SOIL SURVEY OF

Sac County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa State University Agriculture and
Home Economics Experiment Station and
Cooperative Extension Service and the
State of Iowa Department of
Soil Conservation

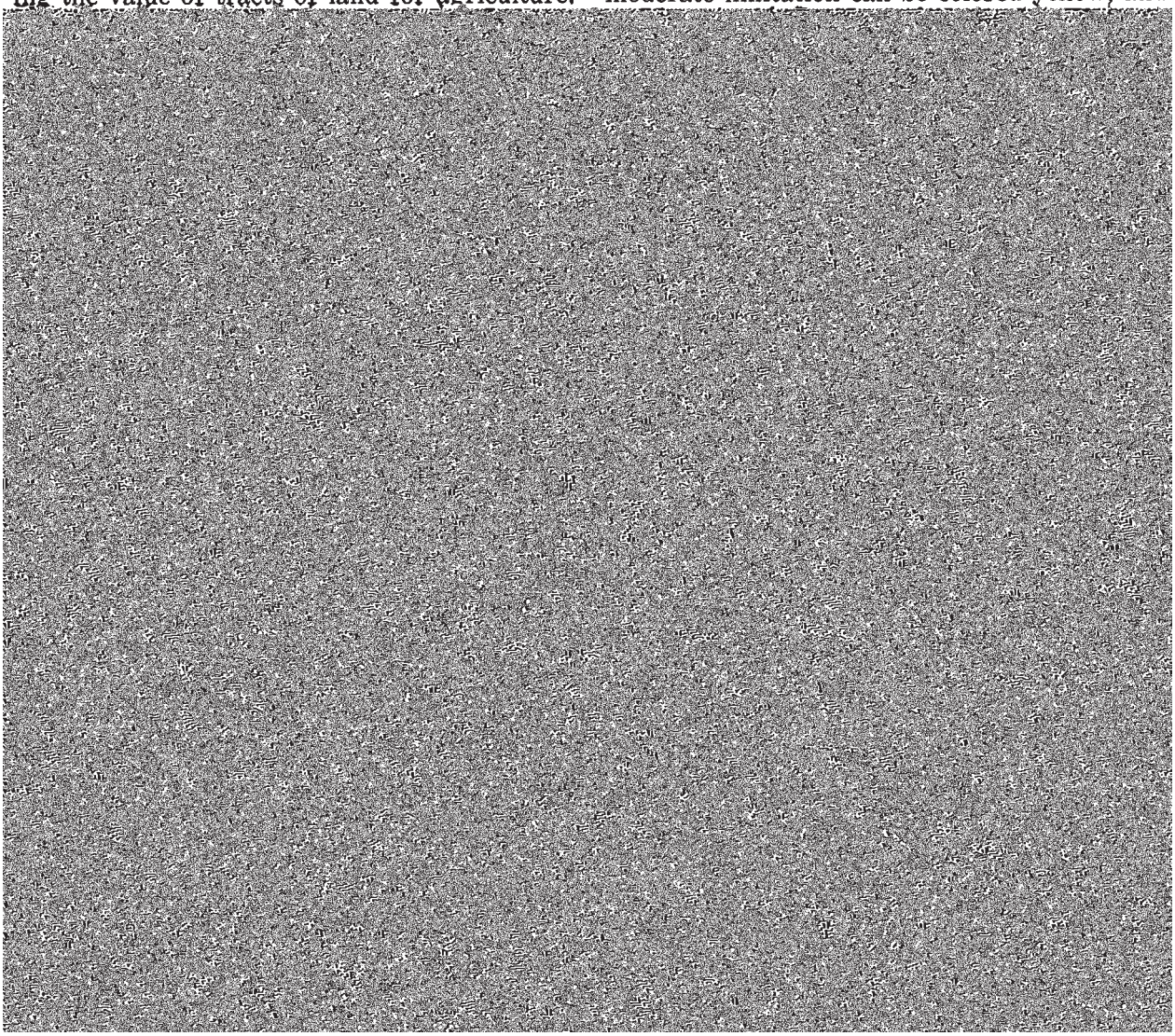
This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1968–72. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. Funds appropriated by Sac County were used for part of the cost of this survey. This survey was made cooperatively by the Soil Conservation Service, Iowa State University Agriculture and Home Economics Experiment Station and Cooperative Extension Service, and the State of Iowa Department of Soil Conservation. It is part of the technical assistance furnished to the Sac County Soil Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture.



over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and

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SOIL SURVEY OF SAC COUNTY, IOWA

By Maynard P. Koppen and John R. Worster, Soil Conservation Service

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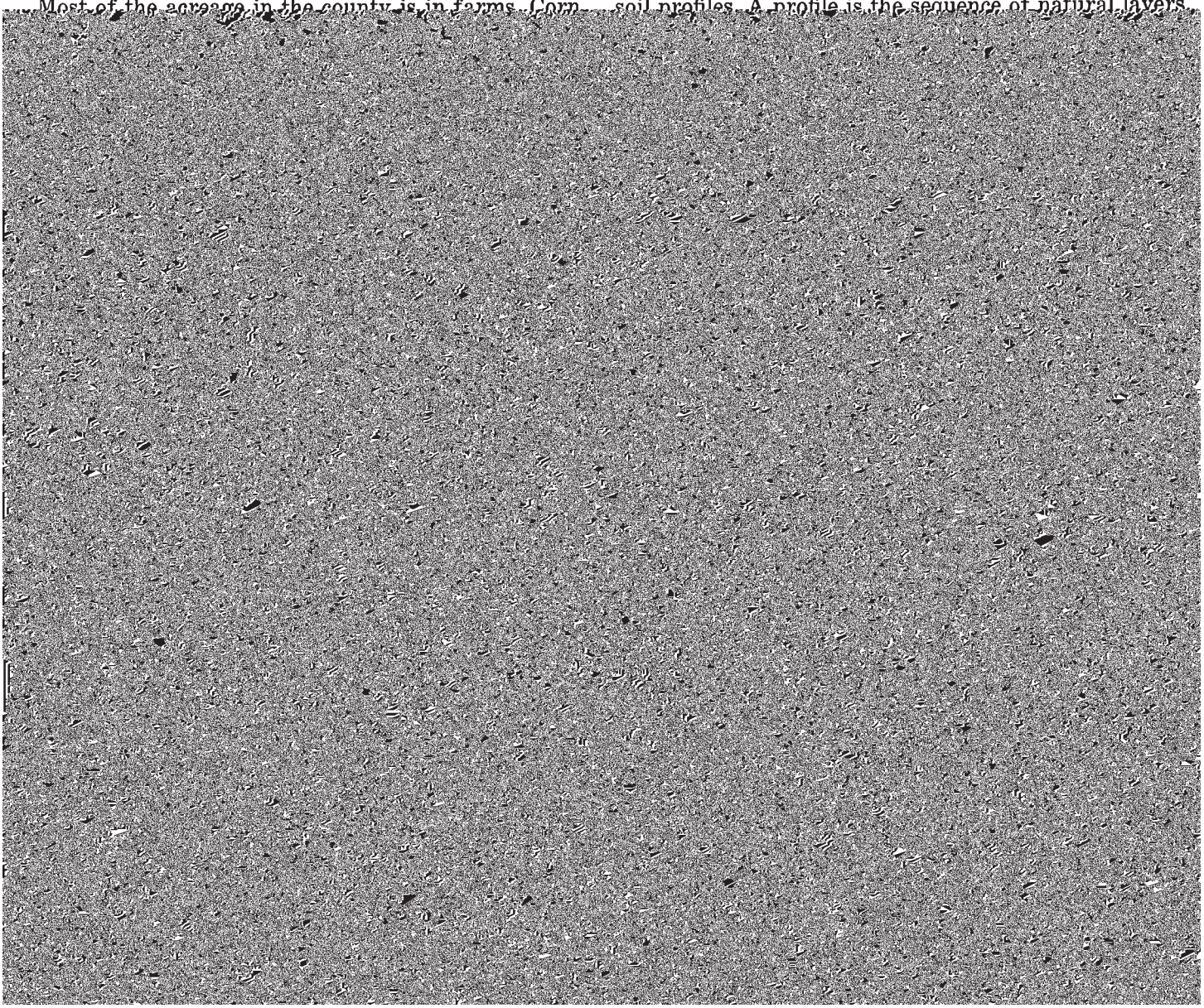
United States Department of Agriculture, Soil Conservation Service, in cooperation with Iowa State University Agriculture and Home Economics Experiment Station and Cooperative Extension Service and the State of Iowa Department of Soil Conservation

SAC COUNTY is in northwestern Iowa (fig. 1). It has an area of about 369,920 acres. Sac City is the county seat.

Most of the acreage in the county is in farms. Corn-

slopes; the size and nature of streams; the kinds of native plants or crops; the 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



ping unit is nearly equivalent to a soil phase. 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 kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit, the soil complex, is shown on the soil map of Sac County.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils. The pattern and relative proportions of the dominant soils are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Coland-Spillville complex is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map, are described in the survey, and are given descriptive names. Alluvial land is an example in this survey.

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

agement of a farm or field, because the soils in any one association ordinarily differ in slope, depth, drainage, or other characteristics that affect management. The six soil associations in Sac County are described in the following paragraphs.

1. *Clarion-Nicollet-Canisteo association*

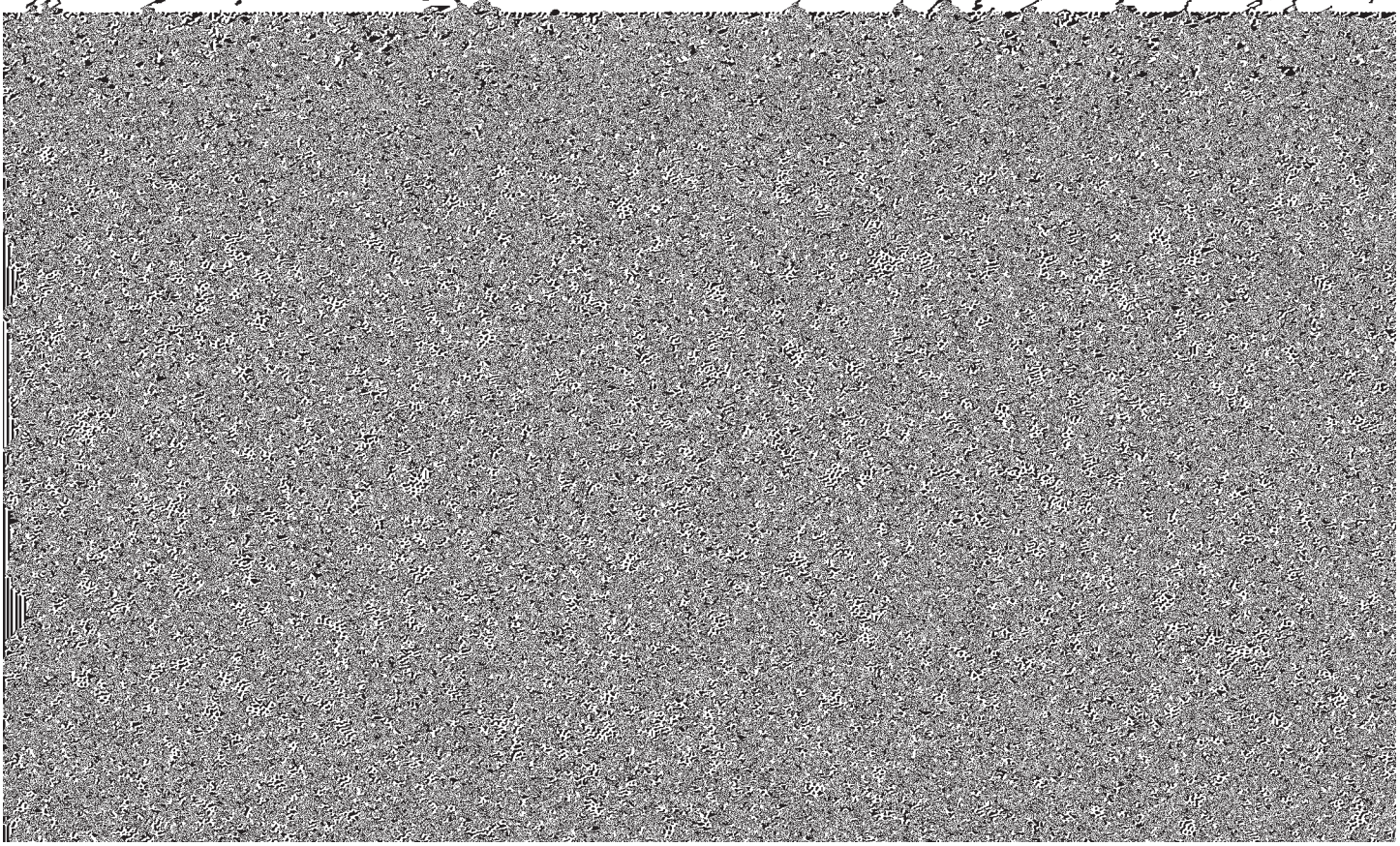
Well drained to poorly drained, loamy, nearly level to strongly sloping soils on uplands

This association is in the eastern part of the county. Most of the soils are nearly level or gently undulating; however, near the larger streams many of the soils are gently rolling to hilly and a few are steep or very steep (fig. 2). The soils are drained almost entirely by Raccoon River and its tributaries. The drainage pattern is not well established, and closed depressions, or "potholes," are common.

This association covers about 48 percent of the county. It is about 30 percent Clarion soils, about 14 percent Nicollet soils, about 14 percent Canisteo soils, and about 10 percent Webster soils. The remaining 32 percent is minor soils.

Clarion soils are on convex knolls and hillsides at higher elevations than most of the adjoining soils. They are gently sloping to strongly sloping and are well drained. The surface layer is black and dark brown loam about 16 inches thick. The subsoil is brown and dark yellowish brown friable loam.

Nicollet soils are at intermediate elevations between the adjoining well drained soils and the poorly drained soils. They are nearly level to gently sloping and are



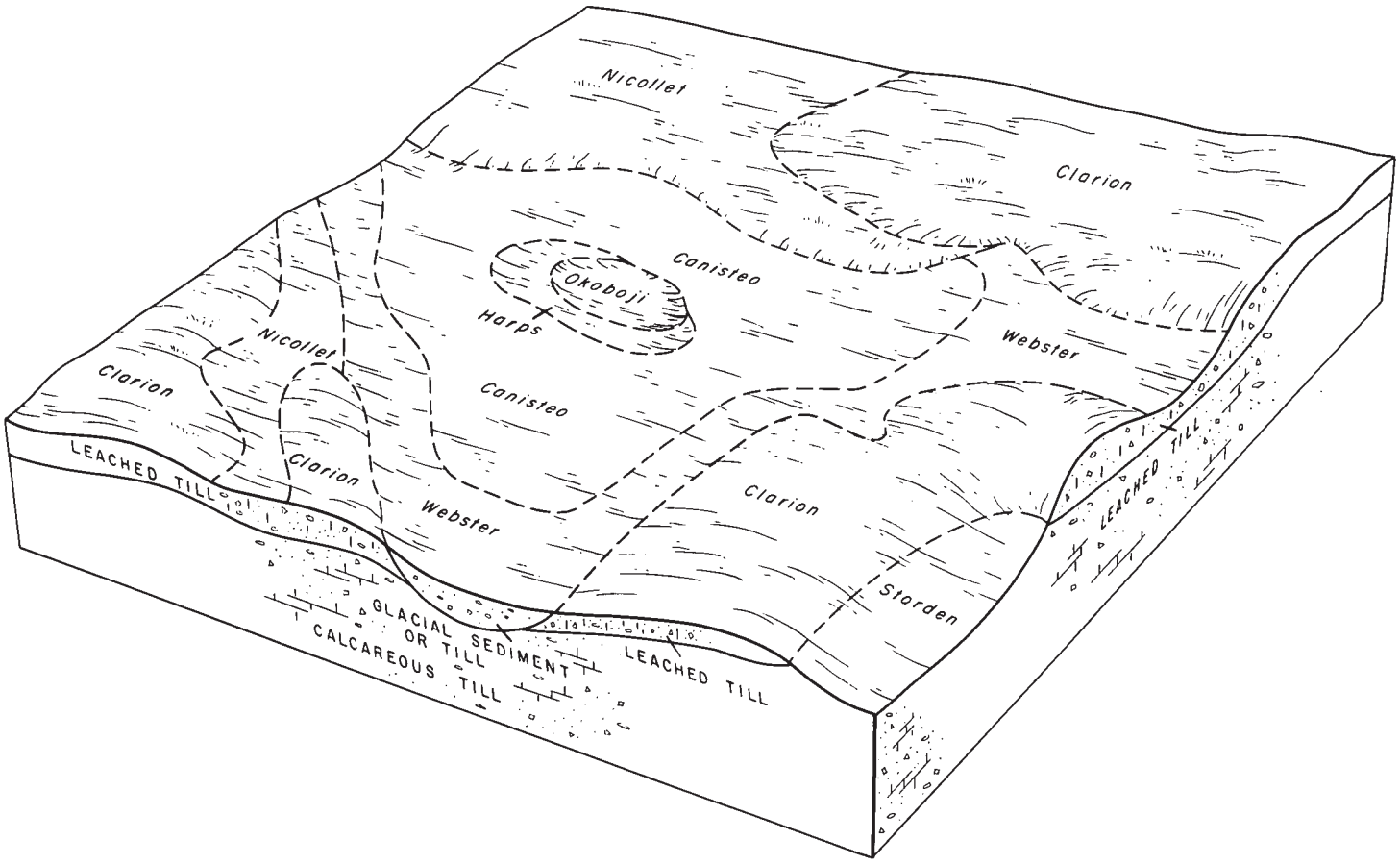


***Figure 2.*—Relationship of parent material and soils in the Clarion-Nicollet-Canisteo association.**

strongly sloping to very steep soils, which have a very severe hazard of erosion; and on the poorly drained and very poorly drained soils that have not been artificially drained. Fertility varies, but if row crops are grown intensively, nitrogen, phosphorus, and potassium are beneficial. The high content of lime in some of the soils reduces the availability of phosphorus and some other plant nutrients.

Many areas of these soils require artificial drainage. Most areas are drained by tile lines. Shallow drainage ditches are used in some depressions, and large drainage ditches are also used in places. Erosion is a hazard on the sloping soils. Terraces and other practices that involve contour tillage are difficult to establish. The soils that are subject to erosion typically have short, irregular slopes and are intermingled in an intricate

2. *Galva-Primghar-Sac association*

Well drained to somewhat poorly drained, silty, nearly level to moderately sloping soils on uplands

This association forms a band about 3 miles wide along the east side of Boyer River. It is drained by the Boyer and its tributaries. These soils are dominantly well drained and gently sloping. Slopes are long, and there is a well established drainage pattern. The soils in the drainageways are mainly somewhat poorly drained or poorly drained and are nearly level or gently sloping. The soils near the major streams generally are moderately sloping (fig. 3).

This association covers about 12 percent of the county. It is about 35 percent Galva soils, about 20 percent Primghar soils, and about 16 percent Sac

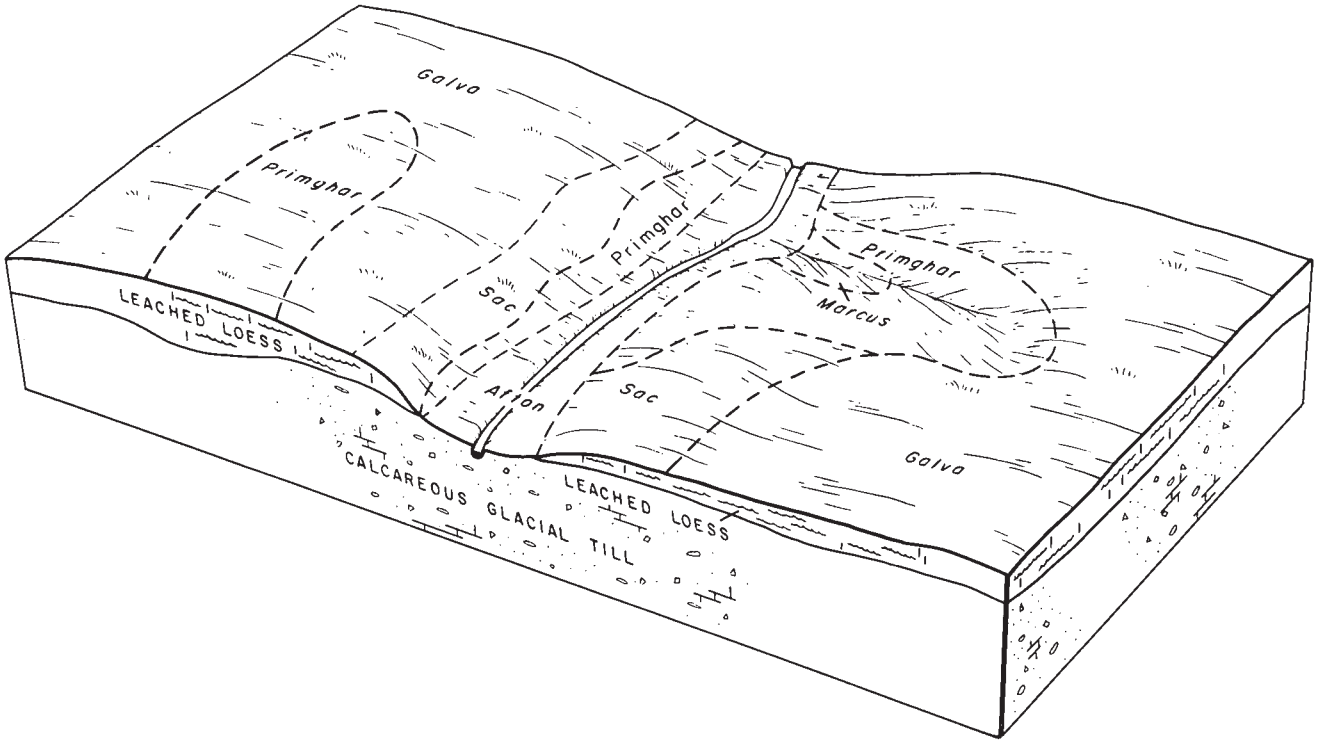


***Figure 3.*—Relationship of parent material and soils in the Galva-Primghar-Sac association.**

gently sloping and are somewhat poorly drained. Typically, the surface layer is black and very dark gray silty clay loam about 20 inches thick. The subsoil is dark grayish brown and olive brown, friable silty clay loam.

Sac soils are on convex ridgetops and hillsides. They are gently sloping and moderately sloping and are well drained. The surface layer is black, very dark gray,

Erosion is a hazard on the sloping soils. The soils are well suited to terraces, contour tillage, stripcropping, and other practices that follow the contour of the land. Slopes are long and relatively smooth. Most of the soils have a friable subsoil that can be restored to reasonable productivity if it is exposed in terrace cuts. Soil blowing is a management concern when the soils are plowed in fall, especially following soybeans.

drained or poorly drained and are nearly level or gently sloping. Some of the soils near the major streams are moderately sloping and have shorter slopes.

This association covers about 25 percent of the county. The association is about 42 percent Galva soils, about 17 percent Primghar soils, about 9 percent Afton soils, and 8 percent Sac soils. The remaining 24 percent is minor soils.

county. Fields are generally large. Contoured fields are common, and most have long rows. Roads are on a majority of the section lines, and most are graveled or paved.

4. *Marshall association*

Well drained, silty, gently sloping to strongly sloping soils on uplands

This association is in the southwestern most slop

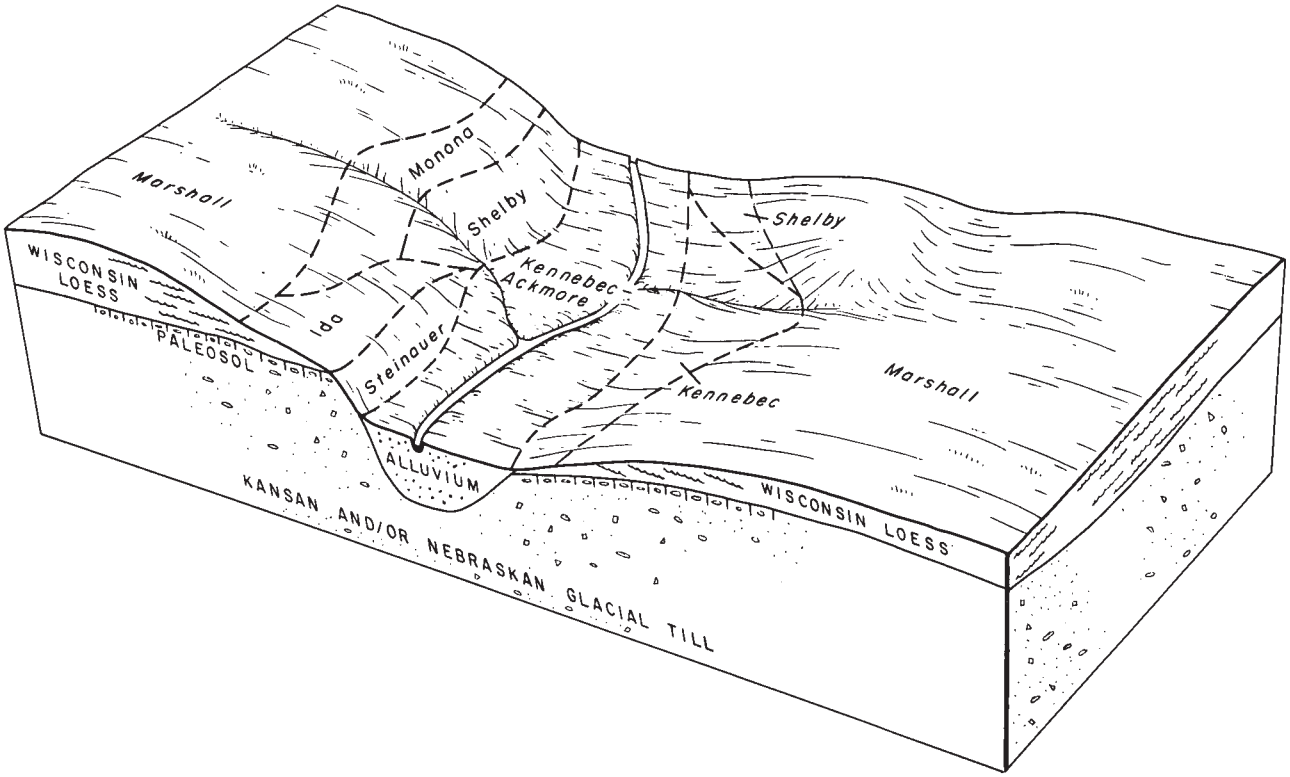


Figure 4.—**Relationship of parent material and soils in the Marshall association.**

5. *Colo-Galva association* [illegible]

The soils are mainly nearly level or gently sloping, except for narrow bands of more sloping soils on foot slopes or on breaks from benches to the flood plain.

This association covers about 3 percent of the county. It is about 25 percent Coland soils, about 25 percent Alluvial land, and about 20 percent Spillville soils. The remaining 30 percent is minor soils.

Coland soils are on bottom lands mainly next to the stream, and some areas are on foot slopes. These soils are nearly level and gently sloping, and they are poorly drained. Typically, these soils are black or very gray clay loam to a depth of 3 or 4 feet.

Alluvial land consists of material recently deposited by the Raccoon River. Most of the areas are nearly level, but some are gently sloping. Other properties vary widely. These soils are subject to frequent flooding.

Spillville soils are on bottom lands and foot slopes. They are nearly level and gently sloping, and they are moderately well drained to very poorly drained. [illegible]

to a soil series. They are listed, nevertheless, in alphabetic order along with the soil series.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists and others who want detailed information about soils. Unless otherwise indicated, the colors given in the descriptions are those of a moist soil. Some of the terms used to describe the soils are defined in the Glossary at the back of this soil survey. More detailed information about the terminology and the methods of mapping can be obtained from the Soil Survey Manual (*12*).[1]

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the map-

TABLE 1.—*Acreage and proportionate extent of the soils*

Map symbol	Soil name	Acres	Percent
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	695	0.2
1E3	Ida silt loam, 14 to 20 percent slopes, severely eroded	465	0.1
1F3	Ida silt loam, 20 to 30 percent slopes, severely eroded	245	0.1
5B	Kennebec-Ackmore complex, 2 to 5 percent slopes	5,325	1.4
C5B	Kennebec-Ackmore complex, channeled, 2 to 5 percent slopes	210	0.1
6	Okoboji silty clay loam, 0 to 1 percent slopes	6,620	1.8
8C	Judson silty clay loam, 3 to 8 percent slopes	345	0.1
9B	Marshall silty clay loam, 2 to 5 percent slopes	1,870	0.5
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	1,290	0.3
9C	Marshall silty clay loam, 5 to 9 percent slopes	315	0.1
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	13,385	3.6
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	4,320	1.2
9D3	Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	5,845	1.6
10D3	Monona silt loam, 9 to 14 percent slopes, severely eroded	825	0.2
10E3	Monona silt loam, 14 to 20 percent slopes, severely eroded	700	0.2
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	765	0.2
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded	770	0.2
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded	415	0.1
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded	210	0.1
26B	Kennebec silty clay loam, 2 to 5 percent slopes	1,170	0.3
27C	Terril loam, 3 to 8 percent slopes	420	0.1
31	Afton silty clay loam, 0 to 2 percent slopes	11,320	3.1
33E	Steinauer loam, 9 to 18 percent slopes	200	0.1
33F	Steinauer loam, 18 to 40 percent slopes	365	0.1
41D	Sparta loamy fine sand, 5 to 14 percent slopes	125	([1])
54	Zook silty clay loam, 0 to 2 percent slopes	1,260	0.3
55	Nicollet loam, 1 to 3 percent slopes	27,155	7.3
62C	Storden loam, 5 to 9 percent slopes	1,100	0.3
62D	Storden loam, 9 to 14 percent slopes	2,725	0.7
62E	Storden loam, 14 to 18 percent slopes	1,020	0.3
62F	Storden loam, 18 to 25 percent slopes	805	0.2
62G	Storden loam, 25 to 40 percent slopes	1,920	0.5
73C	Salida gravelly loamy sand, 5 to 9 percent slopes	515	0.1
73D	Salida gravelly loamy sand, 9 to 14 percent slopes	365	0.1
77B	Sac silty clay loam, loam substratum, 2 to 5 percent slopes	6,670	1.8
77B2	Sac silty clay loam, loam substratum, 2 to 5 percent slopes, moderately eroded	205	0.1
77C	Sac silty clay loam, loam substratum, 5 to 9 percent slopes	340	0.1
77C2	Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	5,100	1.4
78B	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	4,970	1.3

TABLE 1.—*Acreage and proportionate extent of the soils*—Continued

Map symbol	Soil name	Acres	Percent
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	245	0.1
310	Galva silty clay loam, 0 to 2 percent slopes	855	0.2
310B	Galva silty clay loam, 2 to 5 percent slopes	48,470	13.1
310B2	Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	435	0.1
310C	Galva silty clay loam, 5 to 9 percent slopes	2,515	0.7
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	4,220	1.1
T310	Galva silty clay loam, benches, 0 to 2 percent slopes	2,980	0.8
T310B	Galva silty clay loam, benches, 2 to 5 percent slopes	720	0.2
315	Alluvial land	3,380	0.9
323B	Terril loam, sandy substratum, 2 to 5 percent slopes	185	0.1
325	Le Sueur loam, 1 to 3 percent slopes	220	0.1
354	Marsh	220	0.1
384	Collinwood silty clay loam, 1 to 3 percent slopes	370	0.1
390	Waldorf silty clay loam, 0 to 2 percent slopes	1,050	0.3
397B	Letri silty clay loam, 1 to 4 percent slopes	500	0.1
428	Ely silty clay loam, 1 to 3 percent slopes	1,010	0.3
430	Ackmore silt loam, 0 to 2 percent slopes	2,280	0.6
430B	Ackmore silt loam, 2 to 5 percent slopes	330	0.1
485	Spillville loam, 0 to 2 percent slopes	3,740	1.0
485B	Spillville loam, 2 to 5 percent slopes	2,990	0.8
506	Wacousta silty clay loam, 0 to 1 percent slopes	700	0.2
507	Canisteo silty clay loam, 0 to 2 percent slopes	27,385	7.4
511	Blue Earth silty clay loam, 0 to 1 percent slopes	2,345	0.6
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	385	0.1
577C2	Everly clay loam, 4 to 9 percent slopes, moderately eroded	600	0.2
577D2	Everly clay loam, 9 to 14 percent slopes, moderately eroded	260	0.1
606	Lanyon silty clay loam, 0 to 1 percent slopes	320	0.1
733	Calco silty clay loam, 0 to 2 percent slopes	1,110	0.3
823B	Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes	865	0.2
823C2	Flagler sandy loam, calcareous subsoil variant, 5 to 9 percent slopes, moderately eroded	450	0.1
	Gravel pits and quarries	1,065	0.3
	Water, borrow areas, and miscellaneous land	550	0.1
	Total	369,920	100.0

[1] Less than 0.1 percent.

(10YR 3/2) silt loam; some thin strata of dark grayish brown (10YR 4/2); moderate thin platy structure; friable; common medium distinct reddish mottles; neutral; clear smooth boundary.

C2—25 to 35 inches; very dark gray (N 3/0) heavy silt loam; common fine faint very dark grayish brown (2/5Y 3/2) mottles; moderate thin platy structure; friable; common medium reddish brown mottles; slightly acid; abrupt smooth boundary.

A11b—35 to 39 inches; black (10YR 2/1) light silty clay loam; common fine faint very

dark grayish brown (10YR 3/2) silt loam but are light silty clay loam in places. The Ab horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1) or very dark gray (5Y 3/1).

The upper boundary of the Ab horizon generally is at a depth of 20 to 40 inches, but in mapping unit 430B the boundary is below a depth of 40 inches. This is not within the defined range of the Ackmore series, but this difference does not significantly affect the use and behavior of the soil.

Ackmore and Kennebec soils formed in similar parent material and are in similar landscape positions. Ackmore soils are more stratified than Kennebec soils, and they typically have a buried soil that Kennebec

soil is on foot slopes. Most areas are 2 to 20 acres in size and are long and narrow in shape.

This soil has a moderate erosion hazard. It receives runoff from adjoining slopes, which, if not controlled, causes rilling, siltation, and, in places, wetness. This soil is well suited to cultivation if runoff is controlled. This soil is generally farmed with nearly level bottom land soils, but some areas are farmed with the adjoining upland soils. Capability unit IIe–1.

Afton series

The Afton series consists of poorly drained, nearly level soils in drainageways. These soils formed in moderately fine textured loess and local alluvium. The native vegetation was tall grasses and some sedges.

In a representative profile the surface layer is black silty clay loam about 25 inches thick. The subsoil is silty clay loam about 23 inches thick and has distinct yellowish brown mottles. The upper part of the subsoil is very dark gray, and the lower part is gray and olive gray. The underlying material is gray silty clay loam that has distinct yellowish brown mottles.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Afton soils are generally used for cultivated crops. Undrained areas are generally used for pasture.

Representative profile of Afton silty clay loam, 0 to 2 percent slopes, in a cultivated area, 1,100 feet south and 100 feet east of the northwest corner of sec. 1, T. 89 N., R. 38 W.:

Ap—0 to 8 inches; black (N 2/0) heavy silty clay loam; cloddy; friable; neutral; abrupt smooth boundary.

A12—8 to 19 inches; black (N 2/0) medium silty clay loam; weak medium angular blocky structure parting to moderate fine granular and moderate very fine subangular blocky; firm; thin discontinuous shiny coats on ped surfaces; neutral; gradual smooth boundary.

A3—19 to 25 inches; black (N 2/0) heavy silty clay loam; moderate fine granular and [illegible]

B31g—39 to 43 inches; olive gray (5Y 5/2) light silty clay loam with some gray (5Y 5/1) and dark gray (5Y 4/1) coats on ped surfaces; many fine distinct yellowish brown (10YR 5/6) mottles; moderate very fine and fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

B32g—43 to 48 inches; gray (5Y 5/1) light silty clay loam; many fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky structure; friable; few fine dark accumulations (oxides); mildly alkaline; gradual smooth boundary.

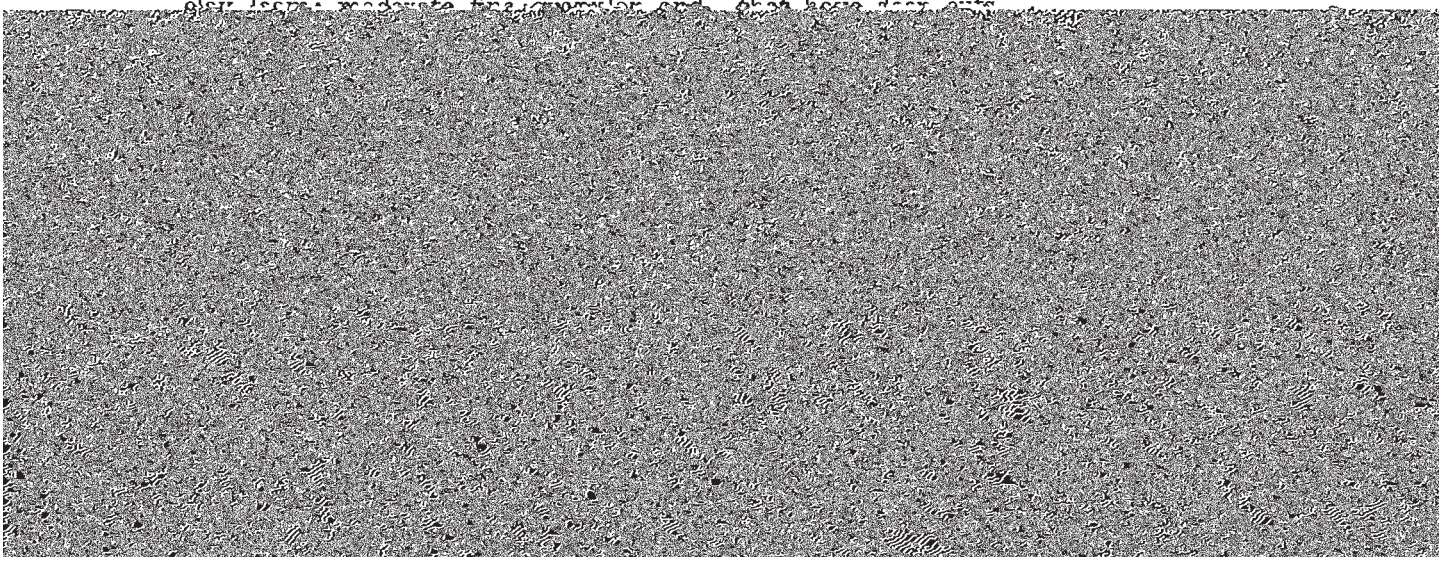
Cg—48 to 60 inches; gray (5Y 5/1) light silty clay loam; many medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; very weak coarse prismatic structure; friable; few fine dark accumulations (oxides); strong effervescence; moderately alkaline.

The A horizon is neutral or mildly alkaline and is 20 to 30 inches thick. The upper part of the B horizon is mildly alkaline or neutral, and the lower part is mildly alkaline or moderately alkaline. The B horizon is very dark gray (5Y 3/1) or dark gray (5Y 4/1) in the upper part and dark gray (5Y 4/1) to light olive gray (5Y 6/2) in the lower part. It has distinct yellowish brown or strong brown mottles and is 20 to 30 inches thick. The C horizon is gray (5Y 5/1) to light olive gray (5Y 6/2) light silty clay loam or heavy silt loam.

Afton, Primghar, and Marcus soils formed in similar material. Afton soils have a thicker A horizon than Marcus and Primghar soils, and they are more poorly drained than Primghar soils.

31—Afton silty clay loam, 0 to 2 percent slopes. This soil is in concave or plane areas in drainageways. Most areas are 5 to 20 acres in size and are long and narrow in shape. Most areas of this soil are cut by a waterway.

Included with this soil in mapping are some calcareous soils similar to this Afton soil. Also included are a few areas of wet, seepy land and a few areas that have clay cuts [illegible]



areas have old stream channels, many of which are ponded for long periods after floods. Many areas are somewhat droughty because of the limited available water capacity. These miscellaneous areas are generally used for pasture or woodland. They are suited to pasture and hay if flooding is infrequent, and they are well suited to wildlife habitat and woodland. Capability unit Vw–1.

Biscay series

The Biscay series consists of poorly drained, nearly level soils on uplands and stream benches. These soils formed in alluvial sediment over sand and gravel. The native vegetation was tall prairie grasses and sedges.

In a representative profile the surface layer is black and very dark gray clay loam and loam about 17 inches thick. The subsoil is about 21 inches thick. The upper part is dark olive gray loam, and the lower part is dark gray and olive gray sandy loam and sandy clay loam. The underlying material is olive gray loamy sand, sand, and gravel.

Permeability is moderate in the upper part of the

sand; some gravel; single grained; loose; weak effervescence; mildly alkaline.

The A horizon is slightly acid to mildly alkaline and is 14 to 24 inches thick. It is loam or light clay loam. In some places to lower part is black (N 2/0). The B horizon is loam, sandy clay loam, or light clay loam and is 10 to 24 inches thick. The B2 and B3 horizons are gray (5Y 5/1), dark gray (5Y 4/1), or olive gray (5Y 4/2 or 5/2). The IIC horizon is loamy sand, sand, or gravel. It is commonly calcareous and moderately alkaline throughout, but in places the upper part is leached of carbonates and is mildly alkaline. The IIC horizon is gray (5Y 5/1), olive gray (5Y 5/2), light gray (5Y 6/1), or olive gray (5Y 5/3). Colors are stratified and mixed.

In places the lower part of the B horizon is sandy loam and is thicker than the defined range of the Biscay series, but these differences do not significantly alter the use and behavior of the soils.

Biscay and Talcot soils formed in similar parent material. Biscay soils are noncalcareous in the solum, and Talcot soils are calcareous. Biscay soils and Webster soils are poorly drained, but Biscay soils are

loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Lco2—9 to 14 inches; black (5Y 2/1) silty clay loam; few thin sandy lenses; few fine faint very dark gray (5Y 3/1) mottles; weak fine subangular blocky structure; friable; numerous snail shells; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Bolan series

The Bolan series consists of well drained, gently sloping to strongly sloping soils on uplands. These soils formed in mixed, moderately fine textured loess and loamy sand or sand over loamy sand and sand of eolian origin. The native vegetation was prairie grasses.

In a representative profile the surface layer is 11 inches thick. The upper part is very dark brown loam, and the lower part is very dark grayish brown

The upper part of the B horizon is dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4) loam or silt loam that is high in content of sand, and it is brown (10YR 4/3) to dark yellowish brown (10YR

the plow layer is very dark grayish brown and is partly mixed with material from the brown subsoil.

Included with this soil in mapping are areas of soils that are stratified with fine sandy loam in the

friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2g—59 to 63 inches; black (5Y 2/1) light silty clay loam; massive; friable; yellowish red (5YR 4/8) coats on root channels; light gray (5Y 6/1) streaks; strongly effervescent; moderately alkaline; abrupt smooth boundary.

The A horizon is 24 to 36 inches thick. The B horizon, if present, is black (N 2/0) to very dark gray (5Y 3/1) and is less than 15 inches thick. The C horizon is mainly black (N 2/0 or 5Y 2/1) and very dark gray (5Y 3/1) to gray (5Y 6/1) silty clay loam, but in places it is stratified with clay loam, silt loam, or loam.

Calco, Colo, and Coland soils are poorly drained and formed in alluvial material. Calco soils are calcareous, and Colo and Coland soils are noncalcareous. Calco soils have less sand in the solum than Coland soils.

733—Calco silty clay loam, 0 to 2 percent slopes. This soil is in areas next to streams or waterways. Most areas are 5 to 20 acres in size and are long and narrow in shape.

Included with this soil in mapping are areas of soils that are more sandy than this Calco soil. Also included are areas of noncalcareous Colo soils.

The main management concern is wetness. Another management concern is the reduced availability of some plant nutrients caused by the high content of lime. This soil is well suited to cultivated crops if it is adequately drained and if flooding is controlled. Most areas can be farmed separately or with other nearly level soils. Maintaining good tilth is a moderate concern. Inadequately drained areas are generally better suited to pasture than to cultivated crops. Capability unit IIw-2.

Canisteo series

The Canisteo series consists of poorly drained, nearly level soils on uplands. Canisteo soils formed in medium textured and moderately fine textured glacial sediment. The native vegetation was tall grasses and sedges.

In a representative profile the surface layer is

cent; moderately alkaline; abrupt smooth boundary.

A12—8 to 11 inches; black (N 2/0) light silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

A3—11 to 16 inches; very dark gray (10YR 3/1) medium silty clay loam; common very fine olive gray (5Y 4/2) mottles; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

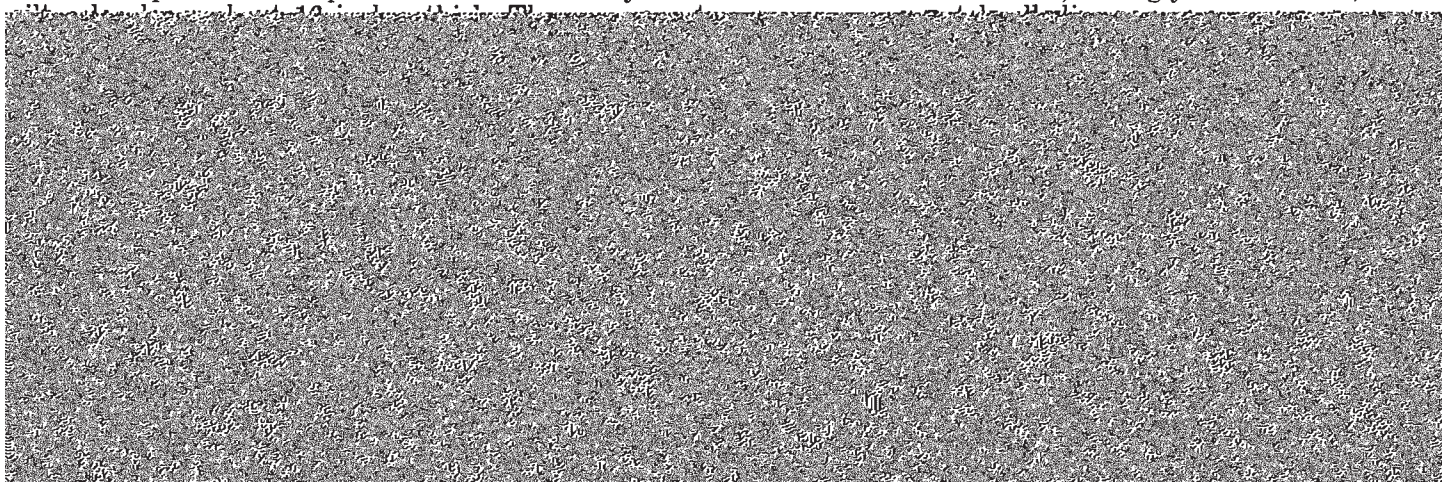
B1g—16 to 23 inches; gray (5Y 5/1) and very dark gray (5Y 3/1) light clay loam; weak fine granular and weak very fine subangular blocky structure; friable; yellowish brown (10YR 5/6) accumulations (oxides); strongly effervescent; moderately alkaline; clear smooth boundary.

B2g—23 to 31 inches; gray (5Y 5/1) and olive gray (5Y 5/2) light clay loam; weak very fine subangular blocky structure; friable; few fine distinct yellowish brown accumulations (oxides); dark gray fills in wormholes and root channels; strongly effervescent; moderately alkaline; gradual smooth boundary.

B3g—31 to 46 inches; light olive gray (5Y 6/2) loam; weak fine subangular blocky structure; friable; common fine distinct yellowish brown accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C1—46 to 64 inches; olive gray (5Y 5/2) loam; common medium yellowish brown (10YR 5/8) mottles; massive; friable; few reddish concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—64 to 70 inches; olive gray (5Y 5/2) light clay loam; strong brown (7.5YR 5/6) mottles; massive; friable; few reddish concretions; strongly effervescent; mod-



acres in size. They are at lower elevations than most of the better drained adjoining soils.

Included with this soil in mapping are small areas in depressions which tend to pond.

The main management concern is wetness. Another management concern is the reduced availability of some plant nutrients caused by the high content of lime. This soil is well suited to cultivated crops if it is

The solum is slightly acid or neutral. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) loam or light clay loam 6 to 12 inches thick. If cultivated, the Ap horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) loam or light clay loam. The A3 horizon, if present, is generally very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) with darker coats on the peds. It is loam

slopes. Good use of crop residue and manure is helpful in these areas. Many areas are in pasture where it is not possible to establish adequate conservation practices. Maintaining good tilth is generally not a concern. Capability unit IIIe–1.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This soil is on convex side slopes. Most areas are 5 to 10 acres in size. They generally adjoin

water capacity is high. The rooting zone is deep where root growth is not restricted by a high water table. Organic matter content is high.

Coland soils are generally used for cultivated crops or pasture. Willows and other water-tolerant trees grow in a few places.

Representative profile of Coland clay loam, 0 to 2 percent slopes, in a cultivated field, 600 feet north and

on hillsides. Most areas are 2 to 10 acres in size and are long and narrow in shape. In places, lighter colored overwash as much as 15 inches thick overlies the black surface layer.

The main management concern is wetness. Erosion is also a hazard. Water from the adjoining soils runs across areas of this soil and causes rilling. This soil is well suited to cultivated crops if it is adequately drained. Undrained areas are better suited to pasture.

able water capacity is high. The rooting zone is deep. Organic matter content is high.

Collinwood soils are generally used for cultivated crops, although a few areas are in pasture.

Representative profile of Collinwood silty clay loam, 1 to 3 percent slopes, in a cultivated area, 500 feet east and 120 feet south of the northwest corner of sec. 17, T. 89 N., 36 W.:

Ap—0 to 9 inches; black (10YR 2/1) medium

clay loam. The A3 horizon is black (10YR 2/1) or very dark gray (10YR 3/1) heavy silty clay loam or light silty clay. The A horizon is 14 to 24 inches thick. The B1 horizon, if present, is very dark grayish brown (10YR 3/2 or 2.5Y 3/2) or dark grayish brown (10YR 4/2). The B2 horizon is light silty clay or heavy silty clay loam. The B3 horizon is light silty clay to medium silty clay loam. The B horizon is 15 to 30 inches thick. The C horizon is dark grayish brown (2/5Y 5/2), grayish brown (2/5Y 5/2), or olive gray (5Y 4/2 or 5/2) and has distinct mottles. It is heavy to medium silty clay loam.

Collinwood soils in this county have less clay in the upper part of the A horizon and in the C horizon than in the defined range of the Collinwood series. Also, the 5Y hue in the lower part of the B horizon is not in the defined range. These differences do not significantly alter the use and behavior of the soils.

Collinwood and Waldorf soils formed in similar parent material. Collinwood soils are better drained than Waldorf soils. They formed in finer textured material than Nicollet soils, which have somewhat similar colors.

384—Collinwood silty clay loam, 1 to 3 percent slopes. Most areas of this soil are 5 to 20 acres in size and are irregular in shape. Included with this soil in mapping are soils that are similar to this Collinwood soil but that have clay loam or loam glacial till in the underlying material.

This soil has no major limitations, but the surface layer has a relatively high clay content and maintaining good tilth is a concern of management. This soil is well suited to cultivated crops. Slopes are such that surface drainage is generally good, but they are not steep enough to cause a severe hazard of erosion. Tile has been installed in a few areas for earlier completion of field operations. Capability unit I–1.

Colo series

The Colo series consists of poorly drained, nearly

A12—7 to 24 inches; black (10YR 2/1) medium silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—24 to 34 inches; black (N 2/0) medium silty clay loam; moderate very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

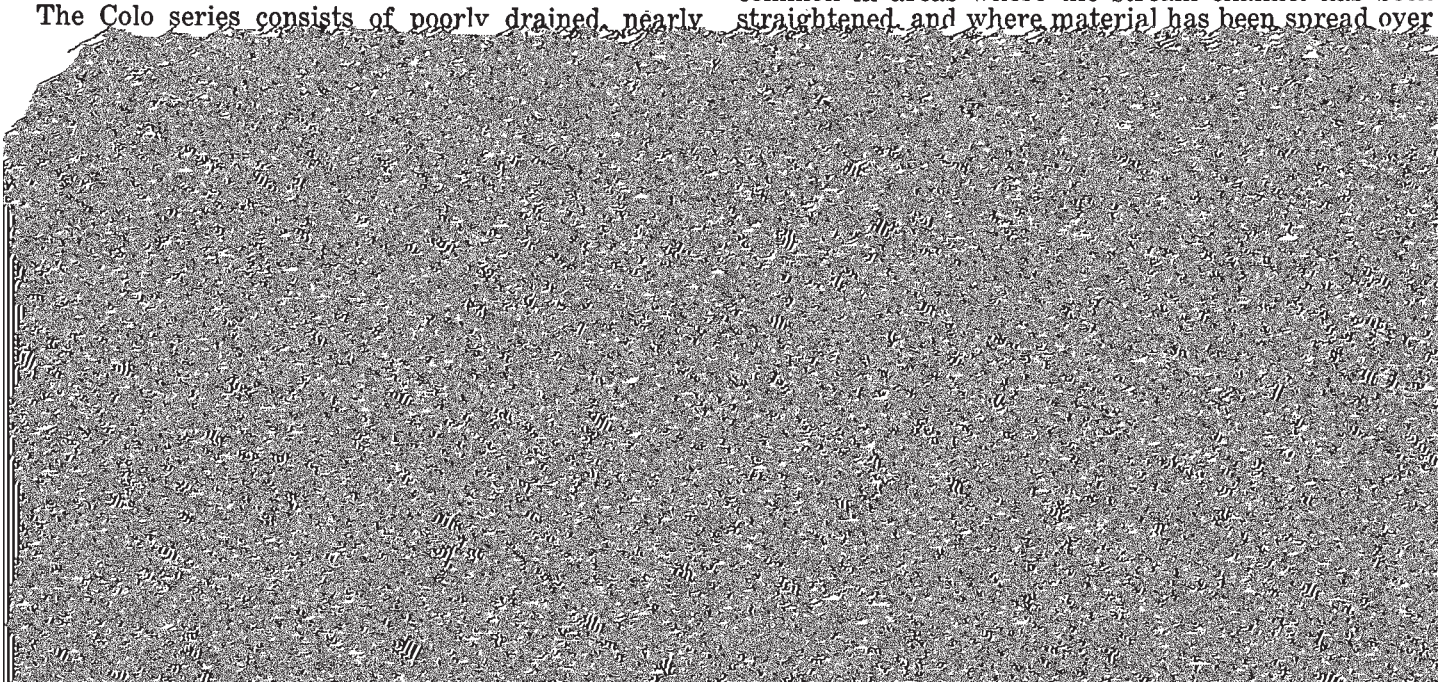
AC—34 to 47 inches; black (10YR 2/1) medium silty clay loam; moderate very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C—47 to 62 inches; very dark gray (10YR 3/1) light clay loam; weak very fine prismatic structure parting to weak fine subangular blocky; friable; very fine distinct olive brown accumulations (oxides); neutral.

The solum is neutral or slightly acid. The A horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1) in the upper part and black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1) in the lower part. It is 36 to 54 inches thick. In places the A and C horizons are mixed or there is a thin B horizon. The C horizon is very dark gray (10YR 3/1 or 5Y 3/1) to gray (5Y 5/1) silty clay loam or clay loam and is stratified with loam and silt loam in places.

Colo, Calco, and Coland soils formed in alluvial material. Colo soils are noncalcareous, but Calco soils are calcareous throughout. Colo soils have less sand in the solum than Coland soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This soil is generally in elongated areas along streams. Most areas are 5 to 40 acres in size. This soil has the profile described as representative of the series. In places, as much as 15 inches of very dark gray or very dark grayish brown silty clay loam overwash is on the surface or is mixed with the surface layer. The overwash is common in areas where the stream channel has been straightened, and where material has been spread over



drained areas are suited to pasture. In places the waterways prevent the use of farm equipment. Because of this, it is impractical to plant cultivated crops in some of these areas, so they are in pasture. Capability unit IIw-1.

Cylinder series

The Cylinder series consists of somewhat poorly drained, nearly level soils on stream benches and on uplands. Cylinder soils formed in glacial sediment or alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black loam about 14 inches thick. The upper part of the subsoil is very dark grayish brown and dark grayish brown loam and sandy clay loam about 20 inches thick. The lower part of the subsoil is dark yellowish brown loamy sand about 6 inches thick. The underlying material is dark yellowish brown sand and gravel.

Permeability is moderate in the upper part of the profile and rapid in the underlying sand and gravel. Available water capacity is moderate. The rooting zone is restricted by the underlying sand and gravel. Organic matter content is high.

Cylinder soils are generally used for cultivated crops, although a few areas are in pasture.

Representative profile of Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated area, 35 feet east and 300 feet south of the northwest corner of SW¼NW¼ sec. 30, T. 89 N., R. 35 W.:

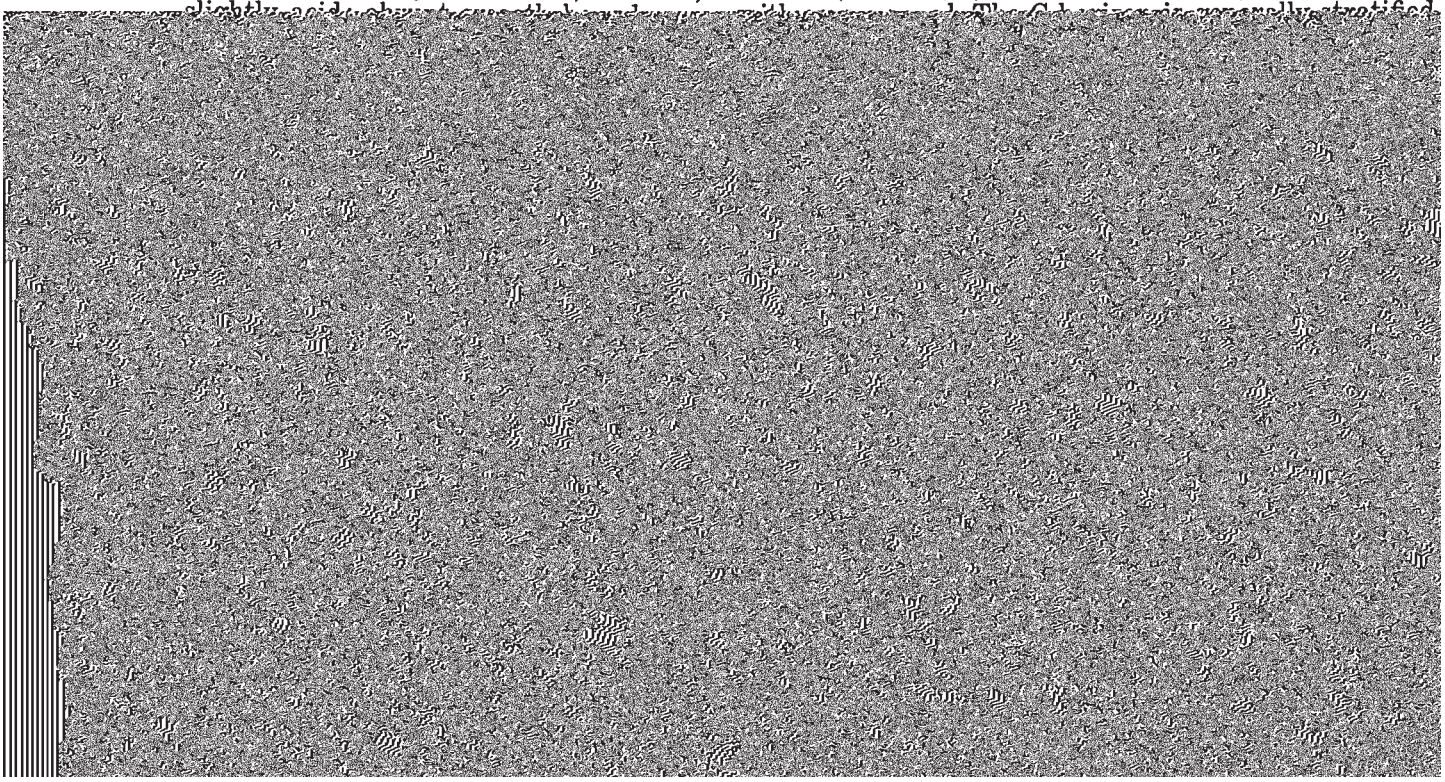
Ap—0 to 9 inches; black (10YR 2/1) heavy loam; weak fine granular and weak very fine subangular blocky structure; friable; [illegible] tions (oxides); neutral; clear smooth boundary.

IIB32—34 to 40 inches; dark yellowish brown (10YR 4/4) loamy sand; few fine distinct grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; very friable; few medium reddish accumulations (oxides); few medium dark concretions; neutral; abrupt smooth boundary.

IIC1—40 to 58 inches; dark yellowish brown (10YR 3/4) sand and some gravel; single grained; loose; weakly effervescent; mildly alkaline; abrupt smooth boundary.

IIC2—58 to 64 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; weakly effervescent; mildly alkaline.

The solum is slightly acid or neutral. The A horizon is loam or light clay loam 10 to 24 inches thick. The medium textured part of the B horizon is typically dark grayish brown (2.5Y 4/2 or 10YR 4/2), but in places it is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3) and has distinct grayish mottles. The B horizon is loam or light clay loam 14 to 32 inches thick. Most profiles have a sandy loam or sandy clay loam transition zone, less than 5 inches thick, between the medium textured part of the B horizon and the coarser textured material below. The IIB horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) and has distinct grayish brown (10YR 5/2 or 2.5Y 5/2) mottles or is dark grayish brown (10YR 4/2 or 2/5Y 4/2) and has dark yellowish brown (10YR 4/4) mottles or yellowish brown (10YR 5/4) mottles. It is loamy sand or sand [illegible]



soils. Most areas are 2 to 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the depth to sand and gravel is less.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified than Cylinder soils in other parts of the county. Also included are small areas of poorly drained soils.

This soil has a drought hazard. It is well suited to

B22—39 to 52 inches; dark grayish brown (2.5Y 4/2) to olive brown (2.5 4/4) light silty clay loam; very dark gray (10YR 3/1) coats on faces of peds; weak fine prismatic structure parting to weak fine subangular blocky; friable; very dark gray (10YR 3/1) fills in wormholes; few fine dark and reddish accumulations (oxides): strongly effervescent; neutral;

ter content is moderate to low, depending on the extent of erosion.

Everly soils are used for cultivated crops and pasture.

Representative profile of Everly clay loam, 4 to 9 percent slopes, moderately eroded, in a cultivated area, 500 feet east and 75 feet north of the southwest corner of sec. 1, T. 89 N., R. 37 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) light clay loam; weak fine granular and weak very fine and fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

B1—6 to 11 inches; dark brown (10YR 3/3) light clay loam; thin very dark grayish brown (10YR 3/2) coats on peds; weak fine granular and weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—11 to 17 inches; brown (10YR 4/3) light clay loam; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

IIB22—17 to 22 inches; yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) heavy loam; weak fine subangular blocky structure; friable; few fine reddish accumulations (oxides); slightly effervescent; moderately alkaline; clear smooth boundary.

IIB31—22 to 28 inches; yellowish brown (10YR 5/4) heavy loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; common medium soft lime accumulations; common lime threads; few fine reddish accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

IIB32—28 to 34 inches; yellowish brown (10YR 5/4) heavy loam; weak fine prismatic structure; friable; few fine reddish accumulations (oxides); common lime threads; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC—34 to 60 inches; yellowish brown (10YR 5/4) heavy loam; massive; friable; few

part. The C horizon is loam or light clay loam.

Everly and Sac soils formed in similar parent material. Everly soils formed in less than 20 inches of loess over glacial till, and Sac soils formed in 20 to 40 inches of loess over glacial till.

577C2—Everly clay loam, 4 to 9 percent slopes, moderately eroded. This soil is on ridgetops and side slopes. Areas range from 2 acres to more than 50 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of slightly eroded soils. Also included are spots of sandy or gravelly soils and ½- to 2-acre areas of Storden soils, both of which are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Most areas are farmed with areas of gently sloping or moderately sloping Galva or Sac soils. All of these soils are generally well suited to contour tillage because of their smooth, relatively long slopes. Capability unit IIIe–1.

577D2—Everly clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape. This soil has a profile similar to the one described as representative of the series, but the surface layer typically is very dark grayish brown.

Included with this soil in mapping are areas of Sac soils. Also included are small spots of sandy and gravelly soils and some ½- to 2-acre areas of Storden soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. However, many areas are used for pasture because of the erosion hazard. Most areas that are used for cultivated crops are farmed with areas of moderately sloping Galva and Sac soils. This soil is suited to contour tillage and terracing because slopes are generally long and smooth. Capability unit IIIe–2.

Flagler variant

The Flagler variant consists of somewhat excessively drained, gently sloping to moderately sloping soils on benches and on uplands. These soils formed in glacial sediment and alluvium. The native vegetation was prairie grasses.

In a representative profile the surface layer is very

Ap—0 to 8 inches; very dark brown (10YR 2/2) heavy sandy loam; weak fine granular and weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—8 to 13 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) sandy loam; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—13 to 19 inches; brown (10YR 4/3) light sandy loam; very dark grayish brown (10YR 3/2) coats on ped surfaces; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

B2—19 to 28 inches; dark yellowish brown (10YR 4/4) light sandy loam; weak medium subangular blocky structure; very friable; neutral; gradual wavy boundary.

IIB3—28 to 36 inches; dark yellowish brown (10YR 4/4) loamy sand; weak medium subangular blocky structure; very friable; neutral; abrupt wavy boundary.

IIC—36 to 63 inches; brown (10YR 4/3) sand, some gravel; single grained; loose; strongly effervescent; moderately alkaline.

The solum ranges from medium acid to neutral. The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 12 to 24 inches thick unless eroded. The B horizon is dark brown (10YR 3/3) to strong brown (7.5YR 5/6) and is 8 to 30 inches thick. The C horizon is dark yellowish brown (10YR 4/4), brown (10YR 4/3), or yellowish brown (10YR 5/4 and 5/6) loamy sand or sand. It ranges from 0 to more than 20 percent gravel.

The Flagler variant and Sparta soils formed in similar parent material. Flagler variant soils are deeper to loamy sand or sand than Sparta soils and are calcareous at a shallower depth than Sparta soils.

823B—Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes. Most areas are on elongated knolls and are 2 to 10 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a loam surface layer and some nearly level Flagler variant soils.

This soil has moderate erosion and drought hazards. It is suited to cultivated crops if erosion is controlled and practices are used to conserve moisture. Contour tillage and practices that leave crop residue on the [illegible] coarse gravel and sand in the underlying material, and areas of soils that are deeply leached. Also included are some areas of soils that are calcareous throughout.

This soil has severe erosion and drought hazards. It is suited to cultivated crops if erosion is controlled and if practices to conserve moisture are used. Contour tillage and mulch tillage are suitable practices on this soil. Capability unit IIIe–3.

Galva series

The Galva series consists of well drained, nearly level to moderately sloping soils on uplands and on stream benches. These soils formed in 40 inches or more of loess over glacial till. The native vegetation was tall prairie grass.

In a representative profile the surface layer is silty clay loam about 16 inches thick. The upper part is black, and the lower part is very dark grayish brown. The subsoil is about 31 inches thick. It is brown silty clay loam in the upper 24 inches and dark yellowish brown silt loam in the lower 7 inches. The underlying material, to a depth of 53 inches, is dark yellowish brown silty clay loam that has distinct grayish brown mottles. Beneath this is dark yellowish brown clay loam that has distinct olive gray mottles.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content typically is moderate.

Galva soils are mostly used for cultivated crops, but a few areas are used for pasture.

Representative profile of Galva silty clay loam, 2 to 5 percent slopes, in a cultivated field, 45 feet north and 1,125 feet east of the southwest corner of sec. 19, T. 89 N., R. 37 W.:

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; cloddy; friable; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) light silty clay loam; moderate fine granular structure; friable; neutral; gradual smooth boundary.

A3—12 to 16 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam; moderate fine granular and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—16 to 23 inches; brown (10YR 4/3) heavy silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; moderate fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B22—23 to 32 inches; brown (10YR 4/3) medium silty clay loam; weak medium prismatic

(10YR 4/4) heavy silt loam; common fine distinct olive gray (5Y 5/2) and few fine distinct strong brown (7/5YR 5/6) mottles; moderate medium prismatic structure parting to weak medium subangular blocky; friable; few soft dark accumulations (oxides); neutral; gradual smooth boundary.

C1—47 to 53 inches; dark yellowish brown (10YR 4/4) silt loam; common medium distinct grayish brown (2.5Y 5/2) mottles; massive; friable; few fine dark and red accumulations (oxides); common fine threads of lime; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC2—53 to 60 inches; dark yellowish brown (10YR 4/4) light clay loam; few medium distinct olive gray (5Y 5/2) mottles; massive; firm; few fine dark accumulations (oxides); few medium red accumulations (oxides), common fine threads of lime; common stones and pebbles at loess-till contact; strongly af-

are important because of the clay content of the surface layer. Capability unit IIe–1.

310B2—Galva silty clay loam, 2 to 5 percent slopes, moderately eroded. This soil is on very slightly convex knobs. Most areas are 5 to 10 acres in size and are irregular in shape. The surface layer is a very dark grayish brown plow layer and is partly mixed with material from the brown subsoil in many places. This soil has 2 to 3 percent organic matter and the total content of the profile is about 45 tons per acre, most of which is in the plow layer.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. This soil is farmed with areas of adjoining soils. Since the slopes are generally slightly steeper and more convex than those of adjoining soils, this soil tends to erode more easily. The loss of organic matter and the mixing of material from the subsoil with that in the plow layer adversely affects tilth. Capability unit IIe–1.

310C—Galva silty clay loam, 5 to 9 percent slopes. This soil is on side slopes. Most areas range from about 5 to 20 acres in size and are irregular in shape. This soil typically has a very dark brown to very dark grayish brown surface layer about 10 inches thick. The

C1—7 to 22 inches; brown (10YR 4/3) silt loam; weak fine subangular blocky structure; friable; common fine lime concretions; few medium dark reddish brown accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—22 to 36 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct grayish brown (2.5Y 5/2) mottles and few fine faint yellowish brown (10YR 5/6) mottles; massive; friable; few medium dark accumulations (oxides); few fine lime threads; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3—36 to 50 inches; yellowish brown (10YR 5/4) silt loam; few fine faint yellowish brown (10YR 5/6) mottles; friable; many fine dark accumulations (oxides); few fine lime threads; strongly effervescent; moderately alkaline; clear smooth boundary.

C4—50 to 60 inches; light olive brown (2/5Y 5/4) silt loam; few fine faint grayish brown (2.5Y 5/2) mottles; massive; friable; few medium dark accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is very dark grayish brown (10YR 3/2) to brown (10YR 4/3) and is about 6 inches thick. The Ap horizon typically is dark grayish brown (10YR 4/2) or brown (10YR 4/3) and is 6 to 10 inches thick. The upper part of the C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4 or 5/6). The lower part ranges from brown (10YR 4/3) to olive brown (2.5Y 5/4).

Ida, Monona, and Marshall soils formed in loess. Ida soils are coarser textured than Marshall soils. Ida soils are moderately alkaline, and Monona and Marshall soils are slightly acid to neutral and are noncalcareous.

1D3—Ida silt loam, 9 to 14 percent slopes, severely eroded. This soil is on convex hillsides. Areas are generally 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of Ida soils that have a darker colored surface layer than that described as representative of the series. Also included are areas of Ida soils that are moderately sloping and areas of Ida soils that have many lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. This soil has a high lime content that reduces the availability of phosphorus and other plant nutrients. It is farmed with areas of Marshall and Monona soils but has a lower level of available nutrients. Because runoff is more rapid on this soil, it has less available water than those soils. It responds well to management that reduces runoff, increases fertility, and controls erosion. Capability unit IIIe–2.

1E3—Ida silt loam, 14 to 20 percent slopes, severely eroded. This soil is on convex hillsides. Most areas are 2 to 10 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soil that have a darker colored surface layer than the one described as representative of the series. Also included are areas of Ida soils that have numerous lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to hay or pasture. It can be planted to cultivated crops part of the time if erosion is controlled. This soil has a high lime content that reduces the availability of phosphorus and other plant nutrients. Much of the precipitation is lost unless runoff is controlled by using practices such as terraces, contour tillage, and adequate plant cover. This soil responds well to management that reduces runoff and erosion and increases fertility. Capability unit IVe–1.

1F3—Ida silt loam, 20 to 30 percent slopes, severely eroded. This soil is at or near the base of hillsides. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that have a darker colored surface layer than the one described as representative of the series. Also included are areas of very steep Ida soils and areas of Ida soils that have numerous lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to hay, although in places the steepness of the slope makes it hazardous to use farm machinery. Capability unit VIe–1.

Judson series

The Judson series consists of well drained and moderately well drained, gently sloping to moderately sloping soils on foot slopes. These soils formed in moderately fine textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is silty clay loam about 25 inches thick. The upper part is black, and the lower part is very dark grayish brown. The subsoil is dark brown silty clay loam about 53 inches thick. The underlying material is olive brown silty clay loam.

Permeability is moderate and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Judson soils are used for cultivated crops.

Representative profile of Judson silty clay loam, 3 to 8 percent slopes, in a cultivated area, 400 feet west and 100 feet north of the southeast corner of NE¼ of sec. 20, T. 87 N., R. 38 W.:

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; cloddy; friable; slightly acid; abrupt smooth boundary.

A12—7 to 10 inches; black (10YR 2/1) light silty clay loam; weak coarse platy structure parting to weak fine granular and weak fine subangular blocky; friable; neutral; gradual smooth boundary.

A3—10 to 25 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) coatings on peds; common medium distinct brown (10YR 4/3)

mottles; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—25 to 45 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual smooth boundary.

B22—45 to 54 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak medium prismatic structure parting to weak fine subangular blocky; few fine dark accumulations (oxides); neutral; gradual; smooth boundary.

B31—54 to 69 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak medium prismatic structure parting to weak fine subangular blocky; friable; common fine dark accumulations (oxides); very few fine reddish accumulations (oxides); slightly acid; gradual smooth boundary.

B32—69 to 78 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; few fine faint brown (10YR 4/3) mottles; weak medium prismatic structure; friable; common dark accumulations (oxides); few fine reddish accumulations (oxides); neutral; clear smooth boundary.

C—78 to 93 inches; olive brown (2.5Y 4/4) light silty clay loam; weak medium prismatic structure; friable; common dark reddish accumulations (oxides); neutral.

The solum is medium acid to neutral in the most acid part. The A horizon is 24 to 36 inches thick. The upper part is very dark brown (10YR 2/2) in some places. The B horizon is dark brown (10YR 3/3) or brown (10YR 4/3) and has grayish mottles below a depth of 30 inches in some places. It is 10 inches to several feet thick. The C horizon is moderately alkaline and calcareous in some places.

Judson soils in Sac County have value of 3 that extends to a depth of 40 inches or more, which is not within the defined range of the Judson series. This difference does not have a significant effect on the use or behavior of the soils.

Judson, Ely, and Kennebec soils formed in similar parent material. Judson soils are generally more sloping, are finer textured, and have a thinner surface layer than Kennebec soils. Judson soils are generally more sloping and better drained than Ely soils.

8C—Judson silty clay loam, 3 to 8 percent slopes. This soil is on foot slopes or alluvial fans. Most areas are 2 to 5 acres in size and are long and narrow in shape.

Included with this soil in mapping are bands of Ely soils along the downslope edge of areas of some Judson soils.

This soil has a moderate to severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Most areas are farmed with areas of adjoining upland soils. This soil receives runoff from adjoining soils that are upslope, which causes rilling and, in places, sedimentation. Capability unit IIIe–1.

Kennebec series

The Kennebec series consists of moderately well drained, gently sloping soils on foot slopes. These soils formed in moderately fine textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile this soil is black silty clay loam to a depth of 20 inches and very dark grayish brown silty clay loam between depths of 20 and 46 inches. The underlying material is silty clay loam that extends to a depth of 72 inches or more. It is very dark grayish brown in the upper part and dark brown in the lower part.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Kennebec soils are generally used for cultivated crops.

Representative profile of Kennebec silty clay loam, 2 to 5 percent slopes, in a cultivated area, 50 feet west and 200 feet south of the northeast corner of NW¼ SE¼ of sec. 22, T. 86 N., R. 38 W.:

Ap—0 to 9 inches; black (10YR 2/1) light silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 20 inches; black (10YR 2/1) light silty clay loam; weak very fine and fine subangular blocky structure; friable; stratified with few thin grayish brown (2.5Y 5/2) lenses; neutral; gradual smooth boundary.

A13—20 to 36 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) ped surfaces; weak very fine and fine subangular blocky structure; friable; stratified with few thin grayish brown (2.5Y 5/2) lenses; neutral; gradual smooth boundary.

A14—36 to 46 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) ped surfaces; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C1—46 to 54 inches; very dark grayish brown (10YR 3/2) light silty clay loam; very dark gray (10YR 3/1) ped surfaces; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

C2—54 to 72 inches; dark brown (10YR 3/3) light silty clay loam; very dark gray (10YR 3/1) ped surfaces; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine reddish accumulations (oxides); neutral.

The A horizon is neutral or slightly acid light silty clay loam or heavy silt loam. It is 36 to 54 inches thick.

The upper part is black (10YR 2/1) or very dark brown (10YR 2/2), and the lower part is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The C horizon is black (10YR 2/1), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) light silty clay loam or heavy silt loam.

The Kennebec soils in this county have a thin, light colored stratum in the A horizon that is not within the defined range of the Kennebec series. This difference does not have a significant effect on the use or behavior of the soils.

Kennebec and Judson soils formed in similar parent material. Kennebec soils have a thicker dark colored surface layer than Judson soils.

moderately fine textured and fine textured glacial sediment. The native vegetation was marshgrasses, sedges, and other water-tolerant grasses.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The underlying material is gray silty clay loam, silty clay, and clay loam.

Permeability is moderately slow to slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Lanyon soils are generally used for cultivated crops. Undrained areas are commonly used for pasture.

Representative profile of Lanyon silty clay loam, 0 to 1 percent slopes, in pasture, 145 feet north and 400

ately alkaline; gradual smooth boundary.

C4g—44 to 56 inches; gray (5Y 5/1) light silty clay, common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure parting to weak very fine angular blocky; firm; common dark reddish accumulations (oxides); strongly effervescent; moderately alkaline; abrupt smooth boundary.

C5g—56 to 66 inches; gray (5Y 5/1) light clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles and few medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; strongly effervescent; moderately alkaline.

The A horizon is medium or heavy silty clay loam or light silty clay 10 to 16 inches thick. The B horizon, if present, is heavy silty clay loam or light silty clay 0 to 8 inches thick. It is very dark gray (N 3/0 or 5Y 3/1) [illegible] (5Y 5/2). The C horizon is dark gray [illegible]

A2—6 to 9 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) loam; weak thin platy structure; friable; many grayish (dry) coats on ped surfaces; medium acid; abrupt smooth boundary.

B1t—9 to 14 inches; brown (10YR 4/3) light clay loam; thin discontinuous dark grayish brown (10YR 4/2) coats on peds; weak very fine subangular blocky structure; friable; many grayish (dry) coats on ped surfaces; medium acid; clear smooth boundary.

B21t—14 to 21 inches; brown (10YR 4/3) light clay loam; thin discontinuous dark grayish brown (10YR 4/2) coats on peds; moderate fine subangular blocky structure; friable; many grayish (dry) coats on ped surfaces; medium acid; clear smooth boundary.

B22t—21 to 25 inches; brown (10YR 4/3) me-

The solum is mainly medium acid or slightly acid, but the lower part ranges to neutral. The A1 or Ap horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) loam or light clay loam and is 6 to 10 inches thick. The A2 horizon is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) loam or light clay loam and is 1 to 4 inches thick. The B horizon is 10 to 39 inches thick. The C horizon is yellowish brown (10YR 5/4 or 5/6) or light olive brown (2.5Y 5/4).

Lester, Le Sueur, and Clarion soils formed in similar parent material. Lester soils are better drained than Le Sueur soils, and have a more clayey B horizon than Clarion soils.

236B—Lester loam, 2 to 7 percent slopes. Most areas of this soil are on knolls and are 2 to 5 acres in size. They are generally surrounded by less well drained soils. Some areas are on ridgetops.

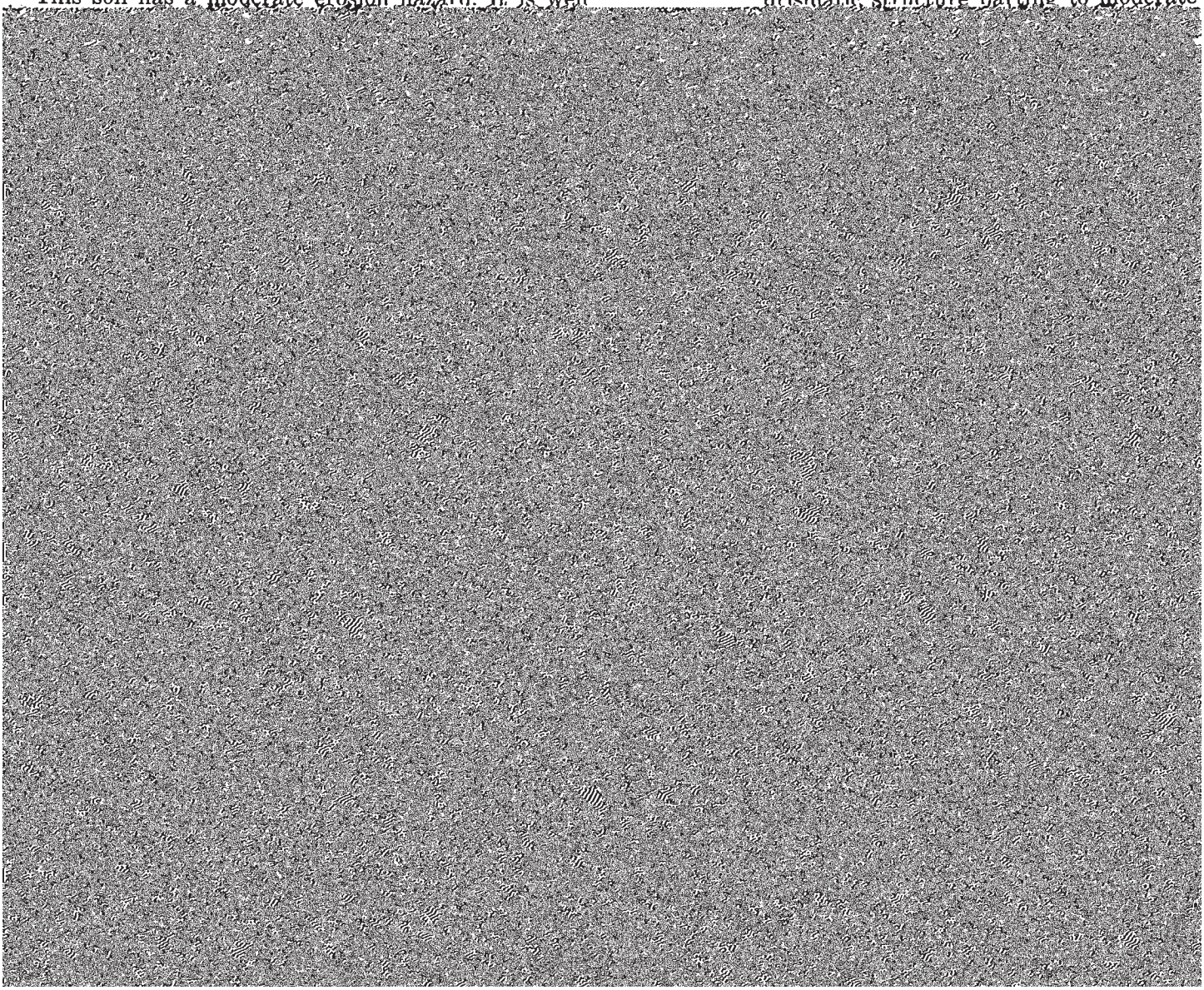
Included with this soil in mapping are spots of sandy or gravelly soils.

This soil has a moderate erosion hazard. It is well

gray (10YR 6/1 and 7/1) coats on peds; moderate very fine subangular blocky structure; friable; many very fine dark accumulations (oxides); few very fine reddish accumulations (oxides); slightly acid; abrupt smooth boundary.

B21t—14 to 23 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) heavy clay loam; common fine distinct olive brown (2.5Y 4/4) mottles; thick very dark gray (10YR 3/1) coats on peds; moderately very fine subangular structure; firm; common very fine dark accumulations (oxides); few very fine reddish accumulations (oxides); medium acid; clear smooth boundary.

B22t—23 to 32 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) medium clay loam; common fine distinct gray (10YR 5/1) mottles; weak fine prismatic structure parting to moderate



few soft lime accumulations; strongly ef-

A3—8 to 14 inches; black (10YR 2/1) medium

significant effect on the use and behavior of these soils.

Letri and Sac soils formed in similar parent material. Letri soils have more sand in the upper part of the profile than Sac soils and are poorly drained. Sac soils are well drained.

397B—Letri silty clay loam, 1 to 4 percent slopes. This soil typically is at lower elevations than adjoining soils. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of somewhat poorly drained soils.

The main management concern is wetness, but maintaining good tilth is also a concern. This soil is well suited to cultivated crops if the soil is adequately drained. It is generally farmed with areas of soils that are better drained. Undrained areas are better suited to pasture. Capability unit IIw–1.

Marcus series

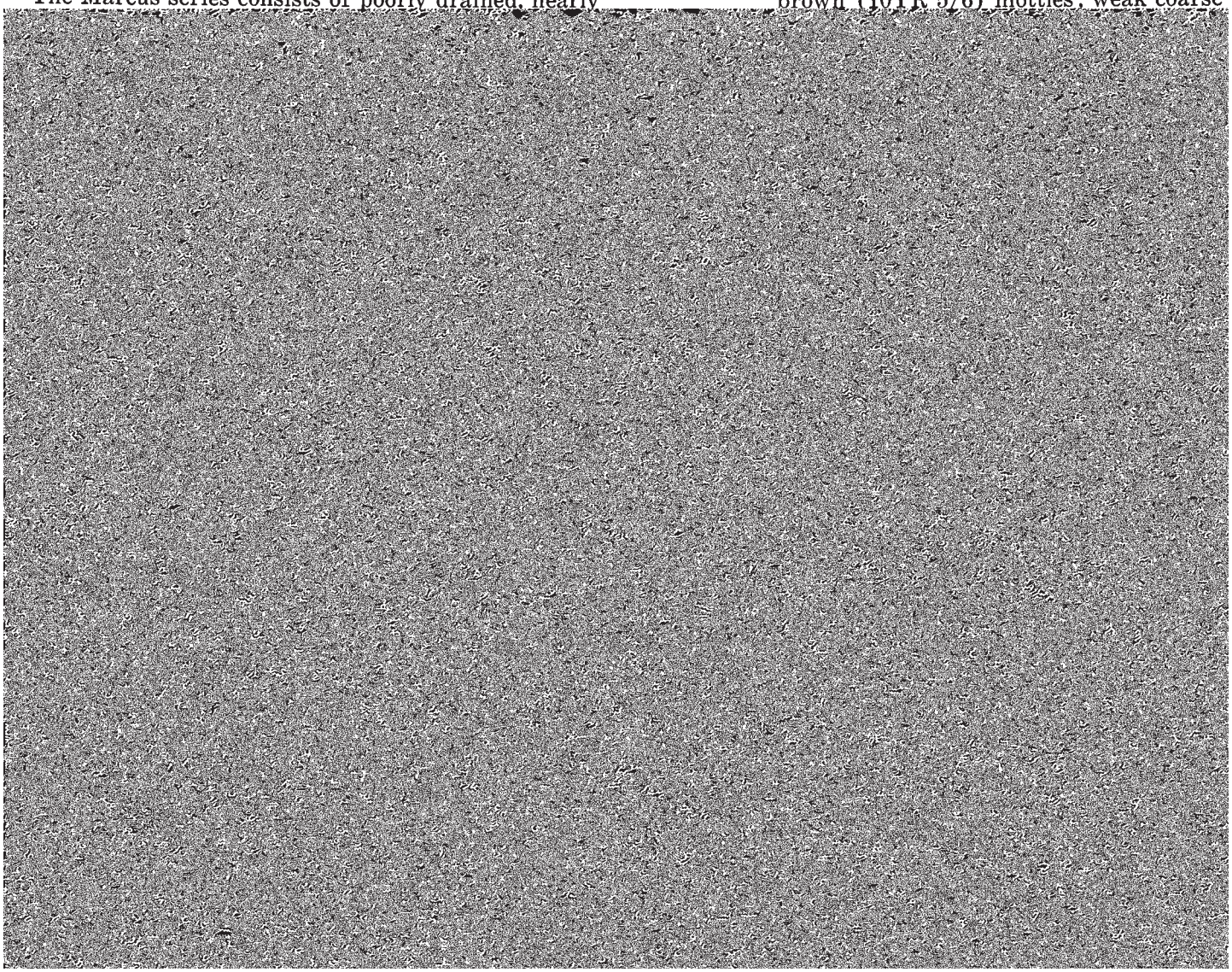
The Marcus series consists of poorly drained, nearly

matic structure parting to moderate very fine subangular blocky; friable; mildly alkaline; gradual smooth boundary.

B22—24 to 32 inches; olive gray (5Y 5/2) light to medium silty clay loam; many fine distinct light olive brown (2/5Y 5/4) mottles and few fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; mildly alkaline; gradual smooth boundary.

B3—32 to 40 inches; olive gray (5Y 5/2) light silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; few soft dark accumulations (oxides); mildly alkaline; gradual smooth boundary.

C—40 to 60 inches; olive gray (5Y 5/2) heavy silt loam; few medium distinct yellowish brown (10YR 5/6) mottles; weak coarse



Marshall series

The Marshall series consists of well drained, gently sloping to strongly sloping soils on uplands. These soils formed in loess. The native vegetation was tall prairie grasses.

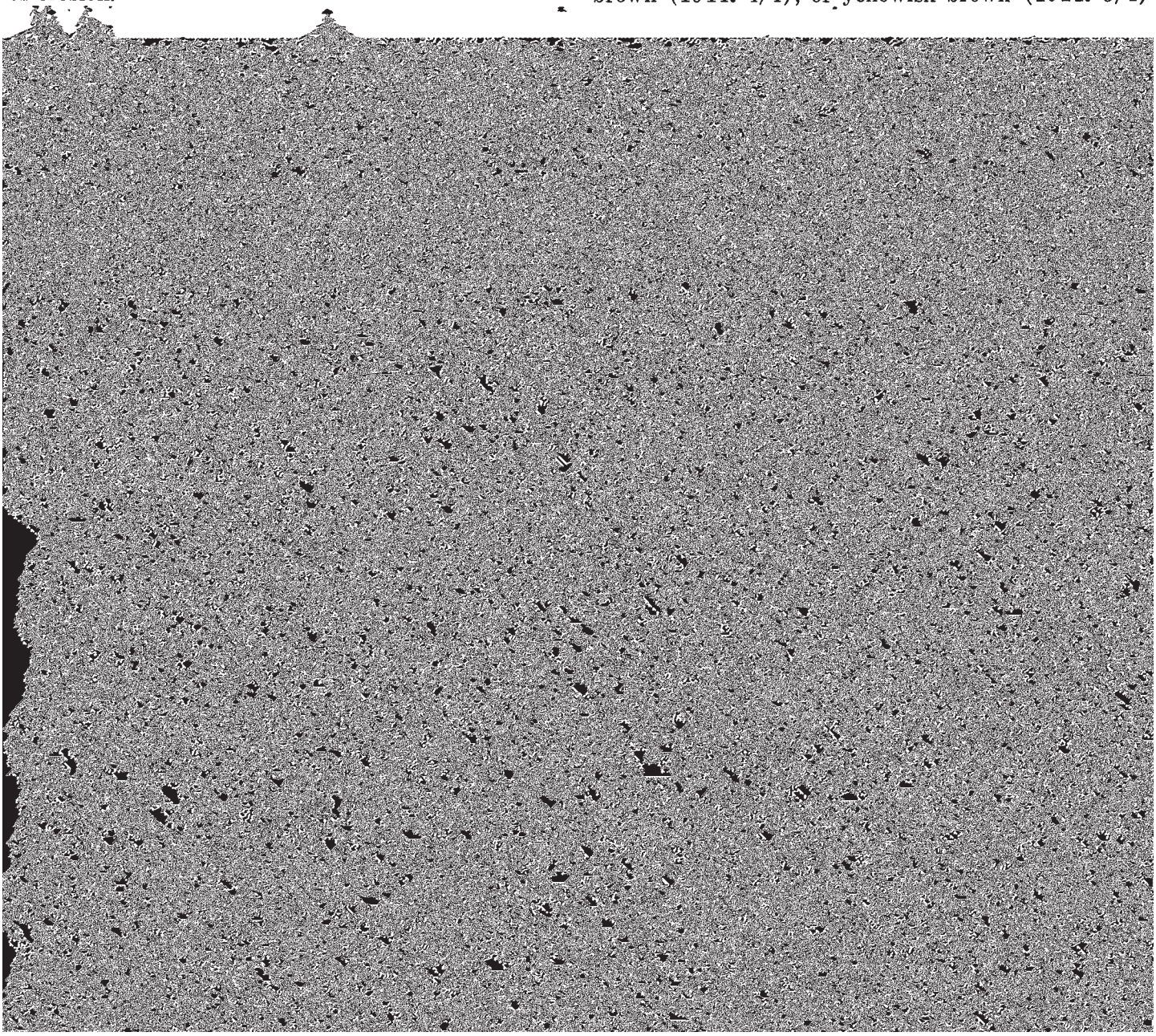
In a representative profile the surface layer is very dark brown and very dark grayish brown silty clay loam about 12 inches thick. The subsoil is silty clay loam about 55 inches thick. The upper part is dark brown, the middle part is brown, and the lower part is dark yellowish brown. The underlying material is yellowish brown silt loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low depending on the extent of erosion.

mon medium olive gray (5Y 5/2) mottles; weak fine prismatic structure; friable; many fine dark accumulations (oxides); common very fine red accumulations (oxides); neutral; gradual smooth boundary.

C—67 to 85 inches; yellowish brown (10YR 5/4) heavy silt loam; few medium olive gray (5Y 5/2) mottles; massive; friable common fine dark accumulations (oxides); few fine red accumulations (oxides); neutral.

The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 10 to 20 inches thick unless eroded. The B horizon is 25 to 60 inches thick. The C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4)



Included with this soil in mapping are areas of somewhat poorly drained and poorly drained soils in narrow hillside drainageways.

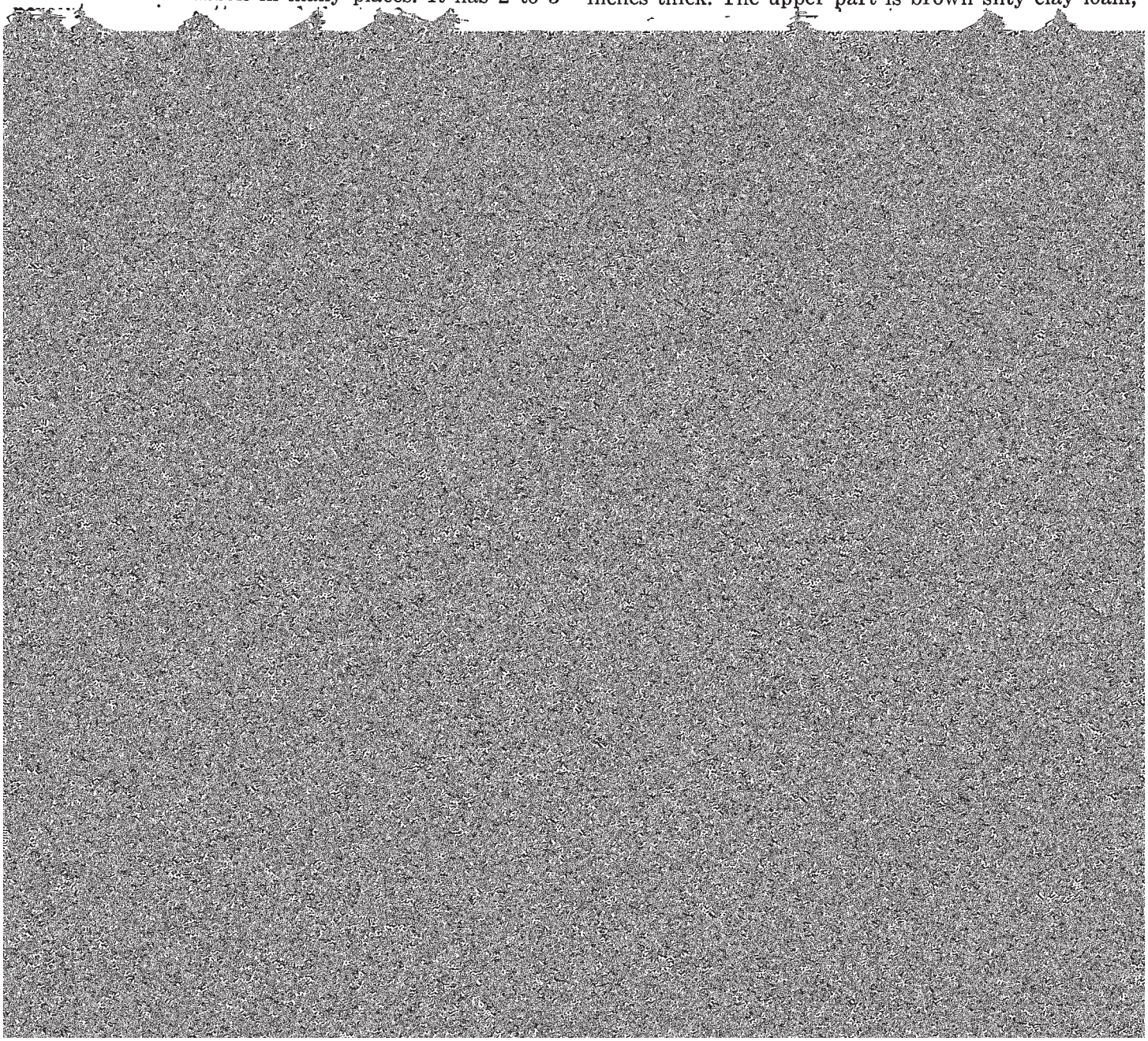
This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern. However, timely field operations are important because of the high clay content in the surface layer. Capability unit IIIe–1.

9C2—Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded. Most areas of this soil are on side slopes. Areas are 500 to 1,000 feet wide. Many areas extend for several miles along the contour of the landscape. The surface layer is a very dark grayish brown plow layer that is partly mixed with material from the dark brown subsoil in many places. It has 2 to 3 [illegible] plant cover is generally relatively sparse, infiltration is less, and runoff and erosion are greater. This soil is suited to cultivated crops if erosion is controlled, but some areas are used for pasture. Capability unit IIIe–2.

Monona series

The Monona series consists of well drained, strongly sloping and moderately steep soils on uplands. These soils formed in loess. Native vegetation was prairie grasses.

In a representative profile the surface layer is mixed very dark grayish brown, dark brown, and brown silt loam about 4 inches thick. The subsoil is about 31 inches thick. The upper part is brown silty clay loam,



accumulations (oxides); many fine dark accumulations (oxides); strongly effervescent; moderately alkaline; diffuse smooth boundary.

The solum is neutral or mildly alkaline. The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 10 to 18 inches thick unless eroded. It is generally silt loam but in places is light silty clay loam. The B horizon is brown (10YR 4/3) to yellowish brown (10YR 5/6) and is 6 to 30 inches thick. The C horizon is brown (10YR 4/3) to yellowish brown (10YR 5/6) and in most places has grayish mottles.

The Monona soils in this county are eroded, and the dark colored surface layer is thinner than is defined in the range of the series. In places, the content of grayish mottles is higher in the profile than is defined in the range of the series. These differences do not have a significant effect on the use or behavior of the soils.

Monona, Ida, and Marshall soils formed in similar [illegible]

Nicollet soils are used for cultivated crops.

Representative profile of Nicollet loam, 1 to 3 percent slopes, in a cultivated area, 260 feet north and 60 feet east of the southwest corner of SE¼SW¼ of sec. 8, R. 88 N., R. 35 W.:

Ap—0 to 9 inches; black (10YR 2/1) heavy loam; weak fine granular and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A3—9 to 14 inches; black (10YR 2/1) heavy loam; some peds of grayish brown (10YR 3/2); weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

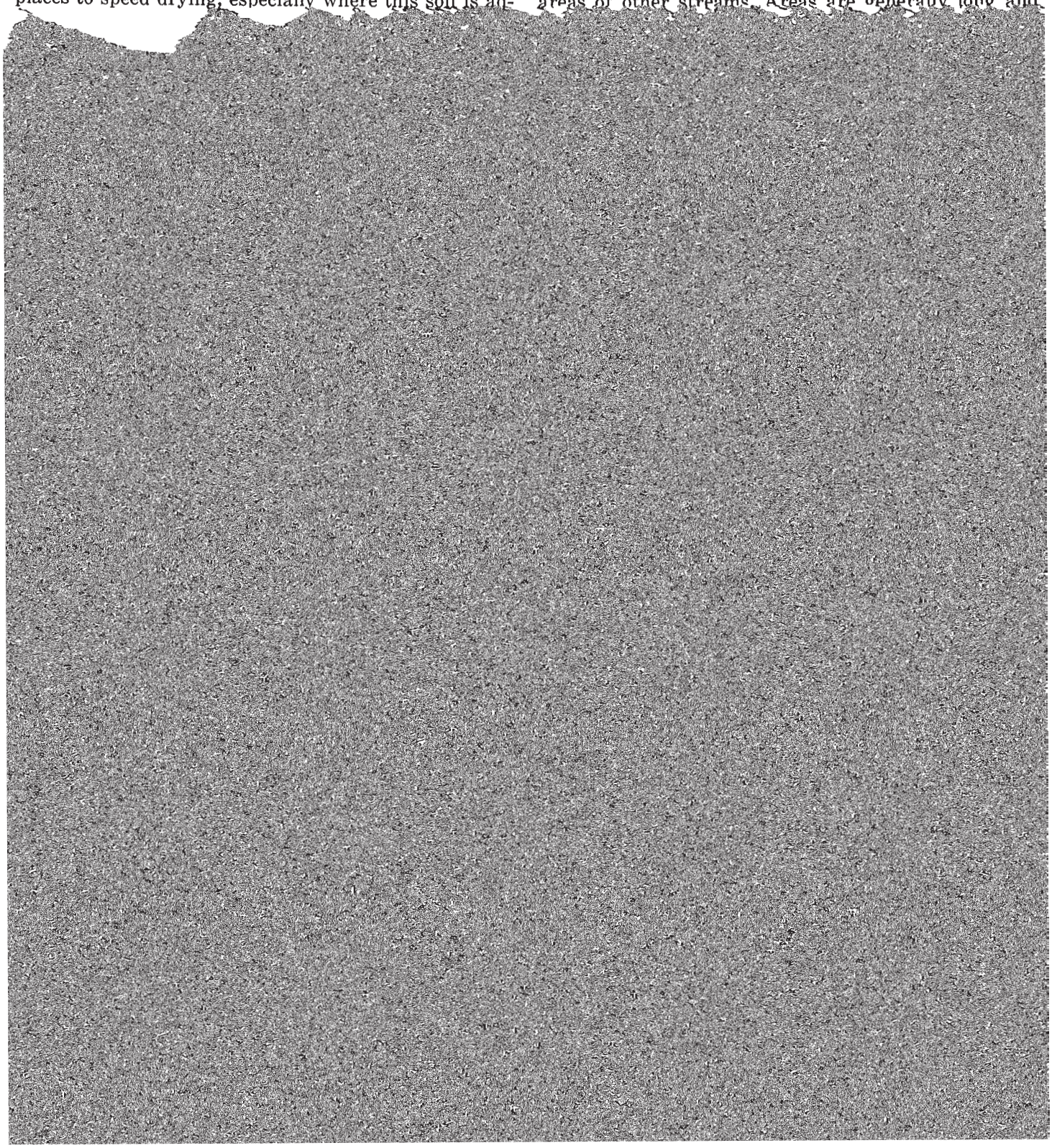
B1—14 to 20 inches; very dark grayish brown (10YR 3/2) light clay loam; some very dark gray (10YR 3/1) coats on peds; very dark grayish brown (10YR 3/2 to 2.5Y 3/2) kneaded; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

this soil are 2 to 40 acres or more in size and are irregular in shape.

This soil has no major limitations, but runoff from the gently sloping areas can cause rilling. This soil is well suited to cultivated crops. Tile drainage is used in places to speed drying, especially where this soil is ad-

parent material. Nishna soils are calcareous throughout; Zook soils are noncalcarous in the solum. Nishna soils are more clayey than Calco soils.

234—Nishna silty clay loam, 0 to 2 percent slopes. This soil is next to a sluggish stream or in slack water areas of other streams. Areas are generally long and



angular blocky; friable; thin continuous shiny surfaces on faces of peds; mildly alkaline; gradual smooth boundary.

B2g—39 to 49 inches; very dark gray (5Y 3/1) heavy silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thin continuous shiny surface on faces of prism; mildly alkaline; gradual smooth boundary.

B3g—49 to 60 inches; dark gray (5Y 5/4) olive gray (5Y 5/2) heavy silty clay loam; common fine faint olive (5Y 5/4) mottles and light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure; friable; mildly alkaline.

The solum is slightly acid to mildly alkaline. The A horizon is generally heavy silty clay loam, but in places it is light silty clay. It is more than 25 inches thick. The B horizon is black (5Y 2/1) to olive gray (5Y 5/2) and is generally heavy silty clay loam, but in places it is silty clay. It ranges from a few inches thick to several feet in thickness.

Okoboji, Lanyon, and Wacousta soils formed in similar parent material. Okoboji soils have a thicker solum than Lanyon and Wacousta soils. In places Okoboji

Representative profile of Palms muck, 0 to 1 percent slopes, in a pasture, 400 feet south and 75 feet east of the northwest corner of the SW¼SW¼ of sec. 16, T. 87 N., R. 36 W.:

Oap—0 to 6 inches; black (N 2/0) muck (sapric material); very dark gray (10YR 3/1) dry; common medium faint dark reddish brown (5YR 3/3) mottles; weak fine subangular blocky structure; friable; mildly alkaline; abrupt smooth boundary.

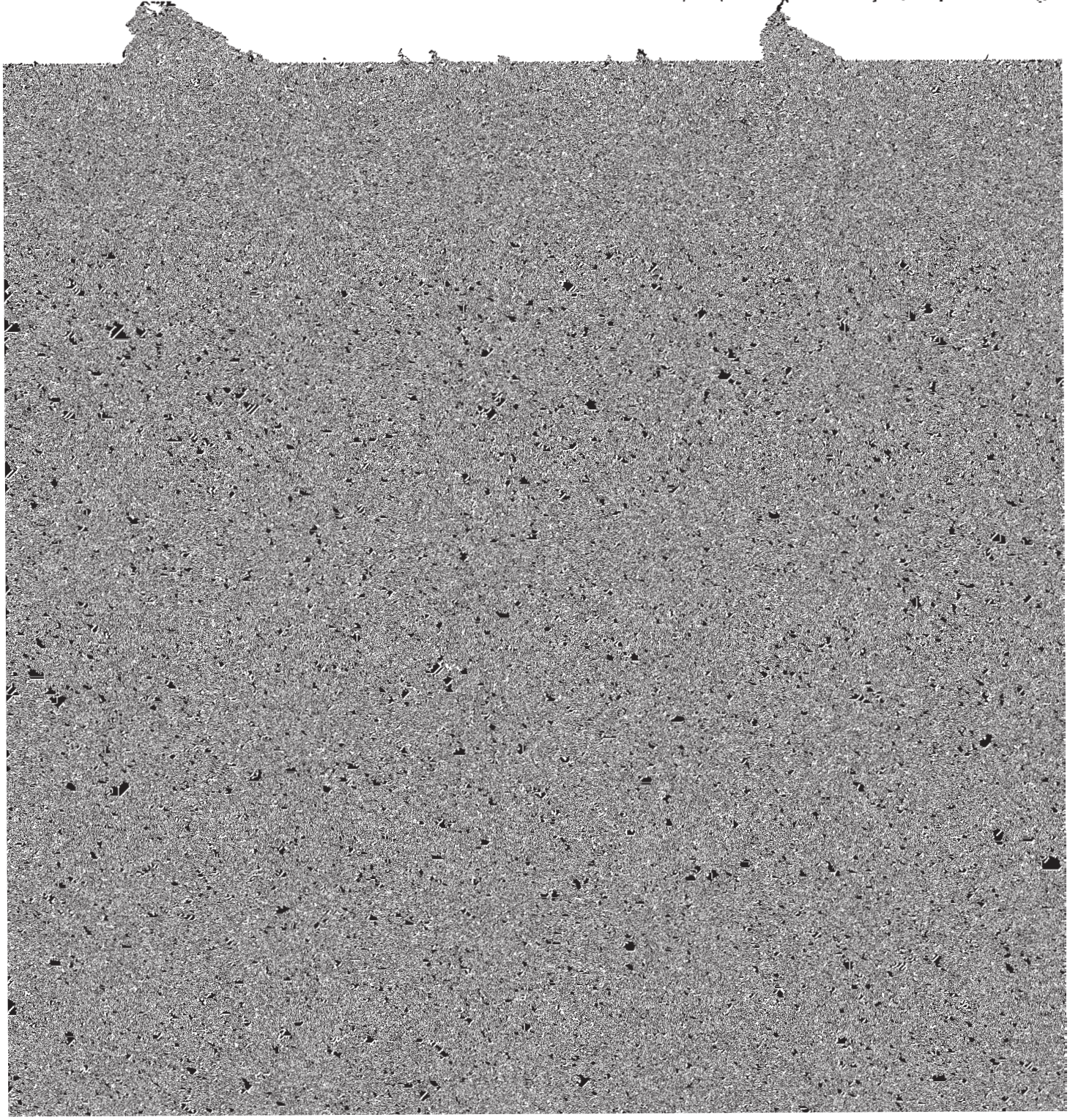
Oa1—6 to 12 inches; black (5Y 2/1) muck (sapric material); very dark gray (10YR 3/1) rubbed moist; dark brown (7.5YR 3/2) rubbed dry; common medium distinct dark brown (7.5YR 3/2) mottles; weak medium platy structure; friable; 1 inch strata of black (10YR 2/1) moist; many white lime flecks; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Oa2—12 to 16 inches; very dark gray (10YR 3/1) muck (sapric material); very dark grayish brown (2.5Y 3/2) dry; moderate thin platy structure; friable; few fine reddish accumulations (oxides) on

dark yellowish brown (10YR 4/4) mottles; weak medium prismatic structure; firm; dark streaks of krotovinas and organic matter in cracks; few undecomposed roots; few dark brown (7.5Y 3/2) coats in root channels and on faces of prisms; strongly effervescent; moderately alkaline; gradual smooth bound-

A12—8 to 15 inches; black (10YR 2/1) heavy silty clay loam; moderate very fine granular and subangular blocky structure; firm; neutral; gradual smooth boundary.

A3—15 to 20 inches; very dark gray (10YR 3/1) heavy silty clay loam; many peds of very dark grayish brown (10YR 3/2); moderate very fine subangular blocky



This nearly level soil is in convex or plane, irregularly shaped areas on uplands and benches and in nearly level to gently sloping, concave, narrow and elongated areas in drainageways. Normally, the areas in the drainageways are adjacent to areas of sloping, well drained soils. Most areas of this soil are 2 to 20 acres in size.

Included with this soil in mapping are areas of poorly drained soils in the center of the drainageways.

This soil has no major limitations to use, but runoff from the more sloping adjoining soils can cause rilling and wetness in the drainageways and on the benches. This soil is well suited to cultivated crops. The sand and gravel that underlie areas of this soil on benches are a limitation for the development of dwellings, landfills, or other such uses. Capability unit I–1.

Rolfe series

The Rolfe series consists of very poorly drained, nearly level soils on uplands and on benches. These soils formed in glacial sediment and glacial till. The native vegetation was prairie grasses, marshgrasses, and water-tolerant sedges.

In a representative profile the surface layer is black loam about 10 inches thick. The subsurface layer is very dark gray, dark gray, and gray silt loam about 7 inches thick. The subsoil is 48 inches thick. It is dark gray clay in the upper 10 inches and olive gray clay and clay loam in the lower 38 inches.

Permeability is slow, and available water capacity is high. The rooting zone is somewhat restricted by the clay subsoil, and during wet seasons it is restricted by a high water table. The organic matter content is moderate.

Rolfe soils are used for cultivated crops if the soil is adequately drained. Undrained areas are used for pasture or for aquatic wildlife habitat.

Representative profile of Rolfe loam, 0 to 1 percent slopes, in a cultivated area, 100 feet south and 125 feet west of the northeast corner of NW¼NE¼ of sec. 11, T. 88 N., R. 36 W.:

Ap—0 to 10 inches; black (10YR 2/1) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A21—10 to 13 inches; very dark gray (10YR 3/1) silt loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak thin platy structure parting to weak very fine subangular blocky; friable; slightly acid; clear smooth boundary.

A22—13 to 17 inches; dark gray (10YR 4/1) and gray (10YR 5/1) silt loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak medium platy structure; friable; slightly acid; abrupt smooth boundary.

B21gt—17 to 27 inches; dark gray (5Y 4/1) light clay; many very dark gray (5Y 3/1) and few black (5Y 2/1) coatings on peds; moderate very fine and fine subangular blocky structure; thick clay films on peds; firm; common fine reddish; slightly acid; clear smooth boundary.

B22—27 to 37 inches; olive gray (5Y 4/2 and 5/2) light clay; moderate fine subangular blocky structure; firm; thin discontinuous clay films; common fine reddish accumulations (oxides); slightly acid; clear smooth boundary.

B31—37 to 47 inches; olive gray (5Y 4/2 and 5/2) heavy clay loam; few fine distinct olive (5Y 5/4) mottles; weak fine subangular blocky structure; firm; black (10YR 2/1) coats in root channels; few fine reddish and dark accumulations (oxides); slightly acid; clear smooth boundary.

B32—47 to 65 inches; olive gray (5Y 5/2) light clay loam; many medium prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; friable; common fine reddish and dark accumulations (oxides); dark coats in root channels; slightly acid; clear smooth boundary.

The solum is medium acid or slightly acid in the most acid part. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1) loam, silt loam, or light silty clay loam 6 to 10 inches thick. The A2 horizon is very dark gray (10YR 3/1), dark gray (10YR 4/1), or gray (10YR 5/1) loam or silt loam 4 to 8 inches thick. The B horizon is generally 20 to 36 inches thick but in places is as thick as 54 inches. The upper part of the B horizon is very dark gray (10YR 3/1 or 5Y 3/1) to olive gray (5Y 5/2) clay or silty clay. The lower part is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 4/2 or 5/2) clay loam or loam.

Rolfe and Webster soils formed from similar parent material. Rolfe soils have an A2 horizon, which Webster soils do not have, and they have a more clayey B horizon than Webster soils.

274—Rolfe loam, 0 to 1 percent slopes. This soil is in depressions and is surrounded by areas of soils that are better drained. Most areas of this soil are 2 to 5 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that do not have the distinct subsurface layer typical of this Rolfe soil.

The main management concern is wetness. This soil is suited to cultivated crops if drainage is adequate and if flooding or ponding is controlled. Deep cuts are commonly needed for outlets for tile or open ditches. If the soil is inadequately drained, cultivated crops drown out or are stunted during wet seasons. Capability unit IIIw–1.

Sac series

The Sac series consists of well drained, gently sloping to moderately sloping soils on uplands. These soils formed in 20 to 40 inches of loess and in the underlying glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black, very dark gray, and very dark grayish brown silty

19 inches thick. It is brown silty clay loam in the upper part and yellowish brown clay loam in the lower part. The underlying material is yellowish brown clay loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low, depending on the extent of erosion.

Sac soils are generally used for cultivated crops.

Representative profile of Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, in a cultivated field, 350 feet west and 350 feet north of the southeast corner of SW¼SE¼ of sec. 14, T. 88 N., R. 38 W.:

Ap—0 to 8 inches; black (10YR 2/1) to very dark gray (10YR 3/1) silty clay loam; weak fine granular and weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A3—8 to 14 inches; very dark grayish brown (10YR 3/2) silty clay loam; dark brown (10YR 3/3) ped faces; few fine distinct brown (10YR 4/3) peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—14 to 21 inches; brown (10YR 4/3) silty clay loam; few discontinuous dark brown (10YR 3/3) coatings on peds; fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—21 to 28 inches; brown (10YR 4/3) silty clay loam; weak fine subangular blocky structure; friable; few thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; neutral; abrupt smooth boundary.

IIB3—28 to 36 inches; yellowish brown (10YR 5/4) clay loam; brown (10YR 4/3) coatings on peds; weak fine subangular blocky structure; firm; few reddish accumulations (oxides); few small pebbles.

lower part. The B horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4 or 5/6) and is 12 to 30 inches thick. The IIB horizon is firm clay loam or friable loam. The lower part has grayish mottles in places. The C horizon is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4 or 5/6) loam or clay loam. It generally has grayish mottles.

Sac and Galva soils formed in similar parent material and are on similar landscape positions. Sac soils have 20 to 40 inches of loess over glacial till, but Galva soils have more than 40 inches.

77B—Sac silty clay loam, loam substratum, 2 to 5 percent slopes. This soil is on ridgetops and side slopes. Areas are about 5 to 40 acres in size and are irregular in shape. This soil has a friable loam substratum. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 90 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled (fig. 5). Maintaining good tilth is not a major management concern. However, timely field operations are important because of the high clay content in the surface layer. Capability unit IIe-1.

77B2—Sac silty clay loam, loam substratum, 2 to 5 percent slopes, moderately eroded. This soil is on ridgetops and side slopes. Areas are about 5 to 30 acres in size and are irregular in shape. This soil has a friable loam substratum. The surface layer is a very dark grayish brown plow layer, and in many places it is mixed with material from the brown subsoil. The surface layer has about 2 to 3 percent organic matter, and the total content of the profile is about 45 tons per acre, much of which is in the plow layer.

Included with this soil in mapping are small areas

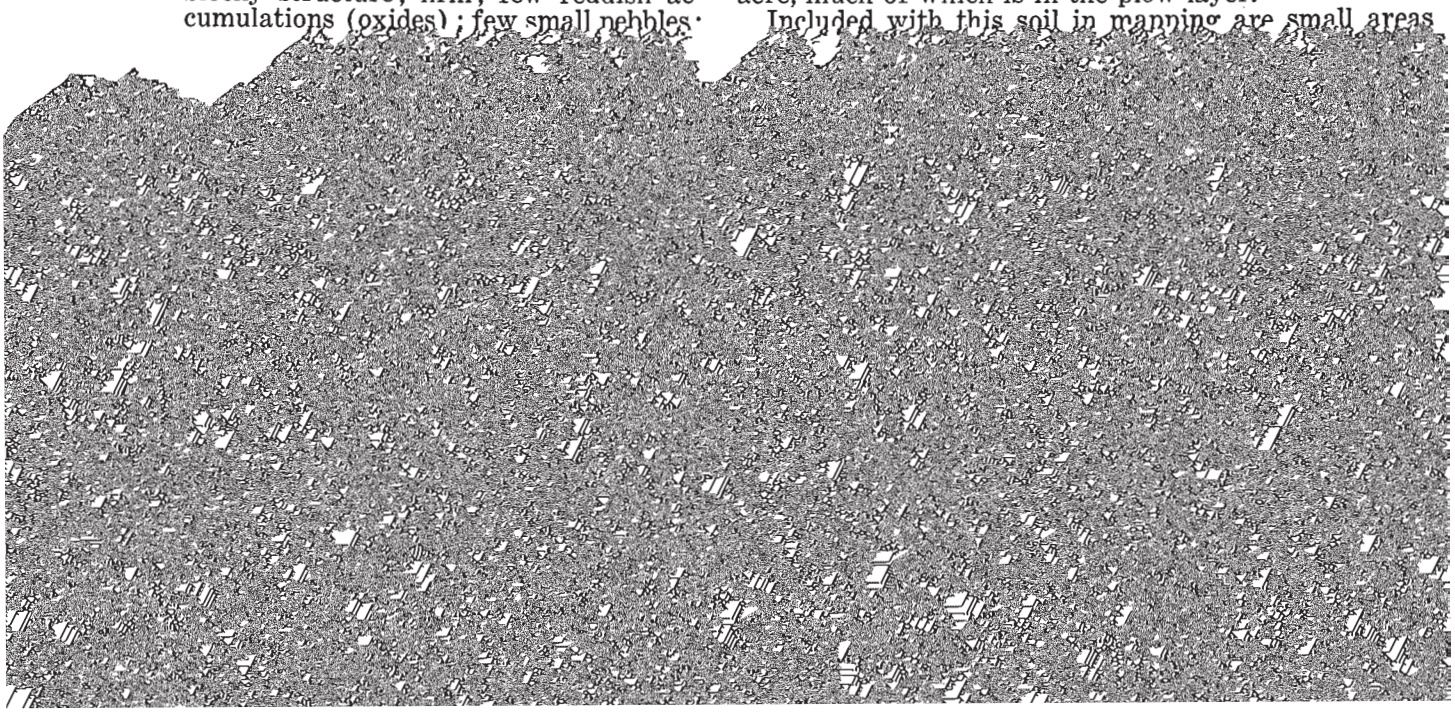


Figure 5.—**Grassed backslope of terrace on Sac silty clay loam, loam substratum, 2 to 5 percent slopes.**

cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern, but timely field operations are important because of the high clay content in the surface layer. Capability unit IIIe–1.

77C2—Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded. This soil is on side slopes. Areas are 5 to 100 acres or more in size. Some of the larger areas are a half mile or more in length. This soil has a friable loam substratum. The surface layer is a very dark grayish brown plow layer and is commonly partly mixed with the brown subsoil. The surface layer has 2 to 3 percent organic matter, and the total content of the profile is about 40 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It erodes more readily than the adjoining soils with which it is farmed, because its slopes are generally steeper and more convex. It is suited to cultivated crops if erosion is controlled. Loss of organic matter and mixing of material from the subsoil and the plow layer lower the tilth of this soil. Capability unit IIIe–1.

78B—Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes. Typically this soil is on slightly elevated knolls. Most areas are 5 to 10 acres in size, but some are 20 to 30 acres. This soil has the profile described as representative of the series. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 90 tons per acre.

Included with this soil in mapping are small areas of sandy or gravelly soils and soils that formed in glacial till. These soils are shown on the map with special symbols.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Care is needed in the construction of terraces or other structures that require the moving of soil. The firm clay loam substratum is poorly suited to plant growth. Capability unit IIe–1.

78B2—Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, moderately eroded. Typically this soil is on slightly elevated knolls. Most areas are 5 to 10 acres in size, but some are larger. The surface layer is a very dark grayish brown plow layer. In many places it is mixed with material from the brown subsoil. Erosion has reduced the depth to the substratum. The surface layer has 2 to 3 percent organic matter, and the total content of the profile is about

45 tons per acre, much of which is in the plow layer.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. It tends to erode more readily than the adjoining soils with which it is farmed, because its slopes are generally slightly steeper and more convex. It is well suited to cultivated crops if erosion is controlled. Loss of organic matter

Salida series

The Salida series consists of excessively drained, moderately sloping to strongly sloping soils on uplands and on stream benches. These soils formed in coarse textured glacial drift. The native vegetation was prairie grasses.

In a representative profile the surface layer is black and very dark gray gravelly loamy sand about 10 inches thick. The next layer is dark grayish brown

inches thick. The B horizon, if present, is dark brown (10YR 3/3) or brown (10YR 4/3) and is less than 10 inches thick. The C horizon is gravelly loamy sand or gravel and has mixed colors. It is commonly brown (10YR 5/3), yellowish brown (10YR 5/4), pale brown (10YR 5/3), light olive brown (2/5Y 5/4), and light brownish gray (2.5Y 6/2).

Salida and Flagler soils formed in similar parent material. The underlying sand and gravel are shallower in Salida soils than in Flagler soils.

73C—Salida gravelly loamy sand, 5 to 9 percent slopes. Most areas of this soil are 2 to 5 acres in size and are irregular in shape. In these areas the Salida soil is intermingled with soils that are better suited to row crops. Included with this soil in mapping are areas of gently sloping Salida soils.

This soil is suited to hay or pasture. Many areas are farmed with areas of adjoining soils. This soil can be planted to cultivated crops part of the time if erosion is controlled. Practices that conserve moisture are needed. Stones and boulders hinder farm operations. It is a common practice to leave areas of this soil in meadow when the rest of the field is planted to row crops. Capability unit IVe–2.

73D—Salida gravelly loamy sand, 9 to 14 percent slopes. Most areas of this soil are 2 to 5 acres in size and are irregular in shape. In these areas the Salida soil is intermingled with soils that are better suited to row crops. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of moderately steep Salida soils.

This soil is suited to hay or pasture, and it can be planted to cultivated crops part of the time if erosion is controlled. Practices that conserve moisture are needed. Stones and boulders hinder cultivation in many places. Capability unit IVe–2.

Shelby series

The Shelby series consists of moderately well drained, moderately sloping to moderately steep soils on uplands. These soils formed in moderately fine textured glacial till. The native vegetation was tall prairie grasses.

In a representative profile most of the surface layer is very dark brown loam and very dark grayish brown and brown clay loam about 14 inches thick. The subsoil is clay loam about 22 inches thick. It is brown in the upper 5 inches and yellowish brown and dark yellowish brown in the lower 17 inches. The underlying material is dark yellowish brown, yellowish brown, olive gray, and strong brown clay loam.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low, depending on the extent of erosion.

Shelby soils are used for cultivated crops and pasture.

Representative profile of Shelby loam, in an area of Shelby loam, 9 to 14 percent slopes, moderately eroded, in a pasture, 300 feet east and 340 feet north of the southwest corner of NE¼NE¼ of sec. 28, T. 87 N., R. 37 W.:

A11—0 to 4 inches; very dark brown (10YR 2/2) heavy loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A12—4 to 9 inches; very dark grayish brown (10YR 3/2) light clay loam; continuous very dark brown (10YR 2/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

AB—9 to 14 inches; brown (10YR 4/3) light clay loam; continuous very dark grayish brown (10YR 3/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21t—14 to 19 inches; brown (10YR 4/3) medium clay loam; discontinuous very dark grayish brown (10YR 3/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; thin clay films; slightly acid; clear smooth boundary.

B22t—19 to 29 inches; yellowish brown (10YR 5/4) medium clay loam; discontinuous olive brown (2.5Y 4/4) coatings on ped surfaces; weak fine prismatic structure parting to moderate fine subangular blocky; firm; thin continuous clay films; few fine dark accumulations (oxides); neutral; gradual smooth boundary.

B3t—29 to 36 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) heavy clay loam; medium distinct olive gray (5Y 5/2) mottles; weak medium prismatic structure parting to weak fine subangular blocky; firm; thin discontinuous clay films; few fine dark and reddish accumulations (oxides); few dark grayish brown (10YR 4/2) coatings on ped surfaces; mildly alkaline; gradual smooth boundary.

C1—36 to 43 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) medium clay loam; medium common distinct olive gray (5Y 5/2) mottles; massive; firm; dark grayish brown (2.5Y 4/2) coatings on ped surfaces; few fine dark and reddish accumulations (oxides); many lime concretions; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2—43 to 76 inches; strong brown (7.5YR 5/6), olive gray (5Y 5/2), and yellowish brown (10YR 5/6) medium clay loam; massive; firm; few fine dark and reddish accumulations (oxides); common lime concretions and threads; strongly effervescent; moderately alkaline.

The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2), depending on the extent of erosion. It is 10 to 18 inches thick if not eroded. The B horizon is dark brown (10YR 3/3) or dark yellowish brown (10YR 4/4) in the upper part; the middle and lower parts are dark yellowish brown (10YR 4/4),

brown (10YR 4/3), or yellowish brown (10YR 5/4 or 5/6) and generally have grayish mottles. The B horizon is 20 to 36 inches thick. The C horizon is mottled with various shades of brown and includes olive gray

to 14 percent slopes, in a wildlife area, 600 feet north of the southeast corner of sec. 31, T. 87 N., R. 38 W.:

Ap—0 to 10 inches; very dark brown (10YR 2/2) loamy fine sand; weak fine subangular

granular and very fine and fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—8 to 19 inches; black (10YR 2/1) loam; few very dark grayish brown (10YR 3/2) peds; weak thin platy structure parting to fine granular and weak very fine and fine subangular blocky; friable; neutral; gradual smooth boundary.

A13—19 to 25 inches; black (10YR 2/1) loam; weak fine granular and weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B1—25 to 32 inches; very dark grayish brown (10YR 3/2) loam; black (10YR 2/1) coatings on peds; very dark brown (10YR 2/2) kneaded; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—32 to 43 inches; very dark grayish brown (10YR 3/2) loam; black (10YR 2/1) coatings on peds; very dark grayish brown (10YR 3/2) kneaded; weak fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.

B22—43 to 47 inches; dark brown (10YR 3/3) loam; very dark gray (10YR 3/1) coatings on peds; very dark grayish brown (10YR 3/2) kneaded; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.

B3—47 to 56 inches; brown (7.5YR 4/4) dark brown (7.5YR 3/2) and dark gray (5Y 4/1) sandy clay loam; brown (7.5YR 4/2) kneaded; weak medium subangular blocky structure; few fine dark and reddish accumulations (oxides); friable; neutral; clear smooth boundary.

C—56 to 66 inches; yellowish brown (10YR 5/4) and olive gray (5Y 5/2) sandy loam; light olive brown (2.5Y 5/4) kneaded; weak medium prismatic structure; friable; common fine dark and reddish accumulations (oxides); mildly alkaline.

The solum is neutral to slightly acid. The A horizon is 24 to 56 inches thick. The lower part of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The B horizon, if present, is dominantly very dark grayish brown (10YR 3/2) but commonly has a mixed matrix of very dark gray (10YR 3/1), light olive brown (2.5Y 5/4), brown (7.5YR 4/4) or olive gray (5Y 4/1). It is loam, sandy clay loam, or sandy loam 4 to 50 inches thick. The C horizon is generally very dark grayish brown (10YR 3/2) to olive gray (5Y 5/2). It is loam, sandy loam, or sand and gravel and is stratified.

Spillville and Coland soils formed in similar parent material. Spillville soils are mainly loam and Coland soils are silty clay loam and clay loam. Spillville soils are better drained than Coland soils.

485—Spillville loam, 0 to 2 percent slopes. This soil is on bottom lands, and areas are generally long and narrow. Most areas are 2 to 20 acres in size. They commonly are intermingled with other nearly level soils on bottom lands.

Included with this soil in mapping are areas of soils that are mildly alkaline.

The main management concern is wetness. This soil is well suited to cultivated crops if drainage is adequate and if flooding is controlled. It usually is farmed with the adjoining nearly level soils, most of which are more poorly drained. Undrained areas and unprotected areas are better suited to pasture than to cultivated crops. Capability unit IIw–2.

485B—Spillville loam, 2 to 5 percent slopes. This soil is on foot slopes and areas are generally long and narrow. Typically it is downslope from areas of Clarion or Storden soils. Most areas are 2 to 10 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that are similar to this Spillville soil but are light clay loam throughout.

This soil has a moderate erosion hazard. It receives runoff from adjoining upslope soils, which causes rilling and, in places, sedimentation. This soil is well suited to cultivated crops if erosion is controlled. It is commonly farmed with adjacent upland soils. Capability unit IIe–1.

Steinauer series

The Steinauer series consists of well drained, strongly sloping to very steep soils on uplands. These soils formed in moderately fine textured glacial till. The native vegetation was prairie grasses and a few scattered trees.

In a representative profile the surface layer is dark grayish brown loam about 5 inches thick. The underlying material is yellowish brown clay loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low.

Steinauer soils are used mainly for pasture.

Representative profile of Steinauer loam, 9 to 18 percent slopes, in pasture, 300 feet west and 25 feet north of the southeast corner of NW¼SE¼ of sec. 29, T. 86 N., R. 37 W.:

Ap—0 to 5 inches; dark grayish brown (10YR 4/2) loam; weak fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1—5 to 24 inches; yellowish brown (10YR 5/4) clay loam; thin discontinuous dark grayish brown (10YR 4/2) coatings on peds; few medium prominent light gray (10YR 6/1) mottles; weak fine prismatic structure and weak fine subangular blocky; firm; few fine black and red concretions; strongly effervescent; moderately alkaline; clear smooth boundary.

C2—24 to 48 inches; yellowish brown (10YR 5/4) medium clay loam; few medium prominent light gray mottles; massive; firm; few fine black accumulations; strongly

effervescent; moderately alkaline; clear smooth boundary.

C3—48 to 73 inches; yellowish brown (10YR 5/4) medium clay loam; few medium prominent light gray (10YR 6/1) mottles; massive; firm; few fine black and brown concretions; few lime concretions; few small pebbles; strongly effervescent; moderately alkaline.

The solum generally is calcareous throughout, but the A horizon is noncalcareous in places. The A horizon commonly is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) loam or clay loam. It is 8 to 14 inches thick if uneroded. Some pedons have a very dark grayish brown (10YR 3/2) A horizon that is less than 6 inches thick. The C horizon is yellowish brown (10YR 5/4), brown (10YR 5/3), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4).

Steinauer and Shelby soils formed in similar parent material. Steinauer soils do not have the B horizon typical of Shelby soils and are generally calcareous throughout. Shelby soils are noncalcareous in the A and B horizons.

33E—Steinauer loam, 9 to 18 percent slopes. This soil is on convex side slopes. Most areas are 2 to 5 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

This soil is suited to pasture and woodland and is moderately suited to hay. Surface stones and boulders hinder farm operations in places. Capability unit VIe-1.

33F—Steinauer loam, 18 to 40 percent slopes. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

loam; moderate fine subangular blocky structure; friable; many light gray concretions; strongly effervescent; moderately alkaline; clear smooth boundary.

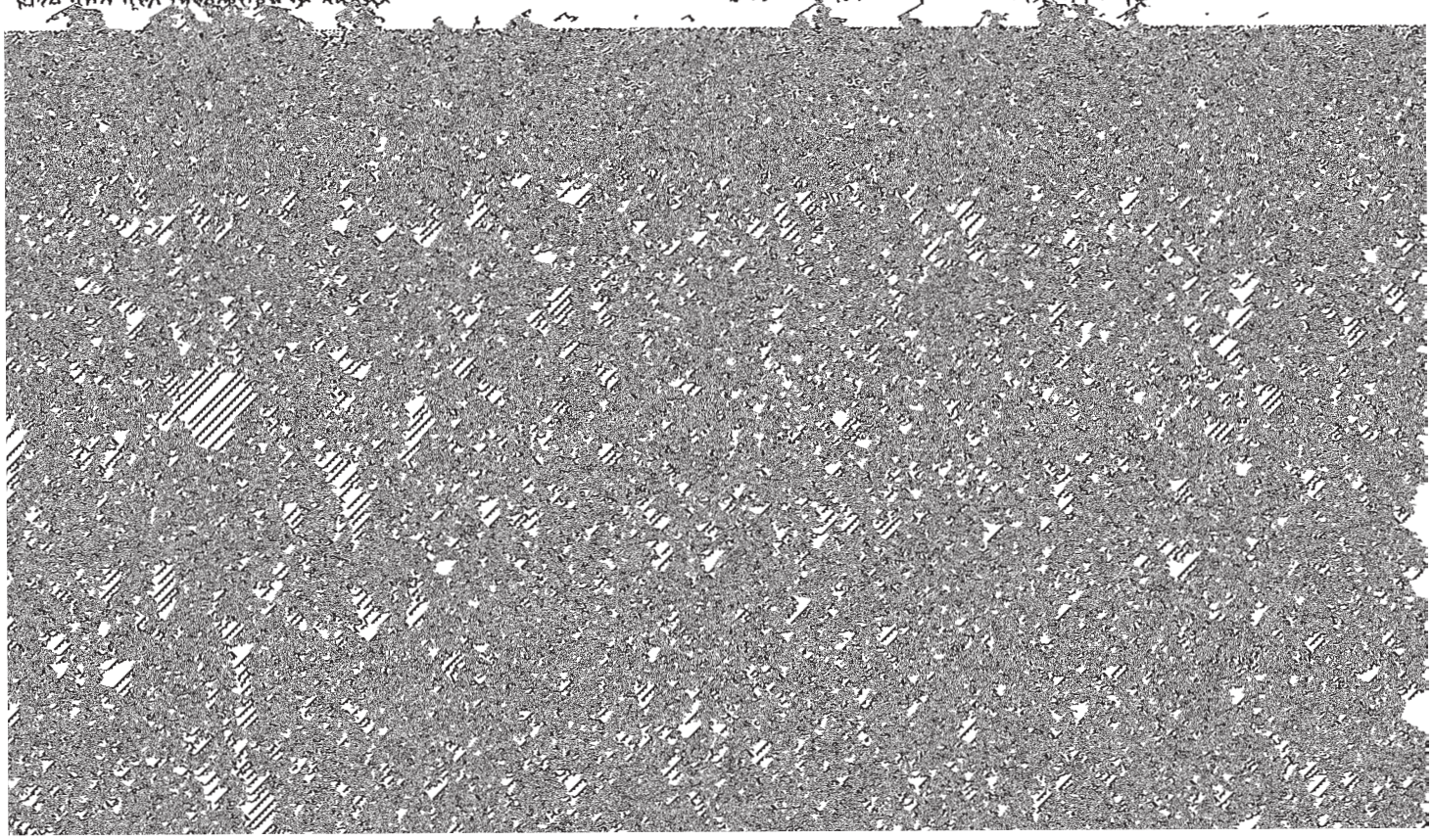
C2—15 to 28 inches; light olive brown (2.5Y 5/6) loam; weak fine subangular blocky structure; friable; vertical lime streaks; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3—28 to 38 inches; yellowish brown (10YR 5/8) loam; weak fine and medium subangular blocky structure; few fine distinct light olive gray (5Y 6/2) mottles; friable; few fine dark accumulations (oxides); very few medium reddish accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C4—38 to 49 inches; yellowish brown (10YR 5/4) loam; few coarse distinct yellowish brown (10YR 4/2) mottles; weak medium subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

C5—49 to 70 inches; yellowish brown (10YR 5/4) loam; massive; friable; thin discontinuous dark coatings (oxides) on cleavage faces; strongly effervescent; moderately alkaline; gradual smooth boundary.

The A horizon is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). It is as much as 10 inches thick if uneroded. The C horizon is yellowish brown (10YR 5/6 or 5/8), light olive brown (2.5Y



to cultivated crops part of the time if erosion is controlled. Capability unit IVe–1.

62F—Storden loam, 18 to 25 percent slopes. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of sand and gravel. Also included are areas of shale outcrop near Grant City.

This soil is suited to pasture and woodland and is moderately suited to hay. The steepness of the slopes makes the use of farm machinery hazardous in places. Capability unit VIe–1.

62G—Storden loam, 25 to 40 percent slopes. This soil is on side slopes. Areas range from 2 acres to more than 50 acres in size and are irregular in shape.

Included with this soil in mapping are a few areas of gravelly soils. Also included are areas of shale outcrop near Grant City.

This soil is suited to pasture and woodland. The steepness of the slopes makes the use of farm machinery impractical or extremely hazardous. Capability unit VIIe–1.

Talcot series

The Talcot series consists of very poorly drained, nearly level soils on uplands and benches. These soils formed in moderately fine textured glacial outwash over coarse textured outwash. The native vegetation was grasses and sedges.

In a representative profile the surface layer is black clay loam about 18 inches thick. The subsoil is clay [illegible] subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

B2g—23 to 29 inches; gray (5Y 5/1) light clay loam; weak fine prismatic structure parting to very fine subangular blocky; friable; very dark gray fills in worm or root channels; few very fine reddish and dark accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

B3g—29 to 37 inches; light gray (5Y 6/1) light clay loam; very few coarse distinct light olive brown (2.5Y 5/6) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; very dark gray (5Y 3/1) fills in worm and root channels; common very fine reddish accumulations (oxides); few fine dark accumulations (oxides); strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIC—37 to 60 inches; light gray (5Y 6/1) medium sand; few stones; common large distinct strong brown (7.5YR 5/6) mottles and iron bands; structureless; loose; common large reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is 14 to 24 inches thick. The B horizon is 10 to 20 inches thick. It is black (5Y 2/1) to very dark gray (5Y 4/1) in the upper part and mot-

on foot slopes and benches. These soils formed in medium textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is loam about 31 inches thick. The upper part is black and the lower part is very dark grayish brown. The subsoil is dark brown, brown, and very dark grayish brown clay loam that extends to a depth of 73 inches or more.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Terril soils are used for cultivated crops and for pasture.

Representative profile of Terril loam, 3 to 8 percent slopes, in a cultivated area, 400 feet south and 300 feet east of the northwest corner of SW¼NW¼ of sec. 36, T. 88 N., R. 36 W.:

Ap—0 to 8 inches; black (10YR 2/1) medium loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral abrupt smooth boundary.

A12—8 to 17 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) heavy loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—17 to 24 inches; very dark grayish brown (10YR 3/2) heavy loam; very dark gray (10YR 3/1) coatings on peds; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—24 to 31 inches; very dark grayish brown (10YR 3/2) heavy loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—31 to 54 inches; dark brown (10YR 3/3) and brown (10YR 4/3) light clay loam; few very dark grayish brown (10YR 3/2) coatings on peds; weak fine and medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B3—54 to 73 inches; very dark grayish brown (10YR 3/2), dark grayish brown (2.5Y 4/3), and brown (7.5YR 4/4) light clay loam; weak prismatic structure parting to weak medium subangular blocky; friable; slightly acid; gradual smooth boundary.

The solum is slightly acid or neutral. The A horizon is loam or light clay loam 24 to 36 inches thick. The B horizon is loam or light clay loam 24 inches to several feet thick. The C horizon, where present, is commonly brown (10YR 4/3), dark yellowish brown (10YR 4/4), olive brown (2.5Y 4/4), or yellowish brown (10YR 5/4) and, in places, has grayish mottles. In mapping unit 323B, the C horizon is loamy sand or sand.

Terril and Spillville soils formed in similar parent material. Terril soils are browner in the B horizon than Spillville soils.

27C—Terril loam, 3 to 8 percent slopes. This soil is on foot slopes. Most areas of this soil are 2 to 5 acres in size and are generally narrow and elongated. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that have a sandy loam surface layer.

This soil has a moderate to severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Runoff from adjoining soils on the hillsides causes rilling and, in places, sedimentation. Capability unit IIIe–1.

323B—Terril loam, sandy substratum, 2 to 5 percent slopes. This soil is on benches. Most areas are 2 to 20 acres in size. They are irregular in shape but are generally slightly elongated.

Included with this soil in mapping are areas of soils that have a sandy loam surface layer.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Runoff from adjoining soils on the hillsides causes rilling and, in places, sedimentation. This soil has lower available water capacity than Terril soils that do not have a sandy substratum. Capability unit IIe–1.

Wacousta series

The Wacousta series consists of very poorly drained, nearly level soils in depressions on uplands. These soils formed in moderately fine textured glacial sediment. The native vegetation was water-tolerant grasses.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The subsoil is very dark gray and dark gray silty clay loam about 4 inches thick. The underlying material is olive gray and light olive gray silty clay loam.

Permeability is moderate to moderately slow, and available water capacity is high. The rooting zone is restricted in wet seasons by a high water table. Organic matter content is high.

Wacousta soils are used for cultivated crops and pasture.

Representative profile of Wacousta silty clay loam, 0 to 1 percent slopes, in a cultivated area, 100 feet west and 100 feet south of the northeast corner of NW¼ of sec. 20, T. 88 N., R. 36 W.:

Ap—0 to 9 inches; black (N 2/0) light silty clay loam; cloddy; friable; neutral; abrupt smooth boundary.

A1—9 to 15 inches; black (5Y 2/1) medium silty clay loam; weak very fine subangular blocky structure; friable; few gray fills in root and worm channels; neutral; abrupt smooth boundary.

Bg—15 to 19 inches; very dark gray (5Y 3/1) and dark gray (5Y 4/1) medium silty clay loam; massive; friable; very dark gray streaks and fills in crayfish holes; many fine light gray lime accumulations and fragments of snail shells; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1g—19 to 30 inches; light olive gray (5Y 6/2) light silty clay loam; many medium distinct light olive brown (2.5Y 5/4) mottles; olive gray (5Y 5/2) kneaded; massive; friable; few fine dark and reddish accumulations (oxides); few fine

soft lime accumulations; darks fills in root and worm channels; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2g—30 to 60 inches; olive gray (5Y 5/2) light silty clay loam; many medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few large lime accumulations; few fine dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is slightly acid or neutral. It is 8 to 16 inches thick. The B horizon, if present, is neutral to moderately alkaline. It is black (5Y 2/1) to light olive gray (5Y 6/2) and is as much as 6 inches thick. The C horizon is dark gray (5Y 4/1) to light olive gray (5Y 6/2). It is generally silty clay loam but is silt loam in places.

Wacousta and Okoboji soils formed in similar parent material in depressions. Wacousta soils have a thinner solum than Okoboji soils and are generally slightly coarser textured. They are coarser textured than Lanyon soils, which also formed in depressions.

506—Wacousta silty clay loam, 0 to 1 percent slopes. This soil is in depressions. Most areas are 5 to 50 acres in size and are irregular in shape.

Included with this soil in mapping are areas of a soil similar to this Wacousta soil, but it is calcareous throughout the profile.

The main management concern is wetness. This soil is subject to runoff from adjoining areas. This soil is suited to cultivated crops if drainage is adequate and if flooding or ponding is controlled. If this soil is inadequately drained, crops drown out or are stunted during flooding or ponding. Capability unit IIIw–1.

Wadena series

The Wadena series consists of well drained, nearly level to moderately sloping soils on benches and on uplands. These soils formed in medium textured glacial outwash and in the underlying sand and gravel. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown loam about 13 inches thick. The subsoil is 21 inches thick. The upper part is very dark brown and very dark grayish brown loam, the middle part is brown loam and dark yellowish brown sandy clay loam, and the lower part is dark yellowish brown sand and gravel. The underlying material is brown sand and gravel.

Permeability is moderately rapid in the upper part of the profile and very rapid in the underlying sand and gravel. Available water capacity is moderate. The rooting zone is restricted by depth to sand and gravel. Organic matter content is moderate to moderately low.

A12—6 to 9 inches; very dark brown (10YR 2/2) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—9 to 13 inches; very dark brown (10YR 2/2) loam; common very dark grayish brown (10YR 3/2) peds; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—13 to 17 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—17 to 23 inches; brown (10YR 4/3) loam; dark brown (10YR 3/3) coatings on peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B22—23 to 27 inches; dark yellowish brown (10YR 4/4) sandy clay loam; weak fine subangular blocky structure; friable; common gravel; neutral; abrupt smooth boundary.

IIB3—27 to 34 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; slightly acid; abrupt wavy boundary.

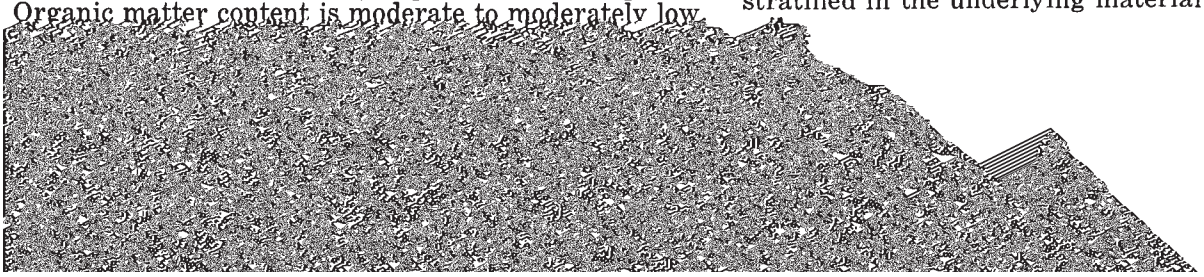
IIC—34 to 60 inches; brown (10YR 4/3) sand and gravel; single grained; loose; strongly effervescent; moderately alkaline.

The solum is neutral or slightly acid. The A horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark brown (10YR 2/2) and is 10 to 20 inches thick if uneroded. The B horizon is generally brown (10YR 4/3) or dark yellowish brown (10YR 4/4), but in places it is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) in the upper part. The B horizon is loam or sandy clay loam, but the B3 horizon is sand and gravel in places. The B horizon is 12 to 24 inches thick.

Wadena and Cylinder soils formed in similar parent material. Wadena soils are better drained than Cylinder soils.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This soil is generally on benches. A few areas formed in outwash on uplands. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified in the underlying material than this Wadena



benches. Most areas are 2 to 10 acres in size and are irregular in shape.

This soil has a moderate erosion hazard and is

to 2 percent slopes, in a cultivated area, 150 feet east and 5 feet south of the northwest corner of NE¼NE¼ of sec. 14, T. 86 N., R. 36 W.:

are more poorly drained than Collinwood soils. They are finer textured and less permeable than Webster soils.

390—Waldorf silty clay loam, 0 to 2 percent slopes. Most areas of this soil are 8 to 10 acres in size and are

few fine dark and reddish accumulations (oxides); mildly alkaline; abrupt smooth boundary.

B3g—25 to 33 inches; olive gray (5Y 5/2), light olive gray (5Y 6/2), and dark gray (5Y

dark gray silty clay about 20 inches thick. The underlying material is very dark gray silty clay

Undrained and unprotected areas are better suited to

ample, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, trees and shrubs, and most other uses of land are influenced

Pastures on soils where farm machinery can be used are generally in bromegrass or alfalfa-bromegrass. These pastures can be plowed and reseeded if neces-

TABLE 2.—*Yields per acre of crops and pasture*

[All yields were estimated for a high level of management in 1975. Absence of a yield figure indicates the crop is seldom grown or is not suited]

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
1D3:						
Ida	68	26	52	2.6	4.0	2.3
1E3:						
Ida	54	20	41	2.1	3.0	1.7
1F3:						
Ida	----	----	----	1.5	2.8	1.2
5B:						
Kennebec-Ackmore	114	43	91	4.2	6.8	4.1
C5B:						
Kennebec-Ackmore	----	----	----	4.1	6.0	3.8
6:						
Okoboji	78	30	62	2.9	4.6	3.1
8C:						
Judson	110	41	88	4.8	6.7	3.7
9B:						
Marshall	101	38	86	4.0	6.0	3.8
9B2:						
Marshall	98	37	85	4.0	5.9	3.7
9C:						
Marshall	96	36	81	3.9	5.8	3.6
9C2:						
Marshall	93	35	75	3.8	5.6	3.6
9D2:						
Marshall	84	31	68	3.4	4.8	3.5
9D3:						
Marshall	78	29	64	3.2	4.6	2.8
10D3:						
Monona	75	28	56	2.9	4.4	2.7
10E3:						
Monona	60	23	45	2.3	3.3	2.3
11B:						
Colo-Ely	86	32	70	3.3	4.9	3.3
24C2:						
Shelby	86	32	70	3.3	4.9	3.3
24D2:						
Shelby	76	28	57	3.0	4.3	2.7
24E2:						
Shelby	66	25	48	2.3	3.7	2.3
26B:						
Kennebec	111	42	88	4.4	6.7	4.2
27C:						
Terril	100	38	80	4.0	6.0	3.8
31:						
Afton	98	37	79	3.8	5.9	3.7
33E, 33F:						
Steinauer:	----	----	----	----	2.0	2.0
41D:						
Sparta	----	----	----	----	2.0	2.0

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-	Smooth	Kentucky

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
T310:						
Galva	102	39	82	4.0	6.1	3.7
T310B:						
Galva	100	38	81	4.0	6.0	3.7
315:						
Alluvial land	----	----	----	----	----	2.5
323B:						
Terril	95	32	76	3.8	5.7	3.7
325:						
Le Sueur	106	40	85	4.2	6.5	4.0
354:						
Marsh	----	----	----	----	----	----
384:						
Collinwood	93	35	74	3.7	5.5	3.7
390:						
Waldorf	85	32	68	3.3	4.9	3.5
397B:						
Letri	75	28	60	2.9	4.3	2.9
428:						
Ely	104	40	83	4.2	6.3	3.9
430:						
Ackmore	99	38	80	4.0	6.0	3.8
430B:						
Ackmore	97	37	77	3.9	5.8	3.7
485:						
Spillville	100	38	80	4.0	6.0	3.8
485B:						
Spillville	98	37	78	4.0	5.9	3.8
506:						
Wacousta	93	35	74	3.6	5.4	3.7
507:						
Canisteo	98	37	78	3.8	5.8	3.8
511:						
Blue Earth	87	33	70	3.3	4.9	3.3
559:						
Talcot	88	33	70	3.4	5.0	3.2
577C2:						
Everly	86	32	68	3.4	5.1	3.1
577D2:						
Everly	77	28	60	3.0	4.5	2.5
606:						
Lanyon	83	31	67	3.2	4.8	3.4

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
823B:						
Flagler	47	19	35	1.8	2.5	1.7
823C2:						
Flagler	39	16	30	1.6	2.0	1.5

[1] Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.

Capability grouping

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they

to range, woodland, or wildlife food and cover.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife water

vey. The groupings of soils shown in this guide are subject to change as new methods are discovered or new information becomes available.

CAPABILITY UNIT I-1

This unit consists of nearly level or gently sloping, well drained and somewhat poorly drained soils mainly on uplands and stream benches. Slopes are 0 to 3 percent. The surface layer is loam or silty clay loam. The subsoil is dominantly loam, silty clay loam, clay loam, or sandy clay loam. Some soils have silty clay layers or a layer of loamy sand in the subsoil. Permeability is mainly moderately rapid, moderate, moderately slow, or slow, but in the substratum of some soils it is very rapid or rapid. Available water capacity is moderate to high. The organic matter content of the surface layer is moderate to high. The rooting zone is generally deep, but soils that have a sand and gravel substratum have a restricted rooting zone. Available phosphorus is generally very low or low in the surface layer and very low in the subsoil. Available potassium is medium or high in the surface layer of the soils that formed in loess, but it is low or medium in the surface layer of the soils that formed in glacial drift. Available potassium is very low or low in the subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops. They are well suited to row crops. Lime and fertilizer are beneficial on cultivated crops and forage crops.

Row crops can be grown often on these soils. Tile drainage is beneficial on some of the soils that are adjacent to poorly drained and very poorly drained soils. Grassed waterways are used in places, especially on the soils that receive runoff from adjoining soils. Minimum tillage or contour farming, or both, are desirable practices, especially on long slopes that have a significant amount of runoff. A cropping system that includes oats or meadow improves tilth and helps control weeds and insects. Plowing in fall increases the hazard of soil blowing, but soil loss can be reduced by leaving a rough plowed surface and alternating plowed and unplowed strips. Chisel plowing, which leaves crop residue on the surface, greatly reduces soil blowing.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping, well drained to somewhat poorly drained soils mainly on uplands, stream benches, and bottom land. Slopes are mostly 2 to 5 percent but range to as much as 7 percent in glacial material. Available potassium is low to very low in the subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops, but many soils on bottom lands are used for permanent pasture because they are in long, narrow areas adjacent to steeply sloping soils that are poorly suited to row crops. All the soils in this unit are well suited to row crops and are moderately susceptible to erosion.

Row crops can be grown often if the soils are adequately protected against erosion. Conservation practices such as terracing, contour farming, and minimum tillage reduce erosion. Good tilth generally can be maintained by returning all crop residue to the soil. A cropping system that includes oats and meadow helps control weeds and insects. Where cuts for terraces expose the subsoil, fertility and tilth generally can be restored in a few years by spreading a layer of topsoil, large amounts of crop residue, and manure over the cuts. Where they expose the firm subsoil, larger amounts of crop residue and a longer time are required to restore good tilth to these areas. Building terraces on the soils that formed in glacial deposits is difficult because the slopes are generally irregular. Diversion terraces are needed in places to protect the soils on bottom lands from runoff. Grassed waterways are needed in places that receive runoff from adjoining soils. On all soils in this unit, adequate erosion control is needed for intensive production of corn and soybeans.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping, well drained soils on uplands and benches. Slopes are 2 to 5 percent. The surface layer is loam. The subsoil is mainly loam or sandy clay loam, but some soils are loamy fine sand in the lower part of the subsoil. Permeability is moderately rapid or moderate in the upper part of the profile and very rapid or rapid in the substratum. Available water capacity is moderate. The organic matter content of the surface layer is generally moderate. Depth of the rooting zone is restricted by sand and gravel. Available phosphorus is very low or low in the surface layer and very low in the subsoil. Available potassium is very low or low in the surface layer and subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops. Lime and fertilizer are beneficial for improved crop production. These soils have a friable surface layer

soils mainly on uplands and benches. These soils are mostly poorly drained and somewhat poorly drained, but they range from moderately well drained to very poorly drained. Slopes are 0 to 5 percent. The surface layer is silty clay loam, clay loam, silt loam, or loam. The subsoil is silty clay loam, silty clay, clay loam, sandy clay loam, sandy loam, silt loam, or loam. Permeability is mainly moderate to moderately slow, but it is rapid in the soils that have a sand and gravel substratum. Available water capacity is high or moderate. The organic matter content of the surface layer is high to moderate. The rooting zone is mainly deep, but it is restricted in the soils that have a sand and gravel substratum. Available phosphorus is generally very low to medium in the surface layer and very low or low in the subsoil. Available potassium is very low to medium in high water table and a moderate wetness limitation.

Row crops can be grown often if the soils are adequately drained. These soils are generally plowed in fall because wetness may delay plowing in spring. Freezing, thawing, wetting, and drying of the areas that are plowed in fall improve tilth. Better seedbeds can be prepared by plowing in fall, but the soils are subject to soil blowing. Soil blowing can be reduced by leaving a rough plowed surface and alternating plowed and unplowed strips. Chisel plowing, which leaves crop residue on the surface, also reduces soil blowing. A cropping system that includes oats and meadow improves tilth and helps control weeds and insects. Grassed waterways are needed in places for erosion protection. Tile drainage systems are commonly used, but they function slowly in the finer tex-

able potassium is mainly very low in the subsoil, but it is high in the soils that formed in glacial till. The reaction of the surface layer is generally slightly acid to neutral, but in the calcareous soils the surface layer is moderately alkaline.

These soils are used for cultivated crops and pasture. They are moderately well suited to row crops. Lime and fertilizer are beneficial on the soils used for cultivated crops and forages. The soils in this unit have a friable surface layer and are highly susceptible to erosion.

Row crops can be grown on these soils if the soils are adequately protected against erosion. Conservation practices such as terracing, farming on the contour, and minimum tillage reduce erosion. Cropping systems that include small grain and meadow are needed to control erosion where terraces are not used. Terraces can be built and farmed easily on the soils that formed in loess because they have long, uniform slopes. Some of the soils that formed in glacial till have short, irregular slopes, so building terraces on these soils is more difficult. Where cuts for terraces expose the subsoil, special practices must be used to restore fertility and tilth. Diversion terraces are needed in places to protect the soils on foot slopes from runoff. In places, grassed waterways are needed to protect the soils against erosion. When row crops are grown on the moderately sloping soils, erosion control practices are necessary. Maintaining good tilth usually is not difficult on these soils.

CAPABILITY UNIT IIIe-2

This unit consists of strongly sloping, well drained and somewhat excessively drained soils on uplands. Slopes are 9 to 14 percent. The surface layer is silty clay loam, silt loam, clay loam, or loam. The subsoil is silt loam, silty clay loam, clay loam, or loam. Permeability is moderate to moderately slow, and available water capacity is high. The organic matter content of the surface layer is moderate to low. Rooting zone is deep. Available phosphorus is very low in the subsoil. Available potassium is medium to high in the surface layer of the soils that formed in loess, and it is medium to low in the soils that formed in glacial till. Available potassium is mainly very low to low in the subsoil, but it is high in one soil. The reaction of the surface layer is mainly slightly acid to neutral, but it is moderately alkaline in some soils.

These soils are used for corn, soybeans, oats, alfalfa, and pasture. They are moderately suited to row crops. These soils are highly susceptible to erosion.

is loam, sandy loam, fine sandy loam, or sandy clay loam. The substratum is sand or gravel. Permeability is moderate to moderately rapid and rapid or very rapid in the substratum. Available water capacity is moderate to low. The organic matter content of the surface layer is moderate to low. Available phosphorus and potassium are generally low to very low in the surface layer and subsoil. The reaction of the surface layer is medium acid to neutral.

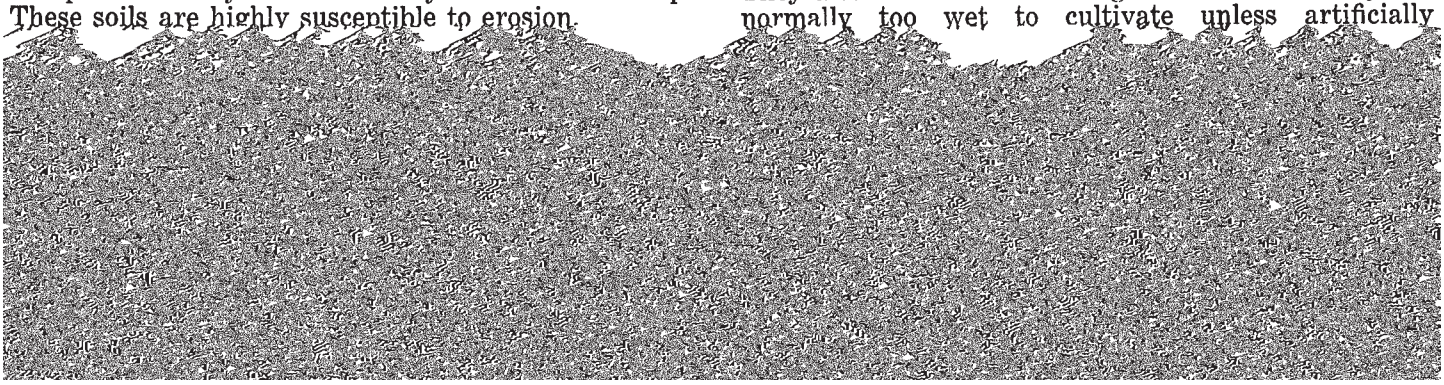
These soils are used for crops and pasture. Fertilizer is beneficial on the soils used for cultivated crops and forage crops; however, applying fertilizer in large amounts is not suitable for these droughty soils. These soils are friable and are easy to till. They are highly susceptible to droughtiness, water erosion, and soil blowing.

Row crops can be grown if the soils are adequately protected against erosion. Conservation practices such as contour tillage and minimum tillage help to reduce erosion and conserve moisture. A cropping system that includes a large proportion of small grain and meadow can also be used in controlling erosion. These soils are not well suited to terraces, because of the underlying sand or gravel. If terraces are built, deep cuts that expose sand and gravel at the surface should be avoided.

CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained and poorly drained soils in potholes or in depressions. Slopes are 0 to 1 percent. The surface layer is silty clay loam, silty clay, loam, or muck. The subsoil is silty clay loam, silty clay, clay loam, or clay. Permeability is moderate to slow, and available water capacity is high. The organic matter content of the surface layer is generally high, but it is moderate in one soil. The rooting zone is mainly deep, but root growth is often restricted by a seasonal high water table. Available phosphorus and potassium are very low to low in the subsoil. The reaction of the surface layer is moderately alkaline to medium acid.

These soils are used for cultivated crops if drainage is adequate and they are suited to this use. If not drained, they are generally used for pasture. Small undrained areas within large cultivated areas are left idle in most years and provide habitat for aquatic wildlife. Fertilizer is beneficial on soils used for cultivated crops and forage crops. The soils on depressions often become ponded after rain or from runoff in spring. They also have a seasonal high water table. They are normally too wet to cultivate unless artificially



CAPABILITY UNIT IVe-1

This unit consists of moderately steep, well drained and somewhat excessively drained soils. Slopes are 14 to 20 percent. The surface layer is silt loam or loam. The underlying material is silt loam, silty clay loam, or loam. Permeability is moderate, and available water capacity is high. The organic matter content of the surface layer is moderate to low. The rooting zone is deep. Available phosphorus is very low to low in the are seldom adequate for preventing runoff and erosion; a cropping system that includes hay and pasture is also needed.

Building terraces on these soils is very difficult because of the moderately steep, short, irregular slopes. In a commonly used cropping system, corn is grown on the contour for a year and then the soil is reseeded to meadow or pasture that is not renovated until the stand becomes thin.

crops, but most areas are used for hay and pasture. Some areas are in permanent pasture. These soils are well suited to hay and pasture.

A row crop is commonly grown when stands of legumes and grasses become poor and need to be plowed and reseeded. These soils are susceptible to severe sheet and gully erosion. Contour tillage and minimum tillage are practices used to control erosion. Terraces are not well suited, because of the coarse texture of the underlying material. Where terraces are built, it is important to make cuts as shallow as possible. Also, heavy applications of fertilizers and manure are needed on the disturbed areas to help plant growth. Organic matter in the form of crop residue, barnyard manure, or plowed-under green manure improves rapid runoff. The organic matter content in the surface layer is moderate to low. Available phosphorus is low or very low in the surface layer and subsoil. Available potassium is mainly low to medium in the surface layer, but it is high in the soils that formed in loess. Available potassium is low to very low in the subsoil of the calcareous soils and high in the soils that are leached of lime. The reaction of the surface layer is slightly acid to moderately alkaline.

Most areas are in pasture, and many of these have been used for cultivated crops. Some areas are planted to row crops, especially small areas adjacent to soils that are better suited to cultivation. The soils in this unit are not generally suited to row crops because of the steepness of slope, the hazard of erosion, and low

Figure 7.—**Alluvial land along the Raccoon River typically supports scattered trees and brush. Alluvial land is in capability unit Vw-1.**

Some areas have stands of trees. Steep slopes limit the use of this soil. Gullies are a hazard in places. This

Windbreaks and environmental plantings

TABLE 3.—*Windbreaks and environmental plantings*

[Absence of an entry means soil does not normally support trees of this height class]

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
1D3, 1E3, 1F3:					
Ida	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
5B:					
Kennebec part	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar, Russian-olive.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood, white ash.
Ackmore part	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry.	Green ash, eastern cottonwood.
C5B:					
Kennebec part	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar, Russian-olive.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood, white ash.
Ackmore part	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce	Eastern white pine, red pine, Scotch	Green ash, eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
24C2, 24D2, 24E2: Shelby	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine.	Green ash, eastern cottonwood.
26B: Kennebec	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood.
27C: Terril	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
31: Afton	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry, northern white-cedar.	Eastern cottonwood.
33E, 33F: Steinauer	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Eastern redcedar, Russian-olive.	Ponderosa pine, Austrian pine, Scotch pine.	Green ash, eastern cottonwood.
41D: Sparta	Gray dogwood, Peking cotoneaster.	Eastern redcedar, lilac, Siberian peashrub.	Norway spruce	Red pine, eastern white pine, jack pine.	Green ash, eastern cottonwood.
54: Zook	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce.	Green ash, silver maple.	Eastern cottonwood.
55: Nicollet	Arrowwood, mockorange.	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Red pine, eastern white pine, green ash, hackberry.	Eastern cottonwood.
62C, 62D, 62E, 62F, 62G: Storden	European cotoneaster, mockorange.	Tall purple willow, Tatarian honeysuckle, Siberian peashrub, northern whitecedar.	Eastern redcedar, white spruce.	Green ash, Russian-olive, golden willow.	Eastern cottonwood.
73C, 73D: Salida	Gray dogwood, Peking cotoneaster.	Eastern redcedar, northern white-cedar, Russian-olive, Tatarian honeysuckle.	Hackberry, bur oak, red pine.	Green ash, eastern cottonwood.	

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
91: Primghar	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry.	Eastern white pine, red pine, Scotch pine, silver maple, Douglas-fir.	Green ash, eastern cottonwood.
92: Marcus	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
95: Harps	Silky dogwood, American cranberrybush.	Northern white cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
107: Webster	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, hackberry, white spruce.	Green ash, silver maple, American sycamore.	Eastern cottonwood.
108, 108B, 108C2: Wadena	European cotoneaster, mockorange.	Siberian crabapple, gray dogwood, Tatarian honeysuckle, lilac.	Eastern redcedar, northern white-cedar, white spruce, red pine, hackberry, bur oak.	Green ash	Eastern cottonwood.
133: Colo	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, laurel willow, American sycamore, poplar.	Green ash, eastern cottonwood.
134: Zook	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, hackberry, white spruce.	Green ash, silver maple.	Eastern cottonwood.
135, 135B: Coland	Silky dogwood, American cranberrybush.	Northern white-cedar.	Northern white-cedar, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry.	Green ash, eastern cottonwood.
138B, 138C, 138C2, 138D2: Clarion	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry, silver maple.	Green ash, eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
174B, 174C2, 174D2:					
Bolan	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, silver maple.	Green ash, eastern cottonwood.
201B:					
Coland part	Silky dogwood, American cranberrybush.	Northern white-cedar.	Northern white-cedar, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry.	Eastern cottonwood, green ash.
Spillville part	Arrowwood, mockorange.	Siberian peashrub, American plum.	Red pine, Norway spruce, hackberry, European larch, eastern redcedar.	Eastern white pine, Scotch pine.	Green ash, eastern cottonwood.
C201B:					
Coland part	Silky dogwood.	Northern white-	Northern white-	Silver maple	Green ash, eastern

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
308, 308B: Wadena	European	Siberian crabapple	Eastern redcedar	Green ash	Eastern

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
430, 430B: Ackmore	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce.	Eastern white pine, red pine, Scotch	Green ash, eastern cottonwood.

tional information about planning windbreaks and screens and the planting and care of trees can be obtained from the local office of the Soil Conservation Service or the Extension Service.

Engineering[2]

This section provides information about the use of soils for building sites, sanitary facilities, construction materials, and water management. Among those who can benefit from this section are engineers, landowners, community decision makers and planners, town and city managers, land developers, builders, contractors, and farmers.

The ratings in tables in this section are based on test data and estimated data in the "Soil Properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service, using known relationships between the soil properties and the behavior of soils in various engineering uses.

Soil properties and site conditions identified by the soil survey that are used in determining the ratings in this section include grain-size distribution, liquid

8. Relate performance of structures already built to properties of the kinds of soil on which they are built. In this way, performance of similar structures on the same or a similar soil in other locations can be predicted.
9. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. The data are generally not presented for soil below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations and testing.

The information is presented mainly in tables. Table 4 shows, for each kind of soil, ratings for the degree and kinds of limitations for building site development; table 5 for sanitary facilities; and table 7 for

TABLE 4.—*Building site development*

[Terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
1D3:					
Ida	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Severe: frost action.
1E3, 1F3:					
Ida	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope, frost action.
5B:					
Kennebec part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action, low strength.
Ackmore part	Severe: floods, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell.	Severe: floods, low strength, shrink-swell.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
24C2: Shelby	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength, slope.	Severe: low strength.
24D2: Shelby	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
24E2: Shelby	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
77C, 77C2, 78C, 78C2: Sac	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Severe: low strength, frost action.
91: Primghar	Severe: wetness	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength, frost action.
92: Marcus	Severe: wetness	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
95: Harps	Severe: wetness	Severe: wetness, low strength.	Severe: wetness, low strength.	Severe: wetness, low strength.	Severe: wetness, low strength, frost action.
107: Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
108, 108B: Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.
108C2: Wadena	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: frost action, slope.
133: Colo	Severe: wetness, floods.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, low strength, frost action.
134: Zook	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength.
135, 135B: Coland	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, frost action.
138B: Clarion	Slight	Slight	Slight	Slight	Moderate: low strength, frost action.
138C, 138C2: Clarion	Slight	Slight	Slight	Moderate: slope	Moderate: low strength, frost action.
138D2: Clarion	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope, low strength, frost action.
174B: Bolan	Moderate: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.
174C2: Bolan	Moderate: cutbanks cave.	Slight	Slight	Moderate: slope	Moderate: frost action.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
174D2: Bolan	Moderate: cut-banks cave, slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: frost action, slope.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
323B: Terril	Moderate: wetness, cutbanks cave.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Moderate: low strength, frost action.
325: Le Sueur	Moderate: wetness, too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
354: Marsh	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
384: Collinwood	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
390: Waldorf	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, frost action, shrink-swell.
397B: Letri	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, low strength.
428: Ely	Severe: wetness	Moderate: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.
430, 430B: Ackmore	Severe: floods, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell.	Severe: floods, low strength, shrink-swell.
485, 485B: Spillville	Severe: floods, wetness.	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
506: Wacousta	Severe: wetness	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: frost action, wetness, shrink-swell.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
511:					

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
606:					
Lanyon	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: frost action, wetness, shrink-swell.
733:					
Calco	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.
823B:					
Flagler	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
823C2:					
Flagler	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.

each soil horizon is defined, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and small commercial buildings referred to in table 4 are built on undisturbed soil. The foundation load is that of a dwelling no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence from settling or shear failure of the foundation do not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity, and in-place density, potential frost

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities, and in identifying limiting soil properties and site features to be considered in design and installation. Also, soil properties that are relevant to ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 5 shows the degree and kind of limitations of each soil for these uses and for use of the soil as daily cover for landfills.

If the degree of soil limitation is indicated by the

TABLE 5.—*Sanitary facilities*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and other terms used to rate soils. Absence of an entry means soil was not rated]

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
ID3: Ida	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
24E2:					
Shelby	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
26B:					
Kennebec	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
27C:					

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption	Sewage lagoon	Trench sanitary	Area sanitary	Daily cover

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
C201B:					
Spillville part	Severe: floods, wetness.	Severe: floods	Severe: floods	Severe: floods	Good.
202, 203:					
Cylinder	Severe:	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer,

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
428: Ely	Severe: wetness	Moderate: excess humus, seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
430, 430B: Ackmore	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
485, 485B: Spillville	Severe: floods, wetness.	Severe: floods, wetness, excess humus.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
506: Wacousta	Severe: percs slowly, wetness, floods.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
511: Blue Earth	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
559: Talcot	Severe: wetness.[1]	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
577C2: Everly	Slight	Moderate: seepage, excess humus, slope.	Slight	Slight	Fair: too clayey.
577D2: Everly	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: too clayey, slope.
606: Lanyon	Severe: percs slowly, wetness.	Moderate: excess humus.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
733: Calco	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
823B: Flagler	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
823C2: Flagler	Slight	Severe: slope, seepage.	Severe: seepage	Severe: seepage	Fair: thin layer.

[1] Danger of contamination of ground water because of porous substratum.

below the tile lines. In these soils the absorption field does not adequately filter effluent, and as a result, ground water supplies in the area may be contaminated. Soils that have a hazard of inadequate filtration are indicated by footnotes in table 5.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil has minimum absorptive capacity.

In many soils that have moderate or severe limitations for septic tank absorption fields, it may be possible to install special systems that lower the seasonal water table or to increase the size of the absorption field to achieve satisfactory performance.

Sewage lagoon areas are shallow ponds constructed to hold sewage while bacteria decompose solid and liquid wastes. Lagoons have a nearly level flow area surrounded by cut slopes or embankments of compacted, nearly impervious soil material. They are gen-

TABLE 6.—*Construction materials*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
31: Afton	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness.
33E: Steinauer	Poor: low strength	Unsuited	Unsuited	Poor: thin layer.
33F: Steinauer	Poor: low strength	Unsuited	Unsuited	Poor: thin layer, slope.
41D: Sparta	Good	Good	Unsuited	Poor: too sandy.
54: Zook	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
55: Nicollet	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
62C, 62D: Storden	Fair: frost action	Unsuited	Unsuited	Fair: slope, thin layer.
62E, 62F: Storden	Fair: slope, frost action	Unsuited	Unsuited	Poor: slope.
62G: Storden	Poor: slope	Unsuited	Unsuited	Poor: slope.
73C, 73D: Salida	Good	Good	Fair: excess fines	Poor: too sandy, area reclaim.
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
91: Primghar	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Fair: too clayey.
92: Marcus	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
95: Harps	Poor: low strength, frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
107: Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
108, 108B: Wadena	Good	Good	Fair: excess fines	Good.
108C2: Wadena	Good	Good	Fair: excess fines	Fair: slope.
133: Colo	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
134: Zook	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
135, 135B: Coland	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
138B, 138C, 138C2:				
Clarion	Fair: frost action, low strength.	Unsuited	Unsuited	Good.
138D2:				
Clarion	Fair: frost action, low strength.	Unsuited	Unsuited	Fair: slope.
174B, 174C2:				
Bolan	Good	Poor: excess fines	Unsuited	Good.
174D2:				
Bolan	Good	Poor: excess fines	Unsuited	Fair: slope.
201B:				
Coland part	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.
Spillville part	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
C201B:				
Coland part	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.
Spillville part	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
202, 203:				
Cylinder	Good	Good	Fair: excess fines	Good.
221:				
Palms	Poor: wetness, excess humus.	Unsuited	Unsuited	Poor: wetness.
234:				
Nishna	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
236B:				
Lester	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
259:				
Biscay	Poor: frost action	Good	Poor: excess fines	Poor: wetness.
274:				
Rolfe	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness.
308, 308B:				
Wadena	Good	Good	Fair: excess fines	Good.
310, 310B, 310B2, 310C, 310C2:				
Galva	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey.
T310, T310B:				
Galva	Poor: low strength, frost action.	Good	Good	Fair: too clayey.
315:				
Alluvial land	Poor: wetness, frost action.	Fair	Fair	Good.
323B:				
Terril	Fair: low strength, frost action.	Fair: excess fines	Poor: excess fines	Good.
325:				
Le Sueur	Poor: frost action, low	Unsuited	Unsuited	Fair: thin layer.

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
354: Marsh	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
384: Collinwood	Poor: shrink-swell	Unsuited	Unsuited	Poor: too clayey.
390: Waldorf	Poor: wetness, frost action, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
397B: Letri	Poor: frost action, low strength.	Unsuited	Unsuited	Poor: wetness.
428: Ely	Poor: frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
430, 430B: Ackmore	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Good.
485, 485B: Spillville	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
506: Wacousta	Poor: area reclaim, shrink-swell, wetness.	Unsuited	Unsuited	Poor: area reclaim, wetness, too clayey.
507: Canisteo	Poor: frost action	Unsuited	Unsuited	Poor: excess lime, wetness.
511: Blue Earth	Poor: excess humus, low strength.	Unsuited	Unsuited	Poor: wetness.
559: Talcot	Poor: wetness, frost action.	Good	Fair: excess fines	Poor: wetness.
577C2: Everly	Fair: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey.
577D2: Everly	Fair: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey, slope.
606: Lanyon	Poor: area reclaim, shrink-swell, wetness.	Unsuited	Unsuited	Poor: area reclaim, wetness, too clayey.
733: Calco	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
823B, 823C2: Flagler	Good	Good	Fair: excess fines	Good.

erally designed so that depth of sewage is 2 to 5 feet. Impervious soil at least 4 feet thick for the lagoon floor and sides is required to minimize seepage and contamination of local ground water. Soils that are very high in organic matter content and those that have stones and boulders are undesirable. Unless the soil is very slowly permeable, contamination of local ground water is a hazard in areas where the seasonal high water table is above the level of the lagoon floor. In soils that have a high water table, seepage of ground water into the lagoon can seriously reduce its capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the location of sites for sewage lagoons and the cost of construction. Shear

TABLE 7.—*Water management*

[Some terms that describe restrictive soil features are defined in the Glossary. Absence of an entry means soil was not evaluated]

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
1D3, 1E3, 1F3:							
Ida	Seepage	Low strength, compressible, piping.	No water	Not needed	Slope, erodes easily, excess lime.	Slope, erodes easily, piping.	Erodes easily, slope.
5B:							
Kennebec part	Seepage	Low strength, com-	Deep to	Floods	Floods	Favorable	Favorable.

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
133:							
Colo	Favorable	Compressible	Slow refill	Floods	Floods	Not needed	Wetness

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
274:							
Rolfe	Favorable	Low strength, compressible, shrink-swell.	Slow refill	Floods, percs slowly, poor outlets.	Floods, percs slowly, wetness.	Not needed	Not needed.
308, 308B:							
Wadena	Seepage	Seepage	No water	Not needed	Seepage, rooting depth.	Rooting depth.	Rooting depth.
310, 310B, 310B2, 310C, 310C2:							
Galva	Favorable	Low strength, compressible, piping.	No water	Not needed	Erodes easily.	Favorable	Favorable.
T310:							
Galva	Seepage	Low strength	No water	Not needed	Favorable	Rooting	Favorable

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
506:							
Wacousta	Slope	Compressible, low strength, hard to pack.	Slow refill	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
507:							
Canisteo	Favorable	Compressible, low strength.	Deep to water.	Favorable	Wetness	Not needed	Not needed.
511:							
Blue Earth	Favorable	Low strength, compressible, excess humus.	Slow refill	Wetness, floods.	Wetness	Not needed	Not needed.
559:							
Talcot	Seepage	Seepage	Slow refill	Cutbanks cave, wetness.	Wetness	Not needed	Not needed.
577C2, 577D2:							
Everly	Favorable	Low strength, piping	No water	Not needed	Erodes easily.	Favorable	Slope.
606:							
Lanyon	Favorable	Compressible, low strength, hard to pack.	Slow refill	Percs slowly, poor outlets, wetness.	Percs slowly, wetness.	Not needed	Not needed.
733:							
Calco	Favorable	Compressible, low strength, hard to pack.	Slow refill	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
823B, 823C2:							
Flagler	Seepage	Seepage, piping	No water	Not needed	Droughty, soil blowing.	Too sandy, piping.	Droughty.

strength and permeability of compacted soils affect the performance of embankments. slight or moderate may not be valid. A site should be investigated before it is selected.

or final cover, thickness of suitable soil material that is available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas, such as slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of road fill, sand, gravel, and topsoil is indicated in table 6 by ratings of good, fair, or poor. Texture, thickness, and organic matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth described in the survey, generally about 6 feet.

Roadfill is soil material used in road embankments.

Soils rated *good* have at least 16 inches of friable loamy soil at the surface. They are free of stones, are low in content of gravel and other coarse fragments, and have gentle slopes. They are low in soluble salts, which can limit plant growth. They are naturally fertile or respond well to fertilization. They are not so wet as to make excavation difficult during most of the year.

Soils rated *fair* are loose sandy, firm loamy or clayey soils in which the suitable layer is only 8 to 16 inches thick. Others have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils, very firm clayey soils, soils that have suitable material less than 8 inches thick, soils that have a high content of gravel, stones, or soluble salt, steep soils, and poorly drained

depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, or boulders can greatly increase the cost of constructing camping sites.

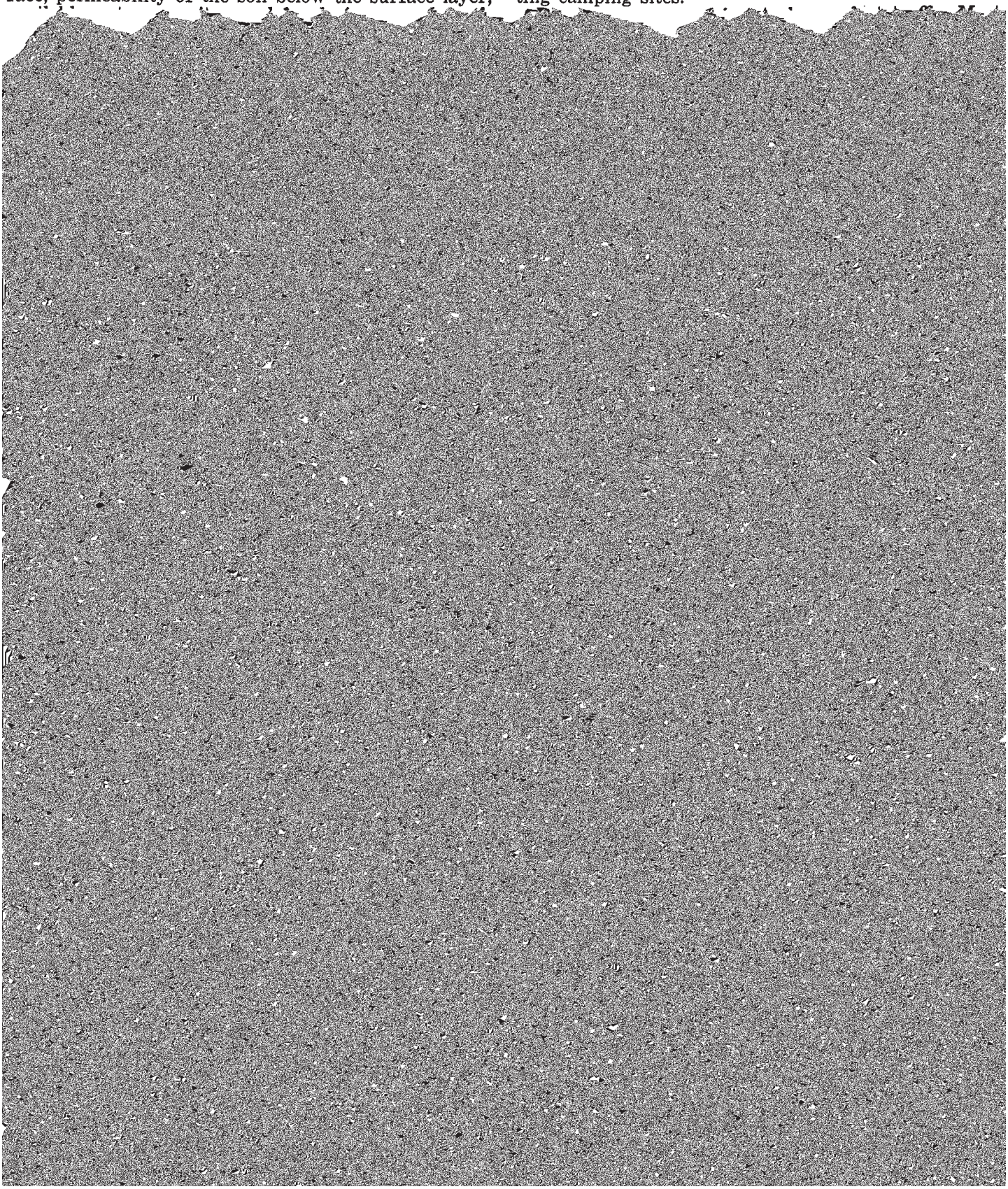


TABLE 8.—*Recreational development*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
1D3:				
Ida	Moderate: slope	Moderate: slope	Severe: slope	Slight.
1E3:				
Ida	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
1F3:				
Ida	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
5B:				
Kennebec part	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
Ackmore part	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
C5B:				
Kennebec part	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
Ackmore part	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
6:				
Okoboji	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
8C:				
Judson	Moderate: too clayey	Moderate: too clayey	Moderate: slope, too clayey.	Moderate: too clayey.
9B, 9B2:				
Marshall	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
9C, 9C2:				
Marshall	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
9D2, 9D3:				
Marshall	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
10D3:				
Monona	Moderate: slope	Moderate: slope	Severe: slope	Slight.
10E3:				
Monona	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
11B:				
Colo part	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Ely part	Severe: floods	Moderate: wetness, too clayey.	Moderate: wetness, too clayey, slope.	Moderate: wetness, too clayey.
24C2:				
Shelby	Moderate: percs slowly.	Slight	Severe: slope	Slight.
24D2:				
Shelby	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
24E2:				
Shelby	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
26B:				
Kennebec	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
27C:				
Terril	Slight	Slight	Moderate: slope	Slight.

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
31: Afton	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
33E: Steinauer	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
33F: Steinauer	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
41D: Sparta	Moderate: too sandy, slope.	Moderate: too sandy, slope.	Severe: slope	Moderate: too sandy.
54: Zook	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
55: Nicollet	Slight	Slight	Moderate: slope	Slight.
62C, 62D: Storden	Moderate: slope	Moderate: slope	Severe: slope	Slight.
62E, 62F: Storden	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
62G: Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
73C: Salida	Moderate: too sandy	Moderate: too sandy	Severe: slope	Moderate: too sandy.
73D: Salida	Moderate: slope, too sandy.	Moderate: slope, too sandy.	Severe: slope	Moderate: too sandy.
77B, 77B2, 78B, 78B2: Sac	Moderate: too clayey.	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
77C, 77C2, 78C, 78C2: Sac	Moderate: too clayey.	Moderate: too clayey	Severe: slope	Moderate: too clayey.
91: Primghar	Moderate: too clayey, wetness.	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: wetness, too clayey.
92: Marcus	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
95: Harps	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
107: Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
108: Wadena	Slight	Slight	Slight	Slight.
108B: Wadena	Slight	Slight	Moderate: slope	Slight.
108C2: Wadena	Moderate: slope	Moderate: slope	Severe: slope	Slight.
133: Colo	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
134: Zook	Severe: wetness, floods, too clayey.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, too clayey.	Severe: wetness, too clayey.

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
135, 135B:				
Coland	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: wetness.
138B:				
Clarion	Slight	Slight	Moderate: slope	Slight.
138C, 138C2:				
Clarion	Slight	Slight	Severe: slope	Slight.
138D2:				
Clarion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
174B:				
Bolan	Slight	Slight	Moderate: slope	Slight.
174C2:				
Bolan	Slight	Slight	Severe: slope	Slight.
174D2:				
Bolan	Moderate: slope	Moderate: slope	Severe: slope	Slight.
201B:				
Coland part	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.
Spillville part	Severe: floods	Moderate: floods	Moderate: floods, slope.	Moderate: floods.
C201B:				
Coland part	Severe: floods, wetness, percs slowly.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.
Spillville part	Severe: floods	Moderate: floods	Moderate: floods	Moderate: floods

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
T310: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
T310B: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
315: Alluvial land	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
323B: Terril	Slight	Slight	Moderate: slope	Slight.
325: Le Sueur	Moderate: wetness	Slight	Moderate: slope	Slight.
354: Marsh	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
384: Collinwood	Severe: too clayey	Severe: too clayey	Severe: wetness, too clayey.	Severe: too clayey.
390: Waldorf	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.
397B: Letri	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
428: Ely	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
430, 430B: Ackmore	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
485, 485B: Spillville	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
506: Wacousta	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
511: Blue Earth	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
559: Talcot	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
577C2: Everly	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
577D2: Everly	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
606: Lanyon	Severe: wetness	Severe: too clayey, wetness.	Severe: percs slowly, wetness, too clayey.	Severe: too clayey, wetness.
733: Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
823B: Flagler	Slight	Slight	Moderate: slope	Slight.
823C2: Flagler	Slight	Slight	Severe: slope	Slight.

TABLE 9.—*Wildlife habitat potentials*

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates the soil was not rated]

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1D3:										
Ida	Fair	Good	Good	Fair	Fair	Very poor	Very poor	Good	Fair	Very poor.
1E3:										
Ida	Fair	Good	Good	Fair	Fair	Very poor	Very poor	Good	Fair	Very poor.
1F3:										
Ida	Poor	Fair	Good	Poor	Poor	Very poor	Very poor	Fair	Poor	Very poor.
5B:										
Kennebec part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Ackmore part	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
C5B:										
Kennebec part	Poor	Poor	Good	Good	Good	Poor	Very poor	Poor	Good	Very poor.
Ackmore part	Poor	Poor	Good	Good	Good	Fair	Fair	Poor	Good	Fair.
6:										
Okoboji	Fair	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
8C:										
Judson	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Poor.
9B, 9B2, 9C, 9C2, 9D2, 9D3:										
Marshall	Good	Good	Good	Good	Good	Poor	Very poor	Good	Fair	Poor.
10D3:										
Monona	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
10E3:										
Monona	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
11B:										
Colo part	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.
Ely part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Poor.
24C2, 24D2:										
Shelby	Fair	Good	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
24F2:										
Shelby	Poor	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.
26B:										
Kennebec	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
27C:										
Terril	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
31:										
Afton	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.

	Potential as habitat for—		
Shallow ter areas	Openland wildlife	Woodland wildlife	Wetland wildlife
ry poor	Fair	Fair	Very poor.
ry poor	Fair	Fair	Very poor.
od	Fair	Fair	Good.
ir	Good	Good	Fair.
ry poor	Fair	Fair	Very poor.
ry poor	Fair	Fair	Very poor.
ry poor	Poor	Poor	Very poor.
ry poor	Good	Good	Very poor.
ry poor	Good	Good	Very poor.
ir	Good	Good	Fair.
ir	Good	Fair	Fair.
ir	Fair	Fair	Fair.
ir	Good	Fair	Fair.
ry poor	Good	Good	Very poor.
ry poor	Good	Good	Very poor.
od	Fair	Fair	Good.
od	Fair	Fair	Good.
od	Fair	Fair	Good.
or	Fair	Fair	Very poor.

TABLE 9.—*Wildlife habitat potentials*—Continued

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
138B:										
Clarion	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
138C, 138C2, 138D2:										
Clarion	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
174B:										
Bolan	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
174C2, 174D2:										
Bolan	Fair	Fair	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
201B:										
Coland part	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
Spillville part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
C201B:										
Coland part	Poor	Poor	Good	Fair	Poor	Poor	Very poor	Poor	Fair	Good.
Spillville part	Poor	Poor	Good	Good	Good	Poor	Very poor	Poor	Good	Very poor.
202, 203:										
Cylinder	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
221:										
Palms	Good	Poor	Poor	Poor	Very poor	Good	Good	Fair	Poor	Good.
234:										
Nishna	Good	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
236B:										
Lester	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
259:										
Biscay	Good	Fair	Good	Fair	Poor	Good	Poor	Fair	Fair	Fair.
274:										
Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
308, 308B:										
Wadena	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
310, 310B, 310B2:										
Galva	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
310C, 310C2:										
Galva	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
T310, T310B:										
Galva	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
315:										
Alluvial land	Poor	Fair	Fair	Fair	Poor	Good	Fair	Fair	Fair	Fair.

TABLE 9.—*Wildlife habitat potentials*—Continued

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
323B: Terril	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
325: Le Sueur	Good	Good	Good	Good	Good	Fair	Poor	Good	Good	Poor.
354: Marsh	Very poor	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
384: Collinwood	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
390: Waldorf	Fair	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
397B: Letri	Fair	Fair	Good	Fair	Poor	Fair	Poor	Fair	Fair	Poor.
428: Ely	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
430, 430B: Ackmore	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485: Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485B: Spillville	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
506: Wacousta	Fair	Fair	Fair	Poor	Very poor	Good	Good	Poor	Poor	Good.
507: Canisteo	Good	Fair	Good	Poor	Very poor	Good	Fair	Fair	Poor	Fair.
511: Blue Earth	Fair	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
559: Talcot	Fair	Fair	Good	Fair	Poor	Good	Poor	Fair	Poor	Fair.
577C2, 577D2: Everly	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
606: Lanyon	Fair	Fair	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
733: Calco	Good	Fair	Good	Poor	Very poor	Good	Fair	Fair	Poor	Fair.
823B, 823C2: Flagler	Fair	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.

proved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

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

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, millet, buckwheat, cowpeas, soybeans, and sunflowers. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, lovegrass, switchgrass, bromegrass, timothy, orchardgrass, clover, alfalfa, trefoil, and crownvetch. Major soil properties that affect growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations.

Wild herbaceous plants are native or naturally established herbaceous grasses and forbs, including weeds, that provide food and cover for wildlife. Ex-

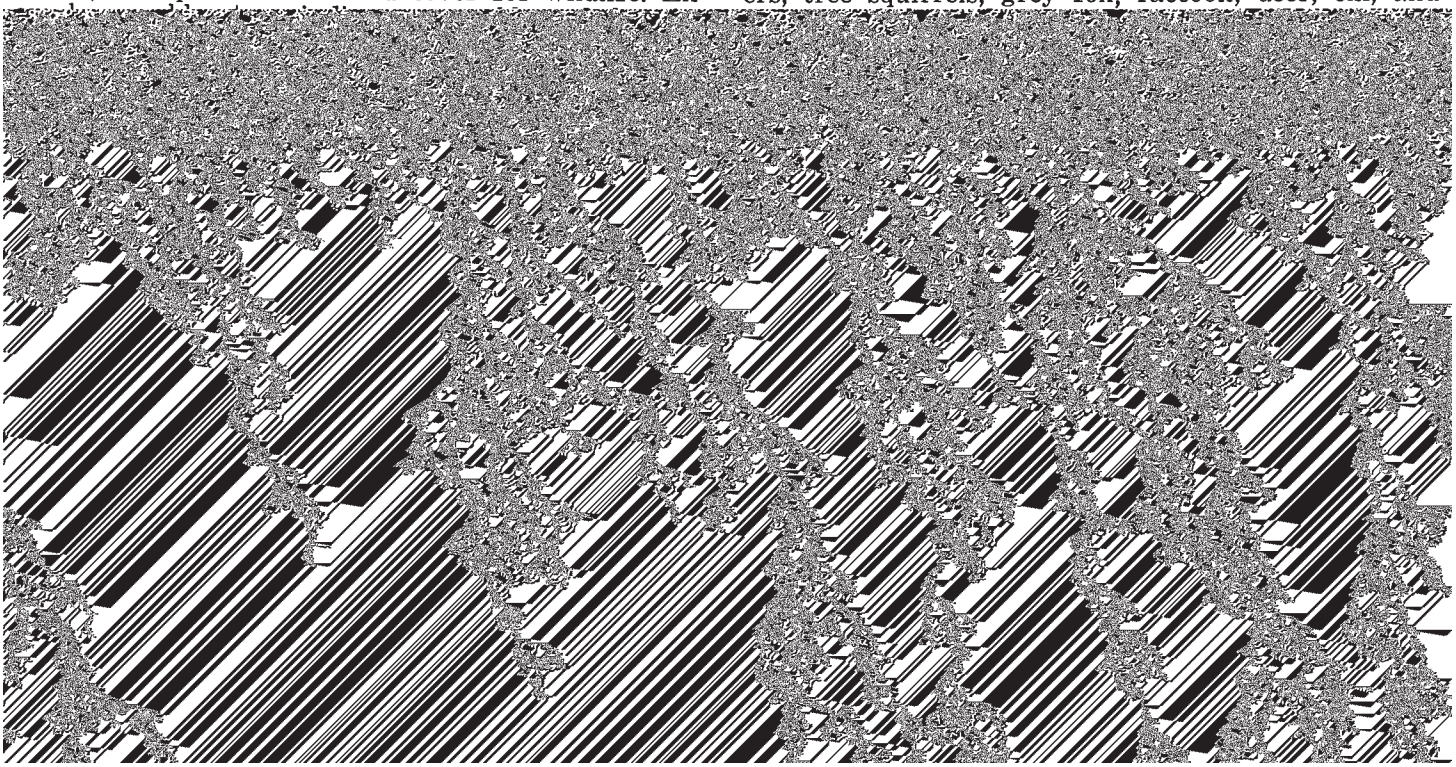
Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Examples of wetland plants are smartweed, wild millet, rushes, sedges, reeds, wildrice, saltgrass, cordgrass, and cattail. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of surface water that have an average depth of less than 5 feet and are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, beaver ponds, and other wildlife ponds. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slopes, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland wildlife habitat consists of croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck.

Woodland wildlife habitat consists of hardwoods or conifers or a mixture of both, with associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are wild turkey, ruffed grouse, woodcock, thrushes, vireos, woodpeckers, tree squirrels, grey fox, raccoon, deer, elk, and



determines soil pH or reaction, and identifies any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to characterize key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil

from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A–1 are coarse grained and low in content of fine grains. At the other extreme, in group A–7, are fine-grained soils. Highly organic soils are classified as A–8 on the basis of visual inspection.

If laboratory data are available, the A–1, A–2, and

likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design of irrigation systems.

Soil reaction is expressed as range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops and ornamental or other plants to be grown, in evaluating the corrosivity of soils.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others it was estimated on the basis of the kind of clay and on measurements of similar soils. Size of imposed loadings and the magnitude of changes in soil moisture content are also important factors that influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A *high* shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion, as used in table 11, pertains to potential soil-induced chemical action that dissolves or

but crops can be grown if intensive measures to control soil blowing are used.

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

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

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

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

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

7. Silty clay loams that are less than 35 percent

TABLE 10.—*Engineering properties*

[The symbol < means less than; > means greater than.

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
1D3, 1E3, 1F3:				
Ida	0–60	Silt loam	ML, CL	A–4, A–6
5B:				
Kennebec part	0–46	Silty clay loam	CL, ML	A–6, A–7
	46–60	Silt loam, silty clay loam	CL, ML	A–6, A–7, A–4
Ackmore part	0–35	Silt loam	CL, ML	A–4, A–6, A–7
	35–70	Silty clay loam, silt loam	CH, CL, MH	A–7, A–6
C5B:				
Kennebec part	0–46	Silty clay loam	CL, ML	A–6, A–7
	46–60	Silt loam, silty clay loam	CL, ML	A–6, A–7, A–4
Ackmore part	0–35	Silt loam	CL, ML	A–4, A–6,

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
33E, 33F:				
Steinauer	0–5	Loam	ML, CL,	A–4, A–6
	5–73	Clay loam	CL, CH	A–6, A–7
41D:				
Sparta	0–60	Loamy fine sand	SM, SP–SM	A–2
54:				
Zook	0–20	Silty clay loam	MH, CH, CL, OL	A–7
	20–60	Silty clay, silty clay loam	CH	A–7
55:				
Nicollet	0–14	Loam	OL, ML, CL	A–6, A–7, A–4
	14–45	Clay loam	CL	A–6, A–7
	45–69	Loam	CL, ML	A–6, A–4
62C, 62D, 62E, 62F, 62G:				
Storden	0–5	Loam	ML, CL	A–4, A–6
	5–60	Loam	CL–ML, CL	A–4, A–6
73C, 73D:				
Salida	0–18	Gravelly loamy sand	SP–SM	A–1
	18–60	Sand and gravel	SP	A–1
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2:				
Sac	0–14	Silty clay loam	ML, CL	A–7
	14–28	Silty clay loam	CL, ML	A–7
	28–76	Clay loam, loam	CL, ML	A–6, A–7
91:				
Primghar	0–20	Silty clay loam	MH, CH	A–7
	20–44	Silty clay loam	CL, CH	A–7
	44–64	Silt loam	CL	A–6
92:				
Marcus	0–15	Silty clay loam	MH, CH	A–7
	15–40	Silty clay loam, silty clay	CH, MH	A–7
	40–60	Silt loam	CL	A–6, A–7
	57–62	Loam	CL	A–6
95:				
Harps	0–21	Loam	CL, CH	A–6, A–7
	21–42	Loam, clay loam, sandy clay loam	CL, CH	A–6, A–7
	42–70	Loam	CL	A–6
107:				
Webster	0–12	Silty clay loam	ML, MH, CL, CH	A–7
	12–25	Clay loam, silty clay loam	CL	A–6, A–7
	25–76	Loam, sandy loam, clay loam	CL, ML	A–6, A–7
108, 108B, 108C2:				
Wadena	0–13	Loam	CL, CL–ML	A–4

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0–5	95–100	95–100	85–95	60–70	25–40	4–15
0–5	95–100	95–100	90–100	70–90	30–55	15–30
0	100	100	60–70	10–20	----------	[1] NP
0	100	100	95–100	95–100	45–70	20–40
0	100	100	95–100	95–100	60–85	40–60
0	95–100	95–100	85–98	65–85	30–50	8–20
0	95–100	95–100	80–95	60–80	30–45	10–25
0	95–100	85–95	75–90	60–75	30–40	5–15
0–5	95–100	95–100	70–85	55–70	30–40	5–15
0–5	95–100	85–97	70–85	55–70	20–40	5–15
0	80–95	50–85	20–40	5–10	----------	NP
0	80–90	40–60	10–30	0–5	----------	NP
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	95–100	90–100	75–90	65–80	35–50	10–25

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
135, 135B:				
Coland	0–42	Clay loam	OL, CL, CH, MH	A–6, A–7
	42–60	Loam, sandy loam, sandy clay loam	CL, SC	A–4, A–6
138B, 138C, 138C2, 138D2:				
Clarion	0–16	Loam	CL, CL–ML	A–4, A–6
	16–32	Loam, clay loam	CL, CL–ML	A–4, A–6
	32–60	Loam, sandy loam	CL, CL–ML	A–4, A–6
174B, 174C2, 174D2:				
Bolan	0–11	Loam	CL, ML	A–4, A–6
	11–24	Loam	CL, SC, CL–ML, SM–SC	A–4, A–6
	24–60	Fine sandy loam	SM, SM–SC, SC	A–4
201B:				
Coland part	0–42	Clay loam	OL, CL, CH, MH	A–6, A–7
	42–60	Loam, sandy loam, sandy clay loam	CL, SC	A–4, A–6
Spillville part	0–47	Loam	CL	A–6
	47–60	Sandy clay loam, loam, sandy clay	CL, SC	A–6, A–7

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	20–35	5–15
0	100	100	85–95	50–70	30–40	5–15
0	100	100	80–90	40–55	25–35	5–15
0	100	100	80–90	35–50	15–25	2–8
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0–5	100	90–100	80–100	50–75	30–50	11–25
0–10	95–100	80–100	80–95	60–75	30–50	7–20
10–50	75–95	75–95	20–40	5–25	----------	NP
0	85–100	80–100	70–95	50–80	<30	5–15
0	100	100	95–100	90–100	55–65	25–35

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
308, 308B:				
Wadena	0–13	Loam	CL, CL–ML	A–4
	13–35	Loam, sandy loam	SC, CL–ML, CL, SM–SC	A–4, A–6
	35–60	Sand and gravel	SP	A–1
310, 310B, 310B2, 310C, 310C2:				
Galva	0–16	Silty clay loam	ML, CL	A–7
	16–40	Silty clay loam	CL	A–7
	40–60	Silt loam, silty clay loam	CL	A–6, A–7
T310, T310B:				
Galva	0–11	Silty clay loam	CL, ML	A–7
	11–36	Silty clay loam	CL, ML	A–7
	36–50	Silt loam	CL	A–6, A–7
	50–60	Sand and gravel	SP–SM, SM	A–1, A–2
315:				
Alluvial land	0–60	Variable	----------	----------
323B:				
Terril	0–31	Loam	CL	A–4, A–6
	31–45	Loam, clay loam	CL	A–4, A–6
	45–60	Sand, gravelly sand	SP–SM, SM	A–2–4
325:				
Le Sueur	0–14	Loam	CL	A–6
	14–44	Clay loam	CL, CH	A–6, A–7
	44–60	Loam	CL–ML, CL	A–6, A–4
354:				
Marsh	0–60	Variable	----------	----------
384:				
Collinwood	0–23	Silty clay loam	OH, OL, CL, CH	A–7
	[illegible]	[illegible]	[illegible]	[illegible]

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	95–100	85–100	80–95	50–60	25–40	5–15
0	95–100	85–100	80–95	40–55	25–40	5–15
0	80–95	70–95	30–50	2–5	----------	NP
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	35–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	35–50	15–25
10–56	75–95	70–90	20–40	5–25	----------	NP
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0–5	100	95–100	70–90	60–80	25–40	8–15
0–5	100	90–100	70–90	60–80	25–40	8–15
0–25	90–100	75–90	60–80	10–35	----------	NP
0	95–100	95–100	90–98	70–85	25–40	10–20
0	95–100	95–100	85–98	60–80	35–60	12–35
0	95–100	90–100	85–95	60–75	20–40	5–20
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0	100	100	95–100	90–95	45–60	20–30
0	100	100	95–100	90–95	50–60	20–30
0	100	100	95–100	90–95	45–60	15–30
0	100	100	95–100	90–100	44–55	14–25
0	100	100	95–100	95–100	50–70	20–30
0	100	100	95–100	95–100	35–55	11–25
0	95–100	95–100	95–100	80–95	40–50	15–25
0–5	95–100	90–100	85–95	75–85	40–50	15–25
0–5	95–100	90–100	85–95	65–75	30–50	7–25
0	100	100	95–100	95–100	30–55	10–25
0	100	100	95–100	95–100	35–50	11–25
0	100	100	90–100	85–100	25–40	10–20
0	100	100	95–100	85–100	25–50	8–20
0	100	100	95–100	85–100	35–65	15–30
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0	100	100	95–100	95–100	40–65	20–40
0	100	100	90–100	90–100	40–60	20–40

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
507:				
Canisteo	0–16	Silty clay loam	OL, CL, CH	A–7
	16–31	Clay loam, loam	CL	A–7, A–6
	31–70	Clay loam, loam	CL	A–6
511:				

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	98–100	95–100	85–98	60–90	40–55	15–25
0	98–100	90–100	85–95	65–85	38–50	25–35
0	95–100	90–98	80–95	60–75	30–40	12–20
0	95–100	95–100	85–95	80–95	41–50	2–8
0	95–100	90–100	80–100	70–80	35–50	11–20
0	100	100	80–90	60–85	40–50	15–25
0	95–100	90–100	70–90	60–85	40–50	15–25
0	65–90	60–85	20–50	2–5	----------	NP
0	100	95–100	85–95	65–80	30–45	11–20
0	95–100	95–100	85–95	70–90	30–50	15–25
0	90–100	85–95	75–85	60–80	30–50	15–25
0	100	100	95–100	90–100	55–70	30–40
0	100	95–100	85–100	80–95	60–75	30–40
0	95–100	90–100	75–85	60–80	35–65	20–40
0	100	100	95–100	85–100	41–60	15–30
0	100	100	90–100	80–100	40–55	15–30
0	95–100	90–100	70–90	25–50	15–30	2–10
0	95–100	85–100	65–85	20–45	15–30	2–10
0–5	80–95	75–95	35–60	2–15	<25	NP–8

tions will function. Also, a high water table affects ease of excavation.

Potential frost action refers to likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action is defined as freezing temperatures in the soil and movement of soil moisture into the freezing zone, which causes the formation of ice lenses. Soil texture, temperature, moisture content, porosity, permeability, and organic matter content are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Formation and classification of soils

This section discusses the factors of soil formation as they relate to the soils of Sac County, describes the processes that result in the formation, and places each family, subgroup, and order in the current system for classifying soils. Detailed descriptions of the representative profiles of the soil series are given in the section "Descriptions of the soils."

Factors of soil formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the

TABLE 11.—*Physical and chemical properties of soils*

[The symbol < means less than; > means greater than. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not available or were not estimated]

Map symbol and soil name	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
						Uncoated steel	Concrete	K	T	
	In	*In/hr*	*In/in*	*pH*						
1D3, 1E3, 1F3:										
Ida	0–60	0.6–2.0	0.20–0.22	6.6–8.4	Low	Low	Low	0.43	5–4	4L
5B:										
Kennebec part	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–60	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		
Ackmore part	0–35	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Low	0.32	5	6
	35–70	0.2–0.6	0.18–0.20	5.6–7.8	High	High	Low	0.32		
C5B:										
Kennebec part	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–60	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		
Ackmore part	0–35	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Low	0.32	5	6
	35–70	0.2–0.6	0.18–0.20	5.6–7.8	High	High	Low	0.32		
6:										
Okoboji	0–31	0.06–0.2	0.21–0.23	7.4–7.8	High	High	Low			4
	31–60	0.06–0.2	0.18–0.20	7.4–8.4	High	High	Low			
8C:										
Judson	0–25	0.6–2.0	0.21–0.23	6.1–7.3	Moderate	Moderate	Low	0.28	5	7
	25–93	0.6–2.0	0.21–0.23	6.1–7.8	Moderate	Moderate	Low	0.43		
9B, 9B2, 9C, 9C2, 9D2, 9D3:										
Marshall	0–12	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate	0.32	5–4	7
	12–67	0.6–2.0	0.18–0.20	5.6–7.3	Moderate	Moderate	Low	0.43		
	67–85	0.6–2.0	0.20–0.22	6.6–7.3	Moderate	Moderate	Low	0.43		
10D3, 10E3:										
Monona	0–9	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Low	Low	0.32	5–4	6
	9–35	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Low	Low	0.43		
	35–60	0.6–2.0	0.20–0.22	6.6–8.4	Moderate	Low	Low	0.43		
11B:										
Colo part	0–47	0.2–0.6	0.21–0.23	5.6–7.3	High	High	Moderate			7
	47–62	0.2–0.6	0.18–0.20	6.1–7.3	High	High	Moderate			
Ely part	0–26	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Moderate	0.32	5	7
	26–52	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	High	Low	0.43		
	52–84	0.6–2.0	0.18–0.20	6.6–8.4	Moderate	High	Low	0.43		
24C2, 24D2, 24E2:										
Shelby	0–14	0.6–2.0	0.20–0.22	5.6–6.5	Moderate	Moderate	Moderate	0.28	5–4	6
	14–36	0.2–0.6	0.16–0.18	5.6–7.8	Moderate	Moderate	Moderate	0.28		
	36–76	0.2–0.6	0.16–0.18	6.6–8.4	Moderate	Moderate	Moderate	0.37		
26B:										
Kennebec	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–72	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		

27C:										
Terril	0–31	0.6–2.0	0.20–0.22	6.1–7.3	Low	Moderate	Low	0.24	5	6
	31–73	0.6–2.0	0.16–0.18	6.1–7.3	Low	Moderate	Low	0.32		
31:										
Afton	0–25	0.2–0.6	0.21–0.23	6.6–7.3	High	High	Low			4
	25–48	0.2–0.6	0.18–0.20	6.6–7.8	High	High	Low			
	48–60	0.2–2.0	0.14–0.16	7.9–8.4	High	High	Low			
33E, 33F:										
Steinauer	0–5	0.6–2.0	0.18–0.20	7.4–8.4	Low	High	Low	0.32	5–4	4L
	5–73	0.2–2.0	0.14–0.17	7.9–8.4	Moderate	High	Low	0.32		
41D:										
Sparta	0–60	6.0–20	0.12–0.14	5.6–6.5	Low	Low	Low	0.17	5	2
54:										
Zook	0–20	0.2–0.6	0.21–0.23	5.6–7.8	High	High	Moderate			7
	20–60	0.06–0.2	0.11–0.13	5.6–7.8	High	High	Moderate			
55:										
Nicollet	0–14	0.6–2.0	0.17–0.22	6.1–7.3	Moderate	High	Low	0.24	5–4	6
	14–45	0.6–2.0	0.15–0.19	5.6–7.8	Moderate	High	Low	0.32		
	45–69	0.6–2.0	0.14–0.19	7.4–7.8	Moderate	High	Low	0.32		
62C, 62D, 62E, 62F, 62G:										
Storden	0–5	0.6–2.0	0.20–0.22	7.4–8.4	Low	Low	Low	0.28	5–4	4L
	5–60	0.6–2.0	0.17–0.19	7.4–8.4	Low	Low	Low	0.37		
73C, 73D:										
Salida	0–18	6.0–20	0.09–0.11	6.6–8.4	Low	Low	Low	0.10		
	18–60	>20	0.02–0.04	7.4–8.4	Low	Low	Low	0.10		
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2:										
Sac	0–14	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Low	0.32	5–4	4
	14–28	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	Moderate	Low	0.43		
	28–76	0.6–2.0	0.14–0.16	6.6–8.4	Moderate	Moderate	Low	0.43		
91:										
Primghar	0–20	0.6–2.0	0.21–0.23	5.6–7.3	High	Moderate	Moderate			4
	20–44	0.2–2.0	0.18–0.20	6.1–8.4	High	Moderate	Low			
	44–64	0.6–2.0	0.20–0.22	7.9–8.4	Moderate	Moderate	Low			
92:										
Marcus	0–15	0.2–0.6	0.21–0.23	6.1–7.8	High	High	Low			4
	15–40	0.2–0.6	0.18–0.20	6.1–8.4	High	High	Low			
	40–60	0.6–2.0	0.20–0.22	7.9–8.4	Moderate	High	Low			
	57–62	0.6–2.0	0.17–0.19	7.9–8.4	Moderate	High	Low			
95:										
Harps	0–21	0.6–2.0	0.19–0.21	7.9–8.4	Moderate	High	Low			4L
	21–42	0.6–2.0	0.17–0.19	7.9–8.4	Moderate	High	Low			
	42–70	0.6–2.0	0.17–0.19	7.9–8.4	Moderate	High	Low			
107:										
Webster	0–12	0.6–2.0	0.19–0.21	6.6–7.3	High	High	Low			6
	12–25	0.2–2.0	0.16–0.18	6.6–7.8	High	High	Low			
	25–76	0.6–2.0	0.17–0.19	7.9–8.4	Moderate	High	Low			
108, 108B, 108C2:										
Wadena	0–13	2.0–6.0	0.20–0.22	6.1–7.3	Low	Low	Low	0.24	4–3	5
	13–27	2.0–6.0	0.12–0.14	6.1–7.3	Low	Low	Low	0.32		
	27–60	>20	0.02–0.04	6.6–8.4	Low	Low	Low	0.10		

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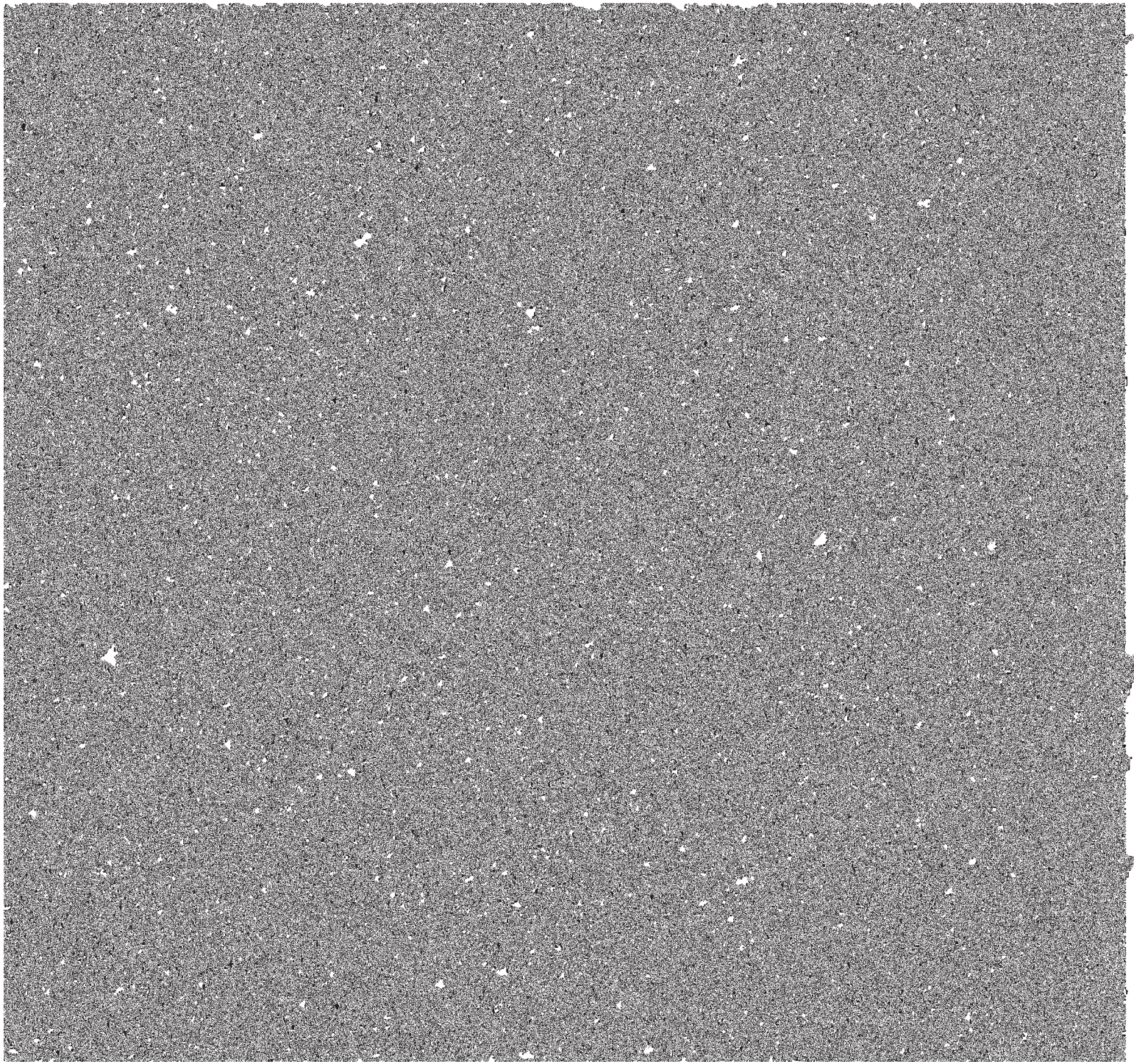

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4–3	5
5–4	7
5–4	7
5	6
5–4	6
5	4
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TABLE 11.—*Physical and chemical properties of soils*—Continued

Map symbol and soil name	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
						Uncoated steel	Concrete	K	T	
	In	*In/hr*	*In/in*	*pH*						
485, 485B:										
Spillville	0–47	0.6–2.0	0.19–0.21	6.1–7.3	Moderate	High	Moderate	0.28	5–4	6
	47–66	0.6–6.0	0.15–0.18	6.1–7.8	Low	High	Moderate	0.28		
506:										
Wacousta	0–15	0.2–2.0	0.21–0.23	6.6–7.3	High	High	Low			7
	15–60	0.2–2.0	0.18–0.20	7.4–8.4	High	High	Low			
507:										
Canisteo	0–16	0.6–2.0	0.18–0.22	7.4–8.4	Moderate	High	Low			4L
	16–31	0.6–2.0	0.15–0.19	7.4–8.4	Moderate	High	Low			
	31–70	0.6–2.0	0.14–0.16	7.4–8.4	Moderate	High	Low			
511:										
Blue Earth	0–40	2.0–6.0	0.18–0.24	7.4–8.4	Moderate	High	Low			8
	40–60	0.2–2.0	0.14–0.16	7.4–8.4	Moderate	High	Low			
559:										
Talcot	0–18	0.6–2.0	0.18–0.22	7.4–8.4	Moderate	High	Low			7
	18–37	0.6–2.0	0.17–0.20	7.4–8.4	Moderate	High	Low			
	37–60	6.0–20	0.02–0.04	7.4–8.4	Low	High	Low			
577C2, 577D2:										
Everly	0–6	0.6–2.0	0.17–0.19	5.6–6.5	Moderate	Moderate	Moderate	0.24	5–4	6
	6–17	0.6–2.0	0.15–0.17	6.1–7.3	Moderate	Moderate	Moderate	0.32		
	17–60	0.6–2.0	0.17–0.19	7.4–8.4	Moderate	Moderate	Low	0.32		
606:										
Lanyon	0–15	0.06–0.6	0.14–0.16	6.6–7.8	High	High	Low			4
	15–56	0.06–0.6	0.12–0.14	7.4–8.4	High	High	Low			
	56–66	0.6–2.0	0.13–0.15	7.9–8.4	Moderate	High	Low			
733:										
Calco	0–36	0.2–0.6	0.21–0.23	7.4–8.4	High	High	Low			7
	36–63	0.2–0.6	0.18–0.20	7.4–8.4	High	High	Low			
823B, 823C2:										
Flagler	0–13	2.0–6.0	0.14–0.17	5.6–7.3	Low	Low	Low	0.20	4	3
	13–28	2.0–6.0	0.10–0.14	5.6–7.3	Low	Low	Low	0.20		
	28–63	>6.0	0.03–0.05	6.6–8.4	Low	Low	Low	0.10		

TABLE 12.—*Soil and water features*

[Absence of an entry indicates the feature is not a concern. See Glossary, under the definition of "flooding" and "water table," for descriptions of such terms as "rare," "brief," and "perched." The symbol < means less than; > means greater than]

Map symbol and soil name	Hydrologic group	Flooding			High water table			Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	
					Ft			
1D3, 1E3, 1F3:								
Ida	B	None			>6.0			High.
5B:								
Kennebec part	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
Ackmore part	B	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
C5B:								
Kennebec part	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
Ackmore part	B	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
6:								
Okoboji	B/D	Common	Brief	Mar-Jun	0–3.0	Apparent	Nov-Jun	High.
8C:								
Judson	B	None			>6.0			High.
9B, 9B2, 9C, 9C2, 9D2, 9D3:								
Marshall	B	None			>6.0			High.
10D3, 10E3:								
Monona	B	None			>6.0			High.
11B:								
Colo part	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
Ely part	B	None			3.0–5.0	Apparent	Nov-Jun	High.
24C2, 24D2, 24E2:								
Shelby	B	None			>6.0			Moderate.
26B:								
Kennebec	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
27C:								
Terril	B	None			>6.0			Moderate.
31:								
Afton	C/D	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
33E, 33F:								
Steinauer	B	None			>6.0			Moderate.
41D:								
Sparta	A	None			>6.0			Low.
54:								
Zook	C/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
55:								
Nicollet	B	None			3.0–5.0	Apparent	Nov-Jun	High.
62C, 62D, 62E, 62F, 62G:								
Storden	B	None			>6.0			Moderate.
73C, 73D:								
Salida	A	None			>6.0			Low.
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2:								
Sac	B	None			>6.0			High.

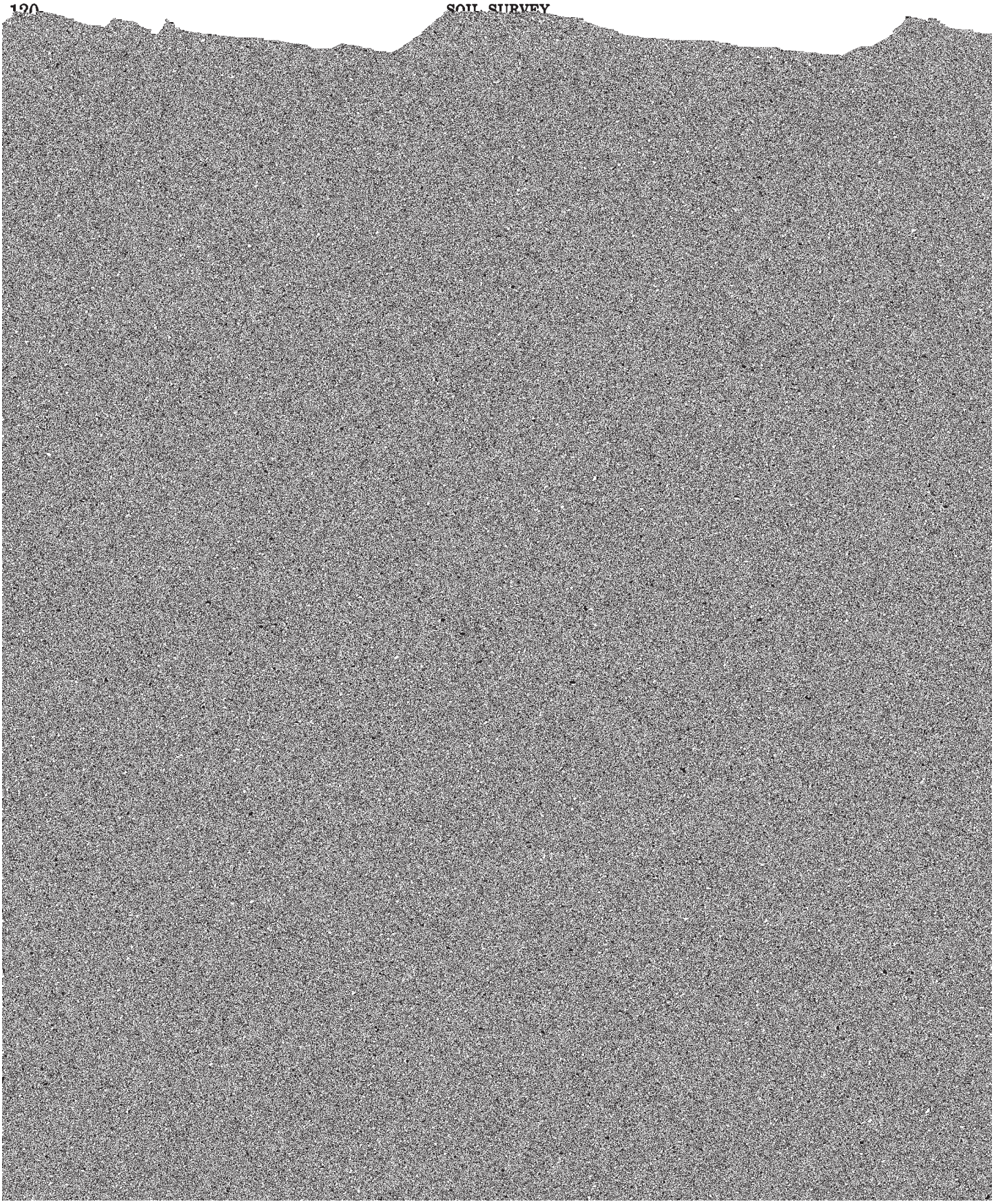


TABLE 12.—*Soil and water features*—Continued

Map symbol and soil name	Hydrologic group	Flooding			High water table			Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	
					Ft			
323B:								
Terril	B	None			>6.0			Moderate.
325:								
Le Sueur	B	None			3.0–5.0	Apparent	Nov-Jun	High.
354:								
Marsh		Frequent	Very long	Jan-Dec	0–1.0	Apparent	Jan-Dec	High.
384:								
Collinwood	C	None			2.0–4.0	Apparent	Nov-Jun	Moderate.
390:								
Waldorf	C/D	None			1.0–3.0	Apparent	Nov-Jun	High.
397B:								
Letri	B/D	None			0–2.0	Apparent	Nov-Jun	High.

terial relationships for some major soils are described in the section "General Soil Map."

Glacial drift includes all material deposited by glaciers. Much material has been sorted by water and is referred to as glacial outwash or glacial sediment. The heterogenous, unsorted deposits are called glacial till.

Glacial till is the parent material for many of the soils in the eastern part of the county and for a few in the western part. Sac County has been subjected to three stages of glaciation. The first two, the Nebraskan and Kansan, covered all of the county. The Tazewell substage of the Wisconsin glacier advanced from the northeast to near the southwest corner of the county, and the Cary substage of the Wisconsin glacier covered approximately the eastern half of the county (*6*, *8*). All the stages left deposits of glacial debris many feet thick.

The glacial deposit in the western part of the county has been covered by wind-deposited silt (loess), and it is exposed only where the loess has been eroded away. The glacial material in eastern Sac County was deposited after the period of loess deposition and is exposed at the surface. Radiocarbon dating estimated the period of deposition of loess to be 14,000 to 30,000 years ago, of the Tazewell drift to be about 20,000 years ago, and of the Cary drift to be 13,000 to 14,000 years ago (*6*).

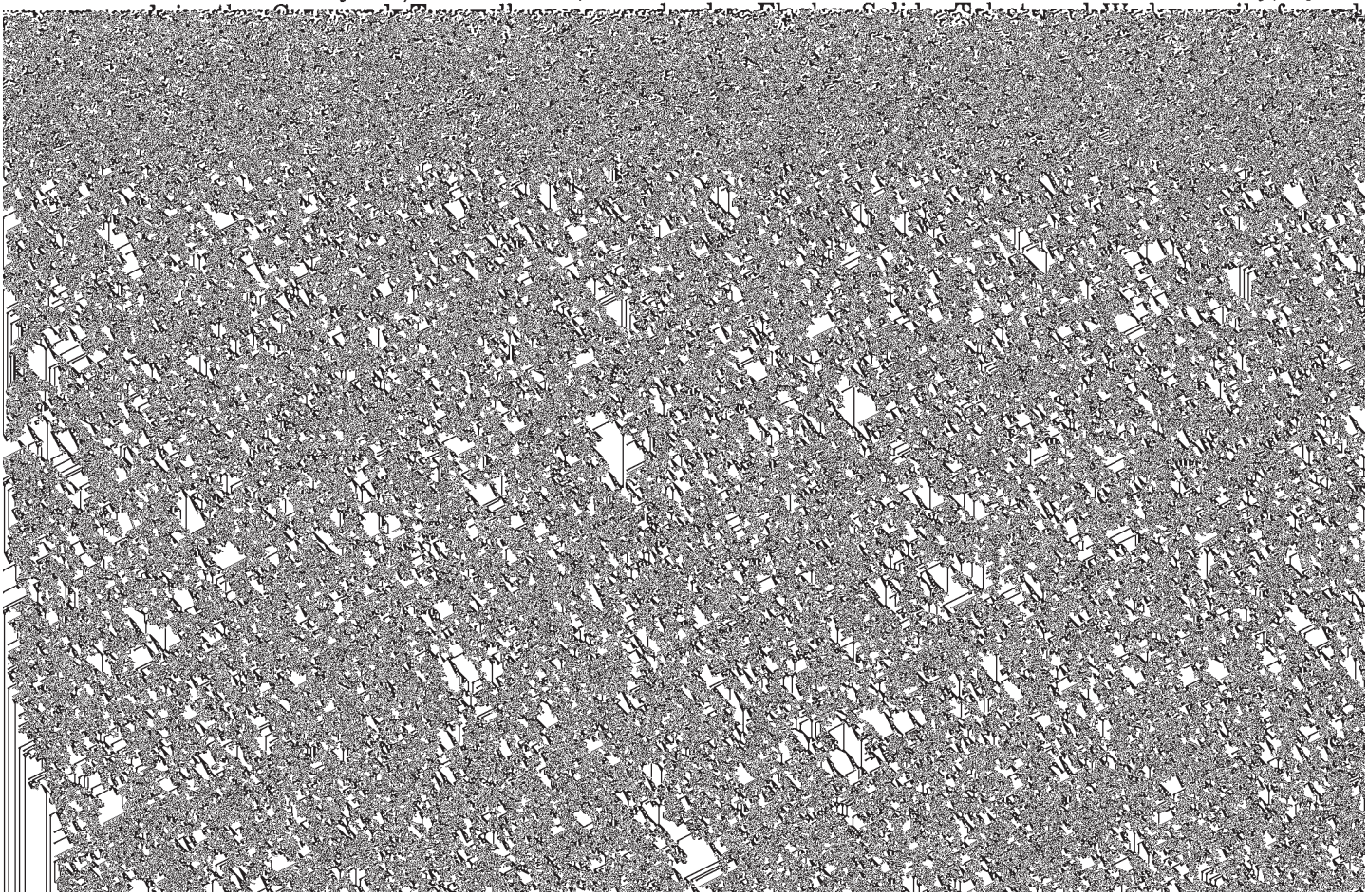
Soils that formed in glacial till include the Clarion and Lester soils in the Cary till; Storden soils, which

when it was deposited. In the Ida soils there has been only a small alteration of the parent material, mainly the addition of organic matter in the surface layer and the segregation of some of the lime into concretions or soft accumulations. The other soils that formed in loess have been leached of carbonates in the upper part of the profile. Also, some of the silt-sized particles have weathered to clay size.

Alluvium consists of sediment deposited by water. Alluvium derived mostly from glacial till has a higher sand content than that derived from loess. Some alluvium that came from loess has a sand content of 5 percent or less. The Coland, Terril, and Spillville soils, which are high in sand, are associated with soils in the Cary drift area. Alluvial soils with a lower content of sand that are mainly in the loess mantled part of the county include Ackmore, Calco, Colo, Ely, Judson, Kennebec, Nishna, and Zook soils.

Some of these soils formed in alluvium that has been washed from adjacent slopes and has been moved only a short distance. This is local alluvium, or colluvium. Terril, Ely, and Judson soils and some areas of Ackmore, Kennebec, and Spillville soils are among those that formed in this kind of parent material. Most areas are on foot slopes at the base of areas of moderately sloping to moderately steep soils.

On many stream benches, moderately coarse textured to moderately fine textured alluvium is underlain by sand and gravel that is presumed to have washed from the Wisconsin drift as it retreated. Biscay, Cylin-



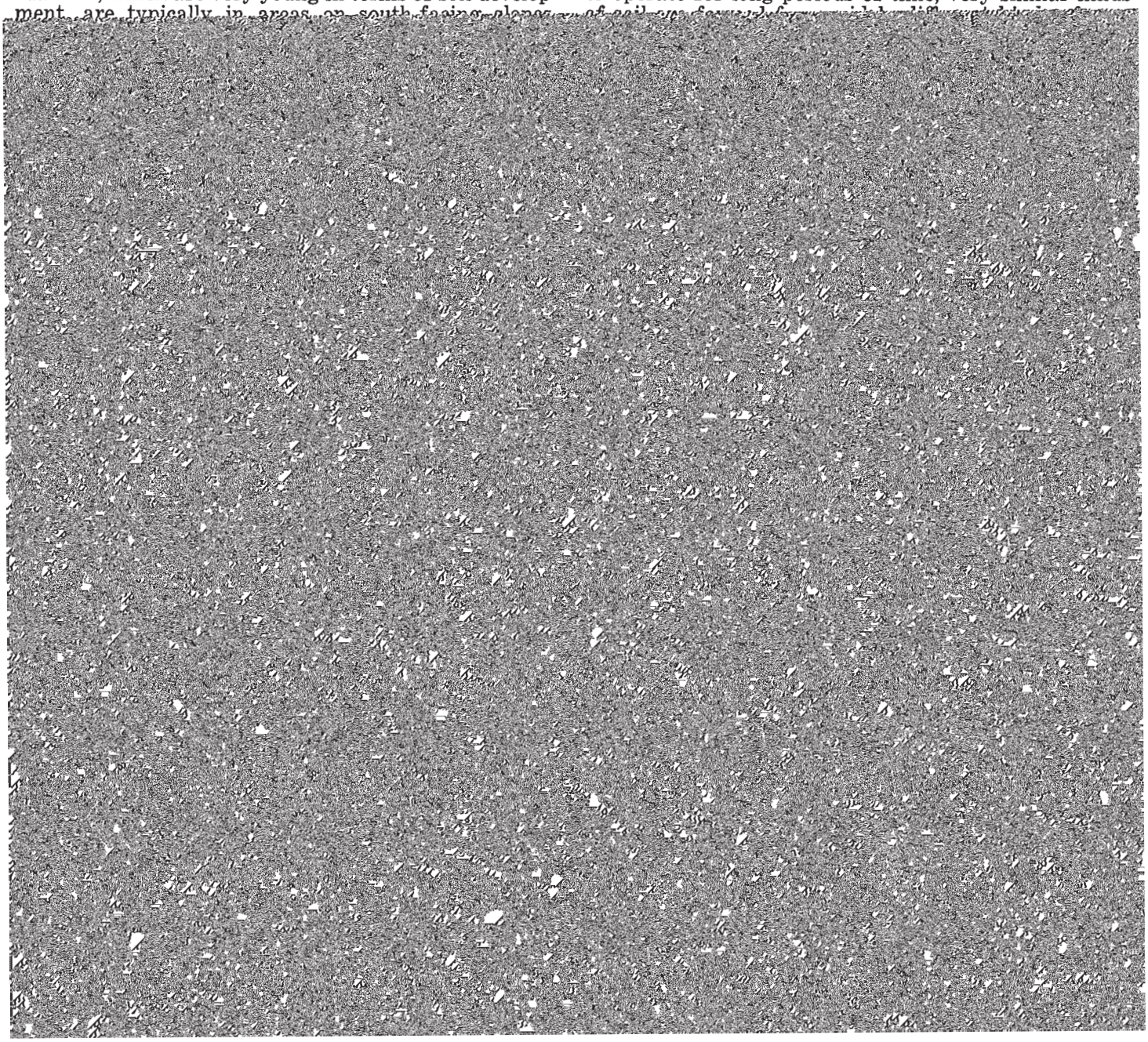
rie to more moist conditions has taken place. This change may have started about 3,000 years ago. The present climate is midcontinental subhumid.

A nearly uniform climate prevails throughout the county. The influence of the general climate is modified by local conditions in or near the developing soil. For example, areas on south-facing slopes have a microclimate that is warmer and less humid than the climate of nearby areas. Areas on north- and east-facing slopes tend to be cooler and more moist than those on south-facing slopes, and in a climate like that in Sac County, natural stands of trees are more likely to grow well. The hot, dry areas on south-facing slopes tend to have sparse vegetation, which allows more natural erosion to occur than on north-facing slopes. Ida soils, which are very young in terms of soil development, are typically in areas on south-facing slopes

strongly sloping to steep; Clarion soils are mainly gently sloping or moderately sloping; and Nicollet soils are mostly nearly level. Likewise, the thickness of the solum increases and depth to carbonates decreases from the Storden to the thicker Clarion and Nicollet soils. In soils that have a wide range of slopes, such as the gently sloping to strongly sloping Marshall soils, the depth to carbonates and the thickness of the solum decrease as the percentage of slope increases and as the slopes become more convex.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in parent material. If these factors continue to operate for long periods of time, very similar kinds



in the soil (*9*). Each of these four kinds of change affects many substances that make up soils. For example, there may be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals, all of which generally promote horizon differentiation. Some processes offset or retard differentiation. The combination of processes and the resulting changes take place simultaneously in soils. The ultimate nature of the profile is governed by the balance of these changes within the profile. The addition of organic matter, the removal of substances from parts of the soil profile, and the translocation of clay have been important in the horizon differentiation of the soils of Sac County.

The addition of organic matter is an early step in the process of horizon differentiation in most soils. The amount of organic matter that has accumulated in the A1 horizon of the soils in Sac County ranges from high to very low. Ida and Storden soils, for example, have a thin A1 horizon and have low organic matter content. Webster and Colo soils have a thick A1 horizon and have high organic matter content. Some soils that had high organic matter content now have low content because of erosion.

The downward movement of calcium carbonates and bases in soils is an example of the removal of substances from parts of the soil profile. Most soils in the county have been leached free of calcium carbonates in the upper parts of their profile. A few have been so strongly leached that they are medium acid or strongly acid in some horizons.

abundant in poorly drained soils, such as the Webster soils, than in such soils as the Nicollet and Clarion soils (*14*).

Another kind of transformation is the weathering of the primary apatite mineral in parent material to secondary phosphorus compounds. Studies indicate that the pH value of the soil must decline to about 7 before appreciable weathering takes place. Storden and Clarion soils are examples of soils that illustrate this type of transformation. Storden soils, which are calcareous, are very low in available phosphorus in the subsoil. Clarion soils, which are leached and are about neutral, have more available phosphorus, although it is also very low.

Classification

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to the latest literature available (*10, 13*).

The system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the bases for classification are the different soil properties that are observable or measurable. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis. In table 13 the soils of the survey area are classified according to the system. Classes of the sys-

TABLE 13.—*Classification of the soils*

[An asterisk in the first column indicates a taxadjunct to the series. See text for a description of those characteristics of this taxadjunct that are outside the range of the series]

Soil name	Family or higher taxonomic class
*Ackmore	Fine-silty, mixed, nonacid, mesic Aeric Fluvaquents
Afton	Fine-silty, mixed, mesic Cumulic Haplaquolls
Alluvial land	Loamy, mixed, nonacid, mesic Udifluvents
*Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Bolan	Coarse-loamy, mixed, mesic Typic Hapludolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
*Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
*Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Ely	Fine-silty, mixed, mesic Cumulic Hapludolls
Everly	Fine-loamy, mixed, mesic Typic Hapludolls
Flagler	Coarse-loamy, mixed, mesic Typic Hapludolls
Galva	Fine-silty, mixed, mesic Typic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Ida	Fine-silty, mixed (calcareous), mesic Typic Udorthents
*Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
*Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Lanyon	Fine, montmorillonitic, mesic Typic Haplaquolls
*Le Sueur	Fine-loamy, mixed, mesic Aquic Argiudolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
*Letri	Fine-loamy, mixed, mesic Typic Haplaquolls
Marcus	Fine-silty, mixed, mesic Typic Haplaquolls
Marsh	Aquolls
Marshall	Fine-silty, mixed, mesic Typic Hapludolls
*Monona	Fine-silty, mixed, mesic Typic Hapludolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Nishna	[illegible]

TABLE 13.— *Classification of the soils*—Continued

Soil name	Family or higher taxonomic class
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Waldorf	Fine, montmorillonitic, mesic Typic Haplaquolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

typify the great group. In example is Typic Haplaquents.

FAMILY. Families are established within a subgroup on the basis of similar physical and chemical properties that affect management. Among the properties considered in horizons of major biological activity below plow depth are particle-size distribution, mineral content, temperature regime, thickness of the soil penetrable by roots, consistence, moisture equivalent, soil slope, and permanent cracks. A family name consists of the name of a subgroup and a series of adjectives. The adjectives are the class names for the soil properties used as family differentiae. An example is fine-loamy, mixed, nonacid, mesic, Typic Haplaquents.

SERIES. The series consists of a group of soils that are formed from a particular kind of parent material. They have horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

General nature of the county

This section is mainly for those not familiar with the county. It discusses the early history; climate; topography and drainage; transportation, industries, and markets; and farming of the county.

TABLE 14.—*Temperature and precipitation*

[Data for Sac City, Sac County, Iowa]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average highest maximum	Average lowest minimum	Average total	1 year in 10 will have— Less than—	1 year in 10 will have— More than—	Number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°F	°F	°F	°F	In	In	In		In
January	28	9	47	−16	0.7	0.2	1.8	20	6
February	33	13	52	− 8	1.0	.2	2.3	15	6
March	44	24	68	2	1.8	.6	3.4	11	7
April	61	37	84	23	2.7	1.0	4.3	0	2
May	73	49	90	33	4.1	1.4	7.1	0	0
June	82	59	95	45	4.9	2.2	7.9	0	0
July	88	64	98	52	3.4	1.0	5.7	0	0
August	86	62	97	49	3.5	1.3	7.1	0	0
September	78	53	91	35	3.1	.4	8.2	0	0
October	66	41	85	24	1.8	.1	3.9	0	0
November	46	26	68	7	1.0	.1	3.0	3	4
December	33	16	53	− 7	.9	.2	1.9	10	5
Year	60	38	100	−18	28.6	17.0	38.9	59	6

through February. Precipitation extremes for each month (1 year in 10) are given in table 14. During the 1951–60 period, Sac City averaged 18 days per year with 0.5 inch or more of rainfall and 49 days with 0.10 inch or more of rainfall.

Most of the heavy showers occur during the warm half of the year. About 65 percent of the annual precipitation occurs as showers during the warm season of April through September. Individual showers may very widely in intensity over the county. An inch or more of rain falls in a 1-week period about 4 years out of 10 in June and a little more than 2 years out of 10 in July and August. Well-developed crops use over an inch of water a week during the summer.

Temperature data for Sac City are representative of those for the rest of Sac County, particularly maximum temperatures. An average of 37 days per year have a maximum temperature equal to or greater than 90° F. This is too warm for optimum crop production because water demand is excessive on those days. Minimum temperatures tend to vary more. Low areas, relative to the immediate surrounding area, have a lower minimum temperature on clear, calm nights than urban or upland areas.

Frost, or freezing temperature, data for Sac City are given in table 15. The average date of the last 32° temperature in spring is May 2, and the average date of the first 32° temperature in fall is October 7. The average frost-free period is 158 days.

Soil moisture reserves are an important part of the moisture supply for crops. A 5-inch reserve early in spring is considered to be a critically low level. This area has about a 25 percent chance that less than 5 inches of water will be available to plants in the top 5 feet of soil on April 14. The average amount of water available at this time of year is 7.0 inches. There is less than a 25 percent chance that more than 9 inches will be present.

Topography and drainage

The soils in the eastern part of the county are dominantly nearly level to undulating. In the western part, except in the southwest corner, they are dominantly undulating. In the southwest corner of the county, they are mainly gently rolling to hilly. The prevailing slope is to the south and east. Elevation ranges from about 1,000 feet at the low point in the southeastern part of the county to about 1,400 feet near the northwest corner.

The North Raccoon River and its tributaries drain the eastern part of the county. This river originates in Buena Vista County about 25 miles north of the Sac County line and enters Sac County at the northern

TABLE 15.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data are from Sac City, Sac County, Iowa]

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
Spring:					
1 year in 10 later than	Apr. 5	Apr. 14	Apr. 23	May 4	May 17
2 years in 10 later than	Mar. 30	Apr. 8	Apr. 18	Apr. 29	May 12
5 years in 10 later than	Mar. 20	Mar. 28	Apr. 7	Apr. 19	May 2
Fall:					
1 year in 10 earlier than	Oct. 27	Oct. 19	Oct. 13	Oct. 8	Sept. 22
2 years in 10 earlier than	Nov. 1	Oct. 24	Oct. 19	Oct. 13	Sept. 27
5 years in 10 earlier than	Nov. 12	Nov. 4	Oct. 30	Oct. 24	Oct. 7

border in the eastern half of the county. It flows southeast and leaves the county to the east, about 6 miles north of the southern border. The eastern part of the county has a poorly integrated drainage system, and drainage ditches have been dug to connect with or to improve natural drainageways.

The Boyer River and its tributaries drain the west-central part of Sac County. It originates near Storm Lake in Buena Vista County about 5 miles from the Sac County border. It enters from the north near the center of the county, flows to the south, and leaves the county about 6 miles east of the western border. The west-central part of the county has a well integrated drainage system. Some artificial drainage systems have been installed, mainly to drain wet soils in drainageways. Tiling is used, and the outlets are normally natural streams.

Part of the western edge of the county is drained by tributaries of the Maple River. The tributaries flow west into that river, which is about 4 to 8 miles west of the county. This part of the county also has a well integrated natural drainage system and an artificial

vice is available at the towns of Sac City and Wall Lake.

Industry in the county is mainly concerned with farm service and processing farm products. The processing of popcorn is an important industry. Sac County is one of the largest producers of popcorn in the world. Out-of-county markets for farm produce include Sioux City, Storm Lake, Spencer, Denison, and Ft. Dodge, all of which are in Iowa, and Omaha, Chicago, and Minneapolis.

Farming[4]

Farming is the main enterprise in Sac County. The farming is diversified and includes crop production and livestock raising. About 98 percent of the county, or 363,836 acres, is in farms. The average size of the farms is 276 acres. In 1970, 39.3 percent of the area was farmed by the owners; the rest was operated by tenants. The trend for a number of years has been for the farm population and the number of farms to de-

County in 1972 was as follows: corn, 154,005; soybeans 69,923; all hay, 16,255; oats, 14,038; popcorn, 2,476; sorghum, 130; wheat, 22; and all pasture, 40,052.

The feeding of beef cattle and hogs is the most important livestock enterprise. Many beef cattle are bought out of State and trucked into the county for feeding. Hogs are mostly farrowed and fed on the same farm, but some feeder pigs are brought in. The beef cattle and hogs are marketed at packing plants in the Midwest.

The number of beef cattle and hogs fed in the county is increasing. Dairy cows and heifers on hand are decreasing, but beef cows and heifers on hand are increasing. The production of chickens has decreased. Turkey production has been variable, but the general trend is to increased numbers.

The numbers of the principal kinds of livestock raised and sold or on hand in 1972 were as follows: grain-fed cattle marketed, 108,276; grain-fed sheep

(16) White, Everett M. 1953. Subsoil texture variations on the Clarion-Webster Experiment Farm as related to the Mankato glacial deposit. Iowa Acad. Sci. 60: 438–441.

Glossary

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

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Area reclaim. An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

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

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

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

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

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

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

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

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not ser-

average of more than once in 2 years. Duration is expressed as very brief if less than 2 days, brief if 2 to 7 days, and long if more than 7 days. Probable dates are expressed in months; November–May, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

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

Frost action. Freezing and thawing of soil moisture. Frost action can damage structures and plant roots.

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

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice.

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

Gleyed soil. A soil having one or more neutral gray horizons as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is [illegible]

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

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

Low strength. Inadequate strength for supporting loads.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Piping. Moving water forms subsurface tunnels or pipelike cavities in the soil.

Poor outlets. Surface or subsurface drainage outlets difficult or expensive to install.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is ex-

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in 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 characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

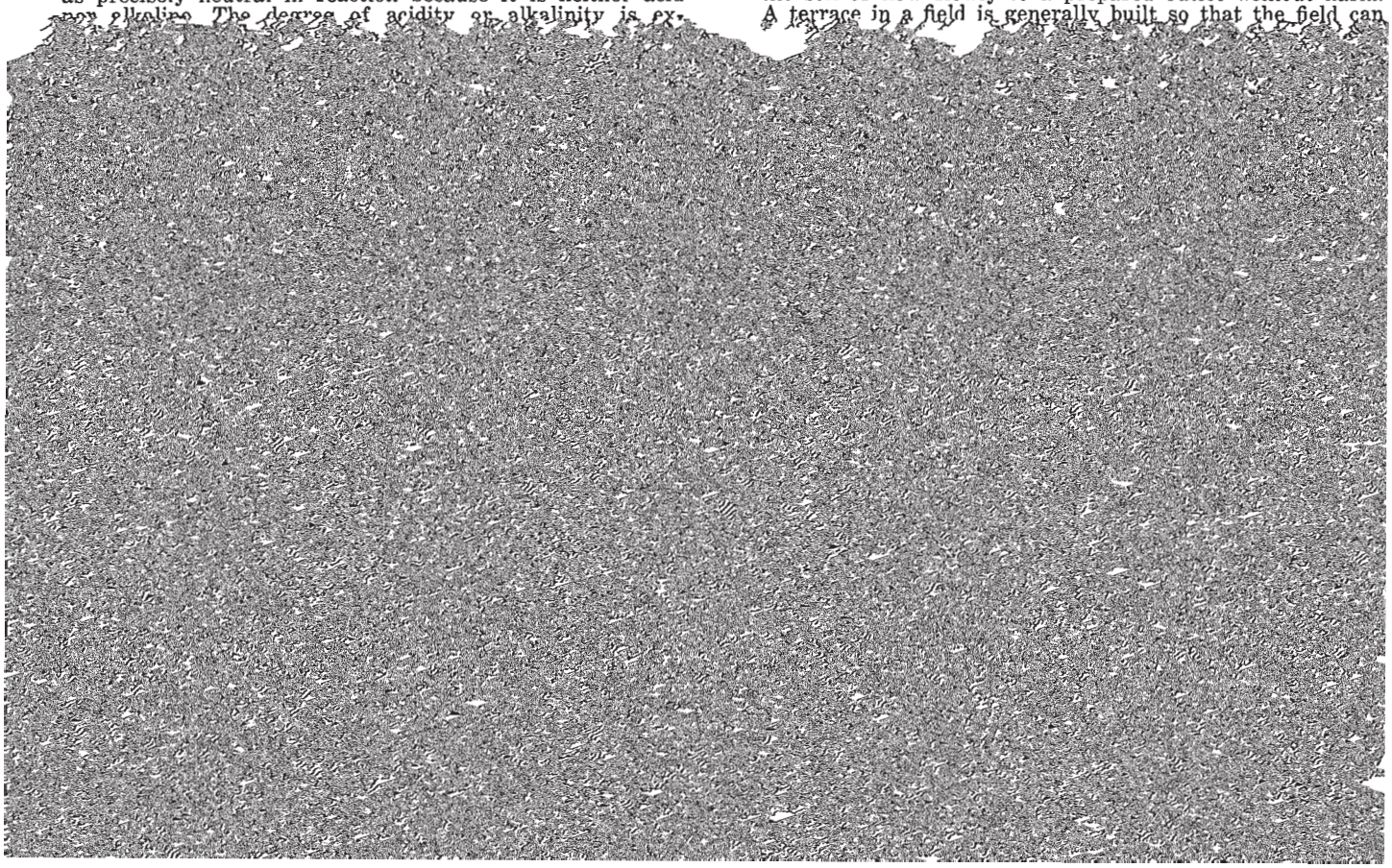
Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoil phosphorus. The relative amount of phosphorus (P) in the soil between depths of 25 and 36 inches. The classes are very low (VL), low (L), medium (M), and high (H).

Subsoil potassium. The relative amount of potassium (K) in the soil between depths of 6 and 12 inches. The classes are very low minus (VL−), very low plus (VL+), low (L), medium (M), and high (H).

Substratum. The part of the soil below the solum.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can



GUIDE TO MAPPING UNITS

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	25	IIIe-2	60
1E3	Ida silt loam, 14 to 20 percent slopes, severely eroded	25	IVe-1	61
1F3	Ida silt loam, 20 to 30 percent slopes, severely eroded	25	VIe-1	62
5B	Kennebec-Ackmore complex, 2 to 5 percent slopes	27	IIw-1	58
C5B	Kennebec-Ackmore complex, channeled, 2 to 5 percent slopes	27	Vw-1	62
6	Okoboji silty clay loam, 0 to 1 percent slopes	36	IIIw-1	60
8C	Judson silty clay loam, 3 to 8 percent slopes	26	IIIe-1	59
9B	Marshall silty clay loam, 2 to 5 percent slopes	32	IIe-1	58
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	32	IIe-1	58
9C	Marshall silty clay loam, 5 to 9 percent slopes	32	IIIe-1	59
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	33	IIIe-1	59
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	33	IIIe-2	60
9D3	Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	33	IIIe-2	60
10D3	Monona silt loam, 9 to 14 percent slopes, severely eroded	34	IIIe-2	60
10E3	Monona silt loam, 14 to 20 percent slopes, severely eroded	34	IVe-1	61
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	18	IIw-1	58
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded	43	IIIe-1	59
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded	43	IIIe-2	60
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded	43	VIe-1	62
26B	Kennebec silty clay loam, 2 to 5 percent slopes	27	IIe-1	58
27C	Terril loam, 3 to 8 percent slopes	47	IIIe-1	59
31	Afton silty clay loam, 0 to 2 percent slopes	10	IIw-1	58
33E	Steinauer loam, 9 to 18 percent slopes	45	VIe-1	62
33F	Steinauer loam, 18 to 40 percent slopes	45	VIe-1	62
41D	Sparta loamy fine sand, 5 to 14 percent slopes	43	VIs-1	62
54	Zook silty clay loam, 0 to 2 percent slopes	51	IIw-2	59
55	Nicollet loam, 1 to 3 percent slopes	34	I-1	58
62C	Storden loam, 5 to 9 percent slopes	45	IIIe-1	59
62D	Storden loam, 9 to 14 percent slopes	45	IIIe-2	60
62E	Storden loam, 14 to 18 percent slopes	45	IVe-1	61
62F	Storden loam, 18 to 25 percent slopes	46	VIe-1	62

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit	
			Symbol	Page
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	16	IIIe-1	59
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	16	IIIe-2	60
174B	Bolan loam, 2 to 5 percent slopes	13	IIe-2	58
174C2	Bolan loam, 5 to 9 percent slopes, moderately eroded	13	IIIe-3	60
174D2	Bolan loam, 9 to 14 percent slopes, moderately eroded	13	IVe-2	61
201B	Coland-Spillville complex, 2 to 5 percent slopes	17	IIw-1	58
C201B	Coland-Spillville complex, channeled, 2 to 5 percent slopes	17	Vw-1	62
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	19	IIs-1	59
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	19	I-1	58
221	Palms muck, 0 to 1 percent slopes	37	IIIw-1	60
234	Nishna silty clay loam, 0 to 2 percent slopes	35	IIw-2	59
236B	Lester loam, 2 to 7 percent slopes	29	IIe-1	58
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	11	IIw-1	58
274	Rolfe loam, 0 to 1 percent slopes	38	IIIw-1	60
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	48	I-1	58
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	48	IIe-1	58
310	Galva silty clay loam, 0 to 2 percent slopes	23	I-1	58

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