow are well suited. Crops grown on the spots of Storden soil respond to additions of phosphate and potash. Runoff is medium. Further erosion is a hazard, but it can be easily controlled. Capability unit IIIe-1.

Lester-Storden complex, 6 to 12 percent slopes, severely eroded (LsC3).—This complex is about 70 percent Lester loam and about 30 percent Storden loam. The surface layer of the Lester soil is browner than that in less eroded areas. The Storden soil is on the convex slopes and appears as lighter colored bumps within areas of darker colored Lester soils. This complex is similar to the moderately eroded complexes of Lester and Storden loams, except that all or nearly all of the surface layer has been removed by erosion.

Small grains and hay are suited. Row crops should be grown only occasionally. Capability unit IVe-2.

Lester-Storden complex, 12 to 18 percent slopes, moderately eroded (LsD2).—This complex is about 70 percent Lester loam and about 30 percent Storden loam. The soils have thinner layers than those in the profiles described for the Lester and Storden series. Mapped with these soils are small areas of only slightly eroded soils. The soils of this complex are well suited to sod crops. The slopes are too steep and irregular for terracing, and other special management practices are needed to maintain satisfactory yields. Runoff is rapid. Capability unit IVe-2.

Lester-Storden complex, 12 to 18 percent slopes, severely eroded (LsD3).—About 70 percent of this complex is Lester soils, and about 30 percent is Storden soils. All or nearly all of the original surface layer has been removed by erosion, and the present surface layer consists mainly of material from the subsoil or from other underlying horizons. Shallow rills are common, and there are a few gullies.

These soils are too steep and the slopes are too irregular for terracing. Improved pasture is the best use; fertilizer is needed to insure satisfactory yields. Runoff is rapid. Capability unit VIe-1.

Lester-Storden complex, 18 to 24 percent slopes (LsE).—About 70 percent of this complex is Lester soils, and 30 percent is Storden soils. The soils have thinner layers than the Lester-Storden complexes that are less steep.

Because of the steep to moderately steep, irregular slopes, this complex should be kept in improved pasture. Fertilizer is needed to maintain satisfactory yields of forage. Runoff is rapid. Capability unit VIe-1.

Lester-Storden complex, 18 to 24 percent slopes, severely eroded (LsE3).—About 70 percent of this complex is Lester soils, and about 30 percent is Storden soils. The areas are small and adjoin areas of less eroded soils.

All or nearly all of the original surface layer of these soils has been removed by erosion, and the present surface layer consists mainly of material from the subsoil or from the underlying material. Shallow rills are common, and there are a few gullies.

Most of the acreage has been converted to pasture, but fertilizer is needed to maintain satisfactory yields of forage. Normal use of machinery is difficult because of the steep slopes. Runoff is rapid. Capability unit VIIe-1.

Lester-Storden complex, 24 to 35 percent slopes (LsF).—This complex consists of about 60 percent Lester loam and about 40 percent Storden loam. The soils have slightly thinner layers than the other Lester-Storden complexes that are only slightly eroded. Most of the acreage is in pasture or woods and is only slightly eroded. Runoff is rapid. Capability unit VIIe-1.

Le Sueur Series

The Le Sueur series consists of dark-colored, deep soils that are moderately well drained to somewhat poorly drained. These soils are gently undulating and are on uplands. They developed under hardwoods.

The surface layer is black to very dark gray, slightly acid to medium acid clay loam that is 8 to 12 inches thick. The subsoil is very dark grayish-brown, medium acid to strongly acid clay loam that is 30 to 40 inches thick. The underlying material is light olive-brown, calcareous loam or clay loam.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high.

The Le Sueur soils are adjacent to the well-drained Lester soils and the poorly drained Webster and Cordova soils. In places they lie above areas of Terril soils. The Le Sueur soils are similar to the Nicollet soils, but they have a more clayey and more acid subsoil. They are also deeper over calcareous material.

Le Sueur clay loam, 0 to 2 percent slopes (LuA).—This soil is generally adjacent to areas of Lester, Webster, and Cordova soils. Mapped with it are small areas of soils that are slowly permeable. The included soils are more grayish than the Le Sueur soils, and they have a mottled subsoil. They are included because of their small extent.

This soil has few limitations for farming, and it is used intensively for row crops. Runoff is slow. Capability unit I–1.

Le Sueur clay loam, 2 to 6 percent slopes (LuB).—In most places this gently undulating soil has slopes of 3 percent. It is generally adjacent to areas of Lester, Webster, and Cordova soils. In some places it lies above areas of Terril soils. The layers in the profile are slightly thinner than those of Le Sueur clay loam, 0 to 2 percent slopes.

This Le Sueur soil is generally farmed intensively to row crops along with areas of nearly level Le Sueur soils. Erosion is a slight hazard, and simple practices are needed to control it. Runoff is slow to medium. Capability unit IIe–1.

Lura Series

The Lura series consists of dark-colored, deep, very poorly drained soils of the uplands. The soils are in shallow basins and drainageways. They developed in moderately fine textured or fine textured lacustrine sediments over clay loam till.

The surface layer is black, slightly acid heavy silty clay loam that is 18 to 28 inches thick. The subsoil is very dark gray to dark gray, slightly acid silty clay that is 20 to 36 inches thick. The underlying material is calcareous clay loam till.

These soils are slowly permeable. They are high in natural fertility and high in moisture-supplying capacity.

The Lura soils are closely associated with the moderately well drained to somewhat poorly drained Guckeen soils and the poorly drained Marna soils. They are somewhat similar to the Glencoe soils, but they developed in finer textured material and have more clay in the subsoil. Their subsoil also has stronger structure.

Lura silty clay loam (Ly).—This is the only Lura soil mapped in the county. It is nearly level and occurs in shallow basins and drainageways. It is associated with the Guckeen and Marna soils. Mapped with it are small areas of a soil that has a surface layer of heavy silty clay loam.

If Lura silty clay loam is adequately drained, row crops can be grown intensively. Tile drainage is needed, and open drains should be installed to provide outlets for the tile drains. Runoff is slow to ponded; shallow field ditches should be installed with the tile to prevent ponding during wet periods. Capability unit IIIw–1.

Marna Series

The Marna series consists of dark-colored, deep, poorly drained soils of the uplands. These soils are in nearly level areas or in slight depressions. They developed under a rank growth of prairie grasses in fine-textured, lake-laid sediments over calcareous glacial till. These soils are mainly in the southwestern part of the county.

The surface layer is black, neutral heavy silty clay loam that is 12 to 18 inches thick. The subsoil is dark grayish-brown, neutral silty clay that ranges from 10 to 16 inches in thickness. The underlying material is olive, calcareous clay loam or silty clay loam that is mottled with grayish brown.

These soils are moderately permeable. They are high in natural fertility and in moisture-supplying capacity, and they are generally neutral in reaction. A few areas, however, are mildly alkaline.

In many places the Marna soils are adjacent to areas of moderately well drained to somewhat poorly drained Guckeen soils. Their drainage is similar to that of the Webster soils, but they are deeper over calcareous material and are more clayey than those soils. Also their subsoil has more pronounced structural development.

Marna silty clay loam (Ma).—This is the only Marna soil mapped in the county. It is nearly level or is in slight depressions. It is adjacent to areas of Guckeen soils. Mapped with this soil are some areas of a soil that has a surface layer of silty clay.

Runoff is slow, and drainage is needed to obtain maximum yields. If adequate drainage is provided, row crops can be grown intensively. Capability unit IIw–1.

Marsh (Mh)

This land type is in shallow lakes and ponds that may be dry in years that have less than normal precipitation. Most areas are wet throughout the year. The vegetation consists mainly of cattails, rushes, sedges, willows, and other plants that tolerate water. These plants provide habitats for waterfowl. Capability unit VIIIw-1.

Nicollet Series

The Nicollet series consists of deep, moderately well drained soils of the uplands. These soils are nearly level to gently undulating. They developed in glacial till under tall prairie grasses and are calcareous at a depth of 30 to 45 inches.

The surface layer is black to very dark grayish-brown, medium acid light clay loam that is 8 to 16 inches thick. The subsoil is dark-gray to grayish-brown, medium acid to slightly acid light clay loam that is 25 to 35 inches thick. The lower part of the subsoil is mottled, and the mottles increase in number with increasing depth. The underlying material is olive-gray, calcareous light clay loam.

The Nicollet soils are closely associated with the well-drained Clarion soils and the poorly drained Webster soils. In some places they lie above areas of Terril soils, and some areas are adjacent to the Truman soils. The Nicollet soils are somewhat similar to the Le Sueur soils, but they have a less clayey and generally less acid subsoil. They are also somewhat similar to the Guckeen soils, but they developed in clay loam glacial till rather than in lacustrine sediments consisting of silty clay.

The Nicollet soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high.

Nicollet clay loam, 0 to 2 percent slopes (NcA).—This soil adjoins areas of Clarion and Webster soils. In places it lies above areas of Terril soils. Where it adjoins the Truman soils, small areas are mapped with it that have a surface layer and subsoil of silt loam. These areas are too small to be mapped separately.

There are few limitations for farming, and row crops are grown intensively. Runoff is slow. Capability unit I–1.

Nicollet clay loam, 2 to 6 percent slopes (NcB).—This gently undulating soil normally has slopes of 3 percent. In most places it adjoins areas of Clarion and Webster soils, but in some places it adjoins the Truman soils. Some areas of this soil lie above areas of Terril soils.

Where this soil adjoins the Truman soils, small areas of a soil that has a surface layer of silt loam are mapped with it. These included areas are too small to be mapped separately.

This Nicollet soil is generally farmed intensively to row crops, along with the nearly level Nicollet soils. There is a slight hazard of erosion, but erosion is easily controlled. Runoff is slow to medium. Capability unit IIe–1.

Peat and Muck

Peat consists of the organic remains of reeds, sedges, and grasses in depressions that are wet most of the year. Muck is finely divided, disintegrated peat. In this county there are four mapping units of Peat and muck. In some of the larger bogs, all four mapping units may occur. The separation is based on the depth of the organic material and on its reaction. Depth and spacing of tile depends upon the depth of the organic material and texture of the underlying material. The need for amendments depends upon the reaction.

Peat and muck, shallow (Ph).—This mapping unit consists of deposits of peat or muck that are 12 to 42 inches thick. These deposits are underlain by mineral soil material that has a texture of sandy loam or finer. The peat in most bogs is brown, fibrous, and spongy and consists of the remains of plants that have undergone little decomposition.

Drainage must be provided before dependable yields of row crops and pasture can be obtained. Special crops, such as vegetables, can be grown if the areas are adequately drained and fertilized. Capability unit IIIw–3.

Peat and muck, shallow and calcareous (Pk).—This mapping unit consists of deposits of peat or muck that are 12 to 42 inches thick. These deposits are underlain by mineral soil material that has a texture of sandy loam or finer. Precipitated lime carbonates and pieces of shells are diffused throughout the profile.

Because of the high content of lime, additional amounts of phosphate and potash are needed. Special crops, such as vegetables, can be grown if the areas are adequately drained and fertilized. Capability unit IIIw–3.

Peat and muck, deep (Pa).—This mapping unit consists of deposits of peat or muck that are more than 42 inches thick. The deposits are in depressions. Drainage is needed before dependable yields of row crops and pasture can be obtained. Special crops, such as vegetables, can be grown if adequate drainage is provided and the areas are fertilized. Capability unit IIIw–3.

Peat and muck, deep and calcareous (Pc).—This mapping unit consists of deposits of peat or muck that are more than 42 inches thick. Precipitated lime carbonates and pieces of shell are diffused throughout the profile.

Because of the high content of lime, additional amounts of phosphate and potash are needed. Special crops, such as vegetables, can be grown if the areas are adequately drained and fertilized. Capability unit IIIw–3.

Rough Broken Land (Rb)

This miscellaneous land type occurs in areas of narrow, steeply sloping glacial till material adjacent to the major drainageways and lakes. The slopes generally exceed 35 percent.

This land type is too steep for agricultural use. It supports a stand of mixed hardwoods and provides some grazing. Capability unit VIIe-1.

Storden Series

The Storden series consists of well-drained soils of the uplands. These soils developed under grass and a thin stand of hardwoods. The soils are undulating to strongly rolling and are on convex slopes.

The surface layer is very dark grayish-brown, calcareous loam that is 4 to 10 inches thick. Their subsoil is grayish-brown, highly calcareous loam that is 6 to 12 inches thick. The underlying material is olive to light olive-brown, highly calcareous loam till.

The concentration of carbonates in the profile reduces infiltration and permeability. It also reduces the amount of nutrients available to plants. The moisture-supplying capacity is good.

The Storden soils are so intermingled with areas of well-drained Lester and Clarion soils and with excessively drained Estherville soils that they are not mapped separately in this county. Instead, they are mapped in complexes with the Lester, Clarion, and Estherville soils.

Talcot Series

The Talcot series consists of dark-colored, moderately deep, very poorly drained soils of the outwash plains and uplands. These soils are in depressions and drainageways. They developed under tall prairie grasses and sedges in glacial outwash material that is calcareous at a depth of 24 to 36 inches.

The upper part of the surface layer is black, neutral to mildly alkaline silty clay loam that grades to very dark gray clay loam in the lower part. In most places this layer is about 24 inches thick. The subsoil is dark-gray, mildly alkaline clay loam that is about 6 inches thick. The underlying material is calcareous, stratified coarse sand and gravel. In some areas, where the outwash material is thin, the coarse sand and gravel are underlain by glacial till at a depth of 42 to 48 inches.

These soils are moderately permeable. Their natural fertility is high, and their moisture-supplying capacity is good.

The Talcot soils are similar to the Biscay soils, but they have a thicker, darker, more clayey surface layer than the Biscay soils. The subsoil of the Talcot soil is also more grayish.

Talcot silty clay loam (Ta).—This is the only Talcot soil mapped in the county. It occupies depressions and drainageways that are surrounded by flat areas of Biscay loam.

Row crops are well suited, but drainage is needed for maximum yields. Installing tile and open ditches is difficult because the underlying material is sandy. This sandy material tends to fill the tile and to cave or slough in the open ditches. Capability unit IIIw-1.

Terril Series

The Terril series consists of dark-colored, deep, moderately well drained soils of the uplands. These soils developed under mixed grasses in glacial till that is calcareous at a depth of 40 to 60 inches. In recent times some areas have been covered with trees.

The surface layer is very dark gray to black, slightly acid loam that is 18 to 30 inches thick. Just below the surface layer is very dark grayish-brown and olive-gray, slightly acid to neutral loam to a depth of about 36 inches. The material below is olive-gray, calcareous loam.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high. The reaction is generally slightly acid to neutral.

The Terril soils are associated with the moderately well drained Nicollet soils, the moderately well drained to somewhat poorly drained Le Sueur soils, and the well drained Clarion and Lester soils. They are somewhat similar to the Nicollet soils, but they have a much thicker surface layer than those soils. They have a thicker surface layer and lower content of clay than the Le Sueur soils.

Terril loam, 2 to 6 percent slopes (Tl).—This is the only Terril soil mapped in the county. It lies on concave slopes below areas of Clarion, Nicollet, Lester, or Le Sueur soils. In some places areas of this kind of soil occur in strips so narrow that they are not mapped separately but are mapped with adjacent soils.

Row crops, small grains, and meadow are well suited, and many areas are used intensively for row crops. Erosion is a hazard because this soil receives runoff from higher areas. Capability unit IIe-1.

Truman Series

The Truman series consists of dark-colored, deep, well-drained soils of the uplands. These soils are gently undulating to rolling. They developed under tall prairie grasses in silt that is calcareous at a depth of 24 to 36 inches.

The surface layer is very dark gray, neutral to slightly acid silt loam that is 8 to 12 inches thick. The subsoil is yellowish-brown, slightly acid to neutral silt loam that is 14 to 18 inches thick. The underlying material is light olive-brown, calcareous silt loam. In many places it contains thin seams of very fine sand.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high, and they are normally slightly acid to neutral.

The Truman soils are associated with the moderately well drained Nicollet soil and the poorly drained Webster soils. They are somewhat similar to the Clarion soils, but they developed in silt rather than in loam or clay loam glacial till. In a few places where the mantle of silt is thin, glacial till occurs at a depth of 42 to 60 inches.

Truman silt loam, 2 to 6 percent slopes (TrB).—This gently undulating soil is adjacent to areas of Nicollet and Webster soils. It is well suited to row crops, small grains, and meadow, but practices are needed to control erosion. Runoff is medium. Capability unit IIe-1.

Truman silt loam, 2 to 6 percent slopes, moderately eroded (TrB2).—This gently undulating soil is adjacent to areas of Nicollet and Webster soils. Because of erosion, plowing has mixed material from the subsoil with that in the surface layer. As a result, the plow layer is lighter colored than that of the less eroded Truman soil.

This soil is well suited to row crops, small grains, and meadow, but practices are needed to control erosion. Runoff is medium. Capability unit IIe-1.

Truman silt loam, 6 to 12 percent slopes, moderately eroded (TrC2).—This rolling soil is on short, irregular slopes adjacent to areas of Nicollet and Webster soils. Mapped with it is a small acreage of steeper Truman soils. The layers in the profile are thinner than those in the less sloping Truman soils. Erosion has mixed material from the subsoil with that in the remaining original surface layer. The present surface layer is lighter colored than the original one.

The hazard of erosion is moderate, and erosion is more difficult to control on this soil than on the less sloping Truman soils. Under proper management, good yields of row crops, small grains, and meadow are obtained. Runoff is medium to rapid. Capability unit IIIe-1.

Wadena Series

The Wadena series consists of moderately deep, well-drained soils of the outwash plains. These soils are gently undulating. They developed in loamy sediments over coarse sand and gravel.

The surface layer is very dark brown, slightly acid to medium acid loam that ranges from 12 to 16 inches in thickness. The subsoil is dark-brown, slightly acid loam to sandy loam that ranges from 14 to 24 inches in thickness. The underlying material is variegated dark yellowish-brown, brown, and pale-brown, calcareous coarse sand and gravel that is interbedded with seams and pockets of fine sand.

These soils are rapidly permeable. Natural fertility is moderate, and the moisture-supplying capacity is good.

The Wadena soils are associated with the somewhat excessively drained Estherville soils. They also occur with the poorly drained Biscay soils.

Wadena loam, 2 to 6 percent slopes (WaB).—This is the only Wadena soil mapped in the county. It is gently undulating and is adjacent to areas of Estherville and Biscay soils. In some places the surface layer contains varying amounts of gravel. Mapped with this soil are moderately eroded spots and small, nearly level areas.

Runoff is medium, and practices are needed to control erosion. Row crops, small grains, and meadow are well suited. Capability unit IIe-3.

Webster Series

The Webster series consists of dark-colored, deep, poorly drained soils of the uplands. These soils are in nearly level areas or in slight depressions. They developed under tall prairie grasses in glacial till that is calcareous at a depth of 18 to 30 inches.

The surface layer is black, neutral clay loam that ranges from 14 to 22 inches in thickness. Just below the surface layer is a layer of grayish-brown, neutral clay loam that is 7 to 14 inches thick. Below is mottled, olive-gray and olive, calcareous clay loam.

These soils are moderately permeable. Their natural fertility and moisture-supplying capacity are high.

The Webster soils are associated with the well drained Clarion soils, the moderately well drained Nicollet soils, and the very poorly drained Glencoe soils. They are somewhat similar to the Marna and Cordova soils, but the Webster soils contain less clay than those soils. Also, the structure of their subsoil is less well developed.

Webster clay loam (Wb).—This is the only Webster soil mapped in the county. It is in nearly level areas or in slight depressions, generally adjacent to areas of Clarion, Nicollet, and Glencoe soils. In some small areas adjacent to the depressional Glencoe soils, the surface layer is calcareous. Mapped with this soil are areas of a soil that has a surface layer of silty clay loam.

Row crops are grown intensively on this Webster soil, but drainage is required for maximum yields of crops (fig. 10). This soil is also suited to small grains and meadow. Runoff is slow. Capability unit IIw-1.

***Figure 10.*—An outlet ditch for a drainage system in a poorly drained Webster soil. In the background are areas of Clarion and Nicollet soils.**

Use and Management of the Soils

In this section are discussed first the basic management practices that should be kept in mind when planning farming operations. Then, estimated acre yields of the crops commonly grown are given, the capability grouping of soils is described, and management needed to obtain high yields is discussed under each capability unit. Finally, the uses of the soils for wildlife and recreation are briefly discussed, and facts about the suitability of the soils for engineering are given.

The facts given in this section are not a substitute for the detailed advice that can be provided by the county agent or a local representative of the Soil Conservation Service. They may, however, help the farmer plan suitable management for his soils.

Basic Practices of Management

Some practices are applicable to all the soils of a county. These include the use of suitable tillage practices, proper liming, adequate drainage, and control of erosion. In addition to using these practices, the farm operator will need to take into account all of the resources available on his particular farm. He should consider the capability of his soils, their need for drainage, and their susceptibility to erosion. Also, he needs to consider the machinery and other equipment and the labor and capital available in relation to expected returns.

Using good management practices may increase the yields from average to high. If present crop varieties and technology are used, however, considerable skill is required to profitably increase the average longtime yields more than 15 percent beyond the highest level shown in the section "Estimated Yields."

Tillage practices.—Frequent tillage or tilling when the soils are too wet or too dry damages the structure of the soils. Frequent tillage makes the surface layer powdery so that water is not absorbed readily. When the surface layer is powdery, the amount of runoff increases, the moisture available to plants is limited, and erosion becomes more serious. Tilling when the soil does not contain the proper amount of moisture also makes the surface layer cloddy (fig. 11) and unsuitable as a seed-

***Figure 11.*—A soil that is not desirable as a seedbed, because poor tillage practices have made it cloddy.**

bed. It destroys the possible benefit to be derived from other practices that improve tilth.

The soils should be tilled only enough to prepare a good seedbed, to control the growth of weeds, and to control the volunteer growth of crops from the previous year. By applying chemicals to control weeds and by using machinery that permits minimum tillage, the amount of tillage needed can be reduced (fig. 12).

***Figure 12.*—A soil that is in good tilth. Such a soil provides a good seedbed for crops and allows roots to penetrate to a depth where they can obtain plant nutrients and moisture.**

Plowing in fall is a common practice on the nearly level to gently undulating soils, which make up about 75 percent of the county. If the soils are plowed in fall, freezing and thawing during the winter months breaks the clods and makes tillage easier in spring. The soils can also be tilled earlier in spring than soils that have not been plowed the previous fall. As a result, a better seedbed is generally prepared, and the possibility of obtaining a good stand of plants is increased.

The practice of plowing in fall is suited to the precipitation pattern of this county. The average monthly low-intensity precipitation between October and March ranges from about 1.5 inches to less than 1 inch. Beginning in March or April, there is a rapid increase in the amount of rainfall. This disrupts the timeliness of spring plowing and often causes the soils to be tilled when they are too wet.

The nearly level to gently undulating soils dry out slowly in spring. Fall plowing is therefore more suitable for those soils than spring plowing. Tillage other than rough plowing, however, should be avoided in fall. A rough surface holds the moisture from melting snow and reduces the hazard of erosion.

Sloping soils can be protected by using minimum tillage and rough tillage and by properly managing all crop residues. These practices help to control erosion and also provide a better seedbed for crops that are adapted to minimum tillage. The hazard of erosion increases as the slope increases. Therefore, sloping soils should be cultivated on the contour. Fall plowing is suitable if such soils are terraced and if manure or some other protective mulch is used.

Liming.—The requirements for lime depend upon the natural acidity of the soils, the previous management, and the cropping system that is planned. Originally, the soils of the county were high in calcium. Now, in some of them the calcium has leached out of the surface layer. After the calcium has leached out, the soils need periodic applications of lime to correct acidity. The need for lime and the response to it vary considerably. The soils of this county are generally so intermingled that the soils in one part of the field may need lime and those in another part may not. Soil tests should be made to determine the requirements for lime.

Correcting the acidity in the surface layer helps to make other plant nutrients available to crops. Where the acidity has been corrected, there is better response to the inoculation of legumes.

Drainage.—About 55 percent of the acreage in the county is made up of wet soils. Many farmers have installed tile, but there are still many areas that need artificial drainage. Artificial drainage has been one of the most important factors that have contributed to the development of agriculture in this county.

A tile drainage system will function properly in most of the soils. In local areas that are underlain by sandy or gravelly material, however, it is difficult to install tile and to maintain open drains. In the small, grayish depressions in the western part of the county, open drains or French drains are the best to use.

Root development is good in soils that are adequately drained because the movement of air and water is not restricted. Soils that are adequately drained generally warm up earlier in spring and are less susceptible to frost heaving than poorly drained soils. Effective drainage also facilitates the use of larger farm equipment and permits more timely field operations than are possible in areas that are not drained.

Areas to be drained should be inspected by someone who knows the soils, because the depth and spacing of the tile depend on the soil type and the pattern of occurrence of the various soils. Open ditches are commonly used to remove excess surface water and to provide an outlet for other drainage systems.

Erosion control.—Controlling erosion and conserving water are necessary on erodible soils to reduce losses of soil and water. Practices that help to control water and wind erosion include contour cultivation, terracing, stripcropping, sodding of waterways, mulch tillage, rough tillage, and minimum tillage. Sloping land can be protected against water erosion by maintaining the content of organic matter and a good level of fertility. A high content of organic matter and a high level of fertility increase the infiltration of water and enable the soil to support crops that improve soil structure.

Erosion by wind is generally not a problem in this county, except on a few of the larger areas of Peat and muck. Blowing of sandy soils and of organic soils may be prevented, however, by stripcropping, rough tillage, maintaining a cover of plants or crop residues, wind stripcropping, and providing windbreaks for exposed areas. Where much of the acreage consists of soils in capability units IIIe-1, IIIe-2, IVe-1, and IVe-2, the cropping system should consist largely of legumes and grasses.

Estimated Yields

Table 10 gives estimated average acre yields of the principal crops grown in this county. Estimated yields given in columns A are those commonly obtained under the average management practiced in the county. Those given in columns B are obtained under a high level of management by using practices such as those suggested in the section "Management by Capability Units." Under this improved management, manure, lime, and fertilizer are applied in accordance with the latest research methods, and tested erosion-control practices and rotations are used.

The yield estimates are based on information taken from (1) records of measured yields obtained when experiments were made on specific soils, (2) records of yields and soil-management practices reported by farmers for crops on specific soils, (3) observation of crops and interviews with farmers during the course of this survey, (4) knowledge of soil properties that are known to affect the growth of crops, (5) consultation with county agents and personnel of the Soil Conservation Service, and (6) figures of average yields taken from agricultural census data. Using improved varieties of seed, new and improved farming practices, and larger amounts of fertilizer may make it possible to obtain higher average yields than those for which estimates are given. On the other hand, new plant diseases or insect pests may cause yields to be lower than the estimated average yields shown.

TABLE 10.—*Estimated average acre yields of the principal crops under two levels of management*

[In columns A are average yields obtained under the management commonly used; in columns B are average yields obtained under improved management. Absence of a yield figure indicates yields are too variable to estimate or the crops listed normally are not grown]

Soil	Corn		Oats		Soybeans		Alfalfa or alfalfa-bromegrass hay	
	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Alluvial land								
Biscay loam [1]	55	75	40	60	26	30	2.0	3.0
Canisteo clay loam	55	75	50	65	25	30	2.5	3.5
Canisteo clay loam, depressional	45	70	40	60	18	24	1.5	2.5
Clarion loam, 2 to 6 percent slopes	70	85	60	70	30	35	3.0	3.5
Clarion loam, 2 to 6 percent slopes, moderately eroded	65	85	60	70	26	30	2.8	3.2
Clarion loam, 6 to 12 percent slopes	65	80	55	65	24	28	2.5	2.9
Clarion loam, 6 to 12 percent slopes, moderately eroded	60	75	50	60	24	28	2.5	2.9
Clarion loam, 6 to 12 percent slopes, severely eroded	45	60	40	50	18	20	2.0	2.5
Clarion loam, 12 to 18 percent slopes, moderately eroded	35	50	30	40			2.0	2.5
Clarion-Estherville complex, 2 to 6 percent slopes, moderately eroded	40	55	30	45	18	20	2.0	2.5
Clarion-Storden complex, 2 to 6 percent slopes, moderately eroded	50	60	35	50	18	22	2.3	2.8
Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded	40	55	30	45	14	18	1.5	2.5
Clarion-Storden complex, 6 to 12 percent slopes, severely eroded	30	45	25	35			1.0	1.5
Clarion-Storden complex, 12 to 18 percent slopes, moderately eroded	30	40	25	30			1.0	1.5
Clarion-Storden complex, 12 to 18 percent slopes, severely eroded			18	25			1.0	1.3
Clarion-Storden complex, 18 to 24 percent slopes			18	25			1.0	1.3
Clarion-Storden complex, 18 to 24 percent slopes, severely eroded			15	20			.5	1.0
Clarion-Storden complex, 24 to 35 percent slopes								
Colo silty clay loam	60	75	45	60	25	30	2.0	3.0
Colo silty clay loam, frequent overflow								
Colo silty clay loam, very wet								
Cordova silty clay loam	70	85	55	65	26	35	2.5	3.5
Dickinson fine sandy loam, 2 to 6 percent slopes	45	55	40	50	15	18	1.8	2.2
Dickinson loam, 0 to 6 percent slopes	50	65	50	60	18	22	2.0	2.5
Dickinson loam, 6 to 12 percent slopes, moderately eroded	45	55	40	50	15	18	1.8	2.2
Dundas silt loam	60	75	50	60	20	25	1.8	2.5
Estherville sandy loam, 0 to 6 percent slopes	40	55	30	40	10	15	1.6	2.2
Estherville sandy loam, 6 to 12 percent slopes, moderately eroded	30	35	25	35			1.4	1.8
Estherville soils, 12 to 25 percent slopes, moderately eroded			20	30			1.4	1.8
Estherville, Lester, and Storden soils, 6 to 12 percent slopes, moderately eroded	30	40	25	35	10	13	1.5	2.0
Estherville, Lester, and Storden soils, 12 to 18 percent slopes, moderately eroded	20	30	20	30			1.0	1.5
Glencoe silty clay loam	50	75	45	65	25	30	2.0	3.0
Guckeen silty clay loam, 0 to 2 percent slopes	70	85	55	70	30	35	3.0	3.5
Guckeen silty clay loam, 2 to 6 percent slopes	70	85	55	70	30	35	3.0	3.5
Huntsville loam, sand substratum	55	65	45	55	18	26	2.0	2.5
Huntsville silt loam [1]	60	75	45	55	22	30	2.5	3.0
Huntsville silt loam, frequent overflow								
Kilkenny clay loam, 2 to 6 percent slopes	60	75	55	65	20	25	2.3	2.8
Kilkenny clay loam, 2 to 6 percent slopes, moderately eroded	55	70	55	65	20	25	2.3	2.8
Kilkenny clay loam, 6 to 12 percent slopes	55	70	50	60	18	23	2.0	2.5
Kilkenny clay loam, 6 to 12 percent slopes, moderately eroded	55	65	50	60	18	23	2.0	2.5

See footnotes at end of table.

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TABLE 10.—*Estimated average acre yields of the principal crops under two levels of management*—Continued

Soil	Corn		Oats		Soybeans		Alfalfa or alfalfa-bromegrass hay	
	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Kilkenny clay loam, 6 to 12 percent slopes, severely eroded	40	55	35	45	10	15	2.0	2.5
Kilkenny clay loam, 12 to 18 percent slopes	45	55	35	45	-----	-----	2.0	2.5
Kilkenny clay loam, 12 to 18 percent slopes, moderately eroded	40	50	35	45	-----	-----	2.0	2.5
Kilkenny clay loam, 12 to 18 percent slopes, severely eroded	25	40	25	35	-----	-----	1.8	2.2
Kilkenny clay loam, 18 to 24 percent slopes	-----	-----	-----	-----	-----	-----	1.0	1.5
Kilkenny clay loam, 18 to 24 percent slopes, moderately eroded	-----	-----	-----	-----	-----	-----	.8	1.3
Kilkenny clay loam, 24 to 35 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----
Lake beaches	-----	-----	-----	-----	-----	-----	-----	-----
Lester clay loam, 2 to 6 percent slopes	70	80	60	70	28	32	2.8	3.5
Lester clay loam, 2 to 6 percent slopes, moderately eroded	65	75	55	65	26	30	2.8	3.2
Lester clay loam, 6 to 12 percent slopes	60	75	55	65	24	28	2.5	3.0
Lester clay loam, 6 to 12 percent slopes, moderately eroded	55	70	50	60	24	28	2.5	2.9
Lester clay loam, 12 to 18 percent slopes	55	70	45	60	-----	-----	2.5	3.0
Lester clay loam, 12 to 18 percent slopes, moderately eroded	45	60	35	50	-----	-----	2.0	2.5
Lester clay loam, 12 to 18 percent slopes, severely eroded	-----	-----	30	45	-----	-----	1.0	1.5
Lester clay loam, 18 to 24 percent slopes	-----	-----	30	45	-----	-----	1.0	1.5
Lester clay loam, 18 to 24 percent slopes, moderately eroded	-----	-----	-----	-----	-----	-----	1.0	1.5
Lester clay loam, 18 to 24 percent slopes, severely eroded	-----	-----	-----	-----	-----	-----	-----	-----
Lester clay loam, 24 to 35 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----
Lester fine sandy loam, sandy variant, 2 to 6 percent slopes	55	65	50	55	20	22	2.0	2.7
Lester-Estherville complex, 2 to 6 percent slopes, moderately eroded	40	55	30	40	18	20	2.0	2.5
Lester-Storden complex, 2 to 6 percent slopes, moderately eroded	50	60	35	50	18	22	2.3	2.8
Lester-Storden complex, 6 to 12 percent slopes, moderately eroded	40	55	30	45	14	18	1.5	2.5
Lester-Storden complex, 6 to 12 percent slopes, severely eroded	30	45	25	35	-----	-----	1.0	1.5
Lester-Storden complex, 12 to 18 percent slopes, moderately eroded	30	40	25	30	-----	-----	1.0	1.5
Lester-Storden complex, 12 to 18 percent slopes, severely eroded	-----	-----	18	25	-----	-----	1.0	1.5
Lester-Storden complex, 18 to 24 percent slopes	-----	-----	18	25	-----	-----	1.0	1.5
Lester-Storden complex, 18 to 24 percent slopes, severely eroded	-----	-----	-----	-----	-----	-----	1.0	1.5
Lester-Storden complex, 24 to 35 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----
Le Sueur clay loam, 0 to 2 percent slopes	70	85	55	70	30	35	3.0	3.5
Le Sueur clay loam, 2 to 6 percent slopes	70	85	55	70	30	35	3.0	3.5
Lura silty clay loam [1]	40	70	40	65	20	30	2.0	3.0
Marna silty clay loam	60	85	50	70	26	35	3.0	3.5
Marsh	-----	-----	-----	-----	-----	-----	-----	-----
Nicollet clay loam, 0 to 2 percent slopes	70	85	55	70	30	35	3.0	3.5
Nicollet clay loam, 2 to 6 percent slopes	70	85	55	70	30	35	3.0	3.5
Peat and muck, deep [2]	50	70	35	50	22	28	1.5	2.0
Peat and muck, deep and calcareous [2]	45	65	35	45	18	22	1.5	2.0
Peat and muck, shallow [2]	55	70	35	50	22	28	1.5	2.0
Peat and muck, shallow and calcareous [2]	45	65	35	45	18	22	1.5	2.0
Rough broken land	-----	-----	-----	-----	-----	-----	-----	-----
Talcot silty clay loam [1]	40	70	40	65	24	30	2.0	3.0
Terril loam, 2 to 6 percent slopes	75	85	55	70	30	35	3.0	3.5
Truman silt loam, 2 to 6 percent slopes	70	85	55	70	30	35	3.0	3.5
Truman silt loam, 2 to 6 percent slopes, moderately eroded	65	80	55	65	26	30	2.8	3.2
Truman silt loam, 6 to 12 percent slopes, moderately eroded	60	75	50	60	24	28	2.5	2.9
Wadena loam, 2 to 6 percent slopes	55	65	45	55	20	24	2.0	2.5
Webster clay loam	65	90	50	70	26	35	2.0	3.5

[1] Yields in columns A fluctuate widely from year to year because of inadequate drainage.
[2] Corn is grown for grain on a minor acreage of these soils. Soybeans and silage corn are the principal crops grown. Hay crops are brome or canarygrass, rather than alfalfa.

The management commonly used to obtain the average yields shown in columns A consists of the following practices: Where corn is planted, no supplemental nitrogen is used the first year after a legume is grown. The second year after a legume is grown, 60 pounds of nitrogen per acre is applied after the corn is planted. In 1960 average yields of corn were obtained by using enough seed so that there would be about 14,000 plants per acre at harvesttime. In addition, 125 pounds per acre of a starter fertilizer was used. (In 1961 this fertilizer was 6–24–24.)

A small grain grown with a legume-grass companion seeding usually receives 200 pounds per acre of the starter fertilizer. A fertilizer that contains nitrogen is used because the nitrogen benefits the small grain. Soybeans do not receive any additional fertilizer, but they derive benefit from the fertilizer left in the soil after a previous crop has been harvested. Most farmers try to time the cutting of alfalfa so that they can get three cuttings during the season.

The management used to obtain the higher yields shown in columns B consists of the following practices, in addition to the practices given in the section "Management by Capability Units." Where corn is planted, only starter nitrogen is used the first year after a legume is grown. The second year after a legume is grown, 80 to 100 pounds of nitrogen is applied 2 to 5 weeks after the corn is planted. In 1961 average yields of corn were obtained by using enough seed so that there would be about 18,000 plants per acre at harvest-time. In addition, 175 to 200 pounds per acre of the starter fertilizer was used.

A small grain grown with a legume-grass companion seeding usually receives 300 pounds per acre of the starter fertilizer. The following year the legume-grass crop is topdressed with 100 pounds of 0–20–20.

Soybeans do not receive any additional fertilizer, but they derive benefit from the fertilizer left in the soil after a previous crop has been harvested. Most farmers try to time the cutting of alfalfa so that they can get three cuttings during the season.

The farmer who obtains high yields usually controls weeds and insects by spraying, and he tills the soils more effectively, although less frequently, than the farmer who obtains average yields. He also usually provides an adequate drainage system.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes, there can be as many as four subclasses. The subclass is indicated 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* means that water in or on the soil will interfere 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 country, indicates that the chief limitation is a climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no susceptibility to erosion but have other limitations that restrict their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe–1 or IIe–2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows.

Class I. Soils that have few limitations that restrict their use.
- (No subclasses)
  - Unit I–1.—Deep, moderately well drained, nearly level to very gently undulating soils.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe–1.—Deep, well drained and moderately well drained, gently undulating or undulating soils.
  - Unit IIe–2.—Deep, well-drained, gently undulating or undulating soils that have a fine-textured, acid subsoil.
  - Unit IIe–3.—Moderately deep, well-drained, nearly level to gently undulating soils that have a sandy or gravelly substratum, generally at a depth of 24 to 36 inches.
  - Unit IIe–4.—Undulating, neutral to slightly acid soils that are intermingled with strongly calcareous soils.
- Subclass IIw. Soils that have moderate limitations because of excess water.
  - Unit IIw–1.—Deep and moderately deep soils that have a perched water table and are in nearly level areas or in slight depressions.
  - Unit IIw–2.—Deep, poorly drained, nearly level bottom-land soil that is subject to occasional flooding.
  - Unit IIw–3.—Deep, well drained and moderately well drained, nearly level bottom-land soils that are subject to occasional flooding.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe–1.—Deep, gently rolling or rolling soils that have a friable, loamy subsoil.
  - Unit IIIe–2.—Deep, rolling soils that have a moderately fine textured, acid subsoil.

Unit IIIe-3.—Moderately deep, well-drained, rolling soil that has a sandy substratum at a depth of 24 to 36 inches.

Unit IIIe-4.—Well-drained or somewhat excessively drained, nearly level to undulating soils that are slightly acid to medium acid.

Subclass IIIw. Soils that have severe limitations because of excess water.

Unit IIIw-1.—Deep or moderately deep soils that have moderate to moderately slow permeability and are in upland depressions and drainageways.

Unit IIIw-2.—Deep, somewhat poorly drained soil that has moderately slow permeability and a significant increase of clay in the subsoil.

Unit IIIw-3.—Very poorly drained organic soils.

Unit IIIw-4.—Deep, very poorly drained, moderately permeable soil of the bottom lands.

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

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe-1.—Deep, rolling to moderately steep soils that have a slightly acid to medium acid surface layer and a slightly acid to strongly acid subsoil.

Unit IVe-2.—Rolling to moderately steep, slightly acid to medium acid soils intermingled with highly calcareous soils.

Unit IVe-3.—Rolling, slightly acid to medium acid soils that are generally underlain by sand.

Subclass IVw. Soils that have very severe limitations for cultivation, because of excess water.

Unit IVw-1.—Very poorly drained, coarse-textured soil on lake beaches.

Class V. Soils not likely to erode that have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife food and cover. (None in Waseca County)

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.

Unit VIe-1.—Well-drained, very strongly sloping to moderately steep soils on uplands.

Unit VIe-2.—Well-drained to excessively drained, strongly sloping soils that are underlain mainly by sand and gravel.

Subclass VIw. Soils severely limited by excess water and generally unsuitable for cultivation.

Unit VIw-1.—Soils that are frequently flooded.

Class VII. Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Unit VIIe-1.—Steep, well-drained soils that overlie medium-textured material.

Unit VIIe-2.—Excessively drained, strongly sloping to moderately steep, moderately coarse textured to medium-textured soils.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial production of plants, and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIw. Extremely wet or marshy land.

Unit VIIIw-1.—Marsh.

Management by capability units

The soils in one capability unit have about the same limitations and similar risks of damage. The soils in one unit, therefore, need about the same kind of management, though they may have formed from different kinds of parent material and in different ways. The capability units are described in the following pages, and management is suggested for the soils of each unit.

CAPABILITY UNIT I-1

In this capability unit are moderately well drained soils formed in glacial till or modified glacial till. The soils are nearly level to very gently undulating, and the slopes are normally 75 to 150 feet long. The surface layer is dark colored, friable, and moderately fine textured. These soils occupy about 8 percent of the county.

These soils have a deep root zone, high moisture-supplying capacity, and high natural fertility. Permeability and infiltration are moderate. The soils in this unit are—

Guckeen silty clay loam, 0 to 2 percent slopes.
Le Sueur clay loam, 0 to 2 percent slopes.
Nicollet clay loam, 0 to 2 percent slopes.

In fields where these soils are dominant, row crops can be grown most of the time because the hazard of erosion is generally slight. Where the soils are used mainly for row crops, special practices are needed to maintain optimum infiltration and permeability. The practices include keeping tillage to a minimum and tilling the soils only when they contain the proper amount of moisture. In addition, the optimum number of plants should be grown at a level of fertilization that economically produces high yields. Crop residue should be left on the soils.

A cropping system in which grasses or legumes are grown 1 year in 6 keeps the soils in good tilth if they are properly fertilized. The response to lime varies. The soils should be tested to determine the need for lime and fertilizer.

Because of their location, some soils in this unit are used for permanent pasture. Present yields of forage are low, however, because fertilizer is not applied and grazing is not controlled. Pastures can be improved by fertilizing them properly and by seeding suitable grasses and legumes.

Odd areas of these soils can be planted to evergreens that will provide food and cover for wildlife. Suggested evergreens are white and Norway spruce and redcedar. Honeysuckle, lilac, and crabapple are also suitable.

CAPABILITY UNIT IIe-1

In this capability unit are well drained and moderately well drained soils formed in glacial till or in modified glacial till. The soils are gently undulating or undulating, and slopes are normally 75 to 150 feet long. The surface layer is dark or moderately dark and friable, and it is medium textured to moderately fine textured. These soils occupy about 20 percent of the county.

The root zone of these soils is deep, and moisture-supplying capacity and natural fertility are high. Permeability and infiltration are moderate. The soils in this unit are—

Clarion loam, 2 to 6 percent slopes.
Clarion loam, 2 to 6 percent slopes, moderately eroded.
Guckeen silty clay loam, 2 to 6 percent slopes.
Lester clay loam, 2 to 6 percent slopes.
Lester clay loam, 2 to 6 percent slopes, moderately eroded.
Le Sueur clay loam, 2 to 6 percent slopes.
Nicollet clay loam, 2 to 6 percent slopes.
Terril loam, 2 to 6 percent slopes.
Truman silt loam, 2 to 6 percent slopes.
Truman silt loam, 2 to 6 percent slopes, moderately eroded.

Where these soils are dominant in a field, the cropping system can consist mainly of row crops. The hazard of erosion is generally slight to moderate, but if most of the farm is planted to row crops, special practices for control of erosion are needed. Terraces and contour cultivation should be considered in areas where the soils and relief are suitable. The amount of water that is lost through runoff can be reduced by maintaining good permeability in the plow layer so that there will be optimum infiltration. Practices that keep the soils permeable, so that water will be absorbed instead of running off, are minimum tillage and tilling only when the soils contain the proper amount of moisture. In addition, growing the optimum number of plants at a level of fertilization that economically produces high yields is desirable.

Where meadow is desired in the rotation, 2 years of meadow in 6 satisfactorily controls erosion if the soils are properly fertilized. If the soils are farmed on the contour, a rotation in which meadow crops are grown 1 year in 5 adequately controls erosion. If fields are terraced, a rotation in which meadow crops are grown 1 year in 6 is satisfactory. Graded terraces are ordinarily built. Outlets should be constructed and seeded the year before the terraces are built, to remove water without forming gullies. If a large acreage of hay is needed, contour strips reduce erosion and help control runoff.

Water from these soils flows rapidly into waterways. Therefore, the waterways need to be properly designed and kept in grass. Response to lime varies. The soils should be tested to determine the need for lime and fertilizer.

Yields vary to some extent because the dark-colored surface layer varies in thickness. Ordinarily, yields are lower on a moderately eroded soil than on a slightly eroded soil of the same soil type.

Because of their location, some of the soils in this unit are used for permanent pasture. Yields of forage are low, however, because fertilizer is not used and grazing is not controlled. The pastures can be made more productive by fertilizing them properly and by seeding suitable forage plants.

Odd areas can be planted to provide food and cover for wildlife. Suggested evergreens are white and Norway spruce and redcedar. Honeysuckle, lilac, crabapple, and similar plantings are suitable.

CAPABILITY UNIT IIe-2

This capability unit consists of well-drained soils formed in glacial till. The soils are gently undulating or undulating, and slopes are normally 75 to 200 feet long. The surface layer is moderately dark, friable, and moderately fine textured, and the subsoil is fine textured and acid. These soils occupy about 2 percent of the county.

The root zone of these soils is deep, and moisture supplying capacity and natural fertility are high. Permeability and infiltration are moderate. The soils in this unit are—

Kilkenny clay loam, 2 to 6 percent slopes.
Kilkenny clay loam, 2 to 6 percent slopes, moderately eroded.

In fields where these soils are dominant, sod crops should be grown frequently, as the hazard of erosion is moderate to severe. The content of clay in the upper part of the subsoil, immediately below the dark-colored surface layer, markedly increases the hazard of erosion. Soil tilth is likely to deteriorate if these soils are tilled when wet. Where these soils are properly fertilized, a rotation in which meadow crops are grown 1 year in 3 provides reasonable control of erosion and maintains optimum infiltration and permeability in the plow layer. If a large acreage of hay is needed, contour stripcropping reduces erosion and helps conserve moisture.

If terraces are built, meadow crops need to be grown only 1 year in 4. The terraces should be constructed carefully. Wetness will develop in the terrace channel and below the terrace if the grade is too nearly level. Outlets should be constructed and seeded the year before the terraces are built. Then, water is removed without forming gullies.

Water flows rapidly from these soils into waterways. Therefore, the waterways need to be properly designed and kept in grass. Response to lime varies. The soils should be tested to determine the need for lime and fertilizer.

Yields vary to some extent because of differences in the thickness of the surface layer. Ordinarily, yields are lower on a moderately eroded soil than on a slightly eroded soil of the same type.

Some of the soils in this unit are used for permanent pasture or are thinly wooded. The pastures can be made more productive by fertilizing them properly, liming, and seeding desirable forage crops. If their location is suitable, however, these soils can be used more profitably for field crops than for pasture.

Odd areas can be planted to provide food and cover for wildlife. Suggested evergreens are white and Norway spruce and redcedar. Honeysuckle, lilac, crabapple, and similar plantings are also suitable.

CAPABILITY UNIT IIe-3

This capability unit consists of well-drained soils formed in glacial outwash. The soils are nearly level to gently undulating, and the slopes are 50 to 125 feet long. The surface layer is dark to moderately dark and is medium acid and either moderately coarse textured or medium textured. In some places the texture of the substratum is fine sand; in other places it is coarse sand mixed with gravel; and in still other places it is gravel. This coarse-textured material is generally at a depth of 24 to 36 inches. These soils occupy about 0.5 percent of the county.

These soils have a moderately deep root zone, moderate moisture-supplying capacity, and moderate natural fertility. They range from slightly acid to medium acid. Permeability and infiltration are moderately rapid. The soils in this unit are—

- Dickinson loam, 0 to 6 percent slopes.
- Lester fine sandy loam, sandy variant, 2 to 6 percent slopes.
- Wadena loam, 2 to 6 percent slopes.

In fields where these soils are dominant, row crops can be grown most of the time because the hazard of erosion is moderate. If most of the acreage is in row crops, all crop residues should be turned under and chemicals used to control weeds. In addition, it is desirable to grow the optimum number of plants and to fertilize them adequately. Satisfactory long-term yields are more predictable where the raising of livestock is the main enterprise than where cash crops are the main source of income, because a larger proportion of forage crops is required in the cropping system.

The hazard of drought is moderate on these soils, and a diversified cropping system is required to compensate for variations in precipitation. Yields are directly related to the amount and distribution of rainfall.

These soils can be plowed either in fall or spring. If they are plowed in fall, the surface should be left rough and crop residues left on the surface. The nearly level soils can be kept in good tilth by using good management that includes growing hay crops 1 year in 5, returning all crop residues to the soils, and maintaining a proper level of fertility. Under a less intensive system of management, a rotation in which hay is grown 1 year in 4 is satisfactory.

More intensive management is needed for the soils that have slopes of 2 to 6 percent than for nearly level soils. On the stronger slopes a rotation of 1 year of row crops, 1 year of small grains, and 2 years of alfalfa-brome is satisfactory, provided contour stripcropping is practiced. Where fields are stripcropped, the alternate strips should be in hay. If these soils are terraced, the rotation suggested for the nearly level areas can be used.

Terraces should be constructed with a very slight grade. The terrace outlets ought to be built and seeded the year before the terraces are built. This insures the removal of water without forming gullies. Properly design all waterways and keep them in grass.

Water from these soils sometimes flows across adjacent steeper areas. Therefore, unprotected waterways may develop into serious gullies. The loose, coarse-textured material in the substratum makes these waterways extremely difficult to stabilize.

Response to lime varies, but lime will likely be needed in most areas. Test the soils to determine the need for lime and fertilizer. High yields require frequent additions of phosphate and potash.

CAPABILITY UNIT IIe-4

This capability unit consists of well-drained soils formed in glacial till. The slopes are undulating and are normally 75 to 125 feet long. The surface layer of these soils ranges from moderately dark to light in color, and it is friable and medium textured. The soils occupy about 0.1 percent of the county.

The Clarion and Lester soils have high moisture-supplying capacity and high natural fertility. Infiltration and permeability are moderate. The Storden soils have medium moisture-supplying capacity and low natural fertility. Infiltration and permeability are slow. The Clarion and Lester soils are neutral to slightly acid, and the Storden soils are highly calcareous. The soils in this unit are—

- Clarion-Storden complex, 2 to 6 percent slopes, moderately eroded.
- Lester-Storden complex, 2 to 6 percent slopes, moderately eroded.

In fields where these soils are dominant, meadow crops should be grown frequently. The hazard of erosion is moderate, but if most of the farm is planted to row crops, special practices for controlling erosion and conserving water are needed. Terraces and contour cultivation should be considered in areas where the soils and relief are suitable. The amount of water lost through runoff is reduced if optimum infiltration and permeability are maintained in the plow layer. Practices that maintain good permeability are minimum tillage and tilling only when the soils contain the proper amount of moisture. In addition, crops should be grown that yield a large amount of residue, which can be turned under.

If meadow crops are needed, 2 years of meadow in 6 satisfactorily controls erosion if the soils are properly fertilized. Where the soils are farmed on the contour, a rotation of 1 year of meadow in 5 adequately controls erosion. A rotation in which meadow crops are grown 1 year in 6 is satisfactory if terraces are built. Graded terraces are needed to remove water. The outlets should be constructed and seeded the year before the terraces are built. Then, water is removed without forming gullies. If a large acreage of hay is needed, growing hay in contour strips reduces erosion and helps control runoff.

Water from these soils flows rapidly into waterways. Therefore, the waterways need to be properly designed and kept in grass because the hazard of erosion is serious. Care is needed to prevent a severe loss of soil and serious damage to crops.

Test the soils to determine the need for lime and fertilizer. Lime is generally not required, but the Storden soils are highly calcareous and need extra additions of phosphate and potash. They also need frequent applications of organic matter. Because the Storden soils are calcareous, yields on these soil complexes usually are low.

Because of their location, some of the soils in this unit are used for permanent pasture. Yields of forage are low, however, because fertilizer is not used and grazing is not controlled. Pastures can be made more productive by fertilizing them properly and seeding suitable forage plants.

Odd areas can be planted to provide food and cover for wildlife. Suggested evergreens are white and Norway spruce and redcedar. Honeysuckle, lilac, crabapple, and similar plantings are also suitable.

CAPABILITY UNIT IIw-1

This capability unit consists of poorly drained soils formed in glacial till, modified glacial till, and lacustrine sediments. The soils are in broad, nearly level areas or in shallow depressions in flats and in narrow draws within more sloping areas. Their surface layer is dark, friable clay loam, silty clay loam, or loam. The Biscay soil is underlain by sand and gravel. These soils occupy about 37 percent of the county.

These soils have a potentially deep to moderately deep root zone, but they have a perched water table and must be drained before roots can extend deep into the subsoil. They have very high moisture-supplying capacity and very high natural fertility. Infiltration and permeability are moderate. The soils in this unit are—

Biscay loam.
Canisteo clay loam.
Cordova silty clay loam.
Marna silty clay loam.
Webster clay loam.

Where these soils are dominant in a field, row crops can be grown a large part of the time in the cropping system. These soils require drainage and careful management to maintain good tilth. If row crops are grown most of the time, special practices that maintain optimum infiltration and permeability and that return a large amount of crop residue to the soils are needed. Minimum tillage and tilling only when the soils contain the proper amount of moisture help to increase the rate of infiltration and to keep the soils permeable. In addition, the optimum number of plants should be grown under a level of fertilization that economically produces high yields. After the crop is harvested, the crop residue should be returned to the soils.

If the soils are fertilized properly, a cropping system in which grasses and legumes are grown 1 year in 6 keeps the soils in good tilth. Lime is generally not required, but the soils should be tested to determine the need for fertilizer. The Canisteo soil needs special fertilization.

Yields are directly related to the adequate use of tile drainage. Install the tile at a depth of 42 to 48 inches. Except in the Biscay soil, the tile lines should be placed at intervals of 90 to 100 feet, or approximately 400 feet of tile per acre. In the Biscay soil they should be installed at intervals of 200 feet if the underlying coarse-textured material is continuous. Blind the tile with finer textured material from the surface layer. The tile should be installed when the water table is low or after methods have been provided to lower the water table so that a proper grade can be obtained. Stabilizing the side slopes of open drains is difficult in the Biscay soil.

Because of their location, some of the soils in this unit are used for permanent pasture. Yields of forage are low, however, because fertilizer is not applied and grazing is not controlled. Pastures can be made more productive by fertilizing them properly and by seeding suitable forage plants.

Odd areas can be planted to provide food and cover for wildlife. Evergreens, such as redcedar; shrubs, such as honeysuckle and caragana; and legumes and grasses should be planted.

CAPABILITY UNIT IIw-2

Colo silty clay loam is the only soil in this capability unit. This soil is nearly level and poorly drained, and it formed in moderately fine textured alluvial sediments. It lies on broad, nearly level bottom lands adjacent to major streams and drainageways. The surface layer is dark, friable silty clay loam. This soil occupies about 0.3 percent of the county.

If this soil is drained, it has a deep root zone, high natural fertility, and high moisture-supplying capacity. Infiltration and permeability are moderate.

Wetness and occasional overflow are the major hazards. Some areas can be diked to protect them from overflow, but adequate tile drainage is also required for satisfactory yields. The tile should be installed at a depth of 42 to 48 inches and at intervals of 90 to 100 feet, or approximately 400 feet of tile per acre. If tile outlets can be located in a suitable place, pumps can be installed to facilitate drainage.

Where this soil is dominant in a field, row crops can be grown most of the time. Grow the optimum number of plants at a level of fertilization that economically produces high yields. A rotation in which grasses or legumes are grown 1 year in 6 keeps the soil in good tilth if the proper kinds and amounts of fertilizer are added. Test this soil to determine the need for fertilizer. Lime is generally not needed.

Because of their location, some areas of this soil are in permanent pasture. Yields of forage are low because fertilizer is not applied and grazing is not controlled.

CAPABILITY UNIT IIw-3

In this capability unit are well drained and moderately well drained soils formed in medium-textured alluvium. These soils are on bottom lands adjacent to the major streams and drainageways. Their surface layer is moderately dark, friable silt loam or loam. These soils occupy about 0.6 percent of the county.

The root zone is deep, and these soils have moderate moisture-supplying capacity and high natural fertility. Infiltration and permeability are also moderate. The soils in this unit are—

Huntsville loam, sand substratum.
Huntsville silt loam.

The soils in this unit are subject to occasional flooding. Where they are dominant in a field, row crops can be grown most of the time. However, special practices are needed that maintain optimum infiltration and permeability and that return a large amount of crop residue to the plow layer. Practices that keep the soils permeable are minimum tillage and tilling only when the soils contain the proper amount of moisture. In addition, the optimum number of plants should be grown under a level of fertilization that economically produces high yields. If the soils are fertilized properly, a rotation in which grasses or legumes are grown 1 year in 6 keeps the soils in good tilth.

Because of their location, some areas of these soils are kept in permanent wooded pasture. In spring and fall the pasture can be kept productive by adding fertilizer when feasible.

CAPABILITY UNIT IIIe-1

In this capability unit are well-drained soils formed in glacial till or silty sediments. These soils are gently rolling or rolling, and the slopes are normally 75 to 150 feet long. In most places their surface layer is dark to moderately dark colored, friable loam, silt loam, or clay loam, but in a few small areas the surface layer is sandy loam. The subsoil is generally friable and loamy. These soils occupy about 6.4 percent of the county.

These soils have a deep root zone and high moisture-supplying capacity. Except for the Storden soils, which have moderately low fertility, the soils have high natural fertility. In most of the soils, permeability and infiltration are moderate, but the Storden soils have slow permeability. The soils in this unit are—

- Clarion loam, 6 to 12 percent slopes.
- Clarion loam, 6 to 12 percent slopes, moderately eroded.
- Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded.
- Lester clay loam, 6 to 12 percent slopes.
- Lester clay loam, 6 to 12 percent slopes, moderately eroded.
- Lester-Storden complex, 6 to 12 percent slopes, moderately eroded.
- Truman silt loam, 6 to 12 percent slopes, moderately eroded.

In fields where these soils are dominant, the cropping system should contain a large proportion of grasses and legumes. Controlling erosion and conserving water are critical problems. Tillage ought to be on the contour, and terraces should be constructed where practical. Managing crop residues properly and using rough tillage are effective ways of increasing infiltration. Erosion can be controlled on the short, irregular slopes by keeping the soils in hay or pasture 3 years out of 5.

If terraces are constructed, 2 years of meadow in 5 is sufficient for controlling erosion. Graded terraces are needed to remove the water. The outlets should be constructed and seeded the year before the terraces are built. Then, water will be removed without forming gullies. The waterways ought to be carefully constructed and kept in grass. Stripcropping, where practical, gives excellent control of erosion. Alternate strips should be kept in grasses and legumes.

Response to lime varies, and the soils should be tested to determine the need for lime and fertilizer. Lime is not needed on the Storden soils.

Yields vary to some extent as a result of differences in the thickness of the surface layer. Ordinarily, yields are lower on a moderately eroded soil than on a slightly eroded soil of the same soil type.

Some of the soils in this capability unit are kept in permanent pasture. Yields of forage are generally low because fertilizer is not applied and grazing is not controlled. Pastures can be made more productive by fertilizing them properly, adding lime, and seeding desirable forage plants.

Bur oak is the principal kind of tree that grows on these soils, but there is also some American elm, red elm, basswood, white ash, ironwood, hard maple, and black cherry. If these soils are left in trees, hard maple, red elm, and basswood should be encouraged.

Odd areas can be planted to provide food and cover for wildlife. Suggested evergreens that will provide cover for wildlife are white and Norway spruce and redcedar. Honeysuckle, lilac, crabapple, and similar plantings are also suitable.

CAPABILITY UNIT IIIe-2

In this capability unit are well drained and moderately well drained soils formed in glacial till. These soils are rolling, and the slopes generally are 75 to 200 feet long. The surface layer is moderately dark, friable, and moderately fine textured, and the subsoil is moderately fine textured. The surface layer varies in thickness, but it is thinnest on the convex slopes. It is thickest on the concave slopes and at the base of slopes. These soils occupy about 2 percent of the county.

These soils have a deep root zone and high moisture-supplying capacity. Natural fertility is also high, and permeability and infiltration are moderate. The surface layer is slightly acid to medium acid, and the subsoil is medium acid to very strongly acid. The soils in this unit are—

- Kilkenny clay loam, 6 to 12 percent slopes.
- Kilkenny clay loam, 6 to 12 percent slopes, moderately eroded.

In fields where these soils are dominant, sod crops should be grown frequently because the hazard of erosion is moderate to severe. Farms that consist mainly of these soils are better suited to the raising of livestock than to the growing of cultivated crops because livestock use a large amount of forage.

The clay in the upper part of the subsoil, immediately below the dark-colored surface layer, causes a severe hazard of erosion. Such practices as mulching and rough tillage are needed to conserve moisture and control erosion. In addition, all crop residues ought to be plowed under or kept on the surface. Terracing and contour cultivation should be considered where pratical.

If terraces are built, a cropping system in which hay crops are grown 2 years in 5 satisfactorily controls erosion. In areas where stripcropping is practical, alternate strips should be planted to grasses or legumes. Erosion can be controlled on the short, irregular slopes where terracing and contour cultivation are impractical by keeping the soils in hay or pasture 3 years in 5.

The terraces should be constructed carefully. Wetness will develop in the terrace channel and below the terrace if the grade is too nearly level. Outlets ought to be constructed and seeded the year before the terraces are built. Then, water will be removed without forming gullies. The waterways ought to be properly designed and kept in grass. Where stripcropping is used, the strips ought to be on a slight grade. If the grade is too nearly level, the soils may become wet.

Lime is needed on these soils, but the response to lime varies. The soils should be tested to determine the requirements for lime and fertilizer.

Yields vary, even under the same level of management, because of differences in the thickness of the surface layer. Ordinarily, yields are lower on a moderately eroded soil than on a slightly eroded soil of the same type.

Some of the soils of this unit are used for permanent pasture or are wooded. In the pastures yields of forage are generally low because fertilizer is not applied and grazing is not controlled. If their location is suitable, permanent pastures and thinly wooded pastures should be cleared and planted to field crops. Productive pastures, however, can be obtained in spring and fall by fertilizing them properly, adding lime, and seeding desirable forage crops.

The principal trees grown on these soils are hard maple, red and American elm, basswood, black cherry, oak, ironwood, and white ash. If these soils are left in trees, hard maple, red elm, basswood, white oak, and white ash should be encouraged.

Odd areas can be planted to provide food and cover for wildlife. Evergreens that can provide suitable shelter for wildlife are white pine, white and Norway spruce, and redcedar. Honeysuckle, lilac, crabapple, and similar plantings are also suitable.

CAPABILITY UNIT IIIe-3

Dickinson loam, 6 to 12 percent slopes, moderately eroded, is the only soil in this capability unit. It is a well-drained soil that formed in medium-textured glacial drift over sand or sand and gravel. This soil is rolling and is on outwash plains or on small, sandy kames within the glacial till plain. The slopes are 50 to 175 feet long. The surface layer is moderately dark to dark, friable, and medium textured. The substratum is sandy and is at a depth of 24 to 36 inches. This soil occupies less than 0.1 percent of the county.

This soil has a moderately deep root zone and moderate moisture-supplying capacity. Permeability and infiltration are also moderate.

Drought is a moderate hazard, and this soil is subject to erosion. The supply of plant nutrients is also difficult to maintain. Yields are directly related to the amount and distribution of rainfall. Farms that consist mainly of this soil need a diversified cropping system so that if one crop fails because of too little rainfall, another may succeed. Such farms are especially well suited to the raising of livestock because livestock require a large amount of forage. Livestock can eat the crops that fail to mature because of drought.

Where this soil cannot be farmed on the contour and terraces cannot be built, a suitable rotation is row crops 1 year, small grain 1 year, and meadow 4 years. If this soil is farmed on the contour, the rotation can be row crops 1 year, small grain 1 year, and meadow crops 3 years. In areas large enough for terracing, the rotation can be meadow crops 2 years, small grain 1 year, and row crops 1 year. Keeping alternate strips in meadow gives excellent control of erosion where stripcropping is practical. Where small areas of this soil are within areas of soils less suitable for farming, a mulch of manure or crop residues should be kept on the surface.

Terraces ought to be constructed with a slight grade, and the outlets should be built and seeded the year before the terraces are built. Then, water is removed without forming gullies.

All waterways should be properly designed and kept in grass. In the many places where this soil adjoins steep slopes, unprotected waterways may develop into serious gullies. The loose, coarse-textured material in the substratum makes gullies extremely difficult to stabilize.

In permanent pastures that consist mainly of desirable grasses, economical yields of forage can be obtained by adding a topdressing of fertilizer. Pastures, however, are not dependable during the summer months. Controlled grazing provides the best results.

Wooded areas are not common on this soil, but odd areas and gravel pits can be developed to provide food and cover for wildlife. Trees and other vegetation suitable for wildlife should be planted.

CAPABILITY UNIT IIIe-4

This capability unit consists of well-drained or somewhat excessively drained soils formed in glacial outwash. These soils are nearly level to undulating, and the slopes are 50 to 175 feet long. The surface layer is dark to moderately dark colored, slightly acid to medium acid, and moderately coarse textured. The texture of the substratum in the Clarion and Lester soils is loam, and that of the substratum in the Dickinson and Estherville soils is gravel or fine sand to coarse sand mixed with gravel. These soils occupy about 0.6 percent of the county.

The root zone of these soils is very deep where the substratum is fine sand, but it is shallow where the substratum is gravel. These soils are low in moisture-supplying capacity and in natural fertility. Permeability and infiltration are moderately rapid. The soils in this unit are—

Clarion-Estherville complex, 2 to 6 percent slopes, moderately eroded.
Dickinson fine sandy loam, 2 to 6 percent slopes.
Estherville sandy loam, 0 to 6 percent slopes.
Lester-Estherville complex, 2 to 6 percent slopes, moderately eroded.

These soils are subject to erosion and drought, and they are low in fertility. Yields are directly related to the amount and distribution of rainfall. Where these soils make up most of a farm, a diversified cropping system is needed so that if one crop fails because of too little precipitation, another may succeed. Such farms are especially well suited to the raising of livestock because livestock use a large amount of forage. The livestock can be fed the crops that fail to mature because of drought.

On the nearly level soils, a rotation in which row crops are grown 2 years, small grains are grown 1 year, and meadow crops are grown 1 year is satisfactory for general farming. Contour farming, where applicable, should be used on the steeper slopes. Where small areas of these soils occur within areas of better soils, a mulch of manure or crop residue will help to improve yields.

Winterkill is a problem unless legumes are properly fertilized. Topdress annually with phosphate and potash, and make only two cuttings of hay. Spring is the best time to plow old meadows, after the effects of

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winter on new seedings needed for hay have been determined.

All waterways should be properly designed and kept in grass. In the many places where these soils adjoin steep slopes, unprotected waterways may develop into serious gullies. The loose, coarse-textured material in the substratum makes gullies extremely difficult to stabilize.

Where these soils are kept in a permanent pasture of bluegrass, a topdressing of nitrogen, phosphate, and potash increases the yield of forage during the spring and fall months. Ordinarily, neither permanent pasture nor rotation pasture provides good yields of forage in dry seasons.

These soils are suited to Scotch pine and red pine. Sand pits and odd corners can be developed to provide food and cover for wildlife. Trees and other vegetation suitable for wildlife should be planted.

CAPABILITY UNIT IIIw-1

In this capability unit are very poorly drained soils formed in glacial till or modified glacial till. These soils are in shallow drainageways or in upland depressions. Their surface layer is dark and friable, and it is medium textured to moderately fine textured. The Talcot soil is underlain by coarse sand and gravel. These soils occupy about 9 percent of the county.

If these soils are adequately drained, they have a deep or moderately deep root zone. Their moisture-supplying capacity and natural fertility are high. Permeability and infiltration are moderate to moderately slow. The surface layer is generally neutral, but in a small acreage it is mildly alkaline. The soils in this unit are—

Canisteo clay loam, depressional.
Glencoe silty clay loam.
Lura silty clay loam.
Talcot silty clay loam.

Flooding is the major limitation of these soils. Average yields are directly related to the adequate use of surface waterways and tile drains. Runoff from higher areas accumulates in the depressions, and surface ditches are needed to remove the excess water. In many places these soils are intermingled with better drained soils, and a system of random tile lines must be used to drain them. Porous material, such as pea-size rocks or corncobs, as filler in the tile trench, helps speed the removal of ponded surface water. For satisfactory drainage, it is essential to locate a tile line near the center of a pothole and to run interceptor lines near the base of adjoining slopes.

In the larger areas of all these soils except the Talcot, tile lines should be installed at a depth of 42 to 48 inches and at intervals of 90 feet. In the Talcot soil the tile lines should also be installed at a depth of 42 to 48 inches, but at intervals of 200 feet if the underlying coarse-textured material is continuous. Blind the tile with finer textured material from the surface layer. Stabilizing the side slopes of open drains is difficult in the Talcot soil. Tile should be installed when the water table is naturally low or after the water table has been lowered artifically so that a proper grade can be obtained.

These soils occur in small areas and are generally farmed the same as the major soils in the field. Row crops can be grown year after year if an optimum number of plants that yield a large amount of residue are grown, and if minimum tillage is used. A satisfactory cropping system consists of 4 years of row crops, 1 year of small grains, and 1 year of hay. The crops need to be fertilized properly for optimum yields. If these soils are tilled when they are too wet or too dry, the rate of infiltration and the efficiency of the tile are reduced.

Test the soils to determine the need for lime and fertilizer. Lime is generally not required, but Canisteo clay loam, depressional, needs special fertilization.

Scattered areas of these soils are in permanent pasture, but yields of forage are generally low because fertilizer is not applied and grazing is not controlled. Shallow drainage ditches may improve the sites for pasture; however, if outlets are available, it is advisable to install tile drainage and to use these soils for field crops.

Odd areas can be developed as nesting sites for waterfowl. They can also be used to provide winter cover for upland game.

CAPABILITY UNIT IIIw-2

Dundas silt loam is the only soil in this capability unit. It is deep, somewhat poorly drained and has formed in glacial till or in slightly modified glacial till. This soil is nearly level and is on slightly convex slopes that are 75 to 200 feet long. The surface layer is moderately dark, friable silt loam. This soil occupies about 0.3 percent of the county.

The root zone of this soil is deep, but the clayey subsoil has a slightly limiting effect on the root penetration. Natural fertility is moderate. Permeability and infiltration are moderately slow, but surface drainage is generally adequate. In most places the surface layer is medium acid, but the subsoil is strongly acid in places.

In fields where this soil is dominant, row crops can be grown most of the time. Good management is needed, however, to maintain good tilth, to improve internal drainage, and to maintain a satisfactory level of fertility. Satisfactory long-term yields are more predictable where the raising of livestock, which need forage, is the main enterprise than where row-crop farming is predominant. If row crops are grown most of the time, minimum tillage should be used. In addition, the optimum number of plants ought to be grown and the soils fertilized properly so that the plants will yield a large amount of residue. Test the soils to determine the need for fertilizer and lime. Grasses or legumes ought to be grown at least 2 years in 5. The surface layer of these soils very rapidly exceeds optimum moisture. Timeliness of field operations is seriously curtailed during periods when rainfall is greater than normal. Dry weather causes the surface layer to slake and crust. As a result, root aeration is limited and yields are reduced.

In this soil tile lines need to be spaced differently in different areas, and they need to be placed at a different depth in some areas than in others because of variations in the subsoil. The correct spacing and depth should be determined separately for each project.

Some of the acreage of this soil is in permanent pasture or in thinly wooded pasture. Yields of forage are generally low because fertilizer is not applied and grazing is not controlled. If tile drainage can be installed, these areas should be cleared and used for field crops. Productive pastures can be obtained, however, by liming, fertilizing, and seeding suitable forage plants.

The principal trees grown on this soil are oak, ironwood, and American elm. If this soil is left in trees, white oak should be encouraged. Odd areas can be developed to provide food and cover for wildlife by planting evergreens, shrubs, and grasses that tolerate wetness.

CAPABILITY UNIT IIIw-3

This capability unit consists of very poorly drained organic soils. These soils formed from an accumulation of reeds, sedges, and hypnum moss in shallow lakes and depressions. The peat beds are generally nearly level. The peat generally ranges from 3 to 6 feet in thickness, but in local areas it is much thicker. These soils occupy about 6 percent of the county.

The root zone of these soils is determined by the depth to the water table. The available moisture-supplying capacity is very high. Natural fertility varies with the type of parent material, but it is generally low. The soils in this unit are—

Peat and muck, deep.
Peat and muck, deep and calcareous.
Peat and muck, shallow.
Peat and muck, shallow and calcareous.

The major limitations of these soils are poor drainage and the difficulty in maintaining an adequate supply of plant nutrients. Also, the fine texture of the surface layer makes these soils subject to wind erosion.

Yields, as well as the type of crops that can be grown on these soils, are directly related to the type of drainage. Tile lines for field crops grown on these soils are generally installed at a depth of 48 inches and at intervals of 150 to 200 feet. Special crops require that the tile lines be spaced at intervals of 100 to 150 feet. Outlet ditches and provisions for removing surface water are essential for adequate drainage (fig. 13). In the large bogs diversion terraces on the surrounding higher areas or interceptor ditches used around the edges of the bog control excess surface water that would otherwise cause flooding. The tile lines should be installed near the base of the surrounding mineral soils to offset probable seepage. Seams of coarse-textured material, which in many places mark beach lines and sandbars of old ponds and lakes, make the installation of tile lines and ditches difficult in some places.

Figure 13.—**Pumping system at the edge of a field of Peat and muck. This system makes the drainage system more effective by pumping water from the tile outlet into a drainage ditch.**

The level of the water table needs to be controlled to reduce oxidation and subsidence of the organic material. After excess water has been removed by outlet ditches, the rate of early subsidence in some bogs is rapid. If subsidence is too rapid, the tile should not be installed for a year or two. The rate of subsidence varies with the depth of the peat, the level of the water table, the degree of wetness of the original site, and the intensity of cropping operations.

The reaction of the peat may vary widely within the bog. In general it ranges from strongly acid to mildly alkaline, but near the outer edges of the bog it is highly calcareous in some places and medium acid in others. Also, there are areas that are strongly acid, medium alkaline, or even strongly alkaline. All the soils in this unit contain sufficient calcium for crops, but they are generally low in phosphorus and potassium. The nitrogen potential is high, but in some recently developed bogs or in bogs that have been cultivated over a long period, adding nitrogen may be worthwhile economically. Some bogs, especially those used for truck crops, may require additions of trace elements. Also, newly developed bogs may benefit from a light topdressing of manure that will add desirable strains of bacteria.

Because these soils have a fine-textured surface layer, they are subject to wind erosion and fire. Erosion is especially serious in the larger areas. It can be controlled by windbreaks, irrigation and rough tillage; or growing a cover crop is helpful.

If these soils are used for general farming, adapted grasses should be grown in the rotation. Where special crops are grown, annual grasses should be interseeded between the rows. The production of canarygrass seed is common in some areas.

Fire is a constant hazard. Once a fire is started, a great deal of effort is required to extinguish it, and the cost of extinguishing it is high.

On the bogs where drainage is adequate, clean-tilled crops are grown. The larger bogs are generally developed for truck crops. The field crops are mainly soybeans, corn for silage, and sweet corn. Field corn that matures early is grown occasionally The hazard of frost damage varies with the air drainage of surrounding areas. High elevations in the surrounding areas increase the hazard.

A large acreage of these soils is in permanent pasture. Yields of forage vary greatly according to the degree of drainage and the type of grasses grown. If some drainage is feasible and if desirable grasses are seeded and fertilized properly, excellent pastures that have a high carrying capacity are obtained.

Undeveloped areas of these soils provide excellent habitats for waterfowl. They can also be used to provide winter cover for upland birds.

CAPABILITY UNIT IIIw-4

Colo silty clay loam, very wet, is the only soil in this capability unit. It is deep and very poorly drained and formed in moderately fine textured material of the bottom lands. The surface layer is black and is moderately fine textured. This soil occupies about 0.2 percent of the county.

If this soil is adequately drained, it has a deep root zone. It has high moisture-supplying capacity and high natural fertility. Permeability and infiltration are moderate.

Where this soil is dominant in an area, all of the acreage is generally kept in permanent pasture. Fair pasture can be obtained in some areas by leveling the hummocks, installing shallow surface drains, and seeding adapted grasses. In some places dikes, pumping plants, and interceptor tile have been installed to develop this soil for field crops. In those areas a number of outlets have been supplied to carry off the excess water. Where this soil is developed as cropland, row crops are grown extensively.

CAPABILITY UNIT IVe-1

This capability unit consists of well-drained soils formed in glacial till or modified glacial till. These soils are rolling to moderately steep. The slopes are generally single and smooth or are complex. They are 75 to 250 feet long. The surface layer is dark to moderately dark, friable, and medium and moderately fine textured. These soils occupy about 1 percent of the county.

These soils have a deep root zone. Their moisture-supplying capacity and natural fertility are high. Permeability and infiltration are slower in cultivated and eroded areas than in other areas. The surface layer is slightly acid to medium acid, and the subsoil is slightly acid to strongly acid. The thickness of the surface layer varies with the relief. The surface layer is thinner on the upper part of the slope and on the convex slopes than on the concave slopes and at the base of the slopes. The soils in this unit are—

- Clarion loam, 6 to 12 percent slopes, severely eroded.
- Clarion loam, 12 to 18 percent slopes, moderately eroded.
- Kilkenny clay loam, 6 to 12 percent slopes, severely eroded.
- Kilkenny clay loam, 12 to 18 percent slopes.
- Kilkenny clay loam, 12 to 18 percent slopes, moderately eroded.
- Lester clay loam, 12 to 18 percent slopes.
- Lester clay loam, 12 to 18 percent slopes, moderately eroded.

The hazard of further erosion is severe; therefore, these soils are suited to only limited cultivation. The best use of farms where these soils are dominant is the raising of livestock, which use a large amount of forage. If contour tillage, stripcropping, minimum tillage, and mulch tillage are not used, a rotation in which small grains are grown 1 year and meadow crops are grown 3 years keeps erosion to a minimum. A rotation in which small grains are grown 2 years and meadow crops are grown 2 years is sufficient where the soils are farmed on the contour. Where stripcropping is practiced, row crops and small grains can be alternated with strips of meadow. Terraces should not be built if the slope is greater than 14 percent.

Meadows that remain longer than 2 years need a topdressing of manure or phosphate and potash in the second year after the first cutting. If the meadow crop remains indefinitely, periodic applications of nitrogen are also beneficial. Pasture should receive a periodic topdressing of a complete fertilizer, and grazing ought to be controlled. Pastures of legumes should be renovated and reseeded as needed. Low yields, however, can be expected from pastures on slopes that face south and west.

Wooded areas can be maintained or improved, but the best and most economical use of these soils is for well-managed meadow or pasture. Odd areas can be developed as habitats for wildlife by planting evergreens, shrubs, legumes, and grasses.

CAPABILITY UNIT IVe-2

This unit consists of well-drained, rolling to moderately steep soils formed in glacial till. The slopes are 75 to 250 feet long. The surface layer is moderately dark to light colored, friable, and medium textured. These soils occupy about 0.4 percent of the county.

The Clarion and Lester soils have high moisture-supplying capacity and high natural fertility, but the Storden soils have moderately low moisture-supplying capacity and fertility. The Storden soils require special applications of phosphate and potash. Permeability and infiltration are moderate for the Clarion and Lester soils and slow for the Storden soils. Clarion and Lester soils are slightly acid to medium acid, but the Storden soils are highly calcareous. The soils in this unit are—

- Clarion-Storden complex, 6 to 12 percent slopes, severely eroded.
- Clarion-Storden complex, 12 to 18 percent slopes, moderately eroded.
- Lester-Storden complex, 6 to 12 percent slopes, severely eroded.
- Lester-Storden complex, 12 to 18 percent slopes, moderately eroded.

The hazard of further erosion is severe; therefore, these soils are suited to only limited cultivation. The best use of fields that consist mainly of these soils is hay or pasture. If contour tillage, stripcropping, minimum tillage, or mulch tillage are not used, a rotation in which small grains are grown 1 year and meadow crops are grown 3 years keeps erosion to a minimum. A rotation in which small grains are grown 2 years and meadow crops are grown 2 years will control erosion if stripcropping is used. Terraces should not be used where the slope is greater than 14 percent.

Meadows that remain longer than 2 years need a topdressing of manure or of phosphate and potash in the second year after the first cutting of hay has been made. If the meadow crop remains indefinitely, periodic topdressings of nitrogen are beneficial. Pastures should receive a periodic topdressing of a complete fertilizer, and grazing ought to be controlled. Pastures of legumes should be renovated and reseeded as needed. Low yields, however, can be expected from pastures on slopes that face south and west.

Wooded areas can be maintained or improved, but the best and most economical use is well-managed meadow or pasture. Odd areas can be developed as habitats for wildlife by planting evergreens, shrubs, legumes, and grasses.

CAPABILITY UNIT IVe-3

In this capability unit are well-drained to somewhat excessively drained soils formed in glacial drift. These soils are rolling and occur generally in outwash areas. The slopes are 50 to 150 feet long. The surface layer is dark, friable, and moderately coarse textured. The texture of the underlying material is sand. These soils occupy about 0.3 percent of the county.

These soils have low moisture-supplying capacity and low natural fertility. Permeability and infiltration are moderately rapid. In most places these soils are slightly acid to medium acid. The soils in this unit are—

- Estherville, Lester, and Storden soils, 6 to 12 percent slopes, moderately eroded.
- Estherville sandy loam, 6 to 12 percent slopes, moderately eroded.

Drought and erosion are the major hazards to farming, and the supply of plant nutrients is also low. Yields are directly related to the amount and distribution of rainfall. In fields where these soils are dominant, a grass or legume crop should be grown. Where these soils occur in a small acreage intermingled with other soils, extra additions of manure, special fertilizer, and crop residues are needed to obtain yields comparable to those obtained on the surrounding soils. Also contour farming, where applicable, ought to be used. All waterways should be properly designed and kept in grass.

Winterkill is a problem unless legumes are properly fertilized. Topdress annually with phosphate and potash, and make only two cuttings of hay.

Yields from permanent bluegrass pastures can be profitably increased in spring and fall if a complete fertilizer is applied. Ordinarily, neither permanent pastures nor rotation pastures provide sufficient yields of forage in dry seasons. Supplemental pastures or other types of feeding are necessary.

These soils are suited to the production of Scotch pine for use as Christmas trees. The best time to plant is early in spring, and transplanted stock is generally more suitable than seedlings. White pine and red pine are also adapted to these soils. Sand pits and odd corners of these soils can be developed or improved for wildlife by planting trees and other vegetation that provide food and cover.

CAPABILITY UNIT IVw-1

Only one miscellaneous land type, Lake beaches, is in this capability unit. It consists of very poorly drained, coarse-textured beach material that is nearly level to gently undulating. The slopes are generally 25 to 50 feet long. This land type occupies less than 0.1 percent of the county.

The root zone is shallow, and the moisture-supplying capacity is low. Natural fertility is also low, and permeability and infiltration are rapid.

Drainage is needed in areas of this land type. Also, the hazard of drought and the low supply of plant nutrients limit the use of the land for farming. Most of the acreage is in pasture, but if the surrounding areas of peat are drained, some of the acreage may be used for crops. Pastures can be made productive in areas that are not drained by seeding suitable grasses and legumes and topdressing with a balanced fertilizer. Some areas may become droughty after the water table is lowered by artificial drainage. Then, yields are directly related to the amount and distribution of rainfall.

CAPABILITY UNIT VIe-1

This capability unit consists of well-drained soils formed in glacial till on the uplands. The soils are very strongly sloping to moderately steep, and the slopes range from smooth to extremely hummocky. The surface layer is moderately dark, friable, and medium textured. It varies in thickness, but it is thinnest on the convex slopes and on the upper part of the slopes and thickest on the concave slopes and at the base of the slopes. These soils occupy about 0.6 percent of the county.

The root zone of these soils is deep, and their moisture-supplying capacity and natural fertility are high. Permeability and infiltration are moderate. The Clarion and Lester soils are generally neutral or slightly acid to medium acid, the Kilkenny soils are strongly acid, and the Storden soils are calcareous. Natural fertility is high for all the soils, except the Storden, which have moderately low natural fertility. The soils in this unit are—

- Clarion-Storden complex, 12 to 18 percent slopes, severely eroded.
- Clarion-Storden complex, 18 to 24 percent slopes.
- Kilkenny clay loam, 12 to 18 percent slopes, severely eroded.
- Kilkenny clay loam, 18 to 24 percent slopes.
- Kilkenny clay loam, 18 to 24 percent slopes, moderately eroded.
- Lester clay loam, 12 to 18 percent slopes, severely eroded.
- Lester clay loam, 18 to 24 percent slopes.
- Lester clay loam, 18 to 24 percent slopes, moderately eroded.
- Lester-Storden complex, 12 to 18 percent slopes, severely eroded.
- Lester-Storden complex, 18 to 24 percent slopes.

These soils are too steep to be suitable for cultivated crops and are probably best suited to permanent pasture or trees or to use as wildlife areas. If they are cultivated, the hazard of erosion is severe. In many places drainageways that provide outlets for small watersheds cross these soils, and they occasionally develop into active gullies. These drainageways need to be properly designed and kept in grass.

Pastures and meadows where hay crops are grown can be renovated and reseeded by digging, disking, or otherwise killing the plants in the old sod, but a cover of sod must be left on the surface. The sod protects the soil against erosion until the new seedlings are large enough to provide cover. If the present cover is bluegrass, the yield of forage can be increased considerably by topdressing with manure or commercial fertilizer. However, the need for fertilizer and lime should be determined by soil tests.

Permanent pastures can be improved by removing stumps and stones, cutting or spraying brush and weeds, applying fertilizer, and controlling grazing. During the hot summer months, yields of pasture are low on slopes that face south and west.

Thinly wooded areas can be improved by underplanting with Norway pine. White spruce is best for thickly wooded, shady areas. The growth of pines may be slow on the spots that are high in lime. Odd areas and steep spots in cultivated fields can be improved as habitats for wildlife by planting shrubs, legumes, and evergreens that provide food and cover.

CAPABILITY UNIT VIe-2

Only one mapping unit, Estherville, Lester, and Storden soils, 12 to 18 percent slopes, moderately eroded, is in this capability unit. These soils are well drained to excessively drained and were formed in glacial drift. They are strongly sloping and occur in outwash areas. The slopes are 50 to 200 feet long. The surface layer is dark and friable, and it is moderately coarse textured. The texture of the underlying material is sand, gravel, or stratified sand and gravel, depending on the soil type. These soils occupy small areas within larger areas of soils of other capability classes. The soils of this capability unit occupy less than 0.1 percent of the county.

The moisture-supplying capacity and natural fertility of these soils is low, and permeability and infiltration are moderately rapid. The reaction is predominantly medium acid. The Storden soils, however, are calcareous.

These soils are not suited to cultivation. They should be kept in pasture, as the hazard of further erosion is very severe. Farms that consist mainly of these soils are best used for raising livestock because livestock can use a large amount of forage.

Meadow crops that are suitable for these soils require phosphate and potash. Nitrogen is needed where grass predominates. An annual topdressing of a complete fertilizer should be considered, and controlled grazing is essential. Yields of forage from permanent pastures of bluegrass can be profitably increased in spring and fall if a complete fertilizer is applied. Ordinarily, neither permanent pastures nor rotation pastures provide enough forage for livestock in dry seasons. Supplemental pastures or other types of supplementary feeding are necessary.

All waterways should be properly designed and kept in grass. Because of the loose, sandy material in the substratum, unprotected waterways may develop into serious gullies.

These soils are suited to Scotch pine for use as Christmas trees. The best time to plant is early in spring. Transplanted stock is generally more suitable than seedlings. White and red pine are also adapted to these soils. Sand pits and odd corners can be developed or improved for wildlife by planting trees and other vegetation that provide food and cover.

CAPABILITY UNIT VIw-1

In this capability unit are well-drained to poorly drained soils that are frequently flooded. These soils formed in medium-textured alluvium on bottom lands that are adjacent to the major streams and drainageways. In many places they are cut by old, abandoned stream channels. Their surface layer is moderately dark to dark, friable, and medium to moderately fine textured. These soils occupy about 1.1 percent of the county.

These soils have moderate to high moisture-supplying capacity and natural fertility. Permeability and infiltration are moderate. The soils in this unit are—

Alluvial land.
Colo silty clay loam, frequent overflow.
Huntsville silt loam, frequent overflow.

Where these soils are used for crops, row crops are generally grown. The hazard of flooding, however, makes yields unpredictable. Generally, the management required for the Huntsville soil is similar to that required for soils in capability unit IIw-3, and potential yields are about the same. The management required for the Colo soil is similar to that required for the Colo soil in capability unit IIw-2, and potential yields are about the same.

CAPABILITY UNIT VIIe-1

This capability unit consists of well-drained soils formed in glacial till. These soils are steep, and the slopes are generally 50 to 150 feet long. The surface layer is moderately dark to light colored. It is medium textured, and the underlying material is also medium textured. These soils occupy 0.5 percent of the county.

The root zone of these soils is deep, and the moisture-supplying capacity and natural fertility are high. Permeability and infiltration are moderate. The soils in this unit are—

Clarion-Storden complex, 18 to 24 percent slopes, severely eroded.
Clarion-Storden complex, 24 to 35 percent slopes.
Kilkenny clay loam, 24 to 35 percent slopes.
Lester clay loam, 18 to 24 percent slopes, severely eroded.
Lester clay loam, 24 to 35 percent slopes.
Lester-Storden complex, 18 to 24 percent slopes, severely eroded.
Lester-Storden complex, 24 to 35 percent slopes.
Rough broken land.

These steep soils should be kept in permanent vegetation, preferably trees. Where the slope is betwen 18 and 25 percent, however, the soils can be improved for permanent pasture, and fair to good yields can be obtained in spring and fall. Plant trees on slopes greater than 25 percent, especially if the soils have been used for crops.

Where good pastures can be established on these soils, limited grazing is feasible. Permanent pastures that are already established require careful management. Grazing needs to be restricted, and weeds and brush ought to be controlled by cutting or spraying. Also, pastures that are not too steep for fertilizer to be spread evenly should be topdressed with nitrogen or a complete fertilizer.

Areas where the slope is greater than 35 percent are not suitable for pasture. Trees should be planted on all open areas. Plant red pine on the slopes facing south and west and white pine on those facing north and east.

CAPABILITY UNIT VIIe-2

Only one mapping unit, Estherville soils, 12 to 25 percent slopes, moderately eroded, is in this capability unit. These soils are excessively drained and formed in glacial drift. They are strongly sloping to moderately steep and occur on outwash plains. The slopes range from 50 to 200 feet in length. The surface layer is dark and friable, and it is moderately coarse textured to medium textured. The subsoil is coarse sand, gravel, and loam. These soils occupy about 0.1 percent of the county.

The moisture-supplying capacity and natural fertility of these soils are low. Permeability and infiltration are moderately rapid.

Areas of these soils that are used for crops should be converted to permanent vegetation, preferably trees. Jack and Norway pine are suited to the slopes facing south and west, and the gravelly and sandy patches on the north- and east-facing slopes can be planted to white and Norway pine. Plant as early in spring as possible, and use transplanted stock rather than seedlings. Odd areas and gravel pits can be improved for wildlife by planting evergreens and shrubs that resist drought.

CAPABILITY UNIT VIIIw-1

Only one miscellaneous land type, Marsh, is in this capability unit. This land is best used as a habitat for wildlife. Waterfowl, muskrat, and upland game find food and cover in and around these areas, and waterfowl find nesting sites. This land type occupies about 0.8 percent of the county.

Marsh can be improved by level ditching and by controlling the level of the water table. Commercial uses of Marsh include the trapping of muskrats and the sale of hunting rights.

Use of the Soils for Wildlife and Recreation

Many parts of Waseca County provide suitable habitats for wildlife. Facilities for outdoor recreation are also abundant. The soil associations named in the paragraphs that follow as best suited to pheasants and other kinds of wildlife, and the lakes that are used for recreation, are shown on the general soil map at the back of the report.

In determining the suitability of a site as a habitat for wildlife and in estimating the kinds and numbers of wildlife species an area will support, it is known that soils are a determining factor. As yet, however, little is known about the extent of the interdependence of the soils, vegetation, and wildlife, but this interdependence will be better understood as more information becomes available.

According to game wardens in this county, the largest population of pheasants appears to be on soil associations made up of large areas of Clarion, Nicollet, Storden, Webster, Glencoe, Guckeen, Marna, and Canisteo soils. Such an association is the Clarion-Nicollet-Webster, which consists of soils that are not only well suited to farm crops but that are also desirable as a habitat for pheasants. This association accounts for approximately 70 percent of the best pheasant habitats in Minnesota. The Storden and Canisteo soils have a limy surface layer, which appears to be a desirable soil characteristic for a pheasant habitat. In addition, the Storden and Canisteo soils are used largely for growing corn, a crop that provides the open landscape and the supply of good-quality food required for a prime pheasant habitat.

Soils, such as the Lester, that are mainly in woods also have a large population of pheasants. There are fewer pheasants on such soils, however, than on areas that consist mainly of Clarion, Nicollet, Storden, Webster, Glencoe, Guckeen, Marna, and Canisteo soils. The areas can be improved for pheasants by providing cover for nesting (fig. 14) and by maintaining sloughs and protecting woody vegetation from fire and overgrazing.

Figure 14.—**A wildlife planting on Lester and Storden soils that are adjacent to the Le Sueur River. In the background is a field occupied by a Colo soil that has been drained by a pumping system.**

This county has some wooded areas large enough for a good deer habitat, in addition to the areas suitable for pheasants. These areas are generally within soil associations that consist largely of Lester and Le Sueur soils.

Practices to conserve the soils, such as rotating crops, stripcropping, and seeding ditchbanks and the borders of fields, provide a dense cover that benefits many kinds of wildlife. Farm shelterbelts also provide nesting cover for squirrels and mourning doves, as well as winter cover for pheasants. A game refuge is located in Blooming Grove Township.

At present, the facilities for outdoor recreation consist mainly of lakes used for fishing, boating, and waterskiing. Also, there are many areas where the hunting of pheasant and waterfowl is popular.

Clear Lake, Lake Elysian, Reeds Lake, and St. Olaf Lake are large enough to make water sports popular. Small boats for fishing can be rented at some of these lakes. Fishing efforts are usually concentrated on gamefish, such as Northern pike, walleyed pike, and bass, and on panfish, such as sunfish and crappy. During the spring months, fishing for bullhead is also popular.

Use of the Soils for Engineering

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Depth to the water table, depth to bedrock, and relief are also important.

This soil survey report contains information that can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils in the planning of agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.

3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations of the selected locations.
4. Locate probable sources of sand and gravel and other material suitable for construction.
5. Correlate performance of engineering structures with soil mapping units to develop information for overall planning that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps, and reports, and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It is not intended that this report will eliminate the need for on-site sampling and testing of the soils. It should be used primarily in planning more detailed field investigations to determine the condition of the soil material in place at the proposed site of construction.

Some of the terms used by the soil scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, and aggregate—may have special meanings in soil science. These terms, as well as other special terms that are used in the soil survey report, are defined in the Glossary at the back of this report. As used in this report, the term "poorly graded" refers to soil material consisting mainly of particles of nearly the same size. Because there is little difference in the size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

This section contains three tables. Table 11 gives a brief description of the soils and their estimated physical properties, table 12 gives estimates of the suitability of the soils for construction and conservation engineering, and table 13 gives test data for five soil types that are considered typical of the soils in Waseca County.

Some of the information useful for engineering can be obtained from the soil map. It will often be necessary, however, to refer to other parts of the report. By using the information in the soil map, the profile descriptions, and the tables in this section, the soils engineer can plan a detailed survey of the soil at the construction site.

Engineering classification systems

Agricultural scientists of the United States Department of Agriculture classify soils according to texture. In some ways this system of naming textural classes is comparable to the two systems used by engineers for classifying soils, that is, the system of the American Association of State Highway Officials (AASHO) and the Unified system. Following is a description of the classification systems used by engineers. Additional information is given in the PCA Soil Primer (*6*).

AASHO Classification System.—Most highway engineers classify soil materials in accordance with the system approved by AASHO (*1*). In this system soil materials are classified in seven principal groups. The groups range from A–1 (gravelly soils of high bearing capacity, the best soils for subgrade) to A–7 (clayey soils having low strength when wet, the poorest soils for subgrade).

Within each group the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. The group index number is shown in parentheses following the soil group symbol, as in table 13. The estimated AASHO classification for the soils of this county is given in table 11.

Unified Classification System.—Some engineers prefer to use the Unified soil classification system established by the Waterways Experiment Station, Corps of Engineers (*10*). In this system soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic. The estimated classification of all the soils of the county, according to the Unified system, is given in table 11. Table 13 shows the Unified classification of the soils that were tested.

Engineering properties of soils

Table 11 gives some of the soil characteristics that are significant in engineering. It also gives the engineering properties of the soil material in the principal horizons. The estimated physical properties are those of the typical soil profile, which is divided into layers significant to engineering. Where test data are available, that information was used. Where tests were not performed, the estimates shown are based on a comparison of these soils with the soils that were tested in Waseca County and with soils in other counties.

Depth to the water table, as shown in table 11, is based on field observations.

Permeability of the soil as it occurs in place was estimated. The estimates are based on the structure and consistence of the soil material and on field observations.

Available water capacity, given in inches per inch of soil depth, refers to the approximate amount of capillary water in the soil when wet to field capacity. When the soil is air dry, this same amount of water will wet the soil material to a depth of 1 inch without deeper percolation. If reliable estimates are to be made, data on representative soils are needed from undisturbed soil samples or from field measurements.

The shrink-swell potential is an indication of moisture changes. It is estimated on the basis of the amount and type of clay in the soil layers. In general, soils classified as A–7 and CH have high shrink-swell potential. Clean sands and gravels (single grain structure) and those having a small amount of nonplastic to slightly plastic fines have low shrink-swell potential, as do most other nonplastic to slightly plastic soil materials.

Engineering interpretations

Table 12 rates the soils according to their suitability as a source of topsoil, sand, and gravel. It also gives soil characteristics that affect the suitability of the soils as sites for highways and for agricultural engineering. The information given in this table is based partly on estimates. It is also based on data obtained by testing soils from this county and partly on data on similar soils from other counties. One of the major factors considered in rating the suitability of the soils for various purposes was the susceptibility to frost heaving.

The soils formed mainly in glacial material derived from limestone, but partly in calcareous shale and granitic material. Most of them contain a fairly large amount of clay. Because of this clay, one of the main engineering problems is the susceptibility of the soils to frost heaving.

Frost heaving is a complex process that results when ice crystals develop and water in thin films moves toward the ice crystals. The water causes the crystals to enlarge, as it sticks to the crystals and freezes. The size of the soil particles affects the movement of the thin films of water. Silt has the optimum size particles that will support a continual flow of the films of water, but particles the size of gravel or sand are too large to support this flow. Particles the size of clay are somewhat less favorable to the development of ice lenses than are the larger size particles, but they support a continual flow of the thin films of water. The water in the larger voids in the clay freezes at a temperature of 32° F., but that in the smaller voids does not freeze. The unfrozen water in the smaller voids is attracted to the ice crystals and freezes when it comes in contact with them. As a result, the crystals become larger. Where a clayey soil is saturated, as in areas where there is a high water table, the soil particles offer an efficient system for the movement of water.

When the temperature begins to rise late in winter and early in spring, differences in the amount and direction of sunlight cause some ice crystals to melt, while others remain frozen. Subsidence results in the areas that thaw the earliest, and this causes the familiar pattern of frost heaving. If melting takes place rapidly, all of the water may not be dissipated from the melting ice lenses; it is especially likely that part of the water will be retained in the plastic soils. Because of this water, the soil is unable to sustain the stresses caused by wheel loads. It breaks in local areas, thus permitting the entrapped, supersaturated soil material to extrude and form what are commonly called frost boils. Frost heaving can be kept to a minimum by providing effective drainage that will remove much of the water. All the soil material that is susceptible to frost action should also be removed.

The surface layer of most of the soils is rated as good as a source of topsoil for use on embankments, on cut slopes, and in ditches along highways. Only a few soils are considered suitable as a source of sand or gravel. In rating the soils as a source of sand or gravel, the susceptibility of the soil material to frost action was considered. In soils that are considered suitable, less than 10 percent of the soil material passes a No. 200 sieve, and the soil material is not susceptible to frost action. However, if there is a scarcity of sand and gravel, a slightly higher percentage passing a No. 200 sieve may be permitted in the subbase and base course of the pavement.

The susceptibility of the soils to frost action affects the amount of earthwork that can be done in winter. The construction of roads in undulating to rolling areas of glaciated uplands may require considerable earthwork. To avoid using frozen soil material in the road fill, it may be desirable to suspend earthwork during the winter months, although this is not always economically feasible. Earthwork in gravelly and sandy material that contains only a small amount of silt or clay can normally be carried on in winter, provided the required standards for compaction of the soils are maintained, and frozen material is excluded.

Some of the deposits of glacial till contain lenses or pockets of fine sand and silt that are susceptible to differential frost heave. Where these lenses or pockets occur, a thick layer of material that is not susceptible to frost heave should be used in the highway subgrade to prevent detrimental heaving of the pavement. The requirements for underdrains in cut sections of roadways should be determined by field exploration.

Peat and layers that are high in organic matter in mineral soils should be excavated where they occur within the roadway section. This material should either be wasted or placed on the slopes of embankments. In depressions where the water table is near the surface, the embankments of highways ought to be constructed of sandy or gravelly material that allows water to pass through it readily, and they should be high enough that the surface of the pavement is at least 4 feet above the highest point reached by the water table. At many construction sites, major variations may occur within the depth of the proposed excavation, and several different kinds of soils may occur within a short distance.

Engineering test data

Soil samples from three extensive soil series in the county were tested in the laboratory by standard procedures to help evaluate the soils for engineering purposes. These samples do not represent the entire range of characteristics in this county, or even within the three soil series sampled, and not all layers in each profile were sampled. The soils were sampled at three different locations for each series. An effort was made to include the central concept in the samples taken, as well as the ranges that occur in this county. The test results, given in table 13, have been used as a general guide in estimating the physical properties of the soils of the county.

Mechanical analyses were made by combined sieve and hydrometer methods. The liquid limit and plasticity index were determined. The results of these tests and the classifications of each sample according to both the AASHO and the Unified systems are given in table 13.

The tests for liquid limit and plastic limit measure the effect of water on the consistence of soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to a semisolid or plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content, expressed as a percentage of the ovendry weight of the soil, at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which the soil material is in a plastic condition.

Table 13 also gives moisture-density, or compaction, data for the tested soils. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of

TABLE 11.—*Brief description of soils*

[Absence of a figure indicates

Map symbol	Soil	Description of soil and site	Depth to water table	Depth from surface
				Inches
Ad	Alluvial land.	A mixture of soil material, ranging from loamy sand to loam, that is moderately well drained or well drained. Old channels cut through these areas. Floods occur nearly every spring and occasionally at other seasons.	(1)	(1)
By	Biscay loam.	8 to 12 inches of loam that is high in content of organic matter and overlies 12 to 24 inches of loam; underlain by loose, calcareous sand and gravel. In places clay loam till is at a depth of 5 to 6 feet.	Generally 18 inches, but in areas that are drained, it is at tile depth.	0–12 12–36 36–60
Ca Cd	Canisteo clay loam. Canisteo clay loam, depressional.	14 to 20 inches of clay loam that is high in content of organic matter (8 percent) and overlies 12 inches of clay loam that is underlain by clay loam till. These soils are very poorly drained and are in depressions in the uplands.	0 to 3 feet.	0–20 20–32 32–48+
ClB ClB2 ClC ClC2 ClC3 ClD2	Clarion loam, 2 to 6 percent slopes. Clarion loam, 2 to 6 percent slopes, moderately eroded. Clarion loam, 6 to 12 percent slopes. Clarion loam, 6 to 12 percent slopes, moderately eroded. Clarion loam, 6 to 12 percent slopes, severely eroded. Clarion loam, 12 to 18 percent slopes, moderately eroded.	30 to 36 inches of loam or clay loam over calcareous loam or clay loam till. Occasional boulders are on the surface and in the profile.	Below a depth of 10 feet.	0–12 12–36 36–48+
CrB2	Clarion-Estherville complex, 2 to 6 percent slopes, moderately eroded.	About 30 percent of this complex is Estherville soils, which occur as sandy areas within areas of the Clarion soils, and about 70 percent is Clarion soils. For properties of the Clarion soils, see information under the Clarion loams, and for properties of the Estherville soils, see information under the Estherville sandy loams.	---------------	--------
CsB2 CsC2 CsC3 CsD2 CsD3 CsE CsE3 CsF	Clarion-Storden complex, 2 to 6 percent slopes, moderately eroded. Clarion-Storden complex, 6 to 12 percent slopes, moderately eroded. Clarion-Storden complex, 6 to 12 percent slopes, severely eroded. Clarion-Storden complex, 12 to 18 percent slopes, moderately eroded. Clarion-Storden complex, 12 to 18 percent slopes, severely eroded. Clarion-Storden complex, 18 to 24 percent slopes. Clarion-Storden complex, 18 to 24 percent slopes, severely eroded. Clarion-Storden complex, 24 to 35 percent slopes.	This complex ranges from about 20 percent Storden soils in gently sloping areas to 40 percent in steep areas, but in most places the Storden soils occupy about 30 percent of the complex. The Storden soils consist of 0 to 6 inches of calcareous loam over highly calcareous loam till. They occur on the upper parts of slopes and convex knolls above areas of Clarion soils. The characteristics described here are for Storden soils. For a description of the Clarion component, see information under the Clarion loams.	Below a depth of 10 feet.	0–6 6–48+
Ct Cu Cw	Colo silty clay loam. Colo silty clay loam, frequent overflow. Colo silty clay loam, very wet.	12 to 24 inches of silty clay loam, high in content of organic matter (7 percent), over calcareous silty clay loam that extends to a depth of 10 feet or more. These are poorly drained soils of the bottom lands and are subject to occasional to frequent flooding.	2 to 5 feet.	0–24 24–48+
Cy	Cordova silty clay loam.	8 to 10 inches of silty clay loam that is high in content of organic matter over 10 to 20 inches of silty clay loam to silty clay; underlain by calcareous clay loam till. Poorly drained soil of the uplands.	2 to 2½ feet.	0–10 10–30 30–48+

See footnote at end of table.

and their estimated physical properties

that data were not available]

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200				
						Inches per hour	*Inches per inch of soil*	*pH value*	
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	6. 8–7. 2	Low to moderate.
Loam	SM or ML	A–4 or A–5	95–100	95–100	35–55	0. 8– 2. 5	0. 2	6. 8–7. 2	Low.
Loam	SC	A–2	95–100	85–90	20–35	0. 8– 2. 5	. 16	6. 8–7. 5	Low.
Sand and gravel	SP or GP	A–1	50–90	35–50	2–5	5. 0–10. 0	. 01	7. 5–7. 8	Low.
Clay loam	OL to CL	A–7	100	95–100	70–80	0. 8– 2. 5	. 25	7. 2–7. 6	Moderate to high.
Silty clay loam	CL	A–7	100	95–100	70–80	0. 2– 0. 8	. 20	7. 2–7. 6	Moderate to high.
Clay loam	CL	A–7	95–100	95–100	65–80	0. 8– 2. 5	. 17	7. 2–7. 6	Moderate to high.
Loam or clay loam.	ML	A–4	100	95–100	55–70	0. 8– 2. 5	. 2	5. 8–6. 2	Low.
Loam or clay loam.	ML–CL	A–7	95–100	90–100	55–90	0. 8– 2. 5	. 16	6. 2–6. 8	Moderate to high.
Loam or clay loam.	CL	A–6	90–100	85–95	55–65	0. 8– 2. 5	. 16	7. 5–7. 8	Moderate.
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Loam	ML	A–4	95–100	95–100	50–60	0. 8– 2. 5	. 16	7. 5–7. 8	Low.
Loam	ML–CL	A–6	95–100	85–95	50–60	0. 8– 2. 5	. 16	7. 8–8. 0	Low.
Silty clay loam	CH or CL	A–7	100	100	70–80	0. 2–0. 8	. 25	7. 0–7. 2	High.
Silty clay loam	CH or CL	A–7	100	100	70–80	0. 2–0. 8	. 17	7. 2–8. 0	High.
Silty clay loam	OH	A–7	100	100	65–70	0. 2–0. 8	. 18	5. 8–6. 5	High.
Silty clay loam or silty clay.	CH	A–7	100	100	60–70	0. 2–0. 8	. 17	5. 4–6. 2	High.
Clay loam	CL	A–7	95–100	95–100	55–65	0. 2–0. 8	. 17	7. 5–7. 8	Moderate to high.

TABLE 11.—*Brief description of soils and their*

Map symbol	Soil	Description of soil and site	Depth to water table	Depth from surface
				Inches
DcB	Dickinson fine sandy loam, 2 to 6 percent slopes.	18 to 24 inches of fine sandy loam underlain by loose sand with some fine gravel. Well-drained to excessively drained soil of the uplands.	Below a depth of 10 feet.	0–12 12–24 24–48+
DkB DkC2	Dickinson loam, 0 to 6 percent slopes. Dickinson loam, 6 to 12 percent slopes, moderately eroded.	12 inches of loam over 12 to 18 inches of loam to sandy clay loam; underlain by sand and some fine gravel. Well-drained soils of the uplands.	Below a depth of 10 feet.	0–12 12–24 24–48+
Du	Dundas silt loam.	12 inches of silt loam over 24 to 36 inches of silty clay loam; underlain by calcareous clay loam till. Somewhat poorly drained or poorly drained soil of the upland.	2 to 5 feet.	0–12 12–40 40–48+
EaB EaC2 EoE2	Estherville sandy loam, 0 to 6 percent slopes. Estherville sandy loam, 6 to 12 percent slopes, moderately eroded. Estherville soils, 12 to 25 percent slopes, moderately eroded.	8 to 10 inches of sandy loam over 8 to 12 inches of sandy clay loam or loam that grades to mixed sand and gravel. Somewhat excessively drained soils on drift or terraces of the uplands.	Below a depth of 10 feet.	0–10 10–22 22–48+
EsC2 EsD2	Estherville, Lester, and Storden soils, 6 to 12 percent slopes, moderately eroded. Estherville, Lester, and Storden soils, 12 to 18 percent slopes, moderately eroded.	The Estherville soils make up about 40 percent of this complex, the Lester soils make up about 30 percent, and the Storden soils make up about 20 percent. For properties of these soils, see the Estherville sandy loams, the Lester clay loams, and the Clarion-Storden complexes.	---------------	--------
Gc	Glencoe silty clay loam.	14 to 20 inches of silty clay loam, high in content of organic matter (8 percent), over 12 inches of silty clay loam; underlain by clay loam till. Very poorly drained soil in depressions in the uplands.	0 to 3 feet.	0–20 20–32 32–48+
GuA GuB	Guckeen silty clay loam, 0 to 2 percent slopes. Guckeen silty clay loam, 2 to 6 percent slopes.	10 to 14 inches of silty clay loam over 24 inches of silty clay; underlain by calcareous heavy clay loam to clay loam. Moderately well drained soils on lacustrine material or on lake-laid, modified, fine-textured till.	4 to 8 feet.	0–14 14–36 36–48+
Hm	Huntsville loam, sand substratum.	32 inches of loam over 4 inches of loam or sandy loam underlain by loamy sand. Well-drained soil of the bottom lands subject to infrequent flooding.	6 to 10 feet.	0–32 32–36 36–48+
Hn Ho	Huntsville silt loam. Huntsville silt loam, frequent overflow.	8 inches of heavy silt loam, high in content of organic matter (6 percent), over 46 inches of loam; underlain by sandy loam. Moderately well drained soils of the bottom lands. Occasional to frequent flooding.	4 to 10 feet.	0–8 8–54 54–60+
KcB KcB2 KcC KcC2 KcC3 KcD KcD2 KcD3 KcE KcE2 KcF	Kilkenny clay loam, 2 to 6 percent slopes. Kilkenny clay loam, 2 to 6 percent slopes, moderately eroded. Kilkenny clay loam, 6 to 12 percent slopes. Kilkenny clay loam, 6 to 12 percent slopes, moderately eroded. Kilkenny clay loam, 6 to 12 percent slopes, severely eroded. Kilkenny clay loam, 12 to 18 percent slopes. Kilkenny clay loam, 12 to 18 percent slopes, moderately eroded. Kilkenny clay loam, 12 to 18 percent slopes, severely eroded. Kilkenny clay loam, 18 to 24 percent slopes. Kilkenny clay loam, 18 to 24 percent slopes, moderately eroded. Kilkenny clay loam, 24 to 35 percent slopes.	10 inches of clay loam over 32 inches of silty clay loam to silty clay underlain by heavy, calcareous clay loam till. The till contains a large amount of shale. Moderately well drained soils of the uplands.	Below a depth of 10 feet.	0–10 10–42 42–48+

See footnote at end of table.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200				
						Inches per hour	*Inches per inch of soil*	*pH value*	
Fine sandy loam	SM	A-2	90–100	90–100	30–35	5. 0–10. 0	0. 13	5. 1–6. 0	Low.
Sandy loam	SM	A-2	80–90	80–90	15–20	5. 0–10. 0	. 07	6. 1–6. 5	Low.
Sand and fine gravel.	SP-SM	A-1 or A-2	75–85	35–40	5–10	10. 0+	. 02	7. 0–7. 5	Low.
Loam	SM	A-4	90–100	90–100	40–45	2. 5–5. 0	. 2	5. 5–6. 2	Low.
Loam to sandy clay loam.	SC	A-4 or A-6	90–100	90–100	40–45	2. 5–5. 0	. 2	5. 8–6. 2	Low to moderate.
Sand and fine gravel.	SP-SM	A-1 or A-2	75–85	35–40	5–10	5. 0–10. 0+	. 02	7. 0–7. 5	Low.
Silt loam	ML	A-4 or A-6	100	100	80–90	0. 8–2. 5	. 17	5. 2–6. 0	Low to moderate.
Silty clay loam	MH or CH	A-7	100	95–100	75–95	0. 2–0. 8	. 17	4. 7–5. 9	High.
Clay loam	CL	A-6 or A-7	95–100	90–100	50–90	0. 8–2. 5	. 17	6. 8–7. 5	Moderate.
Sandy loam	SM or ML	A-2 or A-4	85–100	75–100	20–55	2. 5–5. 0	. 13	5. 1–6. 0	Low.
Sandy clay loam or loam.	SC, SM, or GM.	A-1 or A-2.	65–100	60–90	10–30	5. 0–10. 0	. 10	6. 1–6. 5	Low.
Sand and gravel.	SP or SM	A-1	60–95	40–90	3–15	10. 0+	. 02	7. 0–7. 5	Low.
Silty clay loam	MH or ML	A-5 or A-7	100	95–100	70–90	0. 8–2. 5	. 25	7. 0–7. 2	Moderate to high.
Silty clay loam	MH–CH	A-7	100	95–100	75–90	0. 8–2. 5	. 20	6. 5–7. 0	High.
Clay loam	CH	A-7	100	95–100	75–90	0. 8–2. 5	. 17	7. 5–7. 8	High.
Silty clay loam	CH	A-7	100	100	80–90	0. 2–0. 8	. 18	5. 8–6. 5	High.
Silty clay	CH	A-7	100	100	85–90	0. 2–0. 8	. 17	7. 5–7. 8	High.
Clay loam	CL	A-7	95–100	95–100	75–90	0. 8–2. 5	. 17	7. 5–7. 8	Moderate to high.
Loam	SM	A-2 or A-4	95–100	95–100	35–45	0. 8–2. 5	. 2	6. 1–6. 5	Low.
Sandy loam	SM	A-2	95–100	95–100	20–35	2. 5–5. 0	. 10	6. 5–7. 0	Low.
Loamy sand	SP or SM	A-3	95–100	95–100	5–10	5. 0–10. 0+	. 02	6. 5–7. 2	Low.
Heavy silt loam	CL	A-4 to A-6	100	95–100	75–80	0. 8–2. 5	. 2	6. 1–6. 5	Moderate.
Loam	CL	A-4 to A-6	100	95–100	75–80	0. 8–2. 5	. 17	6. 5–7. 2	Moderate.
Sandy loam	SM	A-4	95–100	95–100	35–50	2. 5–5. 0	. 10	7. 0–7. 2	Low.
Clay loam	OH or OL	A-7	95–100	95–100	70–85	0. 2–0. 8	. 18	5. 7–6. 2	High.
Silty clay loam to silty clay.	MH or CH	A-7	95–100	90–95	60–80	0. 2–0. 8	. 17	4. 5–6. 0	High.
Clay loam	MH, ML, or CL.	A-7	95–100	90–95	60–75	0. 8–2. 5	. 17	7. 5–7. 8	Moderate to high.

TABLE 11.—*Brief description of soils and their*

Map symbol	Soil	Description of soil and site	Depth to water table	Depth from surface
				Inches
La	Lake beaches.	Poorly sorted to exceedingly well sorted sand, gravel, and cobbles. No classification possible.	---------------	--------
LcB	Lester clay loam, 2 to 6 percent slopes.	6 to 12 inches of light clay loam over 30 inches of clay loam; underlain by calcareous clay loam or loam till. Well-drained soils of the uplands. Occasional boulders on the surface and in the profile.	Below a depth of 10 feet.	0–12
LcB2	Lester clay loam, 2 to 6 percent slopes, moderately eroded.			12–42
LcC	Lester clay loam, 6 to 12 percent slopes.			42–48+
LcC2	Lester clay loam, 6 to 12 percent slopes, moderately eroded.			
LcD	Lester clay loam, 12 to 18 percent slopes.			
LcD2	Lester clay loam, 12 to 18 percent slopes, moderately eroded.			
LcD3	Lester clay loam, 12 to 18 percent slopes, severely eroded.			
LcE	Lester clay loam, 18 to 24 percent slopes.			
LcE2	Lester clay loam, 18 to 24 percent slopes, moderately eroded.			
LcE3	Lester clay loam, 18 to 24 percent slopes, severely eroded.			
LcF	Lester clay loam, 24 to 35 percent slopes.			
LfB	Lester fine sandy loam, sandy variant, 2 to 6 percent slopes.	6 to 18 inches of fine sandy loam over 20 to 24 inches of loam or clay loam; underlain by calcareous clay loam or loam till. Well-drained soil of the uplands.	Below a depth of 10 feet.	0–10
				10–30
				30–48+
LhB2	Lester-Estherville complex, 2 to 6 percent slopes, moderately eroded.	About 30 percent of this complex is made up of Estherville soils, and the rest is mainly Lester soils. For properties of these soils see the Estherville sandy loams and the Lester clay loams.	---------------	--------
LsB2	Lester-Storden complex, 2 to 6 percent slopes, moderately eroded.	The Storden soils make up about 30 percent of these complexes in most places; in gently sloping areas they occupy about 20 percent of the complex, and in steep areas, about 40 percent. Lester soils make up most of the rest. For properties of these soils see the Lester clay loams and the Clarion-Storden complexes.	---------------	--------
LsC2	Lester-Storden complex, 6 to 12 percent slopes, moderately eroded.			
LsC3	Lester-Storden complex, 6 to 12 percent slopes, severely eroded.			
LsD2	Lester-Storden complex, 12 to 18 percent slopes, moderately eroded.			
LsD3	Lester-Storden complex, 12 to 18 percent slopes, severely eroded.			
LsE	Lester-Storden complex, 18 to 24 percent slopes.			
LsE3	Lester-Storden complex, 18 to 24 percent slopes, severely eroded.			
LsF	Lester-Storden complex, 24 to 35 percent slopes.			
LuA	Le Sueur clay loam, 0 to 2 percent slopes.	8 to 14 inches of clay loam to silty clay loam over 24 inches of clay loam to silty clay loam; underlain by calcareous clay loam till. Moderately well drained soils of the uplands.	5 to 10 feet.	0–14
LuB	Le Sueur clay loam, 2 to 6 percent slopes.			14–38
				38–48+
Ly	Lura silty clay loam.	16 to 24 inches of silty clay loam or silty clay, high in content of organic matter (8 percent), over 24 inches of plastic clay or silty clay; underlain by calcareous clay loam till. In places the till is modified. Very poorly drained soil in depressions in the lake plain.	0 to 3 feet.	0–24
				24–48
				48–60+
Ma	Marna silty clay loam.	12 to 16 inches of silty clay loam or silty clay, high in content of organic matter (8 percent), over 10 to 20 inches of silty clay; underlain by calcareous clay loam till. In places the till is modified. Poorly drained soil of the lake plain.	1 to 3 feet.	0–16
				16–30
				30–48+

See footnote at end of table.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200				
						Inches per hour	*Inches per inch of soil*	*pH value*	
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Light clay loam	ML or CL	A-6 or A-7	95–100	95–100	50–60	0. 8–2. 5	0. 20	6. 0–6. 5	Low to moderate.
Clay loam	CL	A-6	95–100	90–100	50–60	0. 8–2. 5	. 18	5. 5–6. 0	Moderate.
Clay loam or loam.	ML or CL	A-6 or A-4	95–100	90–95	50–55	0. 8–2. 5	. 17	7. 5–7. 8	Low to moderate.
Fine sandy loam	SM–SC	A-2	95–100	95–100	30–35	2. 5–5. 0	. 1	5. 8–6. 2	Low.
Loam to clay loam.	CL	A-4 or A-6	95–100	95–100	50–60	0. 8–2. 5	. 16	5. 8–6. 2	Low to moderate.
Loam or clay loam.	CL	A-6	95–100	90–95	70–75	0. 8–2. 5	. 16	7. 5–7. 8	Moderate.
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Clay loam to silty clay loam.	MH or OH	A-7	100	95–100	70–85	0. 8–2. 5	. 20	6. 0–6. 5	Moderate to high
Clay loam to silty clay loam.	CL or CH	A-6 or A-7	95–100	95–100	60–85	0. 8–2. 5	. 18	5. 5–6. 0	Moderate to high.
Clay loam	CL	A-6 or A-7	95–100	95–100	55–65	0. 8–2. 5	. 17	7. 5–7. 8	Moderate.
Silty clay loam or silty clay.	CH	A-7	100	100	80–90	0. 2–0. 8	. 18	6. 0–6. 5	High.
Clay or silty clay.	CH	A-7	100	100	80–90	0. 2–0. 8	. 17	6. 5–7. 0	High.
Clay loam	CH	A-7	100	100	60–70	0. 8–2. 5	. 17	7. 0–7. 5	High.
Silty clay loam or silty clay.	MH or OH	A-7	95–100	95–100	85–90	0. 2–0. 8	. 18	6. 0–6. 5	Moderate to high.
Silty clay	MH or CH	A-7	95–100	90–100	75–95	0. 2–0. 8	. 17	5. 2–6. 0	High.
Clay loam	ML or CL	A-7	95–100	85–95	60–70	0. 8–2. 5	. 17	7. 5–7. 8	Moderate to high.

TABLE 11.—*Brief description of soils and their*

Map symbol	Soil	Description of soil and site	Depth to water table	Depth from surface
				Inches
Mh	Marsh.	Peaty material to a depth of 30 feet or more. Permanently wet. Cattails and other marsh vegetation. No classification possible.	----------------	--------
NcA NcB	Nicollet clay loam, 0 to 2 percent slopes. Nicollet clay loam, 2 to 6 percent slopes.	10 to 16 inches of clay loam, high in content of organic matter (6 percent), over 24 inches of clay loam; underlain by calcareous clay loam till. Moderately well drained soils of the uplands. Occasional boulders on the surface and in the profile.	4 to 10 feet.	0–16 16–38 38–48+
Pa Pc Ph Pk	Peat and muck, deep. Peat and muck, deep and calcareous. Peat and muck, shallow. Peat and muck, shallow and calcareous.	Organic soils that vary in depth. The shallow phases are generally less than 42 inches deep over mineral soil material, normally clay loam till. The deep phases range from 42 inches to 20 feet in depth over mineral soil material. In depressions or in seep areas on slopes.	0 to 3 feet.	--------
Rb	Rough broken land.	Calcareous clay loam till that has been little altered by the processes of soil formation; less than 10 percent of the acreage has gravelly or sandy pockets in the till. There are a few boulders and stones throughout the till. In narrow, steep belts between the bottom lands and the uplands along rivers and streams.	Below a depth of 10 feet.	0–60+
	Storden loam.	Not mapped separately in this county. See Clarion-Storden complexes.	----------------	--------
Ta	Talcot silty clay loam.	17 inches of silty clay loam to clay loam, high in content of organic matter (8 percent), over 10 to 12 inches of clay loam; underlain by 4 inches of calcareous coarse gravelly sandy loam over calcareous coarse sand and gravel. Very poorly drained soil in depressions in outwash plains.	0 to 3 feet.	0–17 17–28 28–32 32–48+
Tl	Terril loam, 2 to 6 percent slopes.	24 to 30 inches of loam, high in content of organic matter (6 percent), over 12 to 16 inches of loam; underlain by calcareous loam. On low, concave slopes below steeper areas. Moderately well drained soil of the uplands.	5 to 10 feet.	0–28 28–42 42–48
TrB TrB2 TrC2	Truman silt loam, 2 to 6 percent slopes. Truman silt loam, 2 to 6 percent slopes, moderately eroded. Truman silt loam, 6 to 12 percent slopes, moderately eroded.	6 to 12 inches of silt loam, high in content of organic matter (5 percent), over 24 inches of silt loam; underlain by calcareous silt loam or clay loam till. Well-drained, lake-laid soils.	Below a depth of 10 feet.	0–12 12–36 36–48+
WaB	Wadena loam, 2 to 6 percent slopes.	14 inches of loam over 10 inches of sandy loam; underlain by calcareous sand and gravel. Well-drained soil of the uplands.	Below a depth of 10 feet.	0–14 14–24 24–48+
Wb	Webster clay loam.	15 inches of clay loam or silty clay loam, high in content of organic matter (7 percent), over 12 to 18 inches of clay loam; underlain by calcareous clay loam or loam till. Poorly drained soil of the uplands.	18 inches to 3 feet.	0–15 15–30 30–48+

[1] Variable.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200				
						Inches per hour	*Inches per inch of soil*	*pH value*	
Clay loam	ML	A-4	100	95–100	55–70	0. 8–2. 5	0. 20	6. 0–6. 5	Low.
Clay loam	CL	A-7	95–100	95–100	55–85	0. 8–2. 5	. 17	6. 5–7. 0	Moderate to high.
Clay loam	ML or CL	A-6	90–100	85–95	55–65	0. 8–2. 5	. 17	7. 5–7. 8	Moderate.
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Clay loam	CL (SM and GW in pockets).	A-6 (A-1 or A-3 in pockets).	95–100	90–95	50–55	0. 8–2. 5	. 17	7. 0–7. 8	Moderate.
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Silty clay loam to clay loam.	MH or OL	A-7	95–100	95–100	50–75	0. 2–0. 8	. 2	7. 0–7. 5	Moderate to high.
Clay loam	MH or CH	A-7	95–100	85–90	50–75	0. 2–0. 8	. 17	7. 2–7. 5	High.
Gravelly sand loam.	GC or SC	A-2	50–75	45–70	20–35	0. 8–2. 5	. 10	7. 5–7. 8	Low.
Coarse sand and gravel.	GW or SW	A-1	40–60	35–50	2–5	10. 0+	. 01	7. 5–7. 8	Low.
Loam	ML	A-4	100	95–100	55–70	0. 8–2. 5	. 2	6. 3–7. 0	Low.
Loam	ML	A-4	95–100	95–100	55–85	0. 8–2. 5	. 16	6. 8–7. 2	Low.
Loam	ML	A-4	90–100	85–95	55–65	0. 8–2. 5	. 16	7. 5–7. 8	Low.
Silt loam	ML or CL	A-4	100	100	75–85	0. 8–2. 5	. 2	6. 1–6. 5	Low.
Silt loam	ML or CL	A-4 or A-6	100	100	80–90	0. 8–2. 5	. 18	6. 1–6. 5	Low to moderate.
Silt loam or clay loam.	CL	A-6	100	100	75–85	0. 8–2. 5	. 18	7. 5–7. 8	Moderate.
Loam	SM or SC	A-4	85–90	75–85	35–45	0. 8–2. 5	. 2	6. 1–6. 5	Low.
Sandy loam	SC	A-2	60–70	55–70	10–20	5. 0–10. 0	. 17	5. 8–6. 2	Low.
Sand and gravel	GW–GM and SP–SM.	A-1 or A-2	50–60	35–50	5–10	10. 0+	. 02	7. 0–7. 5	Low.
Clay loam or silty clay loam.	MH or OH	A-7	95–100	95–100	60–85	0. 8–2. 5	. 25	6. 1–6. 5	Moderate to high.
Clay loam	CL or CH	A-7	95–100	90–100	60–75	0. 8–2. 5	. 20	5. 6–6. 5	High.
Clay loam or loam.	CL	A-6	95–100	85–100	45–85	0. 8–2. 5	. 17	7. 5–7. 8	Moderate.

TABLE 12.—*Interpretation of engineering*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Alluvial land (Ad)	Poor to good; check each site.	Not suitable	Not suitable	Poor to good; check each site; variable; high water table.	Flood hazard and high water table; roadbed must be raised above the level reached by floodwaters.	Fair stability; poor to fair resistance to piping.
Biscay (By)	Good	Good; mixed, medium to coarse sand and fine gravel; wash for concrete.	Not suitable; gravel too fine.	Good; good compaction characteristics; fair stability; erodes easily; good shear strength.	High water table; remove and waste uppermost 2 to 3 feet.	Reasonably stable; may be used in dikes that have flat side slopes; piping hazard.
Canisteo (Ca, Cd)	Good	Not suitable	Not suitable	Not suitable in upper 3 to 4 feet; fair in underlying till, if drained.	High content of organic matter; high water table; high compressibility; poor workability; poor compaction characteristics; fair to poor shear strength.	High water table; high compressibility in surface layer; poor workability; impervious when compacted.
Clarion (ClB, ClB2, ClC, ClC2, ClC3, ClD2).	Good	Not suitable	Not suitable	Fair to good; stable; fair to good compaction characteristics; fair shear strength; moderate susceptibility to frost action.	Stable; fair to good compaction characteristics; medium compressibility; fair shear strength; good to fair workability.	Stable; impervious when compacted.
Clarion-Estherville complex (CrB2).[4]	----------	----------	----------	----------	----------	----------

See footnotes at end of table.

properties of soils in Waseca County

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Hazards of flooding and piping.	Fair stability; piping hazard.	Outlets difficult to obtain; needs surface drainage; flooding is frequent.	Questionable because floods may damage crops.	Not needed	Flooding causes scouring and deposition of debris.	Not suitable, because of flooding.
Piping hazard; dugout ponds best because of high water table.	Reasonably stable; good compaction characteristics; piping hazard; positive cutoff or upstream blanket and toe drains and wells required.	Needed; sloughing of side slopes is a constant hazard; installing closed drains is hazardous because of caving and high water table.	Drainage is a prerequisite.	Not needed	Drainage needed before construction; difficult to establish sod where substratum is exposed.	Not suitable, because of high water table.
Suitable for dugout ponds because of high water table.	Underlying till is stable and suitable for impervious cores and blankets.	Needed; surface ditches may be needed in addition to tile drainage.	Drainage is a prerequisite.	Not needed	Drainage needed before construction.	Not suitable, because of high water table.
Bottom of reservoir should be scarified and compacted; impervious when compacted.	Stable; good for impervious cores and blankets; fair to good compaction characteristics; slow permeability when compacted.	Not needed; well drained.	Generally good characteristics for irrigation.	Suitable for terraces where slopes are 12 percent or less; slopes are irregular and complex in many places; diversions can be used on slopes of more than 12 percent; occasional stones and boulders may interfere with construction.	Fertilizing and mulching necessary to establish sod rapidly; occasional stones and boulders may interfere with construction.	Suitable; moderately permeable.
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TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Clarion-Storden complex (CsB2, CsC2, CsC3, CsD2, CsD3, CsE, CsE3, CsF).[5]	Fair	Not suitable	Not suitable	Fair to good; stable; fair to good compaction characteristics; fair shear strength; moderate susceptibility to frost action.	Stable; fair to good compaction characteristics; medium compressibility; fair shear strength; good to fair workability.	Stable; impervious when compacted.
Colo (Ct, Cu, Cw)	Good	Not suitable	Not suitable	Not suitable; high in content of organic matter; poor stability; fair to poor shear strength.	High in content of organic matter; high water table; subject to flooding; poor stability; poor compaction characteristics.	Poor stability; may be used for low embankments with proper control.
Cordova (Cy)	Good	Not suitable	Not suitable	Fair to good in till substratum; stable; fair to good compaction; fair shear strength.	High in content of organic matter; high water table; must be drained; till substratum is stable; susceptible to frost action.	Till substratum stable; impervious when compacted.
Dickinson (DcB, DkB, DkC2).	Poor to fair	Poorly graded sands; not suitable for concrete.	Not suitable	Good; cuts or fills subject to erosion; good compaction characteristics; very low compressibility.	Cuts or fills subject to erosion; good compaction characteristics; rapid permeability; very slight compressibility.	Reasonably stable; may be used in dikes with flat side slopes; pervious when compacted; piping hazard.
Dundas (Du)	Fair	Not suitable	Not suitable	Fair to good in till substratum; stable; good to poor compaction characteristics; fair workability; susceptible to frost action.	Susceptible to frost action; good to poor compaction characteristics; poor to fair stability.	Poor to fair stability; poor to fair resistance to piping; may be used for low embankments with proper control.

See footnotes at end of table.

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Bottom of reservoir should be scarified and compacted; impervious when compacted.	Stable; good for impervious cores and blankets; fair to good compaction characteristics; slow permeability when compacted.	Not needed; well drained.	Generally good characteristics for irrigation.	Suitable for terraces where slopes are 12 percent or less; slopes are irregular and complex in many places; diversions can be used on slopes of more than 12 percent; occasional stones and boulders may interfere with construction.	Fertilizing and mulching necessary to establish sod rapidly; occasional stones and boulders may interfere with construction.	Suitable; moderately permeable.
Dugout pits feasible; subject to flooding; moderate to slow permeability when compacted.	Poor stability; good core material; poor compaction characteristics; fair to poor shear strength; high compressibility.	Outlets difficult to obtain; open ditch drainage best to use; subject to flooding.	Suitable, but must be protected from floods; drainage must be installed.	Not needed	Drainage needed before construction; hazard of flooding.	Not suitable, because of high water table and flooding.
In nearly level areas; sites not suited to ponds but may be suitable for dugout pits.	Till substratum stable; impervious when compacted.	Needed; place tile in till substratum.	Drainage must be installed first.	Not needed	Drainage needed before construction.	Not suitable; low permeability; high water table.
Rapid permeability; piping hazard.	Reasonably stable; good compaction characteristics; slope protection required; very slight compressibility; piping hazard.	Not needed	Suitable; moderate water-holding capacity; good areas for disposal of effluent from canning factories.	Level terraces; rapid permeability.	Design to maintain low velocity; do not excavate too deep, because substratum is very pervious, and sod is difficult to establish on it.	Suitable; rapid permeability.
Bottom of reservoir should be scarified and compacted; possible piping hazard.	Poor to fair stability; good to poor compaction characteristics; close control necessary; possible piping hazard.	May be needed in some places; good tilth in surface layer needed for adequate function of tile drainage.	Moderately slow permeability of subsoil requires special application rates.	Not needed	Areas that need drainage should be tiled before construction starts.	Not suitable; moderately slow permeability; water table at a depth of 2 to 5 feet.

TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Estherville (EaB, EaC2, EoE2).	Poor	Good source of sand, but mixed with gravel; wash for concrete.	Good source of gravel, but mixed with sand; wash for concrete.	Good; good compaction characteristics; very stable; good shear strength.	Very stable; good compaction characteristics; good shear strength; low susceptibility to frost action.	Very stable; good for pervious shells of dikes and dams.
Estherville, Lester, and Storden soils (EsC2, EsD2).[6]						
Glencoe (Gc)	Good	Not suitable	Not suitable	Poor; high in content of organic matter; high water table; high susceptibility to frost action; high compressibility; poor shear strength.	Poor to fair stability; high in content of organic matter; high water table; high susceptibility to frost action; high compressibility.	Poor to fair stability; use for thin cores, blankets, or dike sections; fair to poor compaction characteristics.
Guckeen (GuA, GuB)	Good	Not suitable	Not suitable	Poor; high in content of organic matter in uppermost 2 feet; high susceptibility to frost action; medium compressibility; fair compaction characteristics; fair workability.	Fair stability; high in content of organic matter; high susceptibility to frost action; medium compressibility.	Fair stability; good to fair resistance to piping; impervious when compacted; substratum suitable for cores and blankets.
Huntsville, sand substratum (Hm).	Good	Not suitable; poorly graded sands; not suitable for concrete.	Not suitable	Suitable; cuts or fills subject to erosion; good compaction characteristics; very slight compressibility; low susceptibility to frost action in substratum.	Cuts or fills subject to erosion; rapid permeability when compacted; good compaction characteristics; very slight compressibility.	Reasonably stable; may be used in dikes with flat side slopes; pervious when compacted.
Huntsville (Hn, Ho)	Good	Not suitable	Not suitable	Fair; subject to flooding; fair to good compaction characteristics; fairly stable; fair shear strength; moderate susceptibility to frost action.	Subject to flooding; fair stability; moderate susceptibility to frost action; medium compressibility; fair to good compaction characteristics.	Fairly stable; not well suited to shells, but may be used for impervious cores or dikes; fair to poor resistance to piping.

See footnotes at end of table.

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Rapid permeability; piping hazard.	Rapid permeability when compacted; piping hazard; very stable.	Not needed	Suitable, but has low to moderate water-holding capacity; requires frequent applications of water; may not be economically feasible.	Normally not necessary; shallow depth to gravel makes terraces unsuitable.	Excavation must not be deep; substratum very pervious, and sod is difficult to establish on it.	Suitable; rapidly permeable substratum.
Suitable for dugout ponds or level ditches for wildlife management; high water table.	Poor to fair stability with flat slopes; fair to poor compaction characteristics; impervious when compacted; excellent resistance to piping.	Needed; surface ditches may be needed in addition to tile drains.	Suitable, but must be drained first.	Not needed	Drainage needed before construction.	Not suitable; high water table; local flooding.
Suitable; slow permeability.	Fair stability; fair compaction characteristics; uppermost 2 feet high in content of organic matter; fair workability; medium compressibility; good to poor bearing value; impervious when compacted.	Generally not needed.	Suitable; permeability slow in subsoil.	Suitable, but generally occurs as isolated knolls; permeability slow in subsoil; caution must be used, as too level a grade may cause wetness.	Suitable	Suitable; moderate permeability in substratum.
Rapid permeability; piping hazard.	Reasonably stable; good compaction characteristics; slope protection required; pervious when compacted; piping hazard; very slight compressibility.	Generally not needed.	Suitable	Not needed	Excavation must not be too deep, because substratum is very pervious and sod is difficult to establish on it; design to maintain low velocity.	Not suitable; subject to infrequent flooding.
Subject to flooding; piping hazard.	Fairly stable; fair to good compaction characteristics; fair to poor resistance to piping; low to medium compressibility.	Generally not needed.	Suitable	Not needed	Design to maintain low velocity.	Not suitable; subject to flooding.

TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Kilkenny (KcB, KcB2, KcC, KcC2, KcC3, KcD, KcD2, KcD3, KcE, KcE2, KcF).	Good	Not suitable	Not suitable	Poor; high susceptibility to frost action; fair to poor stability; poor to fair compaction characteristics; medium to high compressibility.	Fair to poor stability; high susceptibility to frost action; medium to high compressibility; fair to poor workability; fair to poor shear strength.	Fair stability with flat slopes; suitable for thin cores, blankets, and dike sections; semipervious to impervious when compacted.
Lake beaches (La)	Poor	Not suitable; too well assorted.	Not suitable	Fair; seasonally high water table; material too variable.	Seasonally high water table; variable material.	Not suitable; material too variable.
Lester (LcB, LcB2, LcC, LcC2, LcD, LcD2, LcD3, LcE, LcE2, LcE3, LcF, LfB).	Good	Not suitable	Not suitable	Fair to good in substratum; fair stability; high susceptibility to frost action; fair to good compaction characteristics; fair shear strength.	Fairly stable; high susceptibility to frost action; medium compressibility; fair workability; fair shear strength.	Fair stability; semipervious to impervious when compacted.
Lester-Estherville complex (LhB2).[7]						
Lester-Storden complex (LsB2, LsC2, LsC3, LsD2, LsD3, LsE, LsE3, LsF).[8]						
Le Sueur (LuA, LuB)	Good	Not suitable	Not suitable	Poor; stable; fair to good compaction characteristics; fair shear strength; highly susceptible to frost action; good to fair workability.	Stable; highly susceptible to frost action; medium compressibility; fair shear strength; impervious when compacted.	Stable; impervious when compacted.

See footnotes at end of table.

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Suitable; semipervious to impervious when compacted.	Fair to poor stability; poor to fair compaction characteristics; medium to high compressibility; fair to poor shear strength; semipervious to impervious when compacted.	Not needed	Suitable; permeability slow in subsoil.	Suitable for terraces where slopes are 12 percent or less; diversions can be used where slopes are more than 12 percent; caution must be used; too level a grade may cause wetness.	Fertilizing and mulching necessary to establish sod rapidly.	Suitable; permeability is slow in the subsoil.
Dugout ponds or level ditches can be used for wildlife management; high water table.	Not suitable	Needed, but depends on extensive development of outlets.	Not suitable; high water table; variable and in many places unproductive soil material.	Not needed	Poor material for establishing sod.	Not suitable; high water table.
Suitable; semipervious to impervious when compacted.	Fair stability; fair to good compaction characteristics; fair shear strength; medium compressibility; semipervious to impervious when compacted.	Not needed	Generally good characteristics for irrigation.	Suitable for terraces where slopes are 12 percent or less; diversions can be used where the slopes are more than 12 percent; occasional stones and boulders may interfere with construction.	Fertilizing and mulching necessary to establish sod rapidly; occasional stones and boulders may interfere with construction.	Suitable; moderate permeability.
Impervious when compacted.	Stable; suitable for impervious cores and blankets; fair to good compaction characteristics; fair shear strength; medium compressibility; good to fair workability.	Generally not needed.	Suitable	Suitable	Suitable	Suitable; moderate permeability.

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TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Lura (Ly)	Good	Not suitable	Not suitable	Poor; poor shear strength; poor workability; fair to poor compaction characteristics; highly susceptible to frost action.	Fair stability; high compressibility; highly susceptible to frost action; poor shear strength; impervious when compacted; high water table.	Fair stability with flat slopes; suitable for thin cores, blankets, and dike sections; impervious when compacted.
Marna (Ma)	Good	Not suitable	Not suitable	Poor in substratum; poor to fair shear strength; fair to poor compaction characteristics; fair workability; highly susceptible to frost action.	Fair stability; medium to high compressibility; highly susceptible to frost action; semipervious to impervious when compacted; high water table.	Fair stability with flat slopes; semipervious to impervious when compacted.
Marsh (Mh). [9]						
Nicollet (NcA, NcB)	Good	Not suitable	Not suitable	Fair to good; stable; fair to good compaction characteristics; fair shear strength; moderate susceptibility to frost action.	Stable; fair to good compaction characteristics; medium compressibility; fair shear strength; good to fair workability.	Stable; impervious when compacted.
Peat and muck, shallow and deep (Pa, Pc, Ph, Pk).	Not suitable	Not suitable	Not suitable	Not suitable; organic soils.	Organic soils; high water table; remove and waste material to underlying mineral soils; avoid locating roads on these soils.	Do not use for constructing embankment.
Rough broken land (Rb)	Fair to poor	Not suitable	Not suitable	Fair to good; stable; fair to good compaction characteristics; fair shear strength; moderate susceptibility to frost action.	Stable; steep topography; fair to good compaction characteristics; medium compressibility; fair shear strength; some stones and boulders.	Stable; impervious when compacted; generally not needed in steep areas.

See footnotes at end of table.

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Suitable for dug-out ponds or level ditches for wildlife management; high water table	Fair stability with flat slopes; suitable for thin cores and blanket sections; fair to poor compaction characteristics; poor shear strength.	Needed; surface ditches may be necessary with tile drainage.	Suitable, but must be drained first.	Not needed	Drainage needed before construction.	Not suitable; high water table; slow permeability.
Suitable for dug-out ponds because of high water table, but normally not used for that purpose.	Fair stability with flat slopes; suitable for thin cores and blanket sections; fair to poor compaction characteristics; poor to fair shear strength; semipervious to impervious when compacted.	Needed	Suitable, but must be drained first.	Not needed	Drainage needed before construction.	Not suitable; high water table; slow permeability.
Impervious when compacted.	Stable; good for impervious cores and blankets; fair to good compaction characteristics; slow permeability when compacted.	Generally not needed.	Suitable; good characteristics for irrigation.	Suitable	Fertilize and mulch to establish sod rapidly; occasional stones and boulders may interfere with construction.	Suitable; moderate permeability.
Suitable for dug-out ponds or level ditches for wildlife management; high water table.	Not suitable	Both open and closed drains needed.	Suitable, but must be drained first.	Not needed	Not suitable	Not suitable; high water table.
Blankets of impervious material needed over pockets or strata of sand and gravel.	Stable; good for impervious cores and blankets; fair to good compaction characteristics; slow permeability when compacted.	Not needed	Not suitable; too steep.	Not suitable; too steep.	Not suitable; too steep.	Suitable, but too steep; moderate permeability.

TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Storden loam (not mapped separately in this county. See Clarion-Storden complexes.)						
Talcot (Ta)	Good	Good; mixed medium to coarse sand and fine gravel; wash for concrete.	Not suitable; gravel too fine.	Good; good compaction characteristics; fair stability; fills erode easily; good shear strength.	High water table; remove and waste uppermost 2 to 3 feet.	Reasonably stable; may be used in a dike that has flat side slopes; piping hazard.
Terril (Tl)	Good	Not suitable	Not suitable	Poor; poor stability; good to poor compaction characteristics; under close control; high susceptibility to frost action; fair shear strength.	Poor stability; subject to liquefaction; high susceptibility to frost action.	Poor stability; may be used for low embankments with proper control; semipervious to impervious when compacted.
Truman (TrB, TrB2, TrC2).	Good	Not suitable	Not suitable	Poor; poor stability; may be used for embankments with proper control; good to poor compaction characteristics; susceptible to liquefaction; high susceptibility to frost action.	Poor stability; susceptible to liquefaction; high susceptibility to frost action; fair shear strength; medium compressibility.	Poor stability; may be used for embankments with proper control; poor to very poor resistance to piping; semipervious to impervious when compacted.
Wadena (WaB)	Fair	Good; mixed sand and gravel; wash for concrete.	Good; mixed sand and gravel; wash for concrete.	Good; good compaction characteristics; very stable; good shear strength; very low compressibility.	Reasonably stable; low susceptibility to frost action; good shear strength; very low compressibility; pervious when compacted.	Reasonably stable; may be used in dikes with flat slopes; suitable for pervious shells of dikes; not suitable for cores.

See footnotes at end of table.

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
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Piping hazard; dugout ponds best because of high water table.	Reasonably stable; good compaction characteristics; piping hazard; positive cutoff on upstream blanket and toe drains and wells required.	Needed; sloughing of side slopes is a constant hazard; a hazard if closed drains are installed because of caving and high water table.	Suitable, but must be drained first.	Not needed-----	Drainage needed before construction; difficult to establish sod where substratum is exposed.	Not suitable, because of high water table.
Semipervious to impervious when compacted; piping hazard.	Good to poor compaction characteristics; with close moisture control; piping hazard; positive cutoff or upstream blanket and toe drains or wells necessary; poor stability; fair shear strength.	Not needed-----	Suitable--------	Suitable--------	Fertilize and mulch to establish sod rapidly.	Suitable, but subject to light overflow.
Piping hazard; semipervious to impervious when compacted.	Poor stability, may be used for embankments with proper control; good to poor compaction characteristics; positive cutoff or upstream blanket and toe drains or wells required; piping hazard.	Not needed-----	Suitable; generally good characteristics for irrigation.	Suitable--------	Fertilizing and mulching necessary to establish sod rapidly.	Suitable; moderate permeability.
Not suitable; will not hold water.	Not suitable; rapidly permeable.	Not needed-----	Suitable--------	Not needed-----	Excavation must not be too deep; substratum very pervious, and sod is difficult to establish on it.	Suitable; rapidly permeable substratum.

TABLE 12.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—				Soil features affecting engineering practices	
	Topsoil [1]	Sand	Gravel	Road fill [2]	Highway location [3]	Dikes or levees
Webster (Wb)	Good	Not suitable	Not suitable	Fair; stable; fair to good compaction characteristics; fair shear strength; moderate susceptibility to frost action.	Stable; fair to good compaction characteristics; medium compressibility; fair shear strength; high water table; good to fair workability in substratum.	Substratum stable; impervious when compacted.

[1] Refers to the surface soil only.
[2] Refers to the use of underlying material or substratum, except where otherwise specified.
[3] Content of organic matter in this column refers to surface layer only.
[4] For soil features that affect engineering, see the Clarion and Estherville series.
[5] Soil features that affect engineering are the same as for the Clarion series, except for suitability as a source of topsoil.

the compacted soil material increases until the optimum moisture content is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed maximum dry density. Moisture-density data are important in earthwork, for as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

Formation and Classification of Soils

In this section are discussed the factors that affect the formation of soils, the processes of soil formation, and the classification of soils into higher categories. Following this, the great soil groups are defined and a profile that is typical of each series is described.

Formation of Soils

Soils are formed when the forces of weathering and soil development act on material that has been deposited or accumulated by geologic agencies. The characteristics of the soil in any particular place are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and has existed since its accumulation; the plant and animal life on and in the soil; the relief, or lay of the land, and the drainage that results from it; and the length of time the forces of development have acted on the material. These five factors of soil formation are interdependent; each modifies the effects of the others.

Man has also influenced the development of soils. He has removed the natural vegetation and has used methods of farming that have accelerated erosion; has changed the drainage; and has changed the relief or the effects of relief. Man has also modified the natural differences between soils by adding fertilizer that improved the fertility of some soils. He also lowered the fertility of some soils by removing crops without replacing plant nutrients.

Parent material

Waseca County is covered by drift of the Mankato substage of the Wisconsin glaciation. The Mankato glacier occupied the land between 8,000 and 11,000 years ago. The drift is composed of relatively recent material derived through the reworking of older glacial deposits.

Moderately fine textured glacial drift covers the northwestern part of Woodville Township and the southwestern part of Blooming Grove Township. It also covers some areas in the northern part of Janesville Township and the north-central part of Iosco Township, as well as scattered areas in St. Mary Township. The Kilkenny soils are predominant where this moderately fine textured drift occurs. The drift in which the Kilkenny soils were formed is 2 to 4 feet deep.

The soils in the southwestern part of Alton Township, in the western part of Freedom Township, and in Vivian Township have been strongly influenced by moderately fine textured or fine textured, lake-laid sediments of glacial Lake Minnesota. The Guckeen and Marna soils formed in these lake-laid sediments. Loose, sandy and gravelly glacial outwash occurs throughout parts of Otisco Township and parts of section 1 in Janesville Township. The Estherville, Talcot, and Biscay soils formed in this outwash.

The Storden soils formed in unstratified glacial drift, mainly of loam to clay loam texture. In contrast to the other soils formed in unstratified drift, which have carbonates at a depth of as much as 4 feet, the Storden soils are calcareous at the surface. The underlying calcareous drift is light yellowish brown or light olive brown and is slightly mottled with pale yellow and gray. This material has a high content (15 to 25 percent) of calcium

of soils in Waseca County—Continued

Soil features affecting engineering practices—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Fields for septic tanks
Reservoir area	Embankment [2]					
Impervious when compacted.	Stable; good for impervious cores and blankets; fair to good compaction characteristics; slow permeability when compacted.	Needed	Suitable, but must be drained first.	Not needed	Drainage needed before construction.	Not suitable; high water table.

[6] For soil features that affect engineering, see the Estherville and Lester series and Clarion-Storden complex.
[7] For soil features that affect engineering, see the Lester and Estherville series.
[8] For soil features that affect engineering, see the Lester series and Clarion-Storden complex.
[9] Interpretations are not provided; check each site.

carbonate, and it effervesces strongly when dilute hydrochloric acid is applied. It is composed mostly of material derived from limestone and calcareous shale, but it contains enough material from granite and sandstone to provide an abundance of minerals and a favorable range in soil texture. Additional information about the parent material of the soils in this county can be found in the section "Geology and Water Supply" in the front of the report.

Climate

Waseca County has a cool, subhumid, continental type of climate with wide variations in temperature from summer to winter. In winter, soil-forming processes are largely dormant. Generally, the soils are frozen to a depth of 2 to 3 feet for 4 to 5 months of the year. The depth to which frost penetrates depends mostly on the amount of snowfall late in fall or early in winter.

The climate is essentially uniform throughout the county; however, differences in vegetation, soil material, and relief can cause variations in the microclimate. Soils in the prairie regions are exposed to a greater variation in temperature than those in the forest regions. The Marna, Lura, and other fine-textured soils warm up more slowly in spring than coarse-textured soils, such as the Estherville and Dickinson, because they contain more moisture. Dark-colored soils, such as the Clarion and Nicollet, absorb more heat from sunlight than light-colored soils. Soils on south- and west-facing slopes receive more sunlight and tend to be drier and warmer than soils on north- and east-facing slopes. The interaction of all these factors affects the development of soils. More information about the climate of Waseca County is given in the section "General Nature of the County."

Plant and animal life

Before this county was settled, the native vegetation was most important in the complex of living organisms that affect soil development. The activities of animals were of minor importance, except for the activities of earthworms. Earthworms performed an important function in the transformation and translocation of organic material.

Two types of vegetation, forest and prairie, have strongly influenced the development of soils in this county. The county is located along the northern margin of a large area that has been covered part of the time by prairie and part of the time by forest. The prairie vegetation encroached on the forests, or forest vegetation came into the prairie as shifts in the climatic pattern affected temperature, relative humidity, wind velocity, and the pattern of precipitation (fig. 15).

The Le Sueur River forms a general boundary between the area called the Big Woods and the oak openings to the north and east and the prairie peninsula to the south and west. Pioneer settlers and many early scholars believed that the prairies in this area were caused by fire. This, no doubt, was a modifying factor along the edge of the forest, but generally the dominant vegetation is that best adapted to the climate (*4*).

The southern fringe of the Minnesota Big Woods reached the northwestern parts of Iosco and Janesville Townships and the western part of Alton Township. The forest vegetation in the Big Woods influenced the development of the Kilkenny, Lester, Le Sueur, and Cordova soils. Belts of timber occurred along the rivers and in the lake region in Woodville and Blooming Grove Townships and were adjacent to and in the central part of Freedom Township. Bur oak was the dominant kind of tree on the better drained sites, but there were some white oaks and red oaks. Elm and basswood were dominant on the wetter sites.

Tall prairie grasses and occasional oak groves covered the northeastern part of Blooming Grove Township, the southeastern part of Woodville Township, parts of St. Mary Township, and the southern part of Iosco

TABLE 13.—*Engineering test data* [1] *for soil*

Soil name and location	Parent material	Minnesota report No.	Depth	Horizon	Moisture-density [2]	
					Maximum dry density	Optimum moisture
		SS60	*Inches*		*Lb. per cu. ft.*	*Percent*
Clarion clay loam: NE. corner of NE¼SW¼ sec. 10, T. 108 N., R. 22 W. (Modal profile.)	Glacial till.	7187	0–9	Ap	99	20
		7188	15–25	B2	95	24
		7189	32–40	C1	111	15
NE. corner of NE¼NE¼ sec. 11, T. 105 N., R. 23 W. (Intermingled with Storden soils.)	Glacial till.	7193	0–5	Ap	99	18
		7194	5–12	B2	102	20
		7195	20–36	C2	110	16
SW¼SW¼ sec. 18, T. 107 N., R. 22 W. (Stronger horizonation than that in modal profile.)	Glacial till.	7190	0–8	Ap	96	23
		7191	12–20	B21	94	23
		7192	36–40	C	95	22
Glencoe clay loam: NW¼NE¼ sec. 16, T. 106 N., R. 23 W. (Modal profile.)	Glacial till.	7178	0–8	Ap	87	26
		7179	19–22	A3g	92	23
		7180	22–36	C1g	95	23
Glencoe silty clay loam: NE¼SW¼ sec. 1, T. 106 N., R. 24 W. (Thicker A1 horizon than that in modal profile.)	Glacial till.	7181	0–22	A1	73	36
		7182	22–36	A3g	100	20
		7183	36–60	C1g	86	30
SW¼SW¼ sec. 12, T. 108 N., R. 22 W. (Slight effervescence.)	Glacial till.	7184	0–10	Ap	84	29
		7185	14–32	A3g	93	20
		7186	32–42	C1g	97	21
Marna silty clay loam: SE¼SE¼ sec. 17, T. 107 N., R. 24 W. (Modal profile.)	Shallow lacustrine sediments over glacial till.	7196	0–7	Ap	81	32
		7197	18–30	B2	86	28
		7198	30–42	C1	93	24
NW¼NE¼ sec. 15, T. 106 N., R. 24 W. (Grumusol characteristics.)	Glacial till.	7202	0–8	Ap	82	28
		7203	22–36	B2g	86	28
		7204	36–48	C	94	25
Marna silty clay loam: SE¼SE¼ sec. 27, T. 107 N., R. 23 W. (Slight illuvial B horizon.)	Lacustrine sediments over glacial till.	7199	0–11	A1	76	36
		7200	28–42	B22	81	29
		7201	48–54	C2	97	22

[1] Tests performed by the Minnesota Department of Highways in cooperation with U.S. Department of Commerce, Bureau of Public Roads, in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Based on AASHO Designation T 99–57(*1*).Method C.

[3] Mechanical analyses according to AASHO Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure the fine material is analyzed by the hydrometer method and the

Township. The tall prairie grasses affected the development of the Clarion, Nicollet, and Webster soils. Except for oak groves near the streams and lakes, Wilton, New Richland, Byron, and Vivian Townships were in tall prairie grasses. Outliers of timber have persisted within the prairie areas, and outliers of prairie grasses have persisted within the timbered areas.

Most of the soils that developed under forest have recently been influenced by prairie grasses and are transitional between the Gray-Brown Podzolic and the Brunizem great soil groups. The soils of the grasslands show well-developed characteristics of Brunizems. In some areas, however, the textural development in the subsoil suggests the influence of forest vegetation. The influence of forest on soils that are lower in carbonates has resulted in a stronger horizonation within the profile. The rank growth of grass on the poorly drained prairie soils, such as the Webster, Marna, and Glencoe, has caused the soils to have a thick surface horizon and a large accumulation of organic matter.

Relief

Waseca County is in the Central Lowland province of the Western Young Drift section of the Interior Plains. It lies in a glaciated region characterized by young glaciated plains, moraines, lakes, and lacustrine beds.

The relief of this county is the product of a backwasting continental glacier. The glacial drift that was deposited was of such thickness that the underlying rock strata have had little effect on the configuration of *samples taken from nine soil profiles*

Mechanical analysis [3]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—							
¾ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO [4]	Unified [5]
-------	100	99	94	66	58	46	23	17	32	4	A-4(6)	ML.
-------	-------	100	97	86	76	58	36	29	44	16	A-7-6(11)	ML-CL.
100	96	92	82	57	48	33	20	12	32	12	A-6(5)	CL.
100	98	95	85	54	44	32	17	9	37	10	A-4(4)	ML.
100	98	94	85	57	48	38	26	21	39	14	A-6(6)	ML-CL.
100	93	88	79	56	45	35	19	14	31	11	A-6(5)	CL.
-------	100	99	94	70	58	40	24	19	41	12	A-7-6(8)	ML.
100	99	98	92	67	58	44	29	22	48	21	A-7-6(12)	ML-CL.
100	98	96	89	66	54	44	27	19	47	22	A-7-6(12)	CL.
-------	-------	100	95	78	73	59	35	-------	49	9	A-5(10)	ML.
-------	100	99	94	78	70	55	38	33	54	24	A-7-5(16)	MH-CH.
100	99	98	91	78	73	58	38	30	54	29	A-7-6(19)	CH.
-------	100	99	94	70	62	48	33	25	64	10	A-5(10)	MH.
-------	100	99	96	77	69	54	33	23	41	11	A-7-5(9)	ML.
-------	100	99	98	93	89	75	54	32	65	34	A-7-5(20)	MH-CH.
-------	-------	100	98	87	82	66	42	33	60	18	A-7-5(15)	MH.
-------	-------	100	99	89	86	70	45	36	57	26	A-7-5(17)	MH-CH.
-------	-------	100	99	91	84	69	39	31	54	27	A-7-6(18)	CH.
-------	100	99	96	84	76	62	35	23	50	14	A-7-5(12)	ML.
100	96	93	90	78	73	64	50	39	68	39	A-7-6(20)	CH.
100	96	94	88	67	60	50	35	26	50	24	A-7-6(14)	ML-CL.
100	99	97	95	84	80	64	42	32	55	18	A-7-5(14)	MH.
-------	100	99	97	92	90	82	67	55	76	42	A-7-5(20)	MH-CH.
100	96	88	81	64	54	46	32	22	46	19	A-7-6(10)	ML-CL.
-------	-------	100	97	89	83	66	40	30	64	23	A-7-5(17)	MH.
-------	-------	-------	100	98	98	93	74	64	82	44	A-7-5(20)	MH-CH.
100	96	93	85	62	54	42	30	24	45	21	A-7-6(10)	CL.

various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[4] Based on AASHO Designation M 145-49(*1*).

[5] Based on the "Unified Soil Classification System"(*9*). SCS and BPR have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification.

the surface relief. The relief ranges from nearly level in the lake plain and on ground moraines to rolling where the end moraines form a complex pattern. In the areas where there were scattered ice block depressions, a few large lakes have formed and there are many small depressions.

The main drainage channels were developed during the retreat of the glacier. They occur as abrupt gorges within the landscape. Secondary drainage was immature and needed extensive artificial development.

Two distinct types of morainic topography are in the county. One is a complex of short, uneven slopes with many, small, indistinct drainage patterns. The dominant soils where this topography prevails are the Clarion-Storden complexes and the Lester-Storden complexes. The other type of topography is a series of flat-topped, smooth-sided drumloids. The major soils on the drumloid hills are the Clarion, Lester, Webster, and Cordova.

Time

Geologically, the soils of this county are young. They were first exposed to the soil-forming processes between 8,000 and 10,000 years ago. Presuming, however, that most of the material was reworked drift carried by earlier glaciers, the weathering of minerals was somewhat advanced at the time of deposition. This is indicated by the dominance of montmorillinite clays in the soils (*2*). Some of the soils have clearly defined horizons, some have poorly defined horizons, and some

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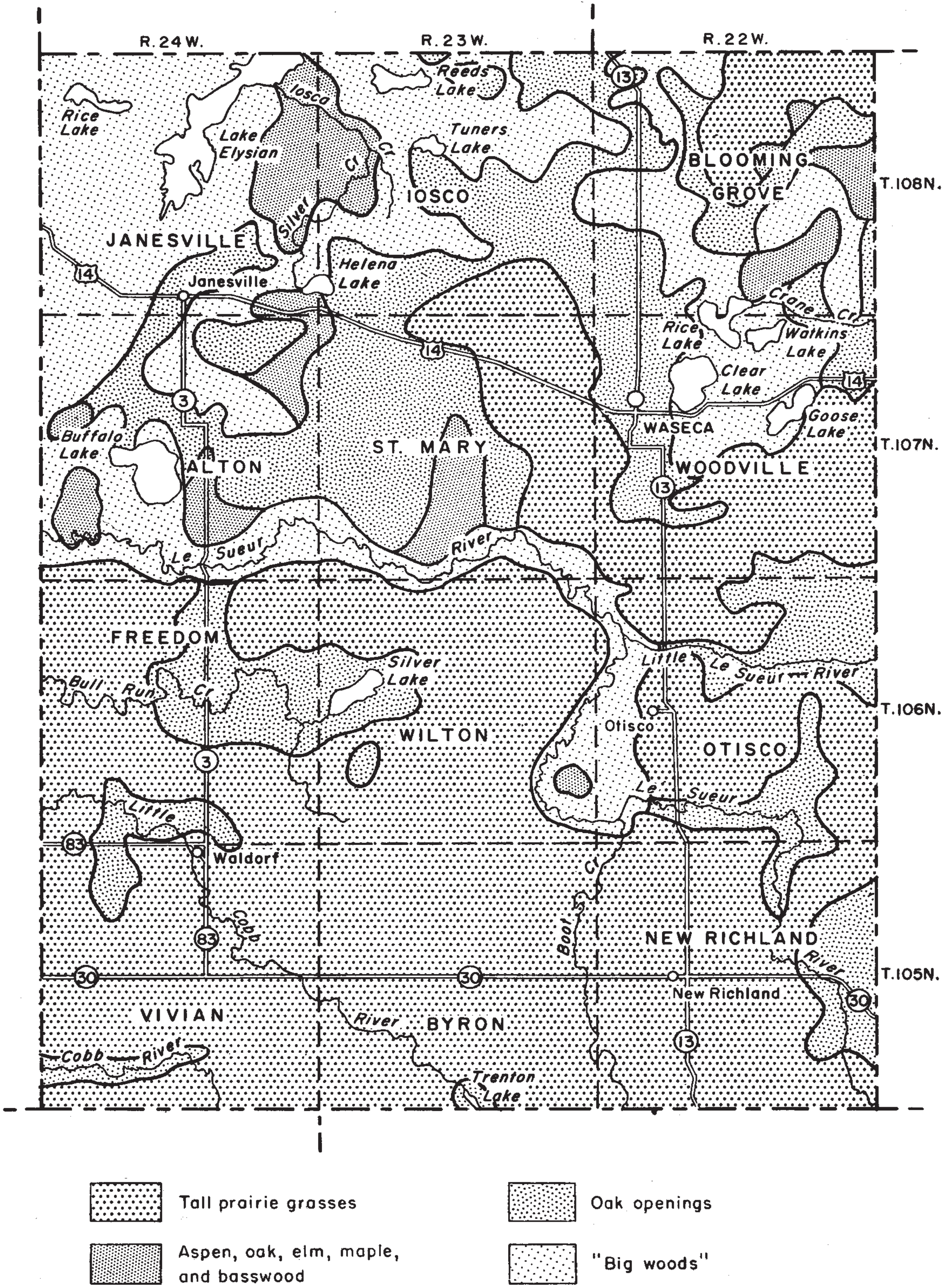

***Figure 15.*—Map showing the original distribution of vegetation in Waseca County.**

have horizons that are moderately well defined, depending upon the intensity of the weathering factors and the resistance to weathering.

The Lester and similar soils were exposed to a more intense influence of the five factors of soil formation than were the other soils in the county. As a result, they have moderately distinct layers, or horizons. The Webster soils have less pronounced horizons in the lower part of their profile than the Clarion soils. The Webster soils are in areas where a fluctuating water table modifies the normal effect of time. The Storden soils, which formed on steep slopes, are calcareous throughout, and they show little horizon development. Soils formed in alluvial deposits adjacent to the major drainageways have little or no profile development.

Processes in Soil Formation

The theories of soil formation reflect the state of knowledge of the soil science of their day. This knowledge includes the extent to which soil properties are recognized and understood.

Soils are natural bodies formed on the surface of the land. Individual bodies of soils are seldom set apart from their neighbors by sharp boundaries. Changes in the combined influence of soil-forming factors are generally manifest in a gradual shifting of properties, as one soil body grades to another.

Soil genesis (*7*) can be viewed as consisting of two steps: The accumulation of parent material, and the development of distinct properties in the profile. Soil properties develop through the interaction of the processes whereby additions, removals, transfers, and transformations of organic matter, silicate clays, silica, soluble salts, iron, aluminum oxides, and carbonates are made. The terms podzolization, calcification, gleization, and laterization stress the dominant processes in the development of soil properties. In this county the five factors of soil formation interact in such a way that three processes are dominant—podzolization, calcification, and gleization.

Podzolization (*9*) is the dominant soil-forming process in areas that have high humidity and forest vegetation. In this county the factors of climate and vegetation are marginal in the podzolization process.

Podzolization is expressed in the formation of the Gray-Brown Podzolic soils that grade toward Brunizems, such as soils of the Kilkenny, Lester, and Le Sueur series. The partial removal of organic matter, iron, and aluminum oxides results in a concentration of silica. This causes a slight graying in the color of the surface layer and a reduction in the thickness of the A horizon. In many areas the silica is concentrated and a thin, clearly expressed A2 horizon has developed; however, there are large areas where the A2 horizon is not clearly expressed.

The silicate clays and organic matter, which have been removed from the surface layer, accumulate in the B horizon as films along channels or on the faces of the structural aggregates. The accumulation of clay and organic matter, together with some weathering of silicate minerals in place, causes a distinct increase in the content of clay in the subsoil. The increase in carbonates in the lower part of the B horizon causes the organic material to precipitate out, and it forms prominent coatings on the surfaces of the structural aggregates just above the calcareous till.

In this county the intensity of the podzolization process is aided by variations in the amount of carbonates in the parent material. This is expressed in the stronger horizonation and thicker solum of the Kilkenny soils. Long-term variations in the climate have restricted the normal influence of timber on the soils of this county.

Calcification (*9*) is a process normally restricted to regions of the temperate zone where rainfall is 25 inches or less and the dominant vegetation is grass or brush. By this process, carbonates are redistributed in the profile but not entirely removed. Because of the low rainfall in this county, not enough water percolates through the profile to remove entirely the calcium carbonate that was originally in the parent material.

In the process of calcification, calcium and magnesium carbonates accumulate at some point in the profile that is at about the same depth as that to which the surface water most frequently percolates. A secondary result of the process is that the soil material becomes somewhat granular. The granulation results from the action of the carbonates on the clay colloids in this soil material. Also, because the colloids are thus influenced, there is little downward movement of colloids in the profile. The calcification process therefore involves the accumulation of carbonates in the soil and the absorption of calcium and magnesium ions by clay colloids.

Vegetation contributes in the formation of soils influenced by calcification. Grasses and other plants that require a relatively large amount of bases, particularly calcium, carry these bases to the surface through their roots. When the plants decay, the calcium is returned to the surface layer. The loss through leaching is partly offset in this way. Soils formed through the process of calcification therefore seldom have a strongly acid surface layer. The large accumulation of decayed grasses on the surface and to a depth of 8 to 16 inches causes organic matter, nitrogen, phosphorus, and sulfur to accumulate in the surface layer.

In this county the Brunizems were influenced by the process of calcification. They formed under higher rainfall, however, than is characteristic for soils where lime has accumulated in the profile. Because of the greater amount of rainfall, the average downward percolation of water in Brunizems under a good cover of grass may be such that there is no zone in which calcium carbonate has accumulated. Yet these soils possess a high degree of base saturation. The colloids of Brunizems normally are high in calcium, even though no free lime is present. In some areas the Brunizems of this county show evidence of relict properties of Gray-Brown Podzolic soils.

Generally the process of calcification causes soils to be fertile, and some of the soils whose development has been influenced by calcification are among the most productive of the soils in the Corn Belt. The Clarion soils of this county are typical.

Gleization (*9*) is a process that forms a horizon of light olive-gray or gray material immediately below the dark-colored surface layer. In this county this process occurs where a perched water table is at or slightly below the surface layer.

The gleization process is evident in the Webster, Marna, and associated poorly drained soils of Waseca County. These soils belong to the Humic Gley great soil group.

Some Humic Gley soils in this county developed in areas where the relief produced a fluctuating water table. This caused percolation to be offset by evaporation, and it resulted in the diffusion of free carbonates throughout the profile, a result of both gleization and solonization.

Soils that formed in small, shallow depressions exhibit a prominent A2 horizon and pronounced textural development in the B horizon. These characteristics are generally associated with areas where a low water table caused the removal of organic matter and silicate clays from the A1 horizon, the concentration of silica in the A2 horizon, and the accumulation of silicate clays and organic matter in the B horizon. This development seems to suggest some modification of the parent material prior to deposition. The soils in these depressions have properties of Planosols.

Soils that belong to the Bog great soil group developed in sites where abundant water encourages the luxuriant growth of reeds, sedges, and mosses. The organic matter from these plants decays slowly in very poorly drained areas. The plant remains accumulate faster than they decay, and organic matter, known as peat, accumulates. Where drainage is improved, the peat decays and oxidizes to form muck.

Classification of Soils

The purpose of this section is to help students of soils to classify the soils of this county in a natural or taxonomic system. This system groups soils by their differentiating properties. These properties are the product of the interaction of the five factors of soil formation, which are discussed under "Formation of Soils."

The broadest category used in the classification of soils is the order. In Waseca County all three orders—zonal, intrazonal, and azonal—are represented.

Zonal soils

Zonal soils have well-developed soil characteristics that reflect the dominant influence of climate and living organisms, chiefly climate. In this county the zonal soils are the Brunizems and Gray-Brown Podzolic soils that are intergrading toward Brunizems.

BRUNIZEMS

Brunizems formed under tall grasses in a relatively humid, temperate climate. They differ somewhat in parent material, relief, and drainage, but they all have a thick, dark A horizon; a brown B horizon that may or may not be mottled; and lighter colored parent material at a depth of 2 to 5 feet. These soils have a narrow carbon-nitrogen ratio and high base saturation that increases with increasing depth. They lack a horizon in which calcium carbonates have concentrated. The structure of these soils ranges from weak to moderate, and in most Brunizems the B horizon contains a slightly higher concentration of clay than the horizons in the rest of the profile.

In this county the Clarion, Dickinson, Estherville, Guckeen, Nicollet, Terril, Truman, and Wadena soils are in this great soil group.

Clarion Series.—Representative profile of a Clarion loam in a cultivated field (NE. corner of NE¼SW¼ sec. 10, T. 108 N., R. 22 W.):

Ap—0 to 9 inches, very dark brown (10YR 2/2) loam; cloddy; friable; slightly acid; abrupt boundary.

B1—9 to 15 inches, dark-brown (10YR 3/3) light clay loam with very dark brown (10YR 2/2) worm channels; weak, fine, subangular blocky structure; friable; slighty acid; clear boundary.

B2—15 to 25 inches, brown (10YR 4/3) light clay loam; dark yellowish-brown (10YR 4/4) when crushed; weak, fine and medium, subangular blocky structure; friable; slightly acid; clear boundary.

B3—25 to 32 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) light clay loam; weak, fine and medium, subangular blocky structure; friable; neutral; clear boundary.

C—32 to 40 inches, variegated grayish-brown (10YR 5/2) and light olive-brown (2.5Y 5/4 and 5/6) loam; tends to have a platy structure; friable; calcareous.

In some areas an A3 horizon is present, and in some areas there is no B3 horizon. Where the Clarion soils are mapped in complexes with the Storden soils, their profile ranges from the central concept to thin and weakly developed.

Dickinson Series.—Representative profile of a Dickinson fine sandy loam on a slope of 3 percent in a cultivated field (SW¼NW¼ sec. 10, T. 106 N., R. 22 W.):

Ap—0 to 8 inches, very dark brown (10YR 2/2) fine sandy loam; cloddy; very friable; slightly acid; abrupt boundary.

B21—8 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam that grades to loam; weak, very fine, subangular blocky structure; medium acid; clear boundary.

B22—16 to 22 inches, dark yellowish-brown (10YR 3/4) sandy loam; weak, very fine, subangular blocky structure; very friable; medium acid; clear boundary.

B31—22 to 30 inches, dark yellowish-brown (10YR 3/4 to 4/4) sandy loam that grades to loamy sand; single grain; loose; slightly acid; clear boundary.

IIB32—30 to 35 inches, dark yellowish-brown (10YR 3/4 to 4/4) loamy sand; single grain; loose; slightly acid; clear boundary.

IIC—35 to 42 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) sand that contains a few pebbles; structureless; loose; slightly calcareous.

In some places an A3 horizon is present. The substratum in a few areas contains thin seams or pockets of fine gravel. A few areas are leached of carbonates to a depth of 60 inches and deeper.

Representative profile of a Dickinson loam on a slope of 2 percent in a cultivated field (NE¼ sec. 2, T. 106 N., R. 22 W.):

A1—0 to 11 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; slightly acid; abrupt boundary.

A3—11 to 16 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) loam; weak, fine and medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B21—16 to 25 inches, very dark grayish-brown (10YR 3/2) loam; single grain; friable; medium acid; clear, wavy boundary.
B22—25 to 32 inches, dark-brown (10YR 3/3 to 4/3) loam grading to sandy loam; single grain; friable; slightly acid; abrupt, wavy boundary.
IIC—32 to 50 inches, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4) loamy sand; single grain; loose; neutral.

Estherville Series.—Representative profile of an Estherville sandy loam on a slope of 2 percent in a cultivated field (NE¼SE¼ sec. 1, T. 106 N., R. 22 W.):

Ap—0 to 6 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; friable; slightly acid; abrupt boundary.
A3—6 to 8 inches, very dark brown (10YR 2/2) and dark grayish-brown (10YR 4/2) sandy loam; weak, fine, granular structure; friable; slightly acid; clear boundary.
B21—8 to 12 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, fine, granular structure; friable; slightly acid; clear boundary.
B22—12 to 15 inches, dark-brown (10YR 4/3) coarse sandy loam; single grain; very friable; slightly acid; clear boundary.
B31—15 to 19 inches, dark-brown (7.5YR 3/2) gravelly sandy loam; single grain; loose; slightly acid; clear boundary.
B32—19 to 21 inches, dark yellowish-brown (10YR 4/4) medium loamy sand; single grain; loose; slightly acid; abrupt boundary.
C—21 to 24 inches, dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) gravel; single grain; loose; strongly calcareous.

In places the lower part of the B horizon contains prominent stains of clay and organic matter. In the lower part of the profile in some areas, there is an abrupt boundary between slightly acid and strongly calcareous soil material. In places there is a gradual boundary between weakly calcareous and strongly calcareous soil material.

Guckeen Series.—Representative profile of a Guckeen silty clay loam on a slope of 2 percent in a cultivated field (SW¼NW¼ sec. 7, T. 105 N., R. 24 W.):

A1p—0 to 8 inches, black (10YR 2/1) heavy silty clay loam; cloddy; friable; slightly acid; abrupt boundary.
A12—8 to 12 inches, black (10YR 2/1) silty clay; moderate, fine, subangular blocky structure; friable; medium acid; clear boundary.
A3—12 to 15 inches, very dark gray (10YR 3/1) silty clay; moderate, fine, subangular blocky structure; friable; medium acid; clear boundary.
B1—15 to 18 inches, dark grayish-brown (10YR 4/2) silty clay; interiors of the peds are grayish-brown (2.5Y 5/2); very dark gray (10YR 3/1) earthworm channels; strong, fine, angular blocky structure; very firm; medium acid; clear boundary.
B21—18 to 24 inches, dark grayish-brown (10YR 4/2) heavy clay loam; the interiors of the peds are grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4); moderate medium, prismatic structure that breaks to moderate, fine, subangular blocky; very firm; medium acid; prominent clay films and films of organic matter on the surfaces of the peds; clear boundary.
B22—24 to 30 inches, dark grayish-brown (10YR 4/2) heavy clay loam; the interiors of the peds are grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4); moderate, coarse, prismatic structure that breaks to moderate, fine and medium, subangular blocky; friable; neutral; clear boundary.
C—30 to 52 inches, dark grayish-brown (10YR 4/2) clay loam; the interiors of the peds are grayish brown (2.5Y 5/2) to olive gray (5Y 5/2); many, fine, distinct, olive (5Y 5/6) mottles; few, medium, prominent, red (2.5YR 4/8) mottles; massive; friable; slightly calcareous.

The texture of the surface layer ranges from a silty clay loam to silty clay. The material in the surface layer is less modified in some areas than in others. A few areas suggest a relict timber influence.

Nicollet Series.—Representative profile of a Nicollet clay loam on a slope of 3 percent in a cultivated field (SW. corner of SW¼SE¼ sec. 1, T. 105 N., R. 23 W.):

Ap—0 to 9 inches, black (10YR 2/1) light clay loam; cloddy; friable; medium acid; abrupt boundary.
A3—9 to 15 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine and medium, subangular blocky structure; friable; medium acid; clear boundary.
B21—15 to 24 inches, dark-gray (10YR 4/1) to dark grayish-brown (10YR 4/2) light clay loam; crushes to grayish brown (10YR 5/2) or brown (10YR 5/3); weak to moderate, fine, subangular blocky structure; friable, medium acid, clear boundary.
B22—24 to 40 inches, grayish-brown (2.5Y 5/2) light clay loam that has many, fine, distinct mottles of light olive brown (2.5Y 5/6); weak to moderate, fine, subangular blocky structure; friable; slightly acid; clear boundary.
B3—40 to 44 inches, olive-gray (5Y 5/2) light clay loam that has many, fine, distinct, olive (5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear boundary.
C—44 to 51 inches, olive-gray (5Y 5/2) light clay loam; many, medium, distinct mottles of olive (5Y 5/6) and red (2.5YR 4/8); massive; friable; slightly calcareous.

In some areas there is a B1 instead of an A3 horizon. In places the B2 horizon grades directly to the C horizon.

Terril Series.—Representative profile of a Terril loam in a cultivated field (NW¼NE¼ sec. 15, T. 108 N., R. 22 W.):

A1p—0 to 9 inches, very dark gray (10YR 3/1) loam; cloddy; friable; slightly acid; abrupt, smooth boundary.
A12—9 to 18 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; weak, fine, granular structure; friable; slightly acid; clear, wavy boundary.
A31—18 to 24 inches, very dark brown (10YR 2/2) loam; weak, very fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.
A32—24 to 28 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam that has a few, fine, faint mottles of grayish brown (2.5Y 5/2) and distinct mottles of reddish brown (5YR 4/4); weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.
C1—28 to 34 inches, dark grayish-brown (2.5Y 4/2) and olive-gray (5Y 5/2) loam; weak, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.
C2—34 to 42 inches, olive-gray (5Y 5/2) loam that has common, medium, distinct mottles of yellowish brown (10YR 5/8); weak, fine, subangular blocky structure; friable; neutral; abrupt boundary.
C3—42 to 48 inches, olive-gray (5Y 5/2) loam that has common, medium, distinct mottles of yellowish brown (10YR 5/8); massive; friable; strongly calcareous.

Truman Series.—Representative profile of a Truman silt loam on a slope of 4 percent in a cultivated field (SE¼NE¼ sec. 31, T. 106 N., R. 22 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) silt loam; cloddy; friable; neutral; abrupt boundary.
A3—6 to 11 inches, very dark gray (10YR 3/1) silt loam; moderate, fine, subangular blocky structure; friable; dark grayish-brown (2.5Y 4/2) worm channels; slightly acid; gradual boundary.
B21—11 to 17 inches, yellowish-brown (10YR 5/4) silt loam; moderate, fine, subangular blocky structure; friable; a few dark-gray (10YR 4/1) worm channels; slightly acid; clear boundary.

B22—17 to 28 inches, yellowish-brown (10YR 5/4) silt loam; moderate, fine and medium, subangular blocky structure; friable; a few grayish-brown (10YR 5/2) worm channels; neutral.

C—28 to 36 inches, light olive-brown (2.5Y 5/4) silt loam that has many, light brownish-gray (2.5Y 6/2) streaks of lime; moderate, fine, subangular blocky structure; friable; strongly calcareous.

Depth to calcareous material ranges from 20 to 32 inches.

Wadena Series.—Representative profile of a Wadena loam in a cultivated field (NE¼NW¼ sec. 11, T. 108 N., R. 24 W.):

Ap—0 to 9 inches, very dark brown (10YR 2/2) loam; cloddy; friable; slightly acid; abrupt boundary.

A3—9 to 15 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; medium acid; clear boundary.

B21—15 to 25 inches, dark-brown (10YR 3/3) loam; weak, fine, subangular blocky structure; friable; slightly acid; abrupt boundary.

B22—25 to 32 inches, dark-brown (10YR 3/3) to brown (10YR 4/3) loam to sandy loam that contains a few pebbles; single grain; very friable; slightly acid; abrupt boundary.

C—32 to 42 inches, variegated dark yellowish-brown (10YR 4/4), brown (10YR 5/3), and pale-brown (10YR 6/3), partly stratified gravel that contains seams and pockets of sand; single grain; loose; strongly calcareous.

The surface layer in many places contains a few fine pebbles. In a few small areas, it contains a considerable amount of coarse gravel.

GRAY-BROWN PODZOLIC SOILS

Gray-Brown Podzolic soils formed under deciduous forest in a humid, temperate climate. The soils of this group have a thin organic covering; a thin organic-mineral layer; a grayish-brown leached layer; and a brown B horizon that is richer in clay than the overlying layer. In this county there are no soils that represent the central concept of Gray-Brown Podzolic soils, but some soils have characteristics of both these soils and of Brunizems.

Gray-Brown Podzolic soils intergrading toward Brunizems.—The Lester, Kilkenny, and Le Sueur soils have some characteristics of Gray-Brown Podzolic soils, but they also have characteristics like those of the Brunizems. They formed partly under deciduous forest and partly under tall grasses.

These soils differ somewhat in relief and drainage, but they have a thick, dark surface layer, a thin eluvial horizon below the surface layer, and a significant increase in content of clay in the underlying illuvial horizon. They are also characterized by a narrow carbon-nitrogen ratio, high base saturation, and moderate to strong structure. In many places the lower part of the B horizon has prominent stains of clay and organic matter. Laboratory data for the Lester and Kilkenny soils are given in the section "Laboratory Determinations." The following profile is typical of this group:

Kilkenny Series.—Representative profile of a slightly eroded Kilkenny clay loam on a slope of 5 percent (NW¼SE¼ sec. 6, T. 107 N., R. 22 W.):

Ap—0 to 8 inches, very dark gray (10YR 3/1) clay loam that dries to dark gray (10YR 4/1) or gray (10YR 5/1); cloddy; friable; medium acid; abrupt boundary.

B1—8 to 12 inches, very dark brown (10YR 2/2) to dark brown (10YR 3/3) clay loam that crushes to very dark grayish brown (10YR 3/2); weak, fine, subangular blocky structure; friable; very dark gray (10YR 3/1) worm channels; strongly acid; clear, wavy boundary.

B21—12 to 22 inches, very dark grayish-brown (10YR 3/2) heavy clay loam; the interiors of the peds are dark grayish brown (10YR 4/2); moderate, fine and medium, subangular blocky structure; firm; clay films and films of organic matter are thick and continuous; very strongly acid; clear, wavy boundary.

B22—22 to 32 inches, dark grayish-brown (2.5Y 4/2) heavy clay loam; the interiors of the peds are dark grayish brown (10YR to 2.5Y 4/2); strong, medium prisms that break to strong, medium, angular blocky structure; very firm; plastic; grains of bleached quartz and very fine silt flour are prominent on the surfaces of the peds; clay films and films of organic matter are thick and continuous; very strongly acid; clear, wavy boundary.

B23—32 to 39 inches, dark grayish-brown (2.5Y 4/2) heavy clay loam; the interiors of the peds are grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4); few, fine, faint mottles of yellowish brown (10YR 5/4); moderate, coarse, prismatic structure; very firm; clay films and films of organic matter are thick and continuous; many fine, rounded pebbles of shale; very strongly acid; clear, wavy boundary.

B3—39 to 47 inches, dark grayish-brown (2.5Y 4/2) to very dark grayish-brown (2.5Y 3/2) clay loam; the interiors of the peds are grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4); common, fine, faint mottles of yellowish brown (10YR 5/6); moderate, coarse prisms; very firm; clay films and films of organic matter are thick and continuous; many fine, rounded pebbles of shale; very strongly acid; abrupt boundary.

C—47 to 54 inches, olive (5Y 5/3 and 5/4) clay loam; many small, rounded pebbles of lime and shale; few reddish mottles; massive; firm; slightly calcareous.

In some places in this county, the Kilkenny soils appear to have formed under moderately good drainage.

Lester Series.—Representative profile of a slightly eroded Lester clay loam on a slope of 4 percent in a cultivated field (NW¼SE¼ sec. 7, T. 108 N., R. 22 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) light clay loam that dries to dark gray (10YR 4/1); friable; medium acid; abrupt boundary.

A2—6 to 9 inches, very dark brown (10YR 2/2) light clay loam; weak, thin, platy structure; friable; medium acid; clear, wavy boundary.

B1—9 to 13 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) light clay loam; moderate, fine, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B21—13 to 22 inches, dark grayish-brown (10YR 4/2) clay loam; crushes to dark brown (10YR 4/3) or dark yellowish brown (10YR 4/4); strong, fine and medium, subangular blocky structure; firm; medium acid; clay films and coatings of organic matter are thin and continuous; clear, wavy boundary.

B22—22 to 30 inches, dark grayish-brown (10YR 4/2) clay loam; crushes to dark brown (10YR 4/3) or dark yellowish brown (10YR 4/4); moderate, medium, prismatic structure that breaks to moderate, fine and medium, subangular blocky structure; firm; medium acid; clay films and stains of organic matter are thick and continuous; clear, wavy boundary.

B3—30 to 36 inches, very dark brown (10YR 2/2) clay loam; prominent stains of organic matter are on the oblique cleavage surfaces of peds, and the interiors of the peds are dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4); massive, but there are a few, prominent, oblique cleavage planes; friable; slightly acid; abrupt boundary.

C—36 to 40 inches, light olive-brown (2.5Y 5/4 and 5/6) loam to clay loam; massive; friable; strongly calcareous.

Where the Lester soils are mapped in complexes with the Storden soils, their profile ranges from the central concept to thin and weakly developed.

Representative profile of Lester fine sandy loam, sandy variant, on a slope of 3 percent in a grove of basswood trees (NW¼NW¼ sec. 1, T. 106 N., R. 22 W.):

A1—0 to 4 inches, very dark brown (10YR 2/2) fine sandy loam; crushes to very dark grayish brown (10YR 3/2); weak, fine, granular structure; very friable; medium acid; abrupt boundary.

A3—4 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, crumb structure; very friable; medium acid; abrupt boundary.

B1—8 to 13 inches, dark grayish-brown (10YR 4/2) fine sandy loam; weak, fine, subangular blocky structure, very friable; medium acid; clear boundary.

B21—13 to 17 inches, dark grayish-brown (10YR 4/2) loam; weak, fine, subangular blocky structure; very friable; medium acid; clear boundary.

B22—17 to 25 inches, dark-brown (10YR 3/4) loam that grades to clay loam; crushes to brown (10YR 5/3); moderate, fine, subangular blocky structure; friable; thick, continuous clay films and films of organic matter on the surfaces of peds; bleached grains of quartz are common; medium acid; clear boundary.

B23—25 to 30 inches, dark-brown (10YR 4/3) clay loam; moderate, fine, subangular blocky structure; friable; thin, continuous clay films and films of organic matter on the surfaces of peds; bleached grains of quartz are common; medium acid; clear boundary.

B3—30 to 36 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) clay loam; massive; friable; very dark grayish-brown (10YR 3/2), fine root channels; slightly acid; clear boundary.

C1—36 to 42 inches, light olive-brown (2.5Y 5/4) clay loam; very dark grayish-brown (10YR 3/2) root channels; massive; friable; neutral; abrupt boundary.

C2—42 to 53 inches +, variegated light olive-brown (2.5Y 5/2, 5/4, and 5/6) clay loam; massive; friable; strong effervescence.

Le Sueur Series.—Representative profile of a Le Sueur clay loam in a small oak grove (NE¼NW¼ sec. 13, T. 105 N., R. 22 W.):

A1—0 to 7 inches, black (10YR 2/1) clay loam; moderate, fine, granular structure; friable; slightly acid; clear boundary.

A3—7 to 9 inches, very dark gray (10YR 3/1) clay loam; crushes to very dark grayish brown (10YR 3/2); moderate, fine, subangular blocky structure; friable; slightly acid; clear boundary.

B1—9 to 13 inches, very dark gray (10YR 3/1) clay loam; crushes to very dark grayish brown (10YR 3/2); moderate, fine and medium, subangular blocky structure; firm; thick, continuous clay films and films of organic matter on the surfaces of the peds; medium acid; clear boundary.

B21—13 to 19 inches, very dark grayish-brown (10YR 3/2) clay loam; crushes to dark grayish brown (10YR 4/2); strong, fine, angular blocky structure; firm; thick, continuous clay films and films of organic matter on the surfaces of the peds; medium acid; clear boundary.

B22—19 to 27 inches, very dark grayish-brown (10YR 3/2) clay loam; crushes to dark grayish brown (10YR 4/2); moderate, fine, prismatic structure that breaks to strong, fine, angular blocky; firm; thick, continuous clay films and films of organic matter on the surfaces of the peds; strongly acid; clear boundary.

B23—27 to 32 inches, very dark grayish-brown (2.5Y 3/2) heavy clay loam; the interiors of the peds are dark grayish brown (2.5Y 4/2); moderate, fine, prismatic structure that breaks to strong, medium, angular blocky; firm; thick, continuous clay films and films of organic matter on the surfaces of the peds; strongly acid; clear boundary.

B24—32 to 41 inches, dark grayish-brown (2.5Y 4/2) clay loam; the interiors of the peds are olive brown (2.5Y 4/4); moderate, medium, prismatic structure; firm; thick, continuous clay films and films of organic matter on the surfaces of the peds; strongly acid; clear boundary.

B3—41 to 48 inches, variegated olive-gray (5Y 5/2) and olive (5Y 5/3 and 5/4) clay loam that contains many, fine, very dark gray (10YR 3/1) root channels; massive; firm; slightly acid; abrupt boundary.

C—48 to 54 inches, variegated grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) loam to light clay loam; massive; friable; strongly calcareous.

Intrazonal soils

Intrazonal soils have more or less well-developed soil characteristics that reflect the dominating influence of relief or parent material over climate and vegetation. Relief influences the drainage under which soils develop. The water table in this county is fluctuating in some places and permanently at or near the surface in others. In most places it is 12 to 24 inches below the surface. Even a slight elevation in relief causes a lower water table. In some areas where there is an elevation in relief, the lower water table favors the growth of forest vegetation, and the process of podzolization has been accentuated. In depressions the fluctuation of the water table allowed evaporation to take place in areas adjacent to the water, and as a result, free carbonates are diffused throughout the profile of those soils.

In this county the intrazonal soils are Humic Gley soils, Humic Gley soils intergrading toward Gray-Brown Podzolic soils, Humic Gley soils intergrading toward Alluvial soils, Planosols that are intergrading toward Gray-Brown Podzolic soils, and Bog soils.

HUMIC GLEY SOILS

The Humic Gley great soil group consists of poorly or very poorly drained soils that have a thick, black A horizon that is high in content of organic matter. Below the surface layer is a gray or mottled B or C horizon. These soils have a narrow carbon-nitrogen ratio and high base saturation that increases with increasing depth. Their structure ranges from weak to moderate. The soils formed under marsh plants or swamp forest in a subhumid, cool-temperate to warm-temperate climate, from different kinds of parent material.

The Biscay, Canisteo, Glencoe, Lura, Marna, Talcot, and Webster soils are in the Humic Gley great soil group. In some areas where the Glencoe soils have not been drained, they have a thin layer of organic matter on the surface. The Lura and Marna soils in the northern part of the county have a slight increase in content of clay in the B horizon.

Biscay Series.—Representative profile of Biscay loam in a drainageway in a cultivated field (NE¼NE¼ sec. 13, T. 107 N., R. 23 W.):

A1—0 to 16 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A3g—16 to 20 inches, dark grayish-brown (2.5Y 4/2) loam that contains tongues of very dark gray (10YR 3/1); weak, fine, subangular blocky structure; friable; neutral; clear boundary.

C1g—20 to 29 inches, grayish-brown (2.5Y 5/2) loam; weak fine, subangular blocky structure; friable; neutral; clear boundary.

C2g—29 to 39 inches, light brownish-gray (2.5Y 6/2) loam; weak, very fine, subangular blocky structure; friable; calcareous; clear boundary.

C3—39 to 48 inches, yellowish-brown (10YR 5/6), olive (5Y 5/6), and grayish-brown (2.5Y 5/2) coarse sand and gravel; calcareous.

Canisteo Series.—Representative profile of Canisteo clay loam in virgin sod (NE¼SE¼ sec. 36, T. 105 N., R. 24 W.):

A1—0 to 12 inches, black (10YR 2/1) clay loam; weak, fine, subangular blocky structure; friable; calcareous; gradual boundary.

A3—12 to 19 inches, very dark gray (10YR 3/1) to black (10YR 2/1) clay loam; weak, fine, crumb structure; friable; calcareous; gradual boundary.

C1g—19 to 26 inches, very dark grayish-brown (2.5Y 3/2) to dark grayish-brown (2.5Y 4/2) clay loam; weak, fine, crumb structure; friable; calcareous; clear boundary.

C2g—26 to 33 inches, olive-gray (5Y 5/2) clay loam; weak, fine, subangular blocky structure; friable; calcareous; clear boundary.

C3g—33 to 42 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay loam matrix that has a few, fine, distinct mottles of light olive brown (2.5 5/6); massive; friable; strongly calcareous.

Representative profile of Canisteo clay loam, depressional, in a pit in Blooming Grove Township (SW¼ sec. 12, T. 108 N., R. 22 W.):

A1p—0 to 10 inches, black (N 2/0) clay loam; cloddy; slightly plastic; calcareous; abrupt boundary.

A12—10 to 24 inches, black (N 2/0) clay loam; weak, fine and medium, subangular blocky structure; calcareous; clear, smooth boundary.

A3g—24 to 32 inches, very dark gray (10YR 3/1) clay loam that has streaks of olive (5Y 4/3); weak, fine and medium, subangular blocky structure; slightly plastic; calcareous; clear, smooth boundary.

Cg—32 to 42 inches, olive-gray (5Y 5/2) clay loam that has streaks of olive (5Y 5/6) and very dark gray (10YR 3/1); massive, slightly plastic; dark-gray (5Y 4/1) krotovinas; a few, soft, white lime concretions; calcareous.

This site has slight effervescence throughout the profile.

Glencoe Series.—Representative profile of Glencoe silty clay loam in a drainageway in a cultivated field (NW¼SE¼ sec. 16, T. 106 N., R. 23 W.):

A1p—0 to 8 inches, black (N 2/0) silty clay loam; cloddy; friable; neutral; abrupt boundary.

A12—8 to 19 inches, black (N 2/0) silty clay loam; moderate, fine, subangular blocky structure; friable; neutral; clear boundary.

A3g—19 to 22 inches, dark-gray (5Y 4/1) silty clay loam that contains tongues of very dark gray (5Y 3/1); moderate, fine, subangular blocky structure; neutral; gradual boundary.

C1g—22 to 36 inches, olive-gray (5Y 5/2) clay loam that has a few, fine, distinct mottles of light olive brown (2.5Y 5/6); weak, fine, subangular blocky structure; friable; neutral; abrupt boundary.

C2—36 to 42 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam that has many, fine, distinct mottles of light olive brown (2.5Y 5/6); massive; friable; strongly calcareous.

Lura Series.—Representative profile of Lura silty clay loam (SW¼NE¼ sec. 15, T. 106 N., R. 24 W.):

A1p—0 to 9 inches, black (N 2/0) heavy silty clay loam; cloddy; firm; slightly acid; abrupt boundary.

A12—9 to 18 inches, black (N 2/0) silty clay; moderate, medium, angular blocky structure; firm; slightly acid; clear boundary.

A3—18 to 27 inches, black (10YR 2/1) silty clay; moderate, coarse, prismatic structure; firm; slightly acid; clear boundary.

B21g—27 to 37 inches, very dark gray (10YR 3/1) silty clay; moderate, coarse and medium, prismatic structure that breaks to strong, fine and medium, subangular blocky; very firm; slightly acid; thin, continuous clay films and films of organic matter are on the surfaces of the peds; clear boundary.

B22g—37 to 47 inches, dark-gray (5Y 4/1) heavy silty clay loam; the interiors of the peds are olive gray (5Y 4/2); moderate, fine and medium, prismatic structure that breaks to strong, fine and medium, angular blocky; very thick, continuous clay films and films of organic matter are on the surfaces of the peds; very firm, slightly acid; clear boundary.

B3g—47 to 62 inches, dark-gray (5Y 4/1) clay loam; the interiors of the peds are olive gray (5Y 4/2); moderate, coarse, prismatic structure; friable; prominent clay films and films of organic material are on the surfaces of the peds; neutral; abrupt boundary.

C—62 to 82 inches, olive-gray (5Y 4/2) clay loam that has many, coarse, prominent, brown (7.5YR 4/4) mottles; massive; friable; slightly calcareous.

The texture of the surface layer ranges from heavy silty clay loam to silty clay. The lacustrine sediments in which these soils formed range from 20 to 60 inches in thickness.

Marna Series.—Representative profile of Marna silty clay loam in a cultivated field (SE. corner of SE¼ SE¼ sec. 17, T. 107 N., R. 24 W.):

A1p—0 to 7 inches, black (N 2/0) heavy silty clay loam; cloddy; firm; neutral; abrupt boundary.

A12—7 to 12 inches, black (N 2/0) silty clay; moderate, very fine, subangular blocky structure; firm; neutral; clear boundary.

A3—12 to 18 inches, dark grayish-brown (2.5Y 4/2) silty clay that contains tongues of black (10YR 2/1); moderate, very fine, subangular blocky structure; firm; neutral; clear boundary.

B2g—18 to 30 inches, dark grayish-brown (2.5Y 4/2) silty clay; many, medium, prominent mottles of yellowish brown (10YR 5/8); the interiors of the peds are olive brown (2.5Y 4/4); moderate, coarse, prismatic structure that breaks to fine and medium, angular blocky; firm; neutral; clear boundary.

C—30 to 42 inches, olive (5Y 4/3) silty clay loam that has many, fine, distinct mottles of grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4 and 5/6); massive; friable; slightly calcareous.

The texture of the surface layer ranges from silty clay to silty clay loam. In some places material in the surface layer has been modified and grades abruptly to the underlying till. In some areas the structure of the subsoil is subangular blocky. In other areas the structure is medium prismatic instead of coarse prismatic, but it breaks readily to subangular blocky structure.

Talcot Series.—Representative profile of Talcot silty clay loam (NW¼NW¼ sec. 17, T. 107 N., R. 24 W.):

A1p—0 to 8 inches, black (N 2/0) silty clay loam; weak, fine, granular structure; friable; neutral; abrupt boundary.

A12—8 to 17 inches, black (N 2/0) clay loam; weak, fine, granular structure; mildly alkaline; gradual boundary.

A3g—17 to 24 inches, very dark gray (10YR 3/1) clay loam; dark grayish-brown (2.5Y 4/2) earthworm channels; weak, fine, granular structure; friable; mildly alkaline; clear boundary.

B2g—24 to 28 inches, dark-gray (5Y 4/1) clay loam; weak, fine, granular structure; friable; very dark grayish-brown (10YR 3/1) earthworm channels; mildly alkaline; clear boundary.

IIC1g—28 to 32 inches, light olive-brown (2.5Y 5/4 and 5/6) coarse gravelly sandy loam; single grain; loose; strong effervescence; abrupt boundary.

IIC2—32 to 36 inches, variegated olive-gray (5Y 5/2) and olive (5Y 5/3 and 5/4) coarse sand and gravel; single grain; loose; strong effervescence when a 10 percent solution of hydrochloric acid is added.

The texture of the surface layer ranges from silty clay loam to clay loam. In places the surface layer is mildly alkaline.

Webster Series.—Representative profile of Webster clay loam in a nearly level cultivated field (NE¼NE¼ sec. 10, T. 105 N., R. 23 W.):

Ap—0 to 10 inches, black (10YR 2/1) clay loam; cloddy; friable; neutral; abrupt boundary.

A1—10 to 15 inches, black (10YR 2/1) clay loam; weak, very fine, subangular blocky structure; friable; neutral; gradual boundary.

C1g—15 to 22 inches, grayish-brown (2.5Y 5/2) clay loam; very dark gray (10YR 3/1) earthworm channels; weak to moderate, very fine, subangular blocky structure; friable; neutral; clear boundary.

C2g—22 to 42 inches, variegated olive-gray (5Y 5/2) and olive (5Y 5/3) clay loam that has many, fine, distinct mottles of light olive brown (2.5Y 5/6); weak, very fine, subangular blocky structure; friable; strongly calcareous.

The texture of the surface layer ranges to silty clay loam. In some places, particularly where this soil is adjacent to depressions occupied by the Glencoe soils, there are small calcareous areas. Thin seams or pockets of coarser textured material occur in places.

Humic Gley soils intergrading toward Gray-Brown Podzolic soils.—The Cordova soils have some characteristics of Humic Gley soils and some characteristics of Gray-Brown Podzolic soils. They have a thick, dark surface layer, a thin eluvial horizon in most places, and a significant increase in the content of clay in the B horizon. They also have a narrow carbon-nitrogen ratio and high base saturation. The structure in the B horizon is moderate. Prominent films of organic matter are on the aggregates in the lower part of the B horizon.

Cordova Series.—Representative profile of Cordova silty clay loam which is typical of this group, in a grove of bur oaks on a slope of less than 1 percent (SE¼SE¼ sec. 30, T. 108 N., R. 22 W.):

A1—0 to 8 inches, black (N 2/0) light silty clay loam; very dark gray (10YR 3/1) when dry; weak, fine, granular structure; friable; slightly acid; clear boundary.

A2—8 to 10 inches, very dark gray (10YR 3/1) silt loam; very dark gray (10YR 3/1) to dark gray (10YR 4/1) when dry; weak, very fine, subangular blocky structure; friable; medium acid; abrupt to clear boundary.

B1g—10 to 14 inches, very dark gray (10YR 3/1) and very dark grayish-brown (2.5Y 3/2) silty clay loam; weak, very fine, subangular blocky structure; friable; medium acid; clear, wavy boundary.

21g—14 to 22 inches, dark-gray (5Y 4/1) to olive-gray (5Y 4/2) silty clay; moderate, fine and medium, subangular blocky structure; very firm; clay films and films of organic matter are thin and continuous; medium acid; clear, wavy boundary.

B22g—22 to 29 inches, very dark gray (10YR 3/1) to dark gray (10YR 4/1) heavy clay loam; the interiors of the peds are dark gray (5Y 4/1) to olive gray (5Y 4/2); few, fine, faint, olive (5Y 4/3) mottles; moderate, medium, prismatic structure that breaks to moderate, fine, angular blocky; very firm; black (10YR 2/1) fillings of organic matter in the root channels; clay films and films of organic matter are thick and continuous on the surfaces of the prisms and thin and continuous to thin and patchy on the horizontal surfaces of the blocky peds; medium acid; clear, wavy boundary.

23g—29 to 35 inches, very dark gray (10YR 3/1) to dark gray (10YR 4/1) heavy clay loam; the interiors of the peds are dark gray (5Y 4/1) to olive gray 5Y 4/2); common, fine, faint, olive (5Y 4/3) mottles; moderate, medium, prismatic structure that breaks to moderate, fine, angular blocky; very firm; black (10YR 2/1) fillings of organic matter in the root channels; clay films and films of organic matter are thick and continuous on the vertical surfaces of the peds and thin and continuous to thin and patchy on the horizontal surfaces of the blocky peds; slightly acid; abrupt, wavy boundary.

C1—35 to 39 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/8) where there is oxidized shale; moderate, very fine, subangular blocky structure with a tendency to vertical cleavage; firm; many, thin, black (10YR 2/1) fillings of organic matter in the root channels; calcareous; clear, wavy boundary.

C2—39 to 42 inches, variegated olive (5Y 5/3 and 5/6) and light olive-brown (2.5Y 5/6) clay loam; firm; massive; a few black (10YR 2/1) fillings of organic matter in the root channels; some lime distributed in a feathered pattern; calcareous.

Humic Gley soils intergrading toward Alluvial soils.—The Colo soils have some characteristics of Humic Gley soils and some charateristics of Alluvial soils. They have a thick, dark surface layer, a narrow carbon-nitrogen ratio, and high base saturation that increases with increasing depth. Their structure is weak. The following profiles are typical of this group:

Colo Series.—Representative profile of Colo silty clay loam (SE¼NW¼ sec. 25, T. 107 N., R. 24 W.):

A1p—0 to 8 inches, black (N 2/0) silty clay loam; cloddy; firm; neutral; abrupt boundary.

A12—8 to 20 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure; firm; neutral; gradual boundary.

A3g—20 to 24 inches, very dark gray (10YR 3/1) silty clay loam; weak fine, subangular blocky structure; firm; neutral; gradual boundary.

C1g—24 to 28 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) silty clay loam that has a few, fine, distinct mottles of light olive brown (2.5Y 5/6); weak, fine, subangular blocky structure; firm; neutral; gradual boundary.

C2g—28 to 54 inches, olive-gray (5Y 5/2) silty clay loam; common, medium, prominent mottles of dark brown (7.5YR 4/4); weak, fine, subangular blocky structure; firm; neutral.

Representative profile of Colo silty clay loam, very wet, in a depression within a glacial channel (NE¼NW¼ sec. 11, T. 108 N., R. 24 W.):

A11—0 to 9 inches, black (N 2-0) silty clay loam; highly organic; weak, fine, granular structure; neutral; gradual boundary.

A12—9 to 20 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual boundary.

A3g—20 to 30 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual boundary.

Cg—30 to 48 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) silty clay loam; weak, fine, subangular blocky structure to massive; friable; common, dark-brown (7.5YR 3/2) iron stains or root channels where sedges have grown; strongly calcareous.

In some areas remnants of snail shells are common in the A11 horizon. Also in some areas the Cg horizon contains thin layers of sandy loam, silt loam, and silty clay loam.

PLANOSOLS

The soils of the Planosol great soil group formed under grass or forest vegetation in nearly level upland areas in a humid or subhumid climate. These soils have an eluviated surface layer underlain by a B horizon that is more strongly illuviated, cemented, or compacted than that of the associated normal soils. None of the soils of this county are representative of this central concept, although some soils have some characteristics of Planosols.

Planosols intergrading toward Gray-Brown Podzolic soils.—The Dundas soils have some characteristics of Planosols and some characteristics of Gray-Brown Podzolic soils. These soils have a dark surface layer and a distinct eluvial horizon just below the surface layer. They also have a distinctly greater clay content in the B horizon, but they lack the prominent clay horizon that is typical of Planosols. The Dundas soils have high base saturation. The structure in the B horizon is moderate to strong. In the lower part of the horizon, prominent films of organic matter are on the surfaces of the peds.

Dundas Series.—Representative profile of Dundas silt loam, which is typical of this group, in a cultivated field on a slope of less than 1 percent (SW¼NW¼ sec. 19, T. 106 N., R. 23 W.):

A1p—0 to 7 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam that crushes to very dark gray (10YR 3/1) and dries to dark gray (10YR 4/1) or gray (10YR 5/1); cloddy; friable; slightly acid; abrupt boundary.

A2—7 to 10 inches, very dark gray (10YR 3/1) to dark gray (10YR 4/1) silt loam; crushes to dark gray (10YR 4/1) and dries to gray (10YR 5/1); weak, medium, platy structure; friable; medium acid; clear boundary.

B1—10 to 17 inches, dark-gray (10YR 4/1) to dark grayish-brown (10YR 4/2) silty clay loam; moderate, fine, subangular and angular blocky structure; firm; bleached grains of quartz are common; thin, continuous clay films and films of organic matter are on the surfaces of the peds; very strongly acid; clear boundary.

B22—17 to 23 inches, very dark grayish-brown (2.5Y 3/2) to dark grayish-brown (2.5Y 4/2) silty clay loam; interiors of the peds are olive gray (5Y 5/2) and olive (5Y 5/3); moderate, medium, prismatic structure that breaks to strong, fine and medium, angular blocky; very firm; prominent coatings of fine silt flour; thick, continuous clay films and films of organic matter on the surfaces of the peds; very strongly acid; clear boundary.

B23—23 to 29 inches, black (10YR 2/1) heavy clay loam; interiors of the peds are olive gray (5Y 4/2); many, medium, prominent mottles of light olive brown (2.5Y 5/6); strong, medium, prismatic structure; very firm; many, fine, black (10YR 2/1) root channels; thick, continuous clay films and films of organic matter are on the surfaces of the peds; very strongly acid; clear boundary.

B3—29 to 45 inches, olive-gray (5Y 5/2) heavy clay loam to clay with very dark gray (10YR 3/1) clay films and films of organic matter on the surfaces of the peds; common, medium, prominent mottles of light olive brown (2.5Y 5/6); massive; firm; many, fine, black (10YR-2/1) root channels; slightly acid; clear boundary.

C1—45 to 52 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay loam; common, medium, distinct mottles of light olive brown (5Y 5/6); massive; firm to friable; many, fine, black (10YR 2/1) root channels; neutral; abrupt boundary.

C2—52 to 60 inches, variegated gray (5Y 5/1), olive-gray (5Y 5/2), and light olive-brown (2.5Y 5/6) clay loam; massive; friable; common, fine, black (10YR 2/1) root channels; slightly calcareous.

BOG SOILS

The Peat and muck mapping units are representative of the soils in the Bog great soil group. These soils formed under swamp or marsh vegetation in a humid or subhumid climate. They consist of brown, dark-brown or black, partly decayed remains of plants that have been preserved in places that remain saturated with water. These soils are poorly drained and are in depressions.

Azonal soils

Azonal soils have little or no profile development, because of their youth, or because the nature of the parent material or the relief prevents normal development. In this county Alluvial soils and Regosols are the azonal soils.

ALLUVIAL SOILS

The soils of this group consist of transported and relatively recently deposited material. They are characterized by a weak modification, or no modification, of the original material by soil-forming processes. The soils of the Huntsville series are representative of the Alluvial great soil group in this county.

Huntsville Series.—Representative profile of Huntsville silt loam (NW¼SW¼ sec. 32, T. 107 N., R. 23 W.):

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam; cloddy; friable; slightly acid; abrupt boundary.

C1—8 to 33 inches, very dark gray (10YR 3/1) loam; weak, fine and medium, subangular blocky structure; friable; slightly acid; clear boundary.

C2—33 to 54 inches, very dark grayish-brown (2.5Y 3/2) to dark grayish-brown (2.5Y 4/2) loam; weak, fine, granular structure; friable; neutral; clear boundary.

C3—54 to 60 inches, dark grayish-brown (10YR 4/2) sandy loam; single grain; very friable; neutral.

Representative profile of Huntsville loam, sand substratum, on a slope of 3 percent in a cultivated field (NE¼SE¼ sec. 18, T. 106 N., R. 23 W.):

A1p—0 to 8 inches, very dark brown (10YR 2/2) loam; cloddy; friable; slightly acid; abrupt boundary.

A12—8 to 10 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; slightly acid; clear, wavy boundary.

A13—10 to 13 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; medium acid; clear boundary.

C1—13 to 24 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; medium acid; clear boundary.

C2—24 to 32 inches, brown (10YR 4/3 to 5/3) loam; weak, fine, subangular blocky structure; friable; medium acid; abrupt boundary.

C3—32 to 36 inches, yellowish-brown (10YR 5/4) sandy loam; single grain; very friable; slightly acid; abrupt boundary.

IIC4—36 to 42 inches, yellowish-brown (10YR 5/4) loamy sand; single grain; loose; neutral.

REGOSOLS

The soils of this group lack definite genetic horizons, and they developed from deep, unconsolidated or soft, rocky deposits. In this county the soils of the Storden series are classified as Regosols. These soils formed under grasses in highly calcareous glacial till. They have a moderately thick, dark, calcareous surface layer. The boundary is abrupt between the surface layer and a highly calcareous C horizon. These soils have a narrow carbon-nitrogen ratio and very weak structure.

In some places the Storden soils in this county are mapped in complexes with the Clarion soils, and in other places they are mapped in complexes with the Lester soils. The following profile is typical of the soils in the Regosols great soil group in this county:

Storden Series.—Representative profile of a Storden loam on a slope of 8 percent in a cultivated field (NE¼NE¼ sec. 14, T. 106 N., R. 22 W.):

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; cloddy; friable; calcareous; abrupt boundary.

C1—6 to 18 inches, grayish-brown (2.5Y 5/2) loam; weak, fine, granular structure; friable; calcareous; clear boundary.

C2—18 to 36 inches, light olive-brown (2.5Y 5/4 and 5/6) loam; few, fine, distinct mottles of yellowish brown; massive; friable; thin, feathered segregations of lime are common; calcareous.

The original dark-colored surface layer of the Storden soils was very thin. Where the Storden soils have been cultivated, however, the present surface layer consists partly of material from the original surface layer and partly of lighter colored, calcareous material that was formerly part of the C horizon.

Laboratory Determinations

In this section a profile selected for laboratory analysis is described for a soil in each of the Kilkenny, Lester, and Webster series. The chemical and physical properties of these soils are shown in table 14. The Kilkenny and Lester soils have profiles that are somewhat similar. The Kilkenny soils, however, have a more distinct and stronger prismatic structure, firmer consistence, thicker and more continuous clay films and coatings of organic matter on the surfaces of the aggregates, and duller colors in the subsoil. They also are more strongly acid, are more deeply leached, and generally have a lower content of lime in the underlying material.

Profile of a Kilkenny loam (SW¼SW¼ sec. 10, T. 108 N., R. 23 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam; cloddy; friable; medium acid; abrupt, smooth boundary.

B1—7 to 10 inches, dark grayish-brown (2.5Y 4/2) clay loam; very dark gray (10YR 3/1) root channels; weak, fine, subangular blocky structure; friable; medium acid; clear, wavy boundary.

TABLE 14.—*Analytical data for selected soils*

Horizon	Depth	Particle-size distribution			Organic matter	Reaction	Exchangeable cations					Cation-exchange capacity	Base saturation
		Sand	Silt	Clay			Ca	Mg	Na	K	H		
KILKENNY LOAM [1]													
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*pH*	*Meq. per 100 gm.*	*Meq. per 100 gm.*	*Meq. per 100 gm.*	*Meq. per 100 gm.*	*Meq. per 100 gm.*		*Percent*
Ap	0–7	40. 8	34. 8	24. 4	4. 28	5. 8	10. 38	5. 92	0. 52	1. 06	8. 02	25. 90	69
B1	7–10	37. 8	32. 8	29. 3	1. 39	6. 0	10. 28	9. 04	. 35	. 93	4. 23	24. 83	83
B21	10–18	33. 5	27. 5	39. 0	1. 39	5. 4	12. 57	10. 37	. 38	1. 34	6. 79	31. 48	77
B22	18–24	34. 4	28. 8	36. 8	. 88	4. 6	11. 78	10. 18	. 46	1. 40	11. 45	35. 27	67
B23	24–30	38. 0	28. 3	33. 7	. 80	4. 6	10. 58	9. 14	. 49	1. 28	8. 80	30. 29	71
B24	30–36	37. 8	29. 3	32. 9	. 54	4. 7	10. 68	9. 52	. 57	1. 34	10. 34	32. 45	68
B3	36–41	37. 0	29. 1	33. 9	--------	5. 4	12. 08	11. 15	. 60	1. 37	5. 91	31. 11	81
C	41–54	41. 4	31. 8	26. 8	--------	7. 4	19. 06	13. 53	. 57	1. 25	1. 62	36. 08	95
LESTER CLAY LOAM													
Ap	0–7	45. 3	25. 0	29. 7	2. 91	5. 8	8. 58	4. 69	0. 19	7. 0	6. 80	20. 96	68
B1	7–14	43. 3	22. 7	34. 0	1. 22	5. 6	8. 78	5. 37	. 27	. 83	5. 95	21. 20	72
B21	14–22	47. 2	18. 2	34. 6	. 70	5. 3	8. 38	6. 26	. 30	1. 02	5. 48	21. 44	74
B22	22–32	49. 9	19. 5	30. 6	. 38	5. 5	7. 49	6. 55	. 33	. 86	4. 72	19. 95	76
B23	32–42	50. 3	29. 3	20. 4	. 32	5. 5	6. 79	6. 10	. 41	. 74	4. 45	18. 49	76
B3	42–47	51. 1	21. 1	27. 8	. 32	6. 4	7. 29	6. 18	. 33	. 83	2. 66	17. 29	85
C1	47–50	51. 7	31. 1	17. 2	--------	7. 4	10. 78	6. 50	. 38	. 51	2. 03	20. 20	90
C2	50–65	52. 1	18. 5	29. 4	--------	7. 5	18. 16	7. 90	. 30	. 35	. 07	26. 78	100
WEBSTER CLAY LOAM													
A1p	0–7	29. 9	37. 2	32. 9	7. 50	7. 2	36. 7	8. 3	0. 3	0. 6	4. 0	49. 9	
A12	7–13	30. 0	37. 0	33. 0	6. 90	7. 2	35. 1	8. 3	. 2	. 5	2. 8	46. 9	
A3g	13–17	34. 4	33. 5	32. 1	2. 90	7. 2	37. 2	7. 6	. 3	. 6	2. 1	37. 8	
B2g	17–23	37. 7	32. 3	30. 0	1. 20	7. 5	23. 5	6. 7	. 3	. 4	1. 7	32. 6	
C1g	23–26	40. 7	29. 8	29. 5	. 72	7. 7	(2)	(2)	(3)	(3)	(3)	(3)	
C2g	26–33	36. 8	34. 6	28. 6	. 47	7. 8	(2)	(2)	(3)	(3)	(3)	(3)	
C3g	33–46	34. 7	38. 8	26. 5	. 34	7. 9	(2)	(2)	(3)	(3)	(3)	(3)	
C4g	46–50	29. 0	36. 7	23. 0	. 30	7. 9	(2)	(2)	(3)	(3)	(3)	(3)	

[1] In this county Kilkenny soil is commonly clay loam.
[2] Calcareous.
[3] Not tested.

B21—10 to 18 inches, dark grayish-brown (10YR 4/2) clay loam that crushes to dark yellowish brown (10YR 4/4); moderate, fine, subangular blocky structure; firm; many, fine, rounded pebbles of shale; the clay films and films of organic matter on the surfaces of the peds are thin and continuous; clear, wavy boundary.

B22—18 to 24 inches, dark grayish-brown (10YR 4/2) clay loam; the interiors of the peds are dark yellowish brown (10YR 4/4); moderate, fine, subangular blocky structure; firm; the clay films and films of organic matter on the surfaces of the peds are thin and continuous; very strongly acid; clear, wavy boundary.

B23—24 to 30 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) clay loam; the interiors of the peds are light olive brown (2.5Y 5/4); few, fine, distinct mottles of light olive brown (2.5Y 5/6); moderate, medium, prismatic structure that breaks to moderate, fine and medium, angular blocky structure; firm; many, very fine, rounded pebbles of shale; very strongly acid; clay films and films of organic matter on the surfaces of the peds are thick and continuous; clear, wavy boundary.

B24—30 to 36 inches, dark grayish-brown (2.5Y 4/2) clay loam; the interiors of the peds are light olive brown (2.5Y 5/4) and 5/6); many, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, medium, prismatic structure that breaks to moderate, medium, angular blocky structure; firm; many, very fine, rounded pebbles of shale; the clay films and films of organic matter on the surfaces of the peds are thick and continuous; very strongly acid; clear, wavy boundary.

B3—36 to 41 inches, light olive-brown (2.5Y 5/4 and 5/6) clay loam that has common, fine, distinct mottles of yellowish brown (10YR 5/8); massive; firm; contains very dark gray (10YR 3/1) and very dark grayish-brown (10YR-3/2) root channels and cleavage planes; strongly acid; abrupt boundary.

C—41 to 54 inches, olive (5Y 5/3 and 5/4) loam with many small pebbles of lime and small fragments of shale; few reddish mottles; massive; friable; slight effervescence.

Profile of a Lester clay loam (SW¼NW¼ sec. 12, T. 106 N., R. 22 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) clay loam, streaked with dark brown (10YR 4/3) material from the B horizon; cloddy; friable; medium acid; abrupt, smooth boundary.

B1—7 to 14 inches, very dark grayish-brown (10YR 3/2) clay loam; interiors of the peds are dark brown (10YR 4/3); a few, very dark gray (10YR 3/1) worm channels; weak, fine, subangular blocky structure; friable; clay films and the films of organic matter are thin and patchy; medium acid; clear, wavy boundary.

B21—14 to 22 inches, dark grayish-brown (10YR 4/2) clay loam; interiors of the peds are dark yellowish brown (10YR 4/4); weak, fine and medium, subangular blocky structure; friable; clay films are thin and continuous over the surface of the peds; strongly acid; clear, wavy boundary.

B22—22 to 32 inches, dark grayish-brown (10YR 4/2) sandy clay loam; interiors of the peds are dark yellowish brown (10YR 4/4); weak, prismatic structure that breaks to weak, coarse, subangular blocky structure; friable; the surface of the horizon is coated with prominent, bleached quartz; clay films are thin and continuous on the surfaces of peds and thin and patchy on the subangular blocky surfaces of peds; strongly acid.

B23—32 to 42 inches, dark grayish brown (10YR 4/2) sandy clay loam; interiors of peds are brown (10YR 5/3) and yellowish brown (10YR 5/4); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; friable; the surface of the horizon is coated with prominent, bleached quartz; clay films are thin and continuous over surfaces of the prisms and thin and patchy on subangular blocky surfaces of the peds; strongly acid; clear, wavy boundary.

B3—42 to 47 inches, yellowish-brown (10YR 5/4) sandy clay loam with very dark grayish-brown (10YR 3/2) root channels; massive; friable; a few reddish mottles; slightly acid; abrupt, wavy boundary.

C1—47 to 50 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4 and 5/6) loam with very dark grayish-brown (10YR 3/2) root channels; a few reddish mottles; massive; friable; slightly effervescent; clear, wavy boundary.

C2—50 to 65 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4 and 5/6) sandy clay loam; massive; friable; violently effervescent.

Profile of Webster clay loam (NW¼NW¼ sec. 19, T. 105 N., R. 23 W.):

A1p—0 to 7 inches, black (10YR 2/1) clay loam; cloddy; friable; neutral; abrupt, smooth boundary.

A12—7 to 13 inches, black (10YR 2/1) clay loam; cloddy; friable; neutral; clear, smooth boundary.

A3g—13 to 17 inches, very dark gray (10YR 3/1) clay loam; weak, very fine, angular blocky structure; friable; neutral.

B2g—17 to 23 inches, dark-gray (5Y 4/1) clay loam with some mixing of olive gray (5Y 5/2); very fine, angular blocky structure; friable; neutral; gradual, irregular boundary.

C1g—23 to 26 inches, olive-gray (5Y 5/2) to olive (5Y 5/3) clay loam; weak, very fine, angular blocky structure; friable; effervesces weakly; clear, wavy boundary.

C2g—26 to 33 inches, olive (5Y 5/3) clay loam; weak, very fine, angular blocky structure; friable; effervesces strongly; clear, wavy boundary.

C3g—33 to 46 inches, olive (5Y 5/3) clay loam; massive; friable; effervesces strongly.

C4g—46 inches +, gray (5Y 5/1) to olive (5Y 5/3) clay loam with many, medium, distinct mottles of yellowish brown (10YR 5/8); friable; sample was obtained with an auger, hence no structure determinations.

Literature Cited

(1) American Association of State Highway Officials.
1961. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 pts., illus. Washington, D.C.

(2) Arneman, Harold F., Khan, Aziz D., and McMiller, P. R.
1958. PHYSICAL, CHEMICAL, AND MINERALOGICAL PROPERTIES OF RELATED MINNESOTA PRAIRIE SOILS. Univ. of Minn. Agr. Expt. Sta. Tech. Bul. 227, 47 pp., illus.

(3) Blake, G. R., Allred, E. R., Van Bavel, C. H. M., and Whisler, F. D.
1960. AGRICULTURAL DROUGHT AND MOISTURE EXCESSES IN MINNESOTA. Univ. of Minn. Agr. Expt. Sta. Tech. Bul. 235. Prepared in coop. with USDA, 36 pp., illus.

(4) Borchert, John R.
1950. THE CLIMATE OF THE CENTRAL NORTH AMERICAN GRASSLAND. Ann. of the Assoc. of Amer. Geog. 15 (1): 39 pp., illus.

(5) Iowa State University.
1959. FIRST REPORT TO THE NORTH CENTRAL REGIONAL TECHNICAL COMMITTEE ON WEATHER INFORMATION FOR AGRICULTURE. 277 pp. Ames, Iowa.

(6) Portland Cement Association.
1956. PCA SOIL PRIMER. 86 pp., illus. Chicago.

(7) Simonson, Roy W.
1959. OUTLINE OF A GENERALIZED THEORY OF SOIL GENESIS. Soil Sci. Soc. Amer. Proc. 23(2): 152–156, illus.

(8) Thiel, George A.
1956. GEOLOGY AND UNDERGROUND WATERS OF SOUTHERN MINNESOTA. Minn. Geol. Surv. Bul. 31, 506 pp., illus.

(9) United States Department of Agriculture.
1938. SOILS AND MEN. U.S. Dept. Agr. Ybk. 1232 pp., illus.

(10) Waterways Experiment Station, Corps of Engineers.
1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3–357, 2 v. Vicksburg, Miss.

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Back-wasting glacier. An ice sheet where the principal melting or wasting occurs along the leading edge.

Calcareous soil. A soil that contains enough calcium carbonate, in many places with magnesium carbonate, to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Calcification. The soil-forming processes that keep enough calcium in the surface layer to saturate the soil colloids with exchangeable calcium to the extent that the colloids are rendered almost immobile and almost neutral in reaction.

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. See also Texture, soil.

Concave slope. An inwardly rounded slope.

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; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle to moderate 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 and brittle; little affected by moistening.

Convex slope. An arched, or outwardly rounded, slope.

Crust. The hard, brittle layer that forms on many soils when dry.

Drift, glacial (geology). Material of any sort deposited by geologic processes in one place after having been removed from another; includes drift material deposited by glaciers and by streams and lakes associated with them. The term "glacial drift" covers both *glacial till,* which is not stratified, and *glacial outwash,* which is stratified.

Drumloid (geology). More or less oval hills or ridges composed of till, approaching the true drumlin in shape, but less regular and less symmetrically arranged.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

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

French drain. A section of a tile trench above the tile that is fitted with stone, gravel, or crushed rock, or a combination of these materials.

Gleization. The reduction, translocation, and segregation of soil compounds, notably of iron, generally in the subsoil or substratum, as a result of poor aeration and drainage; expressed in the soil by mottled colors dominated by gray. The soil-forming processes leading to the development of a gley soil.

Horizon, soil. A layer of soil, approximately parallel to the soil surface, that has distinct characteristics produced by soil-forming processes.

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

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed by the lowering of the water level or elevation of the land.

Lake, glacial. A lake developed by the ponding of waters within or in front of a glacial ice sheet.

Lake plain. A level or undulating surface covered by sediments deposited by the waters of a glacial lake.

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

Mineral soil. Any soil composed mainly of inorganic (mineral) material and low in content of organic matter. Its bulk density is greater than that of an organic soil.

Montmorillonite. A fine, platy, alumino-silicate clay mineral that expands and contracts when water is absorbed or lost. It has a high cation-exchange capacity and is plastic and sticky when moist.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types of moraines are terminal, lateral, medial, and ground.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of 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—*fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Muck. An organic soil consisting of farily well decomposed organic material that is relatively high in mineral content, finely divided, and dark colored.

Organic soil. A soil that consists primarily of organic matter, such as peat, muck, and peaty soil layers.

Outwash, glacial (geology). See Drift, glacial.

Parent material. The unconsolidated mass of material from which the soil develops.

Peat. Unconsolidated soil material, consisting largely of undecomposed or slightly decomposed organic matter, accumulated where there has been excessive moisture.

Podzolization. The process by which a soil is depleted of bases, becomes more acid, and develops a leached surface layer.

Productivity (of soil). The present capability of a soil for producing a specified plant or sequence of plants under a defined system of management.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values or in words, as follows:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having a diameter ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more of sand and not more than 10 percent clay. See also Texture, soil.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay. See also Texture, soil.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata. See also Horizon, soil.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from the adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. 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 (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth. See also Solum.

Surface soil. That part of the soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness; the plowed layer.

Terrace. (1) (*Agricultural*. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

(2) *Geologic*. A flat or undulating plain, commonly rather narrow and commonly with a steep front, that borders a river, a lake, or the sea. Many streams are bordered by a series of terraces at different levels. The various levels indicate the location of the flood plains during successive periods. Many older terraces have become more or less hilly through stream dissection, but they are still regarded as terraces.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions 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." See also Clay; Sand; and Silt.

Till plain. A level or undulating land surface covered by glacial till.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumably fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Transported soil materials. The parent material of a soil that has been moved from its place of origin and redeposited during the weathering process or some part of the process.

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