SOIL SURVEY

Clay County, Iowa

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

Issued April 1968

Major fieldwork for this soil survey was done in the period 1957–62. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1962. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agricultural Experiment Station; it is part of the technical assistance furnished to the Clay County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Clay County contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in estimating the suitability of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Clay County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit and woodland planting suitability group in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay 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 those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about the use and management of the soils in the soil descriptions and in the section that discusses management of soils for crops and pasture.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Use of Soils for Wildlife and Recreation."

Foresters and others can refer to the section "Use of Soils for Woodland," where the soil series of the county are grouped according to their suitability for planting of trees.

Engineers and builders will find under "Use of Soils for Engineering" tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation and Classification of Soils."

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

Cover picture: Soybeans planted on the contour on Everly clay loam, 5 to 9 percent slopes, moderately eroded. The trend is toward terracing and contour farming of cultivated land.

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Contents

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SOIL SURVEY OF CLAY COUNTY, IOWA

BY CHARLES S. FISHER, SOIL CONSERVATION SERVICE[1]

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

CLAY COUNTY is in the northwestern part of Iowa. It is the second county south of the Iowa-Minnesota State line and the third county east of the Iowa-South Dakota State line. Figure 1 shows the location of Clay County in Iowa. Spencer, the county seat, is about 130 miles northwest of Des Moines, the State capital. The county has an area of about 365,440 acres.

Most of the land area of the county is in farms and is used mainly for growing corn, soybeans, oats, hay, and pasture. Corn is the chief grain crop. Raising hogs and feeding beef cattle are the principal livestock enterprises. Most of the soils are dark-colored and fertile. They developed mainly under prairie vegetation. The climate is subhumid and continental. The winters are cold and summers are warm. The growing season is long enough for all common crops to mature.

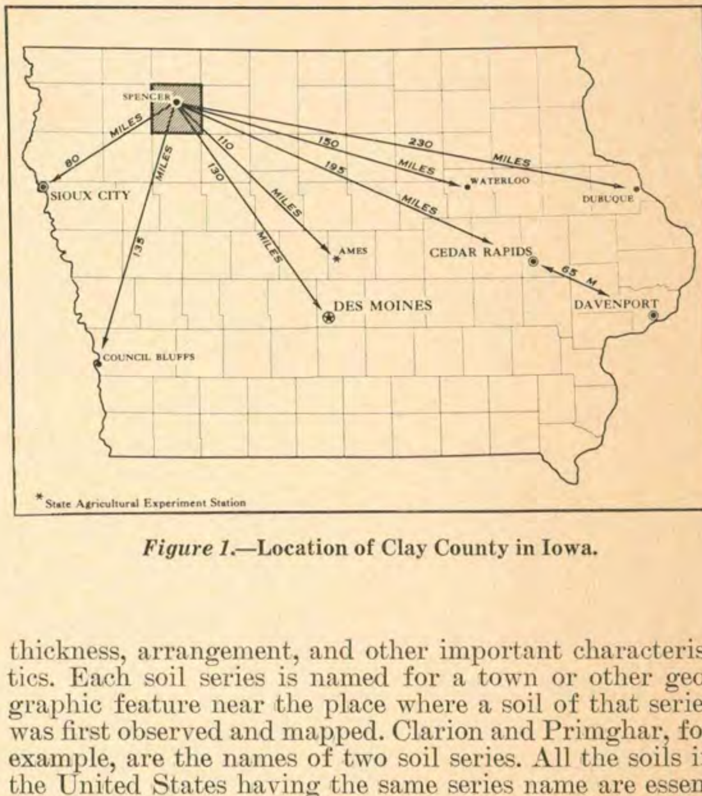

Figure 1.—**Location of Clay County in Iowa.**

How This Survey Was Made

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

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

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

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

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

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting

[1] The soils were surveyed and the survey manuscript prepared under the general direction of W. J. B. BOATMAN, now deceased, and LACY I. HARMON, Soil Conservation Service, and F. F. REICKEN, Iowa Agricultural Experiment Station. Those participating in the field survey were CHARLES S. FISHER, LOREN M. GREINER, LAURENCE T. HANSON, HARVEY A. HARMAN, ROBERT G. JONES, MAYNARD P. KOPPEN, GEORGE SCHABILION, and ROBERT I. TURNER, Soil Conservation Service.

their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Clarion loam, 2 to 5 percent slopes, is one of several phases of Clarion loam, a soil type that ranges from gently sloping to steep.

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

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

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Colo-Terril complex, 2 to 5 percent slopes.

Most surveys include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it is not classified by soil series. These areas are shown on the map like other mapping units, but are given descriptive names, such as Alluvial land or Marsh, and are called land types.

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

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

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Clay County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The general soil map of Clay County shows nine soil associations. Six associations are in the uplands, one is on benches and uplands, one is on benches, and one is on bottom lands.

1. Clarion-Nicollet-Webster Association

Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to strongly sloping soils on uplands

The soils of this association are nearly level to strongly sloping loams, clay loams, and silty clay loams that occur in the eastern part of the county on uplands. The association is generally undulating, though there are many depressions without outlets and many knobs and hills intermingled with the nearly level areas (fig. 2). Most of the slopes are short and irregular. This association occupies about 22 percent of the county.

The Clarion soils make up about 40 percent of this association; the Nicollet soils, about 18 percent; the Webster soils, about 15 percent; and minor soils, the remaining 27 percent.

The main soils in this association are the Clarion, Nicollet, and Webster. The Clarion soils are well-drained loams that are gently undulating to rolling in most places. The Nicollet soils are somewhat poorly drained, nearly level loams and clay loams. The Webster soils are poorly drained, nearly level silty clay loams.

The minor soils in this association are mainly the Glencoe, Okoboji, and Storden. The Glencoe and Okoboji soils are in depressions and are very poorly drained. The Glencoe soils are silty clay loams, and the Okoboji soils are silt loams. The Storden soils are well-drained loams. They are moderately sloping to very steep and occur on side slopes that are generally adjacent to streams or drainageways.

The soils of this association are used mainly for general farming. Much of the acreage is in crops, but in many places the poorly drained and the sloping soils are used for permanent pasture. The percentage of the acreage in permanent pasture in this association is exceeded only by the percentage in the Colo-Spillville-Wabash and the Storden associations. On most farms some of the grain produced is fed to livestock, and the livestock is marketed.

Crops grow well on these soils, except in a few places where they are droughty, in areas that are strongly sloping or steep and susceptible to erosion, and in poorly drained

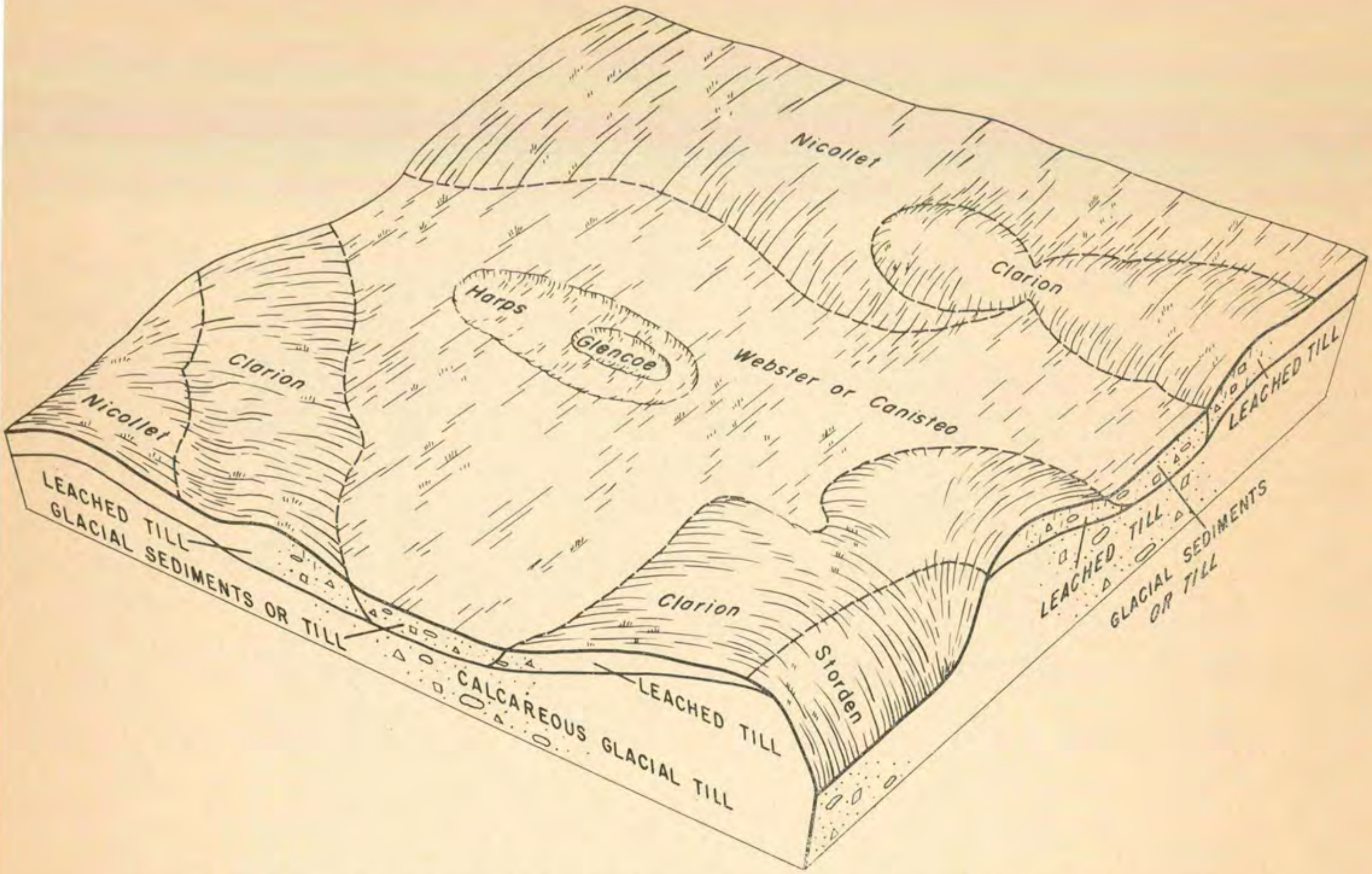

Figure 2.—**Relationship of the soils, relief, and underlying material in the Clarion-Nicollet-Webster association.**

and very poorly drained areas. Tile is effective in draining the poorly drained and very poorly drained soils, but outlets, particularly those for the deeper depressions, are not available in all places. Surface drains are used in some places. Even in drained areas, the soils in depressions are often ponded in spring and after heavy rains.

In size, the farms in this association are about average for the county. Fields generally are fairly large. Because of the undrained depressions, the drainageways, and the drainage ditches, these fields are more irregular in shape than the fields in the other associations. Roads are mainly on section lines, except where they bypass ponds or have not been built because of water or other natural obstacles.

Fertility varies in the soils of this association. On most of them, especially if cropping is intensive, additions of nitrogen, phosphate, and potash are needed to maintain good growth of crops. Lime generally is not needed, except for small amounts in some places.

2. Marcus-Primghar-Sac Association

Well-drained to poorly drained, moderately fine textured, nearly level to moderately sloping soils on uplands

The soils of this association are nearly level to moderately sloping silty clay loams. They occur mainly in the southwestern part of the county, but small areas are in the east-central and west-central parts. This association is adjacent to the Marcus-Primghar association in most places, but it has stronger relief because the nearly level loess-mantled plain is somewhat dissected by shallow drainageways. The soils are nearly level or gently sloping in most places, but they are moderately sloping in areas adjacent to stream valleys and drainageways. Slopes generally are long. This association occupies about 12 percent of the county.

The Marcus soils make up about 30 percent of this association; the Primghar soils, about 30 percent; the Sac soils, about 30 percent; and minor soils, the remaining 10 percent.

In this association the major soils—the Marcus, Primghar, and Sac—are deep, dark-colored silty clay loams. The Marcus and Primghar soils developed in loess that was more than 40 inches thick and the Sac soils developed in loess but are less than 40 inches deep to glacial till. The Marcus soils are nearly level and poorly drained; most areas are flat to slightly concave. The Primghar soils are nearly level and somewhat poorly drained; most areas have slightly convex slopes. The Sac soils are gently sloping to moderately sloping and are well drained.

The minor soils in this association are the Galva, Afton, Colo, Terril, Everly, and Storden. The Galva soils developed in loess and have slopes of 0 to 3 percent. The Afton

***Figure 3.*—Typical view in the Marcus-Primghar soil association. In the foreground is Primghar silty clay loam.**

soils occupy shallow drainageways and are wet in places. The Colo and Terril soils are in drainageways. Adjacent to the drainageways are the moderately sloping to very steep Everly and Storden soils.

The soils in this association are used mainly for general farming. They are some of the better soils of the county for farming. Most of the acreage is cultivated, mainly to corn and soybeans, but oats and hay are also grown. On most farms some of the grain produced is fed to livestock, and the livestock is marketed. The more sloping soils are used for permanent pasture. Some timber grows in a few of the more sloping areas, but these areas are generally managed as pasture. Use of the poorly drained soils is limited by wetness, and the sloping soils are susceptible to erosion.

The average size of farms in this association is slightly larger than that of other associations in the county except the Marcus-Primghar. Fields are large and, except for a few near streams, are either square or rectangular. Roads are generally on section lines, and only a few sections are not completely surrounded by roads.

Except for the strongly sloping to steep soils adjacent to streams, the soils of this association are mostly high in natural fertility. Additions of nitrogen and phosphate are needed to maintain fertility and to support good growth of crops, especially in intensively farmed areas. Most of these soils are medium to high in potassium. The surface layer ranges from neutral to medium acid, and moderate amounts of lime are needed on the acid soils.

3. Marcus-Primghar Association

Poorly drained and somewhat poorly drained, moderately fine textured, nearly level soils on uplands

The soils in this association are nearly level silty clay loams that have slopes of 2 percent or less in about 90 percent of the acreage (fig. 3). This association occupies about 17 percent of the county and is mainly in the southwestern part.

Marcus soils make up about 35 percent of this association; Primghar soils, about 55 percent; and minor soils, the remaining 10 percent.

The Marcus and Primghar are the main soils in this association. These silty clay loams are deep and dark colored. They developed in loess more than 40 inches thick. The Marcus soils are poorly drained and are in nearly flat or

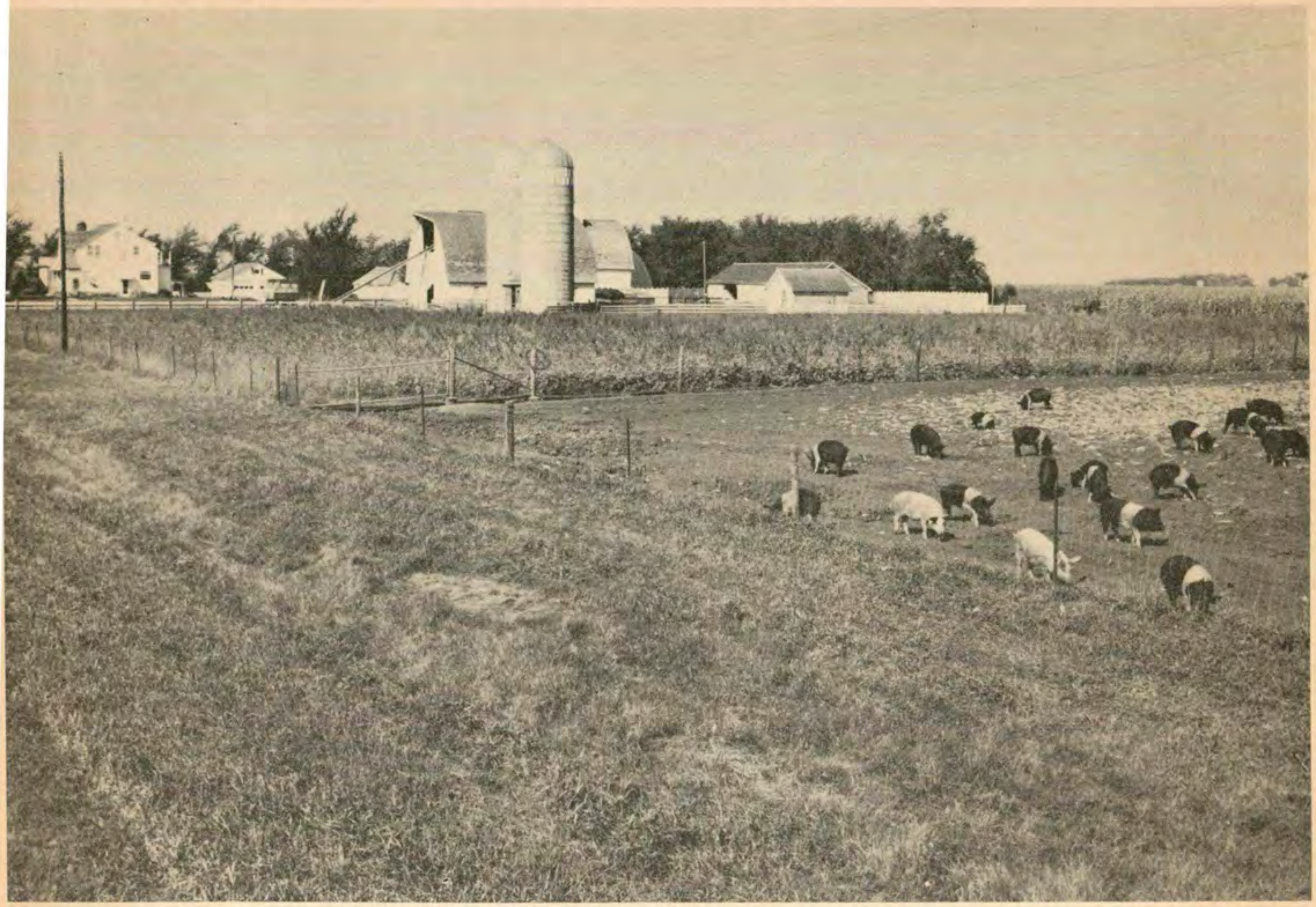

Figure 4.—**Raising and fattening hogs is a major enterprise in the Marcus-Primghar soil association.**

slightly concave areas. The Primghar soils are somewhat poorly drained and, in most places, have convex surfaces and slopes of as much as 2 percent.

The most extensive minor soils are the Afton, but small areas of Sac, Nicollet, Tripoli, and other soils also occur. The Afton soils are deep and dark colored. They developed in loess and local alluvium in shallow drainageways.

Nearly all of this association is used for crops, mainly corn and soybeans. The percentage of acreage in row crops in this association is higher than the percentage in any other association in the county. On most farms some of the grain produced is fed to livestock (fig. 4), but much of it is marketed at local elevators. Much of this association consists of nearly level soils that are excellent for farming.

The Marcus soils and some of the minor soils that are poorly drained need to be drained. Tile drains are effective in improving drainage. Only the well-drained minor soils are susceptible to erosion.

Farms in this association are slightly larger than the average for the county. Most of the fields are large and are rectangular or square. The roads are on section lines and run completely around all except a few sections. Except in windbreaks and around farm buildings, trees are few in this association.

The soils in this association are high in fertility, but additions of nitrogen and phosphate are needed, especially on fields that are farmed intensively. Most of these soils are medium to high in potassium. Reaction ranges from neutral to medium acid, and additions of lime are needed on the acid soils.

4. Wadena-Cylinder-Biscay Association

Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to strongly sloping soils on benches

The soils of this association are loams and silty clay loams that are nearly level in most places but gently sloping in a few. They are generally on benches. Between the benches and between the benches and bottom lands are minor areas that are moderately sloping to steep. The soils in this association formed mainly on benches, in outwash from melting glaciers; but in some areas they formed on stream benches. Most of this association is in the northwestern part of the county, but scattered areas also occur in the eastern and southern parts. The association occupies about 13 percent of the county.

Wadena soils make up about 50 percent of this association; Cylinder soils, about 20 percent; Biscay soils, about 14 percent; and minor soils, the remaining 16 percent.

The main soils in this association are the Wadena, Cylinder, and Biscay. The Wadena soils generally have nearly level to convex slopes and are well drained, but they are gently sloping to strongly sloping in a few small areas. Wadena soils are generally slightly higher on the landscape than either the Cylinder or the Biscay soils. The Cylinder soils are somewhat poorly drained and are higher than the Biscay soils. The Biscay soils are nearly level to slightly concave and are poorly drained.

All of these major soils have a dark-colored surface layer. The Wadena and Cylinder soils are dominantly loam, but the Cylinder soils grade to light clay loam in the subsoil. The Wadena and Cylinder soils overlie sand or gravel at a depth of less than 3 feet in most places, but at a depth of more than 3 feet in some places. These soils are droughty.

The Biscay soils have a silty clay loam surface layer, but they grade to clay loam in the subsoil. Sand and gravel generally is at a depth of more than 3 feet. In these poorly drained soils, drainage is generally needed. Tile drains work well. These drains are difficult to install, however, where the tile must be placed in the coarse material.

The minor soils are the Talcot, Dickinson, and Salida. The Talcot soils occupy a sizable area in the association and are calcareous and poorly drained. They are near the Biscay soils and, like them, generally require tile drainage. The Dickinson soils are of small extent and are on benches. The Salida soils are on breaks between benches or between benches and bottom lands.

The soils of this association are used mainly for crops, but some of the steeper or wetter soils are in permanent pasture. Farming is of the general type, and corn, soybeans, oats, and meadow are the main crops. On most farms part of the grain produced is fed to livestock, and the livestock is marketed. The Wadena and Cylinder soils are suited to crops, but crop growth varies because of droughtiness. The sloping Wadena soils are susceptible to erosion. The Biscay soils are suited to crops in most years if drainage is adequate. A few farmers in this association have installed sprinkler irrigation systems to offset the hazard of drought.

Nearly all roads in this association are on section lines. Most sections are completely surrounded by roads. Fields are large and are mostly rectangular or square. In this association trees grow only in windbreaks around farmsteads. Some farms consist of nearly level soils and have only one or two kinds of them.

Fertility varies in the soils in this association. Nitrogen, phosphate, and potash are generally needed, and in some places lime is also needed.

5. Everly-Nicollet-Tripoli Association

Well-drained to poorly drained, moderately fine textured, nearly level to sloping soils on uplands

The soils of this association are nearly level to sloping clay loams that occur mostly in the northwestern, central, and south-central parts of the county. Most slopes are long and gentle, and the divides between the drainageways are generally broad and nearly level. This association occupies about 18 percent of the county.

Everly soils make up about 33 percent of this association; Nicollet soils, about 33 percent; Tripoli soils, about 15 percent; and minor soils, the remaining 19 percent.

The Everly, Nicollet, and Tripoli are the major soils in this association. All are clay loams. The Everly soils are mostly gently sloping to moderately sloping and are well drained. Tripoli soils are nearly level and poorly drained. The Nicollet soils are on convex slopes ranging from 1 to 3 percent and are somewhat poorly drained. All of these soils developed in a gritty, somewhat loesslike material that overlies glacial till (fig. 5).

The minor soils in this association are the Afton, Colo, and Dickinson. The Afton soils occur in drainageways and are poorly drained. They developed in loess and local alluvium. The Dickinson soils are nearly level to gently sloping and are well drained to somewhat excessively drained. They generally occur on fairly narrow ridges extending in a northwest-southeast direction.

Tile drains are needed on the Tripoli and Afton soils if crops are to be grown successfully. On the Afton soils, improved waterways are needed in places. The Nicollet soils are wet in some places, but tile drainage generally is not needed. The Everly and Dickinson soils are susceptible to erosion, and the Dickinson soils are droughty.

Most of this association is used for crops, but a few areas are used for pasture. In general, these soils are productive if management is good. Farming is mainly of the general type, and corn, soybeans, oats, and meadow are the main crops. Much of the grain produced is fed to livestock, and the livestock is marketed. Farms are about average size for the county. Fields are generally large and are square or rectangular. On some farms, however, streams and drainageways are large enough to affect the size, shape, and arrangement of fields.

Most parts of this association are high in natural fertility. Nitrogen and phosphate are needed to maintain fertility and productivity where the soils are farmed intensively. Less potash is needed. The soils of this association range from medium acid to neutral in reaction. Lime is needed on the acid soils.

6. Colo-Spillville-Wabash Association

Moderately well drained to very poorly drained, medium-textured to fine-textured, nearly level soils on bottom lands

This association is along the major streams, mainly the Little Sioux and Ocheyedan Rivers (fig. 6). The soils developed in alluvium and are generally susceptible to flooding. They are in areas mainly less than three-fourths of a mile wide and closely parallel to the streams. Few farms lie wholly within this association. Generally the soils in it are a part of farms that are in an association in the uplands. This association occupies about 7 percent of the county.

Colo soils make up about 90 percent of this association; Spillville soils, about 4 percent; Wabash soils, about 2 percent; and minor soils, the remaining 4 percent.

The major soils in this association are the Colo, Spillville, and Wabash, but the Colo are by far the most extensive. The Colo soils are dominantly silty clay loam and are poorly drained. They are nearly level, but in many areas they are cut by old stream channels. The Spillville soils are typically loam and are somewhat poorly drained. In some, but not all, places they are in slightly higher

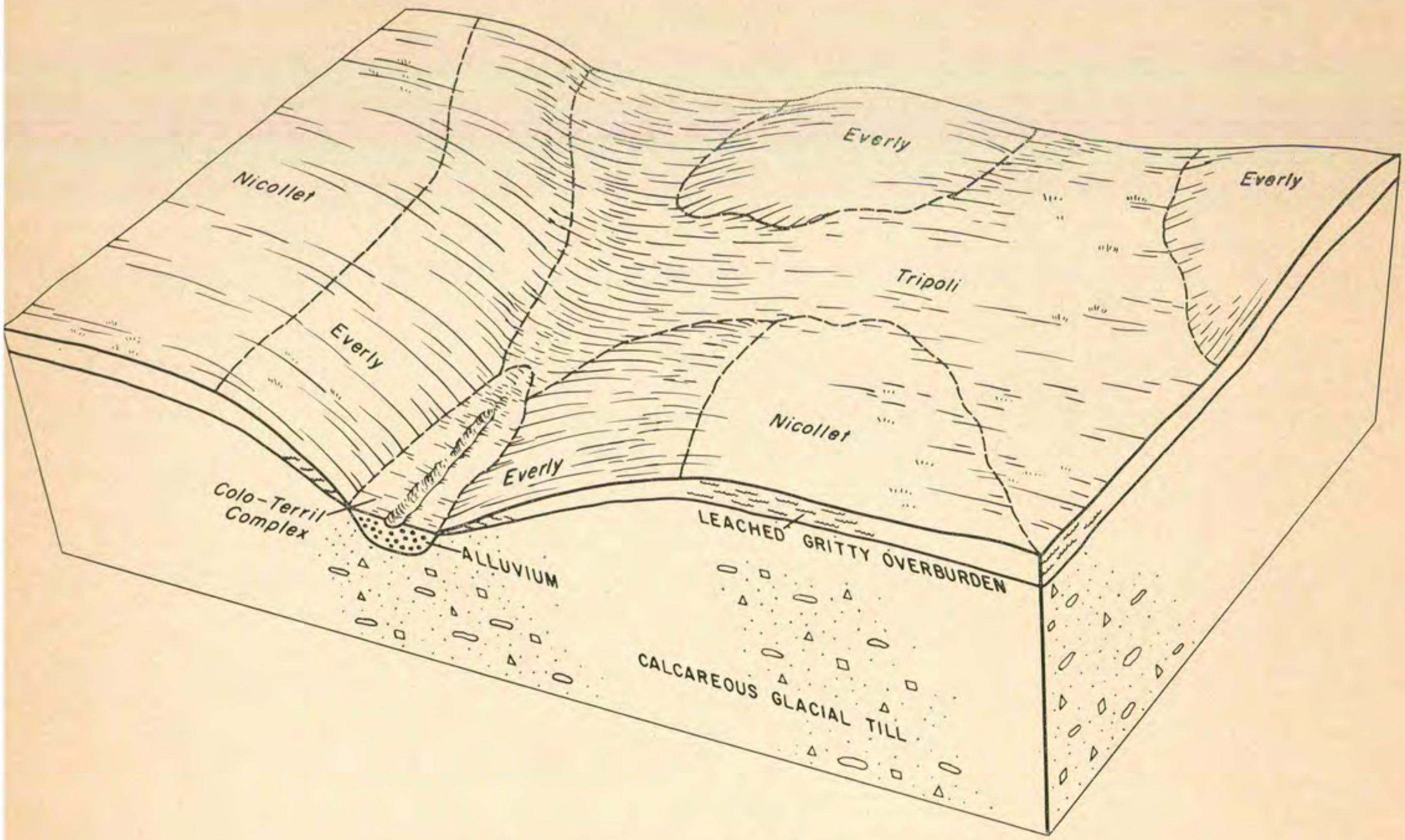

Figure 5.—**Relief and parent material of major soils in soil association 5.**

positions on the bottom lands than the Colo soils. The Wabash soils are silty clay throughout their profile and are poorly drained. They are generally in old stream channels or slack-water areas that are not along the streams.

A minor part of this association is occupied by Alluvial land and Wadena and Cylinder soils. Alluvial land is variable in texture and other characteristics. Most areas are cut by old stream channels. This land is near streams and is more susceptible to flooding than other parts of the association. The few areas of Wadena and of Cylinder soils are too small to be included in soil association 4.

Some of this association is used for crops, but a fairly large percentage is used for permanent pasture. Most areas that are flooded frequently support only timber and brush. The cultivated soils are generally farmed intensively to row crops, commonly corn and soybeans. Productivity of the cultivated areas is variable, depending on the frequency of flooding and on drainage.

The Colo soils generally are benefited by tile drains, but in places there are no suitable outlets. Tile drains do not work well in the Wabash soils because the subsoil is clayey, but in some places surface drains are beneficial. Alluvial land is generally flooded so frequently that it is used only for hay or pasture.

The soils in this association have high natural fertility, but nitrogen and phosphate are needed to maintain productivity and fertility where the soils are intensively farmed. Less potash is needed. These soils are slightly acid or neutral in reaction, and if any lime is needed, the amount is small.

7. Storden Association

Well-drained, medium-textured, sloping to steep soils on uplands

This association is on slopes adjacent to the bottom lands along the Little Sioux River and its larger tributaries. It also occurs in a few areas farther from the larger streams where smaller streams have cut back into the uplands. The areas are narrow and, in the southern half of the county, are roughly parallel to the larger streams. This association occupies about 3 percent of the county.

Storden soils make up about 90 percent of this association, and minor soils make up the remaining 10 percent.

The major soils in this association are the Storden. They are well-drained loams that are limy at or near the surface. They are mainly steep or very steep, but some are sloping.

The Everly soils are of minor extent in this association. They are mapped in a complex with the Storden soils in a few strongly sloping to rolling areas. Other minor soils are Clarion soils that have a loam surface layer and a heavy subsoil and are on north- and east-facing slopes where stands of trees are thick, and the closely intermingled Colo and Terril soils in some drainageways and on bottom lands along small streams.

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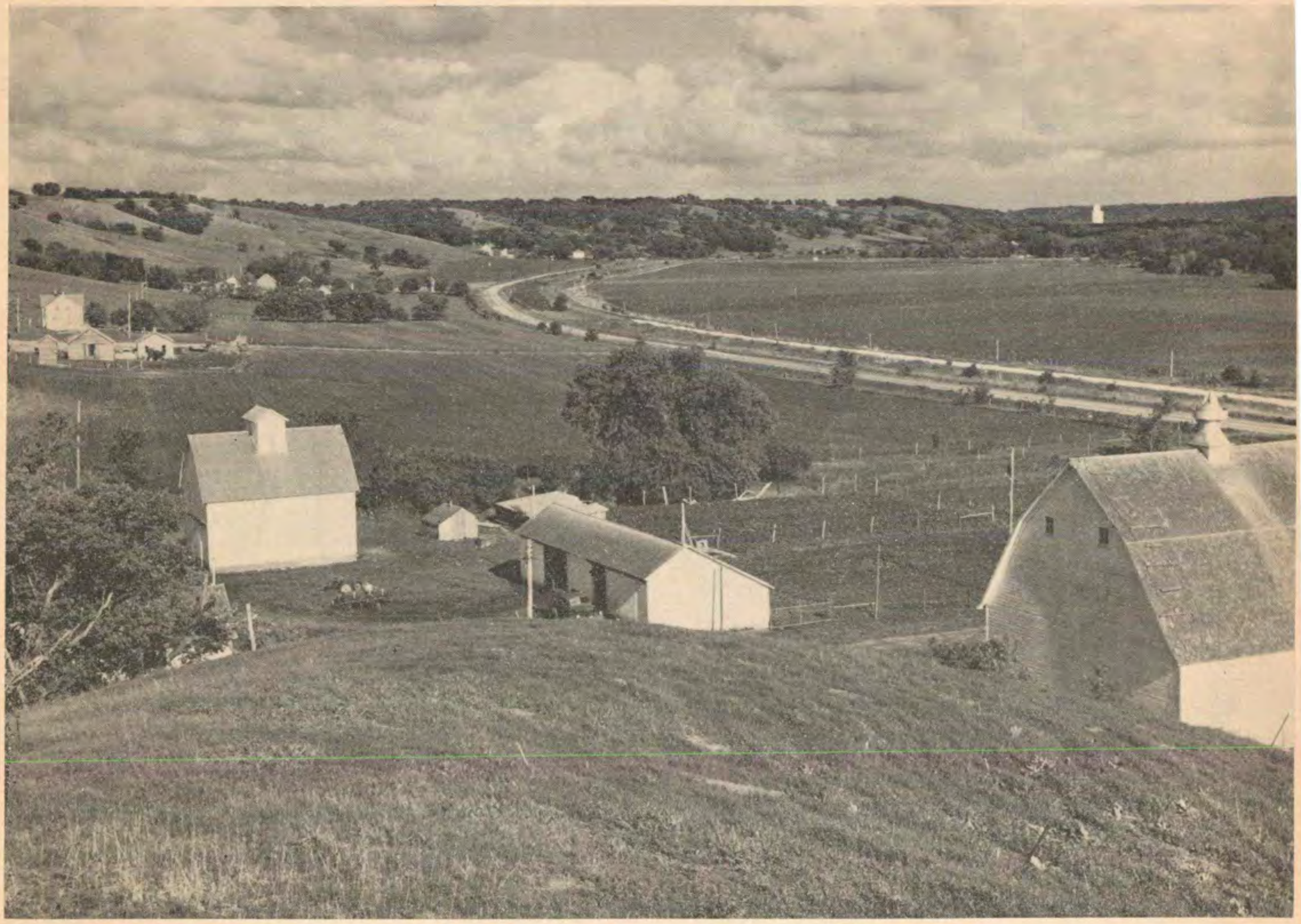

Figure 6.—View in valley of the Little Sioux River northwest of Peterson. Buildings are on Terril loam; bottom lands across the road are dominantly Colo silty clay loam; steep areas at the upper left are Storden loam.

Most of this association is in permanent pasture. Trees occur in some areas that generally are used as pasture. The trees are generally on north- and east-facing slopes. A few of the less sloping areas are cropped, but they are only fairly productive. The Storden soils are susceptible to erosion. Gullies have formed where pastures are overgrazed. Because this association is narrow, it contains only parts of farms.

8. Ocheyedan-Webster-Guckeen-Marna Association

Well-drained to poorly drained, medium-textured to fine-textured, nearly level to gently sloping soils on uplands and benches

This association occupies only about 3 percent of the county and occurs on uplands and outwash areas in the north-central part.

The Ocheyedan soils make up about 10 percent of this association; the Webster soils, about 15 percent; the Guckeen soils, about 25 percent; the Marna soils, about 22 percent; and minor soils, the remaining 28 percent.

The major soils in the association are the Ocheyedan, Webster, Guckeen, and Marna. The Ocheyedan and Webster soils developed in medium textured or moderately fine textured glacial sediments, dominantly loam or clay loam.

The Ocheyedan soils are nearly level to gently rolling and are well drained. The Webster soils have slopes of less than 2 percent and are poorly drained. The Marna and Guckeen soils developed in moderately fine textured or fine textured lacustrine sediments. Areas of these soils are intermingled with areas of other soils in the association in a complex pattern. The two areas of this association that are near Dickens consist mainly of Guckeen and Marna soils. The Marna soils are nearly level and are poorly drained. The Guckeen soils are nearly level to strongly sloping and are somewhat poorly drained to well drained. Their subsoil is light silty clay in texture.

The minor soils in this association are the Fostoria, Canisteo, and Canisteo silty clay loam, gypsic variant. The Fostoria soils are nearly level and are somewhat poorly drained. The Canisteo soils are nearly level and poorly drained.

Most of this association is used for crops, but a few of the steeper areas are used for permanent pasture. Corn, soybeans, oats, and meadow are the main crops. Because they are poorly drained and drainage is difficult to improve, the Marna soils are only moderately productive. Under good management, the other soils in this association are highly productive. Only a few farms lie wholly within the association.

The soils in this association have high natural fertility. Additions of nitrogen, phosphate, and potash are needed, however, to maintain fertility and productivity where these soils are farmed intensively. These soils are generally neutral or slightly acid in reaction, and additions of lime are seldom needed.

9. Ocheyedan-Fostoria-Webster Association

Well-drained to poorly drained, medium-textured to moderately fine textured, nearly level to moderately sloping soils on uplands

This association is mostly nearly level to gently sloping. It occurs in areas scattered through the northwestern and east-central parts of the county. The major soils developed in glacial sediments in the uplands and other soils in the association developed in wind-deposited sandy material. This association occupies about 2 percent of the county.

The Ocheyedan soils make up about 25 percent of this association; the Fostoria soils, about 25 percent; the Webster soils, about 15 percent; and minor soils, the remaining 35 percent.

The major soils in this association are the Ocheyedan, Fostoria, and Webster. The Ocheyedan soils are nearly level to gently rolling and are well drained. The Webster soils are nearly level to slightly concave and are poorly drained. The Fostoria soils are in slightly higher positions and are somewhat poorly drained. They are generally convex, but slopes are less than 2 percent.

Minor soils in this association are the Dickinson, Waukegan, Nicollet, and Everly. They are mainly nearly level and gently sloping, and they occupy low ridges. The Waukegan soils are of loam texture and overlie sandy material. The Dickinson soils are of loam or fine sandy loam texture and also overlie sandy material. Only small areas of Nicollet and Everly soils occur in this association.

This association is used for crops, mainly corn, soybeans, oats, and meadow. Most of the soils are highly productive, but the Waukegan and Dickinson are somewhat droughty and are only moderately productive. The Webster soils are naturally poorly drained, but drainage can be improved by using tile drains. The sloping soils in this association are susceptible to erosion. Farming is mainly of the general type, and only a few farms are wholly within the association. Fields are generally fairly large and are square or rectangular.

The natural fertility of the soils in this association is variable. Nitrogen, phosphate, and potash added to these soils help to maintain productivity and fertility. Additions of lime are needed on some soils.

Descriptions of the Soils

This section describes the soil series, which are groups of similar soils, and the single soils, or mapping units, of Clay County. The acreage and proportionate extent of each mapping unit are given in table 1.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soils	Acres	Percent
Afton silty clay loam	4, 567	1. 3
Alluvial land, channeled	244	. 1
Biscay silty clay loam, deep	8, 262	2. 3
Calco silty clay loam	2, 177	. 6
Canisteo silty clay loam	12, 731	3. 5
Canisteo silty clay loam, gypsic variant	144	(1)
Clarion loam, 2 to 5 percent slopes	23, 885	6. 6
Clarion loam, 5 to 9 percent slopes, moderately eroded	8, 609	2. 4
Clarion loam, 9 to 15 percent slopes, moderately eroded	293	. 1
Clarion loam, heavy subsoil variant, 20 to 40 percent slopes	844	. 2
Clarion-Storden complex, 5 to 9 percent slopes, moderately eroded	496	. 1
Clarion-Storden complex, 9 to 15 percent slopes, moderately eroded	324	. 1
Colo silty clay loam	15, 417	4. 3
Colo silty clay loam, 2 to 4 percent slopes	566	. 2
Colo silty clay loam, channeled	2, 645	. 7
Colo-Terril complex, 2 to 5 percent slopes	2, 594	. 7
Colo-Terril complex, 5 to 9 percent slopes	279	. 1
Cylinder loam, deep	5, 789	1. 6
Cylinder loam, moderately deep	5, 261	1. 4
Dickinson fine sandy loam, 0 to 2 percent slopes	231	. 1
Dickinson fine sandy loam, 2 to 5 percent slopes	1, 365	. 4
Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded	395	. 1
Dickinson fine sandy loam, benches, 0 to 2 percent slopes	362	. 1
Dickinson fine sandy loam, benches, 2 to 5 percent slopes	1, 089	. 3
Dickinson fine sandy loam, benches, 5 to 9 percent slopes, moderately eroded	839	. 2
Dickinson fine sandy loam, benches, 9 to 15 percent slopes, moderately eroded	139	(1)
Dickinson fine sandy loam, benches, 15 to 20 percent slopes, moderately eroded	110	(1)
Dickinson loam, 0 to 2 percent slopes	138	(1)
Dickinson loam, 2 to 5 percent slopes	177	(1)
Everly clay loam, 2 to 5 percent slopes	18, 988	5. 2
Everly clay loam, 5 to 9 percent slopes, moderately eroded	3, 391	. 9
Everly-Storden complex, 9 to 15 percent slopes, moderately eroded	761	. 2
Fostoria clay loam	831	. 2
Fostoria loam	1, 366	. 4
Galva silty clay loam, 1 to 3 percent slopes	2, 407	. 7
Galva silty clay loam, benches, 0 to 2 percent slopes	232	. 1
Glencoe silty clay loam	2, 648	. 7
Glencoe silty clay loam, gravelly substratum	1, 347	. 4
Guckeen silty clay loam, 0 to 2 percent slopes	1, 029	. 3
Guckeen silty clay loam, 2 to 5 percent slopes	533	. 1
Guckeen silty clay loam, 5 to 9 percent slopes, moderately eroded	139	(1)

See footnote at end of table.

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

Soils	Acres	Percent	Soils	Acres	Percent
Guckeen clay loam, silty clay substratum, 0 to 2 percent slopes	951	.3	Sandy lake beaches	52	(1)
Guckeen clay loam, silty clay substratum, 2 to 5 percent slopes	416	.1	Sperry silty clay loam	765	.2
Hagener loamy sand, 4 to 8 percent slopes, moderately eroded	137	(1)	Spillville loam	907	.2
Harps loam	1,896	.5	Storden loam, 5 to 15 percent slopes, moderately eroded	2,192	.6
Ladoga silt loam, 1 to 3 percent slopes	303	.1	Storden loam, 15 to 20 percent slopes, moderately eroded	1,945	.5
Marcus silty clay loam	38,469	10.6	Storden loam, 20 to 30 percent slopes, moderately eroded	3,445	.9
Marna silty clay	2,342	.6	Storden loam, 30 to 50 percent slopes, moderately eroded	2,001	.5
Marna silty clay loam, calcareous variant	122	(1)	Talcot silty clay loam, deep	5,642	1.5
Marsh	964	.3	Terril loam, 2 to 5 percent slopes	1,307	.4
Muck, moderately shallow	873	.2	Terril loam, 5 to 9 percent slopes	802	.2
Muck, moderately shallow, calcareous	284	.1	Terril loam, 9 to 15 percent slopes	246	.1
Muck, shallow	1,362	.4	Tripoli clay loam	10,011	2.7
Nicollet clay loam	24,494	6.7	Wabash silty clay	531	.1
Nicollet loam	13,864	3.8	Wacousta silty clay loam	338	.1
Ocheyedan loam, 0 to 2 percent slopes	1,069	.3	Wadena loam, deep, 0 to 2 percent slopes	2,105	.6
Ocheyedan loam, 2 to 5 percent slopes	1,174	.3	Wadena loam, deep, 2 to 5 percent slopes	899	.2
Ocheyedan loam, 5 to 12 percent slopes, moderately eroded	175	(1)	Wadena loam, moderately deep, 0 to 2 percent slopes	17,709	4.8
Okoboji silt loam	1,392	.4	Wadena loam, moderately deep, 2 to 5 percent slopes	5,271	1.4
Primghar silty clay loam	51,623	14.2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	942	.3
Primghar silty clay loam, benches	206	.1	Wadena loam, moderately deep, 9 to 15 percent slopes, moderately eroded	144	(1)
Rolfe silt loam	152	(1)	Waukegan loam, moderately deep, 0 to 2 percent slopes	499	.1
Sac silty clay loam, 2 to 5 percent slopes	12,015	3.3	Waukegan loam, moderately deep, 2 to 5 percent slopes	698	.2
Sac silty clay loam, 5 to 9 percent slopes	703	.2	Webster silty clay loam	16,035	4.4
Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	665	.2	Gravel pits	393	.1
Salida gravelly sandy loam, 2 to 5 percent slopes	201	.1	Miscellaneous land	199	.1
Salida gravelly sandy loam, 5 to 9 percent slopes, moderately eroded	377	.1	Total	365,440	100.0
Salida gravelly sandy loam, 9 to 15 percent slopes, moderately eroded	204	.1			
alida gravelly sandy loam, 15 to 20 percent slopes, moderately eroded	146	(1)			
alida sandy loam, 20 to 30 percent slopes, moderately eroded	139	(1)			

[1] Less than 0.05 percent.

The procedure in this section is first to describe the soil series and then the mapping units in that series. Thus to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. Unless otherwise stated, the description of all mapping units in this section is for a moist soil. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land and Marsh are miscellaneous land types and do not belong to a soil series; nevertheless, they are listed in alphabetic order along with the series.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol 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 mapping unit has been placed. The pages on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Soil scientists, engineers, students, and others interested in how the soils of the county were formed should turn to the section "Formation and Classification of Soils." Many terms used in this soil survey are defined in the Glossary and in the "Soil Survey Manual" (*13*).[2]

Afton Series

The Afton series consists of dark-colored, nearly level, poorly drained soils in drainageways in the uplands in the western and central parts of the county. These soils developed in loess and local alluvium under native swamp grasses, sedges, and prairie grasses that tolerate wetness.

In a typical profile, the surface layer is black, friable silty clay loam about 26 inches thick. It has subangular blocky and granular structure. The subsoil extends to a depth of 51 inches. It is very dark-gray to olive-gray and olive-brown, friable silty clay loam that has subangular blocky structure. The substratum is gray to olive-gray, friable to firm, massive clay loam and is calcareous.

The Afton soils have high available moisture capacity. They are moderately slowly permeable. These soils generally are medium in available nitrogen, low in available phosphorus, and medium to high in available potassium. The surface layer generally is about neutral in reaction, but in a few areas it is mildly alkaline.

[2] Italic numbers in parentheses refer to Literature Cited, page 100.

Representative profile of an Afton silty clay loam, 1,158 feet south and 290 feet east of the northwest corner of section 5, T. 95 N., R. 37 W., on a southeast-facing slope of about 1 percent, in a cultivated field:

A11—0 to 10 inches, black (N 2/0) silty clay loam; moderate, fine, granular and moderate, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A12—10 to 18 inches, black (N 2/0) silty clay loam; moderate, fine, granular structure with some very weak vertical cleavage; friable; neutral; gradual, smooth boundary.

A3—18 to 26 inches, mainly black (10YR 2/1) but some olive-gray (5Y 4/2) silty clay loam; very weak, medium, subangular blocky structure that breaks to moderate, fine and medium, granular structure with some tendency to break vertically; friable; neutral; clear, smooth boundary.

B21g—26 to 32 inches, very dark gray (5Y 3/1) to dark-gray (5Y 4/1) and olive-gray (5Y 4/2 to 5/2) silty clay loam; some material in old root channels and some worm casts are black (10YR 2/1 and N 2/0); weak, medium, subangular blocky structure that breaks to weak to moderate, fine and medium, granular; friable; mildly alkaline; noncalcareous; clear, smooth boundary.

B22g—32 to 42 inches, olive-gray (5Y 5/2) light silty clay loam; many, fine, faint mottles of grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4) and few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, fine and medium, subangular blocky structure; friable; few, fine, black concretions of oxide; mildly alkaline; noncalcareous; gradual, smooth boundary.

B3g—42 to 51 inches, about equal amounts of gray (5Y 5/1) and olive-brown (2.5Y 4/4) light silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6) and a few of yellowish brown (10YR 5/8); very weak, fine and medium, subangular blocky structure; friable; mildly alkaline; noncalcareous; clear, smooth boundary.

IICg—51 to 65 inches, gray (5Y 5/1 to olive-gray (5Y 5/2) clay loam; olive and yellowish-brown mottles; massive; friable to firm; common, soft concretions of carbonate and few, dark, soft concretions of oxide; moderately alkaline; calcareous.

The black A horizon typically is 20 to 26 inches thick, but in places it is as much as 30 inches. The B horizon generally is very dark gray (5Y 3/1 or N 3/0) to dark gray (5Y 4/1) in the upper part and grades to olive gray (5Y 5/2) or gray (5Y 5/1) in the lower part. In this horizon grayish-brown or olive-brown mottles are common. The texture generally ranges from silty clay loam in the upper part to silt loam in the lower part, but in areas where the surrounding soils developed in gritty material, the lower part ranges from loam to clay loam. The solum ranges from about 36 to 51 inches in thickness. Glacial till generally is at a depth between 50 and 60 inches and is calcareous. Depth to carbonates generally is 40 inches or more.

The Afton soils have a thicker surface layer than the Marcus soils and generally are deeper to calcareous material. Afton soils are gray in color at a shallower depth than the Colo soils and have more clay in their surface layer.

Afton silty clay loam (0 to 2 percent slopes) (Af).—This is a nearly level, poorly drained soil in drainageways. It generally occurs with Sac, Primghar, and Marcus soils, but in some areas it occurs with Nicollet and Tripoli soils. Downstream from this soil are the Colo soils or the Colo-Terril complex of soils.

Included with this soil in mapping were areas similar to the Colo soils and areas near the edge of the drainageways that have a surface layer slightly less than 20 inches thick. In some places the depth to glacial till is less than 50 inches. The surface layer in most areas is about neutral, but in some areas this soil is alkaline throughout the profile.

This soil generally is in cultivated crops, but some areas are in pasture. Where it is at the head of drainageways, this soil is generally cropped in the same way as the adjacent soils. Downstream, where the drainageways carry more water, part of the acreage generally is used as a grassed waterway. Artificial drainage is needed, and tile drains function well. Where this soil has not been tile drained, crossing it with farm machinery is difficult in wet periods or in spring. The growth of crops is moderate to good where drainage is improved. Grassed waterways are needed in some areas to prevent the formation of gullies. (Capability unit IIw–2)

Alluvial Land

Alluvial land is a miscellaneous land type that consists of alluvium recently deposited on flood plains along the larger streams in the county. This land is nearly level but generally is cut by many stream channels. The vegetation consists mainly of grass, brush, and young trees.

Alluvial land varies widely in texture. In most places it is stratified and is silty, loamy, or sandy. Silty clay also is a common texture. In many places the surface layer is sandy and light colored. Even where the texture is fairly uniform, the areas are too small and the pattern too complex for individual soils to be mapped.

The available moisture capacity varies, but in many places it is low. Permeability and drainage also vary. This land is flooded frequently. In many places it is kept wet by flooding or by water standing in low places after flooding.

Alluvial land, channeled (0 to 2 percent slopes) (Au).—This land occurs mainly on the flood plain of the Little Sioux and the Ocheyedan Rivers. Most areas are cut by many old stream channels that are generally filled with water during floods.

Some areas of this land have been cleared and are in permanent pasture; other areas are grown up in brushy willow and other scrub trees. This land can be used for permanent pasture or as woodland. (Capability unit Vw–1)

Biscay Series

The Biscay series consists of dark-colored, poorly drained, nearly level soils that overlie sand and gravel. These soils are on outwash areas and stream benches, mainly in the northwestern and east-central parts of the county. The native vegetation consisted of swamp grasses, sedges, and prairie grasses that tolerate wetness.

In a typical profile, the surface layer is black, friable to firm silty clay loam that feels gritty and is about 18 inches thick. It has granular and subangular blocky structure. The subsoil is dark-gray, friable clay loam that has olive-brown and yellowish-brown mottles and subangular blocky structure. Beginning at a depth of about 40 inches is grayish-brown and olive-brown, calcareous, loose sand and some gravel.

The Biscay soils have high available moisture capacity. Permeability is moderately slow in the upper part and rapid or very rapid in the underlying sand and gravel. The surface layer is generally neutral in reaction. These soils are generally low or medium in available nitrogen, low in potassium, and low or very low in available phosphorus.

Representative profile of a Biscay silty clay loam, 680 feet east and 93 feet north of the southwest corner of section 2, T. 96 N., R. 38 W., on a nearly level slope, in a cultivated field:

Ap—0 to 7 inches, black (N 2/0) silty clay loam; cloddy but breaks to weak, fine, granular structure; friable to firm; abundant roots; neutral; gradual, smooth boundary.

A12—7 to 11 inches, black (N 2/0) silty clay loam; cloddy but breaks to weak, fine and medium, subangular blocky structure; friable to firm; abundant roots; neutral; clear, smooth boundary.

A13—11 to 18 inches, black (N 2/0) clay loam; weak, very fine and fine, subangular blocky structure; friable; abundant roots; neutral; gradual, smooth boundary.

B1g—18 to 23 inches, very dark gray (N 3/0) clay loam; weak, very fine and fine, subangular blocky structure; friable; abundant roots; neutral; gradual, smooth boundary.

B21g—23 to 29 inches, mixed very dark gray (5Y 3/1) and dark-gray (5Y 4/1) clay loam; very weak, fine and medium, subangular blocky structure; friable; few roots; common, very fine, tubular pores; neutral; gradual, smooth boundary.

B22g—29 to 34 inches, dark-gray (5Y 4/1) clay loam; common, fine, distinct mottles of olive brown (2.5Y 4/4); when kneaded, the color is olive gray (5Y 5/2) or olive (5Y 5/3); very weak, fine, subangular blocky structure; friable; few roots; common, very fine, tubular pores; neutral; gradual, smooth boundary.

B3g—34 to 40 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) heavy loam; common, fine, distinct mottles of yellowish brown (10YR 5/6) and few, fine, distinct mottles of yellowish brown (10YR 5/8); very weak, fine, subangular blocky structure to massive (structureless); friable; few roots; common, very fine, tubular pores; moderately alkaline; calcareous; gradual, smooth boundary.

IIC—40 to 48 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) sand and some gravel; single grain (structureless); loose; mildly alkaline; calcareous.

The A horizon ranges from 12 to 18 inches in thickness and from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1) in color. The texture is silty clay loam or clay loam. The B horizon ranges from very dark gray (10YR 3/1) in the upper part to olive gray (5Y 5/2) in the lower part. Typically, the texture of the B horizon is clay loam, but it ranges from clay loam to loam. A Cg horizon occurs in some places and is loam or light clay loam in texture. The underlying material is sand or mixed sand and gravel and generally occurs at a depth of 36 to 42 inches. This material is generally calcareous. Except in the lower part of the solum, reaction is generally about neutral.

The Biscay soils have a surface layer that is thicker and darker colored than that of Cylinder soils and a subsoil that is more gray and olive colored. Except for the sand and gravel underlying material, Biscay soils resemble the Webster soils.

Biscay silty clay loam, deep (0 to 2 percent slopes) (Bs).—This is a nearly level soil on outwash areas and stream benches. It occurs with the somewhat poorly drained Cylinder and the well-drained Wadena soils. Included with this soil in mapping were a few areas where sand and gravel is at a depth of only 24 to 36 inches, and some areas where sand and gravel is as much as 50 inches deep or more.

Most of the acreage of this soil is in cultivated crops, but some is in pasture. Where drainage is improved, this soil can be used for row crops much of the time. Tile drains function well, but in some places caving makes installation difficult. (Capability unit IIw-3)

Calco Series

The Calco series consists of dark-colored, poorly drained, calcareous soils on bottom lands. These soils developed in moderately fine textured alluvium under native swamp grasses, sedges, and prairie grasses that tolerate wetness. They are nearly level and occur mainly in the northwestern part of the county.

In a typical profile, the surface layer is black silty clay loam about 29 inches thick. It has granular and subangular blocky structure. The subsoil is weakly developed and extends to a depth of about 45 inches. It is black to very dark gray, friable silty clay loam and clay loam that feels gritty. It has subangular blocky structure. The substratum is black or very dark gray clay loam. The profile of these soils is calcareous throughout.

The Calco soils have high available moisture capacity. They are moderately slowly permeable. The supply of available nitrogen is generally low or medium, the supply of available phosphorus is very low, and the supply of potassium is low or very low. Reaction is mildly alkaline or moderately alkaline throughout the profile.

Representative profile of a Calco silty clay loam, 135 feet east and 171 feet north of the southwest corner of the SE¼SE¼ of section 31, T. 97 N., R. 37 W., on a nearly level slope, in a pasture:

A1—0 to 10 inches, black (N 2/0) light silty clay loam; somewhat compact and cloddy but breaks to weak or moderate, fine, granular structure; firm; moderately alkaline; calcareous; gradual, smooth boundary.

A12—10 to 20 inches, black (N 2/0) light silty clay loam; weak, medium, subangular blocky structure that breaks to moderate, fine, granular; friable; moderately alkaline; calcareous; gradual, smooth boundary.

A13—20 to 29 inches, black (10YR 2/1) silty clay loam; weak, fine and medium, subangular blocky structure that breaks to weak, fine, granular; friable; mildly alkaline; calcareous; gradual, smooth boundary.

B2g—29 to 36 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silty clay loam; weak, fine and medium, subangular blocky structure; friable; mildly alkaline; calcareous; gradual, smooth boundary.

B3g—36 to 45 inches, black (10YR 2/1) to very dark gray (10YR 3/1) clay loam; weak, fine and medium, subangular blocky structure to massive (structureless); friable; mildly alkaline; calcareous; gradual, smooth boundary.

C—45 to 55 inches, black (10YR 2/1) clay loam; massive; friable; sticky when wet; mildly alkaline; calcareous.

The A horizon generally ranges from 24 to 36 inches in thickness and from black (N 2/0) to very dark gray (10YR 3/1) in color. In texture, this horizon generally is silty clay loam, but in places it has enough sand to feel gritty and grades to clay loam in the lower part. The weakly developed, gleyed B horizon ranges from black to very dark gray or gray in color. In places a few grayish-brown, yellowish-brown, or strong-brown mottles occur, but the mottles generally are masked by darker colors. The B horizon ranges from silty clay loam to clay loam in texture. The solum generally is between 36 and 48 inches thick. The C horizon generally is mottled, calcareous clay loam. In some areas sandy material occurs below a depth of 50 inches. Calco soils are mildly alkaline to moderately alkaline throughout the solum.

The Calco soils are similar to Colo soils but are calcareous throughout their profile.

Calco silty clay loam (0 to 2 percent slopes) (Ca).—This nearly level soil is mostly on narrow bottom lands adjacent to streams in the northwestern and north-central parts of the county. Included with this soil in mapping re a few areas that have old oxbows and channels that n be crossed in most places by machinery. These included as become ponded after floods, and they remain wet ger than the adjacent soils.

This soil is used for cultivated crops and pasture. Its use determined largely by wetness and the frequency of ods. Some areas are cropped without artificial drainage, t in most areas crops benefit from tile drains. Tile drains nction well where outlets are adequate. Where drainage improved and floods are not too frequent, this soil can be ed for row crops much of the time. (Capability unit w–1)

anisteo Series

The Canisteo series consists of nearly level, poorly ained, dark-colored soils. These soils developed under tive swamp grasses and sedges in glacial till or waterrked sediments. They are mainly on the undulating till ain in the eastern part of the county, but they also occur outwash areas and in uplands in the north-central and rthwestern parts.

In a typical profile, the surface layer is black, firm to iable silty clay loam that feels gritty and is about 19 ches thick. It has granular and subangular blocky strucre. The subsoil extends to a depth of about 39 inches. It is ay, friable silty clay loam that feels gritty. It has comon yellowish-brown to strong-brown mottles and subgular blocky structure. The substratum is gray, friable, assive loam and has strong-brown and olive-brown motes. These soils are calcareous throughout their profile.

The Canisteo soils have high available moisture capacy. The supply of available nitrogen generally is medium low, that of available phosphorus is low or very low, nd that of available potassium is low. These soils are modately alkaline or mildly alkaline throughout.

Representative profile of a Canisteo silty clay loam, 433 et south and 165 feet east of the northwest corner of e NE¼ of section 13, T. 97 N., R. 35 W., on a nearly vel slope, in a cultivated field:

Ap—0 to 8 inches, black (N 2/0) silty clay loam; cloddy but breaks to weak, fine, granular structure; friable to firm; a small olive-gray (5Y 5/2) krotovina at a depth of 7 inches; moderately alkaline; calcareous; abrupt, smooth boundary.

A12—8 to 15 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure that breaks to moderate, fine, granular; friable; moderately alkaline; calcareous; gradual, smooth boundary.

A3—15 to 19 inches, about 80 percent black (N 2/0) and about 20 percent dark-gray (5Y 4/1) silty clay loam; weak, fine, subangular blocky structure that breaks to moderate, fine, granular; friable; moderately alkaline; calcareous; clear, smooth boundary.

B1g—19 to 26 inches, about equal parts of very dark gray (5Y 3/1) and olive-gray (5Y 5/2) silty clay loam with a few streaks of black (N 2/0); few, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, very fine, subangular blocky structure; friable; moderately alkaline; calcareous; gradual, smooth boundary.

B21g—26 to 32 inches, mainly gray (5Y 6/1) but some very dark gray (5Y 3/1) silty clay loam; few, fine, distinct mottles of brownish yellow (10YR 6/6); moderate, very fine and fine, subangular blocky structure; friable; some soft white concretions of carbonate; moderately alkaline; calcareous; gradual, smooth boundary.

B22g—32 to 39 inches, gray (5Y 6/1) light silty clay loam; common, fine, prominent mottles of strong brown (7.5 YR 5/6); weak, very fine and fine, subangular blocky structure; friable; few, fine, black concretions of oxide and common, soft concretions of carbonate; moderately alkaline; calcareous; gradual, smooth boundary.

Cg—39 to 48 inches, gray (5Y 6/1) loam; common, fine, prominent mottles of strong brown (7.5YR 5/6) and few, fine, distinct mottles of olive brown (2.5Y 4/4); massive; friable; moderately alkaline; calcareous.

The A horizon is about 14 to 22 inches thick. Typically, it is silty clay loam in texture, but it grades to clay loam. The color is generally black (N 2/0) but grades to very dark gray (10YR 3/1) in the A1 horizon, and in the A3 horizon wherever that horizon occurs. The B horizon typically is very dark gray to olive gray, but in places it is olive. Mottles that have a wide range in color are common in this horizon. In texture, the B horizon ranges from silty clay loam to clay loam. The C horizon has variable texture but is typically loam. In many places this horizon contains thin lenses of silt, sandy loam, or loamy sand. In most places unaltered, friable to firm, calcareous glacial till is at a depth of 40 to 60 inches; but in a few places the till is deeper.

The Canisteo soils are calcareous throughout the profile, whereas Tripoli and Webster soils are not. Canisteo soils lack the coarse-textured substratum that is characteristic of the Biscay and Talcot soils. The Canisteo soils are finer textured in the surface layer than the Harps soils and are not so gray, especially when dry. Also, they are not so rich in calcium carbonate as Harps soils.

Canisteo silty clay loam (0 to 2 percent slopes) (Ce).—This nearly level soil generally is in areas bordering depressions that are occupied by Glencoe soils. It frequently occurs with the Webster, the somewhat poorly drained Nicollet, and the well-drained Clarion soils. In some places it occurs with the Fostoria, Ocheyedan, Guckeen, and Marna soils. The profile of this soil is the one described as typical for the Canisteo series.

This is one of the most extensive soils on the undulating till plain in the eastern part of the county. It also occurs in areas of glacial outwash in the north-central and northwestern parts. Included with this soil in mapping were small areas of Harps soils.

Most areas of this soil are cultivated, and row crops can be grown much of the time. This soil is wet unless it is tile drained. Tile drains function well. Crops grow well if the soil is tile drained and management is good. (Capability unit IIw–2)

Canisteo silty clay loam, gypsic variant (0 to 2 percent slopes) (Cg).—This nearly level soil is in the north-central part of the county northeast of Spencer. The total acreage is small. The surface layer typically ranges from 18 to 26 inches in thickness. The subsoil generally is clay loam in texture. Gypsum crystals occur mainly in the surface layer, but in places they are in the subsoil. This soil occurs with the Marna, Ocheyedan, Fostoria, and Webster soils. Although this soil occurs in fairly large areas, it generally is cropped in the same way as the adjacent soils.

All of the acreage of this soil is cultivated. If drainage is improved, this soil can be used for row crops much of the time. Tile drains function well. If drainage is adequate, fertility is maintained, and high-level management is used, crops grow well on this soil. (Capability unit IIw–2)

Clarion Series

The Clarion series consists of dark colored to moderately dark colored, well-drained soils in the uplands. These soils are gently undulating to steep, and slopes are

Marcus silty clay loam (0 to 2 percent slopes) (Ma).—This soil is extensive and, in places, the areas extend for several miles and include several hundred acres. Many fields are mostly of this soil. This nearly level soil occurs with the somewhat poorly drained Primghar, the poorly drained Afton, and, in some places, the Galva and Sac soils.

Included with this soil in mapping was an area in the SW¼ of section 19 in Lone Tree Township that is calcareous at the surface and that has some crystal-like particles on the surface. Also included were a few other small areas that are calcareous at the surface and a few where the depth to glacial till is slightly less than 40 inches. In some mapped areas, the profile contains more coarse material than the soil described as typical for the series but not enough to change the textural name.

Nearly all the acreage of this soil is used for row crops, for which it is well suited. Wetness is a hazard to use, but this hazard can be overcome by installing tile drains. If drainage is improved, fertility is maintained, and management is good, crops grow well. (Capability unit IIw-2)

Marna Series

The Marna series consists of nearly level, dark-colored, poorly drained soils mainly in the eastern part of the county. These soils developed in clayey lacustrine sediments in the uplands and outwash areas. The native vegetation consisted of swamp grasses, sedges, and prairie grasses that tolerate wetness.

In a typical profile, the surface layer is black, firm, light silty clay about 17 inches thick. It has granular and subangular blocky structure. The subsoil extends to a depth of about 45 inches. It is mainly olive-gray, firm silty clay that has angular blocky and subangular blocky structure. Some very dark gray occurs in the upper part. The substratum is olive-gray, friable to firm silty clay but becomes coarser textured with depth.

The Marna soils have medium to high available moisture capacity. They are slowly permeable. The supply of available nitrogen generally is low or medium, that of available phophorus is low, and that of available potassium is medium. In the calcareous variant, however, the supply of potassium is low. The surface layer generally is about neutral in reaction, but where this soil is calcareous the reaction is mildly alkaline or moderately alkaline throughout the profile.

Representative profile of a Marna silty clay, 158 feet east and 510 feet north of the southwest corner of the NW¼ of section 12, T. 96 N., R. 36 W., on a nearly level slope, in a cultivated field:

Ap—0 to 5 inches, black (N 2/0) light silty clay; cloddy but breaks to weak, fine, granular and subangular blocky structure; firm, neutral; gradual, smooth boundary.

A12—5 to 13 inches, black (N 2/0) light silty clay; moderate fine, granular and very fine subangular blocky structure; firm; neutral; gradual, smooth boundary.

A3—13 to 17 inches, very dark gray (5Y 3/1) light silty clay; very dark gray (10YR 3/1) when kneaded; few, fine, faint stains of very dark gray (10YR 3/1) on ped faces and few, fine, distinct mottles of olive brown (2.5Y 4/4) on ped interiors; moderate to strong, fine and very fine, subangular blocky structure that tends toward angular blocky; firm; few, discontinuous, glossy faces on peds; neutral; gradual, smooth boundary.

B21g—17 to 27 inches, mixed very dark gray (5Y 3/1) and olive-gray (5Y 4/2) silty clay; few, fine, distinct mottles of olive brown (2.5Y 4/4); moderate to very fine, subangular blocky and angular block ture; firm; common, small, dark, hard concre oxide; common, thin, glossy faces on peds; gradual, smooth boundary.

B22g—27 to 36 inches, olive-gray (5Y 4/2) silty cla mon, fine, faint mottles of dark gray (5Y 4 olive (5Y 4/3); moderate to strong, very fine, blocky and subangular blocky structure; fir mon, thin, glossy faces on peds; few, fine, pores; neutral; gradual, smooth boundary.

B3g—36 to 45 inches, olive-gray (5Y 5/2) silty clay; medium, distinct mottles of olive brown (2.5Y 4 a few streaks of very dark gray (10YR 3/1 erate to strong, very fine, angular blocky st firm; few, thin, glossy faces on peds; few, fin lar pores; neutral; gradual, smooth boundar

Cg—45 to 50 inches, olive-gray (5Y 5/2) silty cla medium, distinct mottles of olive brown (2.5 weak, fine, subangular blocky structure; fr firm; common fine pores; neutral.

The clay content of material below 50 inches is bel decrease with depth to light silty clay loam. The glos on peds could be clay films or pressure faces.

The A horizon ranges from about 12 to 20 inches in t and from heavy silty clay loam to light silty clay in text texture of the B horizon is silty clay or clay. The colo B horizon commonly is very dark gray (5Y 4/1), g 5/1), or olive gray (5Y 4/2 or 5/2) with mottles of oliv and olive. The thickness of the solum generally rang about 36 to 48 inches. In places the texture grades to si loam at a depth of 40 to 55 inches, but in other places t lying lacustrine deposits are thicker. The underlying is calcareous in places.

The Marna soils have more clay and less sand thr their profile than the Webster soils and have somewhat structure.

Marna silty clay (0 to 2 percent slopes) (Mc). nearly level, poorly drained soil is in the uplands outwash areas. It is moderately extensive. This soil mainly with the Guckeen soils in the uplands, but occurs in places with the Webster, Nicollet, and C soils. In outwash areas this soil generally occur the Ocheyedan, Fostoria, and Guckeen soils bu few places with Webster and Canisteo soils.

Most areas of this soil are cultivated. The fine-te subsoil restricts the movement of air and water sequently, this soil remains cold and wet late in Tile drains do not function well in this soil, an need to be spaced closer than those in coarser te soils. Row crops can be grown much of the time, wet years, even where this soil is tile drained, the of crops is poor to moderate. In some years it is spring before this soil can be tilled satisfactorily is plowed wet, this soil tends to be cloddy and hard it dries. A good seedbed generally is easier to p if this soil is plowed in fall. (Capability unit IIw

Marna silty clay loam, calcareous variant (0 to cent slopes) (Me).—This nearly level soil is not ext It occurs in only a small area a short distance ea north of Spencer. This soil occurs mainly with the steo, Ocheyedan, Fostoria, Guckeen, and other Marn Unlike a typical Marna soil, it is alkaline and calc throughout the profile.

This soil is poorly drained and tends to be wet an late in spring. Tile drains do not function well, an need to be spaced closer than those in coarser te soils.

Most areas of this soil are cultivated, and row can be grown much of the time. Even where this tile drained, the growth of crops in wet years is p moderate. If it is plowed wet, this soil tends to be cloddy and hard when it dries. A good seedbed generally is easier to prepare if this soil is plowed in fall. (Capability unit IIw–5)

Marsh

Marsh consists of areas that are covered by water most of the time. This land is not used for farming. Because these areas are flooded most of the time, the soil material has not been examined in great detail. This material has variable texture. The native vegetation consisted of cattails and other plants that tolerate wetness.

Marsh (Mh) consists of areas that are covered by water most of the time. In Clay County these areas are in depressions that, for lack of outlets, have not been drained. Their vegetation consists of cattails and other swamp plants. Marsh has no value for farming, but it is an important habitat for waterfowl, muskrats, and other wetland wildlife.

Almost all areas of Marsh are in the eastern part of the county. In the northeastern part, several areas that are made up largely of Marsh have been designated as game refuges and public shooting grounds. These areas include the Dan Green and Barringer Sloughs and Dewey's Pasture. (Capability unit VIIw–1)

Muck

Muck consists of black, very poorly drained, organic soils. These soils generally are in old dry lakebeds or in drained depressions. The areas range from large to small and generally are surrounded by Harps soils. Undrained areas of these soils are ponded, and the native vegetation consisted of swamp grass and sedges.

In a typical profile, the upper part consists of black, friable muck about 28 inches thick. Underlying the muck is black, very dark gray, or olive-brown, friable to firm mucky silt loam and light silty clay loam.

Muck soils are moderately permeable. They are generally high in available nitrogen, low in available phosphorus, and very low in available potassium. In places trace elements are deficient for some crops. These soils range from neutral to moderately alkaline in reaction.

Representative profile of a Muck soil (drained pond), 310 feet west and 200 feet south of the northeast corner of the SW$\frac{1}{4}$SE$\frac{1}{4}$ of section 11, T. 97 N., R. 35 W., on a convex slope, in a cultivated field:

1—0 to 8 inches, black (10YR 2/1) muck, very dark brown (10YR 2/2) when kneaded; massive, but has slight tendency to break horizontally; very friable; neutral; gradual, smooth boundary.

2—8 to 15 inches, black (10YR 2/1) muck, very dark brown (10YR 2/2) when kneaded; very weak, medium and coarse, subangular blocky structure, but has slight tendency to break horizontally; friable; neutral; gradual, smooth boundary.

3—15 to 28 inches, black (10YR 2/1) muck; weak, fine and medium, subangular blocky structure; friable; few fine root channels lined with strong-brown organic material; few very fine fragments of snail shells; neutral; gradual, smooth boundary.

4—28 to 32 inches, black (10YR 2/1 to N 2/0) mucky silt loam; weak to moderate, fine, subangular blocky structure; friable to firm; few root channels lined with strong-brown organic material; neutral; gradual, smooth boundary.

5—32 to 36 inches, very dark gray (10YR 3/1 or N 3/0) light silty clay loam; weak, fine, subangular blocky structure; friable to firm; common root channels lined with strong-brown organic material; neutral; gradual, smooth boundary.

6—36 to 43 inches, very dark gray (10YR 3/1 or N 3/0) light silty clay loam; few, fine, faint mottles of dark olive gray (5Y 3/2); massive (structureless); friable to firm; common root channels lined with strong-brown organic material; mildly alkaline; calcareous; clear, smooth boundary.

7—43 to 50 inches, olive-brown (2.5Y 5/4) heavy silt loam; massive (structureless); friable to firm; moderately alkaline; calcareous.

Muck generally ranges from 10 to 40 inches in thickness, but in a few places it is as much as 60 inches. It ranges from black to very dark brown in color. Where Muck is moderately shallow, a few plant fibers occur in some places below the plow layer. The underlying mineral material ranges from black to olive gray in color. This material typically is silty clay loam or silt loam, but it contains lenses of sandy material in places. In a few places this underlying material contains more sand.

Muck, moderately shallow (0 to 1 percent slopes) (Mm).—This organic soil is in depressions that formerly contained water. It is not extensive. It is surrounded in most places by narrow areas of the highly calcareous Harps soils. The organic layer generally is 20 to 40 inches thick, but in a few areas it is as much as 60 inches. In some areas this soil is mildly alkaline or moderately alkaline; in other areas it is about neutral. Some areas are calcareous throughout the profile.

This soil typically is very poorly drained. Tile drains with open intakes and ditches are used to improve drainage. Some areas are ponded in spring or after heavy rains, even where drainage is improved.

Drained areas of this soil are used for crops, and row crops can be grown much of the time. Small grains tend to lodge badly and to produce grain of poor quality. If this soil is partially drained, it is suited to permanent pasture consisting of bluegrass and reed canarygrass. Undrained areas generally are suited only to wildlife habitat. Crops grow fairly well where this soil is adequately drained, fertilized, and managed well. Growth is better in years of limited rainfall than it is in years when rainfall is above average. Trace elements need to be added for some crops. In some years crops on this soil are damaged by early frost. (Capability unit IIIw–2)

Muck, moderately shallow, calcareous (0 to 1 percent slopes) (Mr).—This soil occurs only in a large old lakebed in sections 25 and 26 of Garfield Township. The organic layer is black to very dark gray in the upper part and very dark gray in the lower part. This layer is about 20 to 40 inches thick and is highly calcareous. In most places it contains fragments of snail shells. Included with this soil in mapping was a narrow area around the edge of the lakebed in which the organic layer is less than 20 inches thick and overlies sand that contains layers of finer textured material. Below the organic layer of this soil is mucky silt loam or silty clay loam that, in places, contains lenses of sand. In one area of about 26 acres in section 26, the organic material overlies sand that extends to a depth of 50 inches or more. Sand probably underlies the whole lakebed at variable depths.

Most areas of this soil are cultivated. Some areas are owned by the Iowa State Conservation Commission, and these have been planted in trees and shrubs for use as wildlife habitat. Because this soil is wet and the supply of plant nutrients is low, the growth of plants is poor to moderate. The supply of available phosphorus and potassium is especially low. Row crops can be grown much of the time, but crops on this soil are likely to be damaged by early frost. (Capability unit IIIw-2)

Muck, shallow (0 to 1 percent slopes) (Ms).—This soil mainly is in large depressions in the eastern part of the county. These depressions originally contained water but have been drained. This soil is surrounded in most places by the highly calcareous Harps soils, which formed on the rim of the depressions. The organic layer ranges from 10 to 20 inches in thickness, but the thickness varies over short distances. In some areas this soil is calcareous throughout the profile, but in other areas it is about neutral.

This soil is very poorly drained. Without artificial drainage it is ponded, and some areas are ponded, even with artificial drainage. Ponding generally results from outlets for tile drains being too small or being submerged after heavy rains. Most of the larger areas are drained by open ditches, but tile drains with open intakes are also used. If drainage is improved, this soil can be used for row crops much of the time. Growth of crops is moderate to good. Drained areas are used mainly for corn and soybeans. Small grains generally lodge badly, and quality of the grain is poor. If partially drained, bluegrass and reed canarygrass can be grown for permanent pasture, but undrained areas generally are suitable only as wildlife habitat. Where enough fertilizer is added, crops on this soil generally grow better in years when rainfall is less than normal. In places trace elements are needed. Damage to crops by early frost is a hazard. (Capability unit IIIw-2)

Nicollet Series

The Nicollet series consists of deep, somewhat poorly drained, dark-colored soils in the uplands in the northwestern and eastern parts of the county. These soils developed under native prairie grasses in glacial till or partly in glacial till and partly in the gritty material overlying the till. They have either convex or concave slopes that range from 1 to 3 percent. In some places these slopes are short, but in other places they are long.

In a typical profile, the surface layer (A horizon) is black, friable heavy loam about 14 inches thick. It has granular structure. The subsoil extends to a depth of about 31 inches. It is dark grayish-brown, friable light clay loam that has subangular blocky structure. The substratum is grayish-brown, friable, massive loam that has yellowish-brown mottles and a few pebbles.

The Nicollet soils have high available moisture capacity. They are moderately permeable. They are among the best soils for farming in the county. The supply of available nitrogen generally is low or medium, that of available phosphorus is low or very low, and that of available potassium is low or medium. The surface layer is slightly acid or neutral in reaction.

Representative profile of a Nicollet loam, 540 feet east and 210 feet north of the southwest corner of the NE¼ of section 26, T. 94 N., R. 36 W., on a convex slope of 1 or 2 percent, in a cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) heavy loam; cloddy but breaks to weak, fine and medium, granular structure; friable; slightly acid; gradual, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) heavy loam; weak, fine and medium, granular structure; friable; neutral; gradual, smooth boundary.

B1—14 to 22 inches, mixed black (10YR 2/1) and dark grayish-brown (2.5YR 4/2) light clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B2—22 to 31 inches, dark grayish-brown (2.5Y 4/2) light clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C1—31 to 42 inches, grayish-brown (2.5Y 5/2) and some light olive-brown (2.5Y 5/4) heavy loam; many, fine and medium, distinct mottles of yellowish brown (10YR 5/6 and 5/8); massive (structureless); friable; common, fine, soft, gray (10YR 6/1) and light-gray (10YR 7/1) concretions of lime; few pebbles; moderately alkaline; calcareous; gradual, smooth boundary.

C2—42 to 48 inches, grayish-brown (2.5Y 5/2) heavy loam; many, fine, distinct mottles of yellowish brown (10YR 5/6 and 5/8); massive (structureless); friable; common, fine, soft, gray (10YR 6/1) and light-gray (10YR 7/1) concretions of lime; few pebbles; moderately alkaline; calcareous.

The A horizon ranges from 10 to 16 inches in thickness and from heavy loam or silt loam to clay loam in texture. In color this horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The B horizon ranges from heavy loam to clay loam in texture. The upper part of the B horizon is very dark grayish brown (2.5Y 3/2) to dark grayish brown (2.5Y 4/2) in color and generally grades to grayish brown (2.5Y 5/2), olive brown (2.5Y 4/4), or light olive brown (2.5Y 5/4). The depth to calcium carbonate ranges from 24 to 45 inches. In some places the thickness of solum and depth to carbonates are the same, but in other places the solum extends into the calcareous material. In some places pockets or thin lenses of sandy material occur in the profile.

Nicollet soils have more sand and less silt in the profile than Primghar soils, but the Primghar soils have more clay in the surface layer. The Nicollet soils have some gravel or pebbles in the profile, whereas the Fostoria soils are largely free of gravel. Also the Nicollet soils have more uniform materials in the substratum and less evidence of sorting of materials than the Fostoria soils. Unlike the Cylinder soils, Nicollet soils are not underlain by sand and gravel.

Nicollet clay loam (1 to 3 percent slopes) (Nc).—This soil is extensive. It has nearly level slopes that are smooth, long, and slightly convex. Areas generally are large and are as much as several hundred acres in places. In most places this soil is adjacent to the well-drained Everly or the poorly drained Tripoli or Afton soils. The surface layer and subsoil generally are clay loam in texture. The subsoil developed partly in calcareous glacial till and partly in gritty material overlying the till. The till generally occurs at a depth of 20 to 35 inches, but commonly it is at 24 to 30 inches.

Included with this soil in mapping were a few areas in section 20 of Herdland Township and in section 23 of Gillett Grove Township that are in a stand of second-growth trees. These included areas have a thinner, siltier surface layer than this soil; a gray, platy subsurface layer a few inches thick; and a subsoil that is more clayey and that is leached to a greater depth.

This is one of the better soils in the county for farming, and most of the acreage is cultivated. Row crops can be grown much of the time, and crops grow well under good management. In most areas this soil can be farmed without improved drainage, but some areas that border Tripoli soils benefit from tile drains. Except where slopes are long and nearly 3 percent, erosion is not a problem. (Capability unit I-1)

Nicollet loam (1 to 3 percent slopes) (No).—This extensive soil is in the eastern part of the county. Slopes genrally are short and convex, but some are concave. Areas enerally are about 10 acres or less but are as much as 30 cres in some places. This soil occurs mainly with the Webster and Clarion soils. Small areas that are similar to he well-drained Clarion and the poorly drained Webster oils were included with this soil in mapping. Also included were a few small areas, mostly in Lake Township, that are alcareous throughout their profile.

Most areas of this soil are used for crops. This soil can e used for row crops much of the time. Good tilth of the oil and the vigor of plants can be maintained if the soil s adequately fertilized and management is good. This soil rdinarily is not eroded, but a few of the more sloping reas are susceptible to erosion if row crops are grown nost of the time. In wet years some nearly level areas adacent to the poorly drained Webster soils are too wet for good growth of plants. Where tile drains are installed in hese areas, drainage is generally improved. (Capability unit I–1)

Ocheyedan Series

The Ocheyedan series consists of deep, dark-colored, well-drained soils that are mainly in the northwestern and north-central parts of the county but also occur in a few areas in the east-central part. These soils are in uplands and outwash areas. They developed under native prairie grasses in medium-textured glacial sediment. The slopes are convex and range from nearly level to strong.

In a typical profile, the surface layer is black, friable loam about 14 inches thick. It has granular structure. The subsoil is brown, friable loam and sandy clay loam in the upper part and dark yellowish-brown fine sandy loam and silt loam in the lower part. The silt loam part is calcareous. The substratum is gray and yellowish-brown silt loam that is calcareous.

These soils typically have high available moisture capacity. They are moderately permeable in the upper part of the profile and moderately rapidly permeable in the lower part. The supply of available nitrogen and phosphorus generally is low, and that of available potassium is medium. The surface layer generally is slightly acid or medium acid in reaction.

Representative profile of an Ocheyedan loam, 960 feet north and 710 feet east of the southwest corner of section 28, T. 97 N., R. 38 W., on a convex slope of about 1 percent, in a cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) heavy loam; weak, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) loam; few brown (10YR 4/3) worm casts; weak, fine and medium, granular structure; friable; slightly acid; gradual, smooth boundary.

B1—14 to 21 inches, brown (10YR 4/3) loam; few black (10YR 2/1) worm casts; weak, fine, subangular blocky structure; slightly acid; friable; gradual, smooth boundary.

B21—21 to 26 inches, brown (10YR 4/3) sandy clay loam; few black (10YR 2/1) worm casts; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—26 to 34 inches, dark yellowish-brown (10YR 4/4) heavy fine sandy loam; weak, medium, subangular blocky structure; friable; many fairly evident pores or old root channels about one-sixteenth of an inch in diameter; neutral; gradual, smooth boundary.

295-993—69——3

IIB3—34 to 40 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, medium, subangular blocky structure; friable; few, fine, dark concretions of oxide; moderately alkaline; calcareous in the lower part; gradual, smooth boundary.

IIC—40 to 48 inches gray (10YR 5/1) and yellowish-brown (10YR 5/4) silt loam; common, fine, faint mottles of yellowish brown (10YR 5/6 and 5/8); friable; few dark concretions of oxide; common soft concretions of carbonate; moderately alkaline; calcareous.

Gray, mottled silt loam extends to a depth of 85 inches, and glacial till is below 85 inches.

The A horizon ranges from about 5 to 15 inches in thickness, depending on slope and erosion. It ranges from dark brown (10YR 2/2) to black (10YR 2/1) in color. The texture of this horizon generally is loam, though in places it is silt loam. The B horizon typically is dark brown or brown (10YR 4/3). In texture, the B horizon is loam, sandy clay loam, or fine sandy loam, but the IIB3 and the IIC horizons range from sandy loam or sandy clay loam to silt loam. The layers of sandy clay loam and fine sandy loam in the solum seldom are thick enough to affect seriously the available moisture capacity. The solum ranges from about 30 to 45 inches in thickness. In places the calcareous substratum contains layers of loamy sand but dominantly it is coarse silt loam in texture. In most places the calcareous glacial till occurs at a depth between 50 and 100 inches, but commonly it is at a depth of about 80 to 90 inches.

The Ocheyedan soils are more stratified in their solum than the Clarion and Everly soils, and their substratum shows more sorting of materials and variation in texture. Unlike the Everly and Clarion soils, they do not have gravel or small pebbles in their profile. Ocheyedan soils overlie silt loam, whereas Waukegan soils overlie sandy loam or loamy sand, and Wadena soils overlie calcareous sand and gravel.

Ocheyedan loam, 0 to 2 percent slopes (OcA).—This nearly level soil is in the uplands in the northwestern and east-central parts of the county, but north of Spencer it is in outwash areas. It is not extensive, and most areas are less than 15 acres in size. This soil has convex slopes, and in most places it is slightly higher than the surrounding soils. It is mainly with the Waukegan, Fostoria, and other Ocheyedan soils. North of Spencer, however, it is with the Canisteo, Webster, Fostoria, or Guckeen soils. Included with this soil in mapping were a few areas that are only 40 to 50 inches deep to glacial till.

Most areas of this soil are cultivated. If fertility is maintained, row crops can be grown much of the time. Crops generally grow well. This soil is friable and easy to work. Erosion is not a hazard. (Capability unit I–2)

Ocheyedan loam, 2 to 5 percent slopes (OcB).—This gently sloping soil is in the uplands in the northwestern and east-central parts of the county and in outwash areas north of Spencer. It is not extensive. The surface layer of this soil is a few inches thinner than that in the profile described as typical for the Ocheyedan series. Included with this soil in mapping were a few areas that are only 40 to 50 inches deep to glacial till.

Most areas of this soil are cultivated. If erosion is controlled by contour farming or terracing and fertility is maintained, row crops can be grown much of the time. Crops generally grow well. The hazard of erosion is slight. (Capability unit IIe–1)

Ocheyedan loam, 5 to 12 percent slopes, moderately eroded (OcC2).—This soil is sloping to strongly sloping, and the slopes generally are short. Most areas are small. In most places the surface layer is about 5 or 6 inches thick, but it ranges from 2 to 7 inches in thickness. This layer generally is browner than that described as typical for the Ocheyedan series.

Most areas of this soil are cultivated. If erosion is controlled by contour farming and terracing and fertility is maintained, row crops can be grown much of the time. This soil is moderately susceptible to erosion. (Capability unit IIIe–1)

Okoboji Series

The Okoboji series consists of deep, dark-colored, very poorly drained soils in depressions. They developed under native swamp grasses and sedges in local alluvium washed from adjacent soils.

In a typical profile, the surface layer is black, friable to firm, heavy silt loam or silty clay loam about 29 inches thick. It has granular and subangular blocky structure. The subsoil is about 16 inches thick and is black to very dark gray silty clay loam. It has subangular blocky structure and is calcareous in the lower part. The substratum is olive-gray silty clay loam that feels gritty, is massive, and is calcareous.

The Okoboji soils have high available moisture capacity. They are slowly permeable. The supply of available nitrogen generally is medium or low, that of phosphorus is low or very low, and that of potassium is low or medium. The surface layer is neutral to mildly alkaline in reaction.

Representative profile of an Okoboji silt loam, 650 feet south and 399 feet west of the northeast corner of the SE¼ of section 34, T. 94 N., R. 35 W., in a nearly level depression in a cultivated field:

- Ap—0 to 9 inches, black (N 2/0) heavy silt loam; cloddy but breaks to weak or moderate, fine, granular structure and very fine, subangular blocky structure; friable to firm; neutral; clear, smooth boundary.
- A12—9 to 14 inches, black (N 2/0) heavy silt loam; moderate, fine, granular and very fine, subangular blocky structure; friable; common, fine and very fine, tubular pores; neutral; gradual, smooth boundary.
- A13—14 to 20 inches, black (N 2/0) silty clay loam; moderate, very fine, subangular blocky structure; friable; common, fine and very fine pores and few, medium, tubular pores; neutral; gradual, smooth boundary.
- A14—20 to 29 inches, black (N 2/0) silty clay loam; common mottles of very dark grayish brown (2.5Y 3/2) to dark olive gray (5Y 3/2); weak, medium, subangular blocky structure that breaks to weak, very fine, subangular blocky; friable; common, very fine, tubular pores; neutral; diffuse, smooth boundary.
- B21g—29 to 36 inches, black (N 2/0) to very dark gray (N 3/0) silty clay loam; common mottles of very dark grayish brown (2.5Y 3/2) to dark olive gray (5Y 3/2); weak, medium and coarse, subangular blocky structure that breaks to weak, very fine, subangular blocky; friable; few to common, very fine, tubular pores; neutral; gradual, smooth boundary.
- B22g—36 to 45 inches, black (N 2/0) to very dark gray (N 3/0) light silty clay loam, some olive gray (5Y 5/2) in the lower part; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium and coarse, subangular blocky structure; firm; sticky when wet; mildly alkaline; calcareous; gradual, smooth boundary.
- Cg—45 to 50 inches, olive-gray (5Y 5/2) silty clay loam; massive; friable; sticky when wet; few, fine, soft concretions of lime; mildly alkaline; calcareous.

The A horizon ranges from about 20 to 35 inches in thickness. The texture typically is heavy silt loam in the upper part and silty clay loam in the lower part. In color, the Bg horizon is black (N 2/0 or 10YR 2/1) to very dark gray (N 3/0 or 10YR 3/1) in the upper part and ranges to dark gray (5Y 4/1), olive gray (5Y 5/2), or olive (5Y 5/3) in the lower part. The texture of this horizon typically is silty clay loam. The solum ranges from about 42 inches to 54 inches in thickness. The Cg horizon ranges from loam to silt loam or silty clay loam in texture. I some places the Okoboji soils are calcareous throughout thei profile.

The Okoboji soils have a thicker solum than Wacousta soil: They are not so fine textured in the upper horizons as th Glencoe soils and typically are somewhat less clayey in the sul soil. Also they are somewhat more friable and permeabl throughout than those soils.

Okoboji silt loam (0 to 1 percent slopes) (Ok).—Thi very poorly drained soil is in depressions. In most place the depressions are surrounded by narrow areas of th highly calcareous Harps soils, and farther away are th Webster or Canisteo soils.

Most areas of this soil are too small to be cropped sepa rately. These small areas are used and managed in the sam way as the adjacent soils. Wetness and ponding after heav rains are the chief hazards to cultivation. Young plant die if they are covered with water for long periods, an replanting is needed. Shallow ditches and tile drains wit open intakes are needed to remove surface water. If out lets are adequate, tile drains function well. If this soil i adequately drained, it can be used for row crops much o the time. Legumes are susceptible to winterkilling. Par tially drained areas of this soil can be used for pasture and undrained areas are suitable as wildlife habitat (Capability unit IIIw–1)

Primghar Series

The Primghar series consists of deep, somewhat poorly drained, dark-colored soils in the uplands and on stream benches. These soils developed under native prairie grasses in loess 40 inches thick or more. In the uplands the loess is underlain mainly by calcareous glacial till; on benches it is underlain by sand and gravel. The Primghar soils are nearly level and occur chiefly in the southwestern part of the county, but some areas are in the northwestern and east-central parts. Nearly all the acreage of Primghar soils is in the uplands, but a small amount is on benches.

In a typical profile, the surface layer is black, friable, heavy silty clay loam about 16 inches thick. It has granular and subangular blocky structure. The subsoil extends to a depth of about 35 inches. It is dark grayish-brown silty clay loam in the upper part and olive-brown and light-olive brown silt loam in the lower part. The subsoil has subangular blocky structure. The substratum to a depth of 47 inches is mottled, grayish-brown and light olive-brown, calcareous, heavy silt loam. Below 47 inches the substratum is yellowish-brown, calcareous clay loam.

The Primghar soils have high available moisture capacity. They are moderately permeable to moderately slowly permeable. The supply of available nitrogen generally is low or medium, that of available phosphorus is low, and that of available potassium is medium or high. The surface layer normally is slightly acid to medium acid in reaction.

Representative profile of a Primghar silty clay loam, 360 feet south and 320 feet west of the northeast corner of the NW¼NE¼ of section 14, T. 95 N., R. 38 W., on a slightly convex slope of 1 percent, in a cultivated field:

- Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; moderate fine, granular structure; friable; medium acid; clear, smooth boundary.
- A12—7 to 11 inches, black (10YR 2/1) heavy silty clay loam; weak to moderate, fine, granular structure; friable; medium acid; gradual, smooth boundary.

A3—11 to 16 inches, black (10YR 2/1) heavy silty clay loam, very dark gray (10YR 3/1) when dry and very dark brown (10YR 2/2) when kneaded; few yellowish-brown mottles 2 to 3 millimeters across; moderate, fine, granular structure and fine, subangular blocky structure; friable; common, fine, tubular pores; many nearly horizontal krotovinas of yellowish-brown silty clay loam about 1 inch in diameter; medium acid; gradual, smooth boundary.

B21—16 to 21 inches, about equal amounts of dark grayish-brown (10YR 4/2 or 2.5Y 4/2) and very dark gray (10YR 3/1) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable; few, fine, spherical, dark concretions of oxide; smooth, shiny patches on surface of peds and in common, fine, tubular pores; slightly acid; clear, wavy boundary.

B22—21 to 30 inches, brown (10YR 4/3) to olive-brown (2.5Y 4/4) silty clay loam; weak, fine, subangular blocky structure; friable; dark-gray (10YR 3/1) fingers 2 to 4 millimeters across extend down into the upper part of this horizon; many, fine, tubular pores; smooth, shiny patches on surface of most peds; common, dark, hard, spherical concretions of oxide; few white concretions of carbonate less than 5 millimeters across in the lower part; neutral; clear, smooth boundary.

B3—30 to 35 inches, light olive-brown (2.5Y 5/3) heavy silt loam; few, fine, faint mottles of light olive brown (2.5Y 5/4 or 5/6); weak, fine, subangular blocky structure and some weak prismatic; friable; many, fine and very fine, tubular pores; few soft concretions of carbonate mostly less than 1 centimeter across; neutral; clear, smooth boundary.

C1—35 to 42 inches, about equal amounts of grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) heavy silt loam, grayish brown predominant on face of weak, coarse prisms; distinct horizontal and vertical parting of prisms form medium blocks; friable; hard when dry; many, fine and very fine, tubular pores; common white concretions of carbonate ½ to 1½ centimeters in diameter, irregular in shape, soft in the outer part, and hard on inside; few, fine, dark concretions of oxide; moderately alkaline; calcareous; clear, smooth boundary.

I&IIC2—42 to 47 inches, color, texture, and structure similar to horizon above except for a number of pebbles ½ inch to 2 inches in diameter and a small amount of sand; pebbles are mostly in upper part and probably represent a discontinuous stone line; lower surface of the pebbles coated with carbonate; many, fine and very fine, tubular pores; feel and consistence similar to horizon above; moderately alkaline; calcareous; clear, smooth boundary.

IIC3—47 to 60 inches, yellowish-brown (10YR 5/4) clay loam; weak, coarse, prismatic structure; some prism faces grayish brown (10YR 5/2); firm; very hard when dry; common, fine, tubular pores lined mainly with grayish-brown or brown clay films; few, vertical, tubular pores 1 to 3 millimeters in diameter; common white concretions of carbonate; few, smooth, shiny patches, probably clay films, on ped faces; moderately alkaline; calcareous.

IIC4—60 to 84 inches, yellowish-brown (10YR 5/4) clay loam; common, fine, distinct mottles of strong brown and grayish brown; white concretions of carbonate, ½ to 1 centimeter across, that decrease in amount with depth; moderately alkaline; calcareous.

The A horizon ranges from 14 to 19 inches in thickness. It is typically black (10YR 2/1) in color but ranges to very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in the A3 horizon. The texture of the A horizon typically is silty clay loam. The upper part of the B horizon is typically dark grayish brown (2.5Y 4/2) but ranges to very dark grayish brown (2.5Y 3/2) in the upper few inches. Colors in the lower part of the B horizon typically are grayish brown (2.5Y 5/2) to light olive brown (2.5Y 5/4). Mottles in the B horizon are few to common and range widely in color. The B horizon ranges from silty clay loam in the upper part to heavy silt loam or light silty clay loam in the lower part. Where Primghar soils are on benches the B3 horizon has loam texture in some places. In the uplands the depth to calcareous material generally is between 28 and 40 inches. Secondary carbonates occur in the B horizon, but the amount generally is not more than that in the C horizon. The thickness of the solum generally is about the same as the depth to carbonates, but in some places the B3 horizon extends into the calcareous material. Glacial till generally is at a depth of 40 to 60 inches. On the benches the depth to sand and gravel generally is between 40 and 52 inches.

The Primghar soils have less sand in their profile than Nicollet soils and more clay in their surface layer. They have a somewhat thinner surface layer than Marcus soils, and their subsoil is not so gray.

Primghar silty clay loam (0 to 2 percent slopes) (Pr).—This nearly level soil is extensive in the southwestern part of the county. Slopes generally are convex, and the areas in most places are large. This soil generally is adjacent to the Afton or Marcus soils, but in places it occurs with the Sac and Galva soils. Included with this soil in mapping were a few areas in section 32 of Hardland Township that have a slightly thinner surface layer than that in the profile described as typical for the Primghar series. In these and a few other areas the native vegetation consisted of grasses and some trees. Also included were a few small areas that are slightly less than 40 inches deep to glacial till.

Nearly all the acreage of this soil is used for crops. It is one of the better soils for farming in the county and can be used for row crops much of the time. Growth of crops is excellent if fertility is maintained and other management is good. This soil can be farmed without artificial drainage, but in wet years some areas would benefit from tile drains. In many places tile lines are laid through this soil to facilitate drainage of the adjacent Marcus soils. (Capability unit I–1)

Primghar silty clay loam, benches (0 to 2 percent slopes) (Ps).—This soil is on benches in the southwestern part of the county along Willow Creek. It is not extensive, and the areas are small. In most places this soil is adjacent to the Galva soils, but in some places it occurs with the Wadena, Cylinder, or Biscay soils. The depth to sand or gravel is more than 40 inches; otherwise, this soil has a profile similar to the one described as typical for the Primghar series.

Nearly all the acreage of this soil is used for crops. Crops grow well on this soil, and row crops can be grown much of the time if management is good. (Capability unit I–1)

Rolfe Series

The Rolfe series consists of dark-colored, nearly level soils in depressions. These soils are in the uplands in the eastern part of the county. They formed under native swamp grasses and sedges in water-worked glacial till or local alluvium.

In a typical profile, the surface layer is black, friable to firm silt loam that feels gritty and is about 9 inches thick. The subsurface layer is dark-gray silt loam about 5 inches thick. It has platy structure. The upper part of the subsoil is very dark gray, dark-gray, and olive-gray, firm light silty clay and clay that has a few strong-brown and yellowish-brown mottles. This part has angular blocky and subangular blocky structure. The lower part of the subsoil is dark-gray, olive-gray, and olive, friable to firm clay loam. It has subangular blocky structure. The substratum begins at a depth of 45 inches. It is olive-gray, friable to firm clay loam that is structureless (massive) and is calcareous.

The Rolfe soils have high available moisture capacity. The subsoil is slowly to very slowly permeable. The supply of available nitrogen and phosphorus generally is low, and the supply of available potassium is medium. The surface layer is medium acid or strongly acid in reaction.

Representative profile of a Rolfe silt loam, 1,056 feet south and 96 feet west of the northeast corner of the SW¼ of section 3, T. 96 N., R. 35 W., in a nearly level depression, in a cultivated field:

Ap—0 to 9 inches, black (10YR 2/1) heavy silt loam; weak clods that break to moderate, fine and medium, subangular blocky structure; friable to firm; strongly acid; abrupt, slightly wavy boundary.

A2—9 to 14 inches, dark-gray (10YR 4/1) silt loam; common, fine, faint mottles of gray (10YR 5/1) and common, fine, distinct mottles of dark yellowish brown (10YR 3/4 and 4/4); moderate to strong, medium platy and thick platy structure; friable; common to many, fine, vertical, tubular pores; strongly acid; clear, smooth boundary.

B21g—14 to 19 inches, very dark gray (10YR 3/1) light silty clay; few, fine, distinct mottles of strong brown (7.5YR 5/6) and dark yellowish brown (10YR 4/4); strong, very fine and fine, angular blocky and subangular blocky structure; firm; thin, continuous clay films on most peds; slightly acid; gradual, smooth boundary.

B22g—19 to 28 inches, very dark gray (5Y 3/1), dark-gray (5Y 4/1), olive-gray (5Y 5/2), and olive (5Y 5/3) light clay; few, fine, distinct mottles of yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/8); strong, very fine and fine, angular blocky and subangular blocky structure; firm; thin, continuous clay films on most peds; neutral; gradual, smooth boundary.

B23g—28 to 38 inches, dark-gray (5Y 4/1), olive-gray (5Y 5/2) and olive (5Y 5/3) heavy clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/6 and 5/8); moderate, fine and medium, subangular blocky structure; friable to firm; thin patchy clay films on most peds; few, fine, dark, soft concretions of oxide; neutral; gradual, smooth boundary.

B3g—38 to 45 inches, olive-gray (5Y 4/2) clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8); few very dark gray streaks in old root channels; very weak to weak, fine and medium, subangular blocky structure; friable to firm; thin, discontinuous clay films on some vertical faces of peds; neutral; clear, smooth boundary.

Cg—45 to 50 inches, olive-gray (5Y 5/2) clay loam; many, fine, distinct mottles of yellowish brown (10YR 5/6) and common, fine, distinct mottles of strong brown (7.5YR 5/8); massive; friable to firm; few, fine, soft and hard concretions of carbonate; moderately alkaline; calcareous.

The A1 horizon ranges from 8 to 12 inches in thickness. It is black (10YR 2/1) or very dark gray (10YR 3/1) in color. Silt loam typically is the dominant texture, but loam also occurs. The A2 horizon ranges from 4 to 8 inches in thickness and from dark gray (10YR 4/1) to grayish brown (10YR 5/2) in color. The texture generally is silt loam. The color of the B horizon ranges from dark gray (10YR 4/1) to very dark gray (10YR 3/1) in the upper part and from dark gray (5Y 4/1) to olive gray (5Y 5/2) in the lower part. Mottles in the B horizon range from few to common in number and from strong brown to yellowish brown in color. The peds generally are coated with thin continuous clay films. The texture of the B horizon ranges from heavy clay loam or clay to silty clay loam or silty clay. The substratum generally begins at a depth of about 45 inches. In places it is somewhat stratified and has lenses of moderately coarse textured and coarse textured material.

The Rolfe soils are not so deep as the Glencoe soils, and their surface layer is not so dark nor so fine textured. Unlike the Glencoe soils, Rolfe soils have a gray subsurface layer.

Rolfe silt loam (0 to 1 percent slopes) (Ro).—This nearly level soil is in depressions in the uplands. It is not extensive. In most places it is surrounded by the poorly drained Webster or the somewhat poorly drained Nicollet and Guckeen soils.

Included with this soil in mapping were some areas that are in outwash areas and that generally are surrounded by the Wadena, Cylinder, or Biscay soils. In these areas the profile is similar to the one described as typical for the Rolfe series except that the subsoil is not so fine textured and sandy or gravelly material is at a depth of 30 inches or more. Because of this sandy or gravelly material tile drains are difficult to install in these areas.

Most areas of this soil are cultivated, generally in the same way as the surrounding soils. Because this soil dries slower than the surrounding soils, tillage of a field may be delayed in spring. If drainage is improved, row crops can be grown much of the time. Growth of crops is only moderate, and winterkilling of legumes is common. Tile drains do not remove water adequately, because the subsoil is clayey and is slowly or very slowly permeable. Tile lines need to be spaced closer in this soil than they are in most other wet soils. Shallow surface ditches or open intakes to tile lines are needed to remove excess surface water and prevent ponding. (Capability unit IIIw-1)

Sac Series

The Sac series consists of deep, dark-colored, well-drained soils in the uplands. These soils developed in loess that overlies calcareous glacial till (fig. 9). They are mostly in the southwestern part of the county, but some areas occur in the east-central, west-central, and northwestern parts. They occur chiefly in areas that slope gently to strongly toward shallow drainageways that are occupied by the Afton soils and in strips that border the Storden soils.

In a typical profile, the surface layer is black, friable heavy silty clay loam about 11 inches thick. It has granular and subangular blocky structure. The upper part of the subsoil is mainly brown, friable silty clay loam. It has prismatic structure that breaks to subangular blocky. The lower part of the subsoil is dark yellowish-brown clay loam that is calcareous and has some concretions of calcium carbonate.

The Sac soils have high available moisture capacity. They are moderately permeable. The supply of available nitrogen generally is low or medium, that of available phosphorus is low, and that of available potassium is medium or high. The upper horizons normally are slightly acid or medium acid in reaction.

Representative profile of a Sac silty clay loam, 305 feet west and 135 yards north of the southeast corner of the NE¼SE¼ of section 16, T. 95 N., R. 38 W., on a southeast-facing slope of 2 or 3 percent, in a cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark grayish brown (10YR 3/2) when dry; cloddy but breaks to weak, fine, granular structure; friable; abundant roots; few fine sand grains are mostly free of coatings; medium acid; clear, smooth boundary.

A3—7 to 11 inches, mixed colors of black (10YR 2/1) and very dark grayish-brown (10YR 3/2) heavy silty clay loam, very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) when kneaded; weak, very fine subangular blocky structure; friable; abundant roots; medium acid; gradual, smooth boundary.

B1—11 to 18 inches, mixed colors, mainly very dark grayish-brown (10YR 3/2), some brown (10YR 4/3), and black (10YR 2/1) heavy silty clay loam; ped faces darker than interiors; weak, coarse, prismatic structure that breaks to weak, very fine, subangular blocky; friable; common roots; medium acid; gradual, smooth boundary.

B21—18 to 25 inches, brown (10YR 4/3) silty clay loam; ped faces slightly darker than interiors; weak, medium and coarse, prismatic structure that breaks to weak, medium to coarse, subangular blocky; friable; common roots; common, fine, tubular pores; medium acid; gradual, smooth boundary.

I&IIB22—25 to 28 inches, brown (10YR 4/3) light silty clay loam; ped faces dark grayish brown (10YR 4/2) with distinct, smooth, shiny patches; weak, medium to coarse, prismatic structure that breaks to weak, medium, subangular blocky; friable; common roots; common, fine, tubular pores; some pebbles and more fine sand than in horizons above; slightly acid; clear, smooth boundary.

IIB23—28 to 33 inches, brown (10YR 4/3) clay loam; weak, medium to coarse, prismatic structure that breaks to weak, medium, subangular blocky; slightly firm; common roots; common, very fine and few, fine, tubular pores; few pebbles; few small concretions of carbonate; noncalcareous; few, fine, dark, soft concretions of oxide; neutral; clear, smooth boundary.

IIB3—33 to 44 inches, dark yellowish-brown (10YR 4/4) clay loam; common, fine, faint mottles of grayish brown (10YR 5/2); weak, medium to coarse, prismatic structure that breaks to very weak, blocky; firm; common, fine, tubular pores; smooth, shiny, brown, patchy films on ped faces; few pebbles; common soft and hard concretions of carbonate 1 to 3 millimeters in diameter; few dark patches or dendrites of oxide; moderately alkaline; calcareous; gradual, smooth boundary.

IIC—44 to 57 inches, yellowish-brown (10YR 5/4) clay loam; massive; firm; common, fine, tubular pores; common concretions of carbonate 1 to 3 millimeters in diameter; pebbles ½ inch to 3 inches in diameter coated on lower surface with carbonate about 1 millimeter thick; few dark patches or dendrites of oxide; moderately alkaline; calcareous.

The A horizon ranges from 6 to 15 inches in thickness. The B horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4) in color. In most places the lower part of the B horizon is glacial till of clay loam texture. The till occurs at a depth of 25 to 40 inches and generally is leached in the upper few inches. Secondary carbonates occur in the B horizon, but the amount is not more than that in the C horizon.

The Sac soils are not so deep to glacial till as the Galva soils. They have less sand in the upper part of their profile than the somewhat similar Everly soils and generally are a few inches deeper to glacial till.

Sac silty clay loam, 2 to 5 percent slopes (SaB).—This soil occurs in areas where the loess-mantled plain is dissected by shallow drainageways that are occupied by the Afton soils. In most places the slopes are long. In a few places, this soil occurs in a strip bordering the Storden soils, which are adjacent to stream valleys. In these strips the slopes are short. This soil also occurs with the Primghar and Marcus soils. Included with this soil in mapping were a few small areas that are deeper than 40 inches to glacial till.

Most areas of this soil are used for crops, but some are in pasture. Although areas of this soil are fairly large, they seldom occupy a whole field. Tilth generally is good and is fairly easy to maintain. Row crops can be grown much of the time. Because this soil is susceptible to erosion, contour farming or terracing is needed. (Capability unit IIe-1)

Sac silty clay loam, 5 to 9 percent slopes (SaC).—This soil generally is adjacent to large drainageways or small valleys that are occupied by the Afton soils or the Colo-

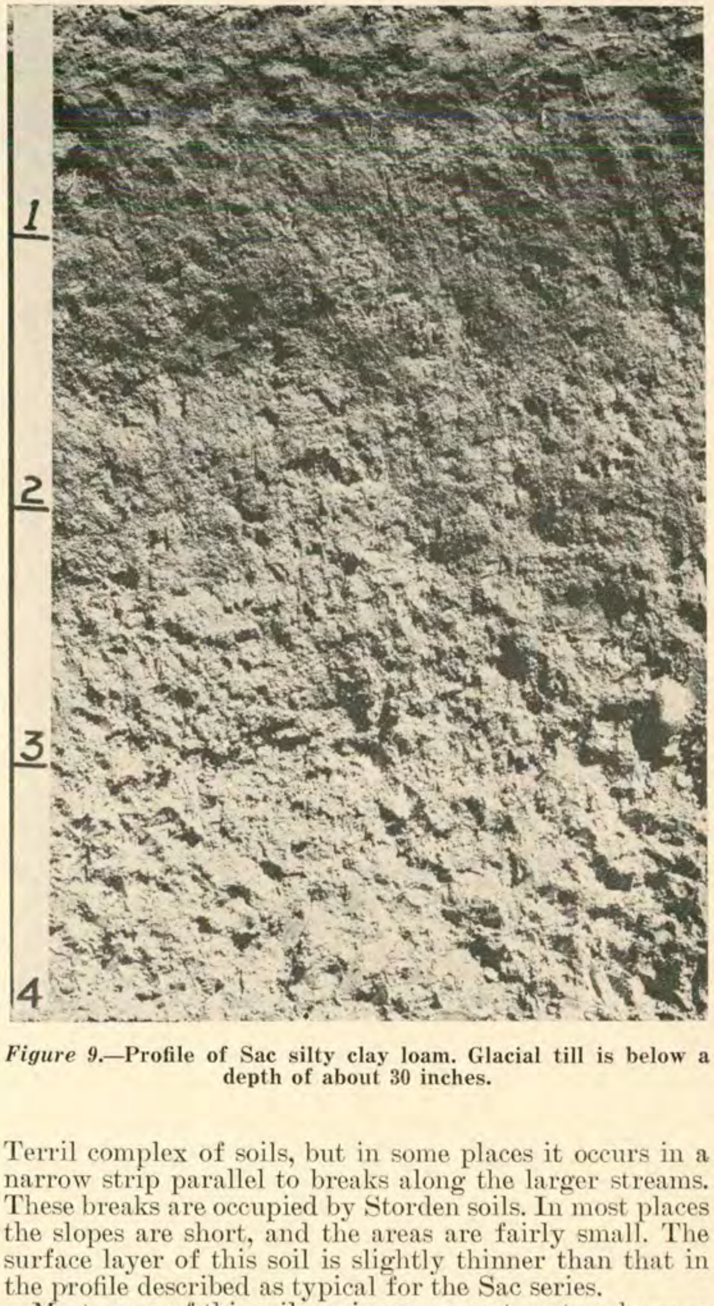

Figure 9.—**Profile of Sac silty clay loam. Glacial till is below a depth of about 30 inches.**

Terril complex of soils, but in some places it occurs in a narrow strip parallel to breaks along the larger streams. These breaks are occupied by Storden soils. In most places the slopes are short, and the areas are fairly small. The surface layer of this soil is slightly thinner than that in the profile described as typical for the Sac series.

Most areas of this soil are in permanent pasture because these areas are adjacent to other areas that are not suited to cultivation or because they are not readily accessible. This soil is suited to all crops commonly grown in the county. Row crops can be grown much of the time if contour farming and terracing are used to protect this soil from erosion. (Capability unit IIIe-1)

Sac silty clay loam, 5 to 9 percent slopes, moderately eroded (SaC2).—This soil chiefly is adjacent to large drainageways and small valleys that are occupied by the Afton soils or the Colo-Terril complex of soils. The slopes generally are short, and the areas are fairly small. The dark-colored surface layer is only 2 to 7 inches thick. Included with this soil in mapping were some areas that have a surface layer almost as thick as that in the profile described as typical for the Sac series. These included areas are mainly near the bottom of fairly short slopes, and mapping them separately is not practical.

This soil generally is cultivated. Although the hazard of erosion is moderate, row crops can be grown a fairly large part of the time if this soil is terraced. Crops do not grow so well on this soil as they do on some other Sac soils, and tilth is not so good. Growth is moderate to good, however, if fertility is maintained and management is good. (Capability unit IIIe–1)

Salida Series

The Salida series consists of moderately dark colored or dark colored, excessively drained soils. In the eastern part of the county these soils are in the uplands, but they are in outwash areas in the rest of the county. In the uplands these soils occupy small kames or knobs that have gently undulating to steep slopes. In outwash areas these soils occur mainly on gently sloping to steep breaks from one level of the area to another or to the bottom lands. In a few places, however, these soils are on knobs or low hills. These soils formed under native prairie grasses.

In a typical profile, the surface layer is very dark brown, friable gravelly sandy loam about 7 inches thick. The subsoil generally is about 4 inches thick, but it is absent in many places. It consists of dark-brown, very friable loamy sand and some gravel. The substratum is dark yellowish-brown, loose, calcareous loamy sand and gravel or sand and gravel.

The Salida soils have very low available moisture capacity. They are rapidly permeable. The supply of available nitrogen and phosphorus is low or very low, and potassium generally is low. The surface layer ranges from neutral to moderately alkaline in reaction.

Representative profile of a Salida gravelly sandy loam, 75 feet north of the southeast corner of the SW¼SW¼ of section 1, T. 95 N., R. 35 W., on a southwest-facing slope of about 6 percent, in a cultivated field:

A1—0 to 7 inches, very dark brown (10YR 2/2) gravelly sandy loam; weak, medium, granular structure; friable; abundant roots; neutral; clear, smooth boundary.

B—7 to 11 inches, loamy sand and gravel; dark brown (10YR 3/3) in the upper part to brown (10YR 4/3) in the lower part; single grain; very friable; abundant roots; neutral; clear, smooth boundary.

C1—11 to 18 inches, dark yellowish-brown (10YR 4/4) loamy, medium and coarse sand and gravel; yellowish brown (10YR 5/4) when dry; few, fine and medium, distinct mottles of strong brown (7.5YR 5/6); single grain; loose; abundant roots; several very dark brown (10YR 2/2) krotovinas; mildly alkaline; calcareous; gradual, smooth boundary.

C2—18 to 28 inches, dark yellowish-brown (10YR 4/4) loamy sand and gravel, light yellowish brown (10YR 6/4) when dry; few, fine and medium, distinct mottles of strong brown (7.5YR 5/6); single grain; loose; common roots; mildly alkaline; calcareous; gradual, smooth boundary.

C3—28 to 44 inches, dark yellowish-brown (10YR 4/4) sand and gravel, light yellowish brown (10YR 6/4) when dry; single grain; loose; roots common in upper part, few in lower part; mildly alkaline; calcareous.

The A horizon ranges from 2 to 9 inches in thickness and from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color. The texture of this horizon ranges from gravelly loam or gravelly sandy loam to sandy loam. A dark-brown to very dark grayish-brown B horizon a few inches thick occurs in most places. In most places the C horizon is calcareous mixed sand and gravel, but the texture ranges to coarse sandy loam.

The Salida soils are calcareous within 16 inches of the su face, whereas the Dickinson soils are leached throughout the profile. Salida soils also have more coarse sand and gravel i their profile than the Dickinson soils.

Salida gravelly sandy loam, 2 to 5 percent slope (SgB).—This soil is on low knobs in the uplands and i outwash areas. It is not extensive, and the areas generall are small. The slopes are short and irregular. This so occurs mainly with the Clarion and Storden soils in th uplands and with the Wadena soils in outwash areas. Th surface layer is typically about 9 inches thick. Include with this soil in mapping were a few moderately erode areas that have a surface layer 3 to 7 inches thick. On th lower part of slopes this soil generally is leached of car bonates to a depth of 20 to 30 inches. Also leached are few areas mapped in sections 25, 35, and 36 of Lak Township.

Many areas of this soil are cultivated, but some are i pasture. Cultivated crops are suited, but growth is poo because this soil is droughty and has low fertility. Mos areas are small and generally are cropped in the same wa as the surrounding soils. This soil is slightly susceptibl to erosion. In places enough gravel and small stones ar in the plow layer to hinder tillage. (Capability uni IIIe–4)

Salida gravelly sandy loam, 5 to 9 percent slopes moderately eroded (SgC2).—This soil is not extensive It is on knobs and low hills of the uplands in the easter part of the county. In the outwash area in the northwestern part, it occurs mostly on moderately sloping breaks from one level of the area to another. Areas of this soil on these breaks are narrow and generally are as much as one-half mile or more in length. In the uplands the areas generally are small. This soil occurs mainly with the Clarion and Storden soils in the uplands and in most places is adjacent to the Wadena or Cylinder soils in outwash areas. In places a very narrow area of Terril soils is at the foot of the breaks.

Included with this soil in mapping were a few severely eroded areas where most or all of the original surface layer has been removed and the calcareous sand and gravel are exposed. Also included were a few areas in sections 25, 35, and 36 of Lake Township that are leached of carbonates to a depth of 20 to 30 inches.

Some of this soil is used for cultivated crops, but many areas are in permanent pasture. This soil is droughty, is susceptible to erosion, and has low fertility. Growth of crops generally is poor. Row crops should be planted on the contour. Crop residue left on the surface helps reduce soil blowing. In many places enough gravel and small stones are in the surface layer to hinder tillage. (Capability unit IIIe–4)

Salida gravelly sandy loam, 9 to 15 percent slopes, moderately eroded (SgD2).—This soil is not extensive. It occurs on knobs and hills in the uplands. In outwash areas it occurs on strongly sloping breaks from one level of the area to another and from these areas to bottom lands. Areas of this soil on the benches are narrow but long, and areas in the uplands generally are small. Where it is in the uplands, this soil is mostly with the Clarion or Storden soils, but in outwash areas it is mostly adjacent to the Wadena or Cylinder soils. In some places a very narrow area of the Terril soils is at the foot of the breaks from the benches.

Included with this soil in mapping were a few severely eroded areas where calcareous sand and gravel are exposed. Also included were a few areas that have a sandy loam surface layer and subsoil and that are leached to a depth of 20 to 30 inches or more.

Some areas of this soil are used for crops, and other areas are in pasture. This soil is susceptible to soil blowing and water erosion. It is droughty and has low fertility. In many places enough gravel and small stones are in the surface layer to hinder tillage. An occasional year of row crops can be grown, but growth of crops is poor. A better use is for hay or permanent pasture. (Capability unit IVe-2)

Salida gravelly sandy loam, 15 to 20 percent slopes, moderately eroded (SgE2).—This soil is not extensive. In outwash areas it is on breaks between one level of the area to another or between these areas and bottom lands. It occurs on hills and knobs in the uplands. In most places narrow areas of Terril soils are at the foot of the escarpments. In some places the surface layer of this soil is slightly thinner than that of the soil described as typical for the Salida series. Also on some escarpments, the calcareous material is deeper. In a few areas the profile is sandy loam throughout.

This soil is droughty, and the hazard of erosion is high. It is not suited to cultivated crops. Most areas are in permanent pasture, which is a better use. (Capability unit VIe-2)

Salida sandy loam, 20 to 30 percent slopes, moderately eroded (SlF2).—This soil is not extensive. In outwash areas it is on breaks between one level of the area to another or between these areas and bottom lands. It occurs on steep hills and knobs in the uplands. The slopes are generally short. In most places narrow areas of Terril soils are at the foot of the escarpments. In some places the surface layer of this soil is slightly thinner than that of the soil described as typical for the Salida series. Also on some escarpments the calcareous material is deeper. In a few areas the profile is dominantly sandy loam. This soil is droughty and highly susceptible to erosion. All the acreage is used for pasture. (Capability unit VIIe-2)

Sandy Lake Beaches

Sandy lake beaches consists of narrow, nearly level to gently sloping beaches of lakes and areas that border the bed of drained lakes. This land type occurs mainly around Trumbull Lake in the northeastern part of the county and near an old lakebed in the southeastern part. The texture generally is loamy sand or sand mixed with some gravel. This land is suited to permanent pasture. Other uses include wildlife habitat and recreation areas.

Sandy lake beaches (Sn).—This miscellaneous land type is narrow and is nearly level to gently sloping. It is not extensive. It is mainly around Trumbull Lake in the northeastern part of the county and borders an old lakebed in sections 25 and 26 in Garfield Township in the southeastern part.

The surface layer varies in thickness, but it is about 7 to 12 inches thick in the area around Trumbull Lake. It is more than 12 inches thick in most places in Garfield Township. This layer generally is slightly alkaline and weakly calcareous, but some areas are neutral. The texture generally is loamy sand or sand mixed with some gravel. The underlying sand generally contains some gravel and is slightly alkaline or moderately alkaline.

Most areas of Sandy lake beaches generally are in permanent pasture, but some are cultivated. This land is suited to permanent pasture or to such uses as wildlife habitat or recreation areas. (Capability unit VIs-1)

Sperry Series

The Sperry series consists of nearly level, poorly drained or very poorly drained soils in shallow depressions in the uplands. These soils developed in loess or local alluvium under native swamp grasses and sedges in the western and south-central parts of the county.

In a typical profile, the surface layer is black, friable to firm silty clay loam about 10 inches thick. It has granular structure. The subsurface layer is very dark gray or dark gray and has platy structure. The subsoil extends to a depth of about 44 inches. It is black, very dark gray, and dark-gray, friable to firm silty clay loam and silty clay with olive, olive-gray, and yellowish-brown mottles. It has angular blocky and subangular blocky structure. The substratum is gray to olive-gray silty clay loam and has mottles of strong brown and yellowish brown.

The Sperry soils have high available moisture capacity. Permeability of the subsoil is slow or very slow. The supply of available nitrogen is low or medium, that of available phosphorus is low, and that of available potassium is medium. The surface layer is slightly acid or medium acid in reaction.

Representative profile of a Sperry silty clay loam, 1,976 feet east and 239 feet south of the northwest corner of the NW 1/4 of section 21, T. 94 N., R. 38 W., in a nearly level depression in a cultivated field:

A1—0 to 10 inches, black (N 2/0) light silty clay loam; weak, coarse, subangular blocky structure that breaks to weak, fine, granular; friable to firm; slightly acid; clear, wavy boundary.

A2—10 to 18 inches, very dark gray (10YR 3/1) to dark-gray (10YR 4/1) light silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4); very weak, thick, platy structure that breaks to weak, fine and medium, subangular blocky; friable to firm; slightly acid; clear, smooth boundary.

B21—18 to 22 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam or light silty clay; strong, very fine, subangular blocky structure; friable to firm; shiny ped surfaces; thin clay films on most peds; neutral; gradual, smooth boundary.

B22g—22 to 31 inches, very dark gray (10YR 3/1 to 5Y 3/1) or dark-gray (10YR 4/1 to 5Y 4/1) silty clay; few, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, coarse, subangular blocky structure that breaks to strong, very fine, angular and subangular blocky; friable to firm; shiny ped surfaces; thin clay films on most peds; neutral; gradual, smooth boundary.

B23g—31 to 36 inches, dark-gray (5Y 4/1) silty clay; few streaks of black (N 2/0); few, fine, faint mottles of olive (5Y 5/3); moderate, coarse, subangular blocky structure that breaks to strong, fine, angular blocky; plastic and sticky when wet; shiny ped surfaces; thin clay films on most peds; neutral; gradual, smooth boundary.

B3g—36 to 44 inches, dark-gray (5Y 4/1) heavy silty clay loam; few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and few, fine, faint mottles of olive gray (5Y 5/2); moderate, fine and medium, subangular blocky structure; plastic and sticky when wet; neutral; gradual, smooth boundary.

Cg—44 to 50 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) light silty clay loam; many, fine and medium, prominent mottles of strong brown (7.5YR 5/8) and few, fine, distinct mottles of yellowish brown (10YR 5/6 and 10YR 5/8) in a fairly distinct layer that appears to be accumulated iron; weak to moderate, fine, subangular blocky structure; slightly sticky when wet; few, soft, white concretions that do not effervesce in weak acid; neutral.

The A1 horizon ranges from about 7 to 12 inches in thickness and from heavy silt loam to light silty clay loam in texture. The A2 horizon ranges from very dark gray (10YR 3/1) to dark gray (10YR 4/1) in color, from heavy silt loam to light silty clay loam in texture, and from 6 to 10 inches in thickness. The B horizon ranges from heavy silty clay loam to silty clay in texture. This horizon generally is slightly acid or neutral in reaction. The solum is about 44 inches thick and generally is leached to a depth of 40 inches or more. In most places the C horizon is silty outwash to a depth of 50 inches or more. Below the outwash is calcareous glacial till.

The Sperry soils have a thinner surface layer and a finer textured subsoil than the Marcus soils. Also Marcus soils do not have a gray subsurface layer. Unlike the Rolfe soils that developed in glacial materials, Sperry soils developed in loess or local alluvium and have less sand in their profile.

Sperry silty clay loam (0 to 1 percent slopes) (So).—This soil generally is in small, shallow depressions. In most places it is surrounded by the Marcus soils, but in a few places it is surrounded by the Tripoli soils. Where it is near the Tripoli soils, this soil tends to have slightly more sand throughout the profile than the one described as typical for the Sperry series. This soil is wet in places and tends to be ponded in wet years. Tile drains with surface intakes and ditches can be used to remove surface water and improve drainage. Tile drains do not function so well in this soil as in the adjoining Marcus soils, because permeability in the subsoil is very slow or slow.

This soil generally is cultivated. It is generally cropped in the same way as the surrounding soils because only a few areas are as large as 10 acres in size. Row crops can be grown much of the time, but their growth is variable, depending on how well drainage is improved. (Capability unit IIIw–1)

Spillville Series

The Spillville series consists of dark-colored, moderately well drained to somewhat poorly drained, nearly level soils. These soils developed on bottom lands, mainly under native prairie grasses, but trees grew in a few areas.

In a typical profile, the surface layer is black, friable loam about 28 inches thick. It has granular and subangular blocky structure. The weakly developed subsoil is very dark brown, friable loam. It has subangular blocky structure. The substratum generally begins at a depth of about 38 inches. It is very dark brown to very dark grayish-brown, friable, massive loam.

The Spillville soils have high available moisture capacity. They are moderately permeable. The supply of available nitrogen is low or medium, that of phosphorus generally is about medium, and that of potassium generally is medium. The surface layer generally is neutral or slightly acid in reaction.

Representative profile of a Spillville loam, 0.3 mile west and 300 feet south of the northeast corner of section 20, T. 94 N., R. 36 W., on a nearly level slope, in a cultivated field:

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy but breaks to weak, fine and very fine, granular structure; friable; common roots; neutral; gradual, smooth boundary.

A12—8 to 18 inches, black (10YR 2/1) loam; weak, fine and medium, subangular blocky structure; friable; few roots; neutral; diffuse, smooth boundary.

A13—18 to 28 inches, black (10YR 2/1) loam; very weak, fine and medium, subangular blocky structure; friable; few roots; neutral; diffuse, smooth boundary.

B2—28 to 38 inches, very dark brown (10YR 2/2) loam; very weak, medium, subangular blocky structure; friable; few roots; neutral; diffuse, smooth boundary.

C—38 to 50 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam; massive; friable; neutral.

The A horizon generally is loam in texture, but it ranges to silt loam and light silty clay loam. This horizon ranges from 18 to 30 inches in thickness. The B horizon ranges from dark grayish brown (10YR 3/2) to very dark brown (10YR 2/2) in color and from loam to light clay loam in texture. The C horizon ranges from dark grayish brown to very dark brown in color and from loam to light clay loam in texture. In some places sand or gravel is below a depth of 50 inches. Reaction throughout the solum is neutral or slightly acid.

The Spillville soils are not so fine textured as the Colo soils. Also they have a browner subsoil and are better drained than those soils.

Spillville loam (0 to 2 percent slopes) (Sp).—This soil is mainly on the bottom lands along and fairly close to the Little Sioux River. It occurs with the Colo soils. Most areas are nearly level, but some are slightly undulating. In the undulating areas a few, shallow, narrow, old stream channels are occupied by the Colo soils.

Most areas of this soil are used for crops, but some are in pasture. Row crops can be grown much of the time. Some areas are flooded only occasionally, but the lower areas are flooded often. Growth of crops varies, depending upon how often these areas are flooded. Tile drains generally are not needed. (Capability unit IIw–1)

Storden Series

The Storden series consists of moderately dark colored, well-drained soils on knobs and hills in the rolling uplands in the eastern part of the county and in sloping areas along streams throughout the county. These soils developed in calcareous glacial till, mainly under prairie grasses, though trees grew in some areas near the streams. Slopes range from 5 to 50 percent.

In a typical profile, the surface layer is very dark brown to very dark grayish-brown, friable loam about 6 inches thick. It is calcareous and has granular structure. Beneath the surface layer is very dark grayish-brown, dark-brown, and brown, calcareous loam. It has granular structure. The substratum is dark yellowish-brown to yellowish-brown, friable loam. It is calcareous and has subangular blocky structure.

The Storden soils have high available moisture capacity, but they are droughty in many places because runoff is rapid. They are moderately permeable. These soils are rich in lime throughout their profile. The supply of nitrogen is very low, that of phosphorus generally is low or very low, and that of potassium generally is low.

Representative profile of a Storden loam, 198 feet east and 500 feet north of a field corner that is 1,000 feet west of the southeast corner of section 10, T. 96 N., R. 35 W., on a southeast-facing slope of 17 percent, in a cultivated field:

Ap—0 to 6 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam; weak, fine, granular structure; friable; few roots; mildly alkaline; calcareous; clear, smooth boundary.

AC—6 to 11 inches, mixed very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) to brown (10YR 4/3) loam; weak, fine, granular structure; friable; few roots; mildly alkaline; calcareous; gradual, smooth boundary.

C1—11 to 16 inches, dark yellowish-brown (10YR 4/4) loam; very weak, medium, subangular blocky structure; friable; moderately alkaline; calcareous; gradual, smooth boundary.

C2—16 to 24 inches, dark yellowish-brown (10YR 4/4) loam in upper part that grades to yellowish brown (10YR 5/4) in the lower part; very weak, medium, subangular blocky structure; friable; few, soft and hard concretions of carbonate 3 to 10 millimeters in diameter; some small pebbles; moderately alkaline; calcareous; gradual, smooth boundary.

C3—24 to 36 inches, yellowish-brown (10YR 5/4) loam; few, fine, faint mottles of yellowish brown (10YR 5/8); very weak, medium, subangular blocky structure; friable; many carbonate concretions, mainly larger than 5 millimeters in diameter and between a depth of 24 and 30 inches; some pebbles; moderately alkaline; calcareous.

The A horizon ranges from about 2 to 8 inches in thickness, depending on the degree of erosion. The color of this horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). In some small areas there is no A horizon, but in many areas there is an A3 or an AC horizon. These horizons have mixed colors to a depth of about 11 inches. They overlie a C horizon of calcareous glacial till that ranges from dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/4) in color. In most places the depth to calcareous material ranges from 6 to 12 inches, but in many places these soils are calcareous at the surface. In some places pockets of sand or gravel occur in the profile.

The Storden soils are not so deep to calcium carbonate as the Clarion soils. Unlike the Clarion soils, Storden soils have not developed a subsoil (B horizon).

Storden loam, 5 to 15 percent slopes, moderately eroded (StD2).—This soil is on knobs and ridges in the eastern part of the county and in strongly sloping areas, along the large drainageways or streams throughout the county. In the eastern part of the county this soil occurs with the Clarion, Nicollet, and Webster soils. Along streams it occurs with the Sac and Everly soils and the Colo-Terril complex of soils.

Included with this soil in mapping were areas where the surface layer consists mostly of the light-colored underlying material. Also included were a few areas at the base of slopes or in pasture that have a surface layer that is slightly thicker than that of the profile described as typical for the Storden series.

Many areas of this soil are cultivated, but some are in permanent pasture. This soil is susceptible to moderate erosion. Row crops can be grown part of the time if the soil is terraced, but the growth of crops generally is only moderate. Because runoff is rapid, this soil is droughty, especially in years when rainfall is below average. Fairly large amounts of fertilizer are needed for satisfactory growth of crops, and phosphate particularly is needed for alfalfa. (Capability unit IIIe-2)

Storden loam, 15 to 20 percent slopes, moderately eroded (StE2).—This soil is on knobs and ridges in the eastern part of the county and in moderately steep areas along streams throughout the county.

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Included with this soil in mapping were some cultivated areas that are severely eroded. In these severely eroded areas, the surface layer consists mostly of the light-colored underlying material. Also included were a few areas that are leached of carbonates to a depth of about 2 feet.

Most areas of this soil are in permanent pasture, but some are cultivated. This soil is highly susceptible to erosion. It is droughty in many places because runoff is rapid. An occasional year of row crops can be grown if tillage is on the contour, but a better use is for hay or pasture. Growth of crops generally is poor. (Capability unit IVe-1)

Storden loam, 20 to 30 percent slopes, moderately eroded (StF2).—This soil is on some hills and ridges but is mainly in sloping areas along streams. In some places the surface layer of this soil is slightly thicker than that in the profile described as typical for the Storden series.

Most areas of this soil are in permanent pasture, but some have trees that generally are scattered. Permanent pasture is a good use for this soil. Fertilizing and seeding adapted grasses or legumes are good practices to improve pasture. On some of the steeper slopes, however, the use of ordinary farm machinery may be either impossible or not practical. Overgrazed areas have a few gullies in places. (Capability unit VIe-1)

Storden loam, 30 to 50 percent slopes, moderately eroded (StG2).—This very steep soil is mainly in areas adjacent to streams. Most areas occur along the Little Sioux River and its larger tributaries. On the average, the surface layer of this soil is slightly thinner than that in the profile described as typical for the Storden series. Included with this soil in mapping were some areas that are severely eroded.

Most areas of this soil are in permanent pasture, but some have a thin stand of trees. Because some slopes are very steep, ordinary farm machinery cannot be used and renovating pastures is not practical. Nevertheless, permanent pasture is a good use for this soil. (Capability unit VIIe-1)

Talcot Series

The Talcot series consists of dark-colored, poorly drained, nearly level soils that overlie sand or gravel. They are in outwash areas and on stream benches, mainly in the northwestern and east-central parts of the county. These soils are calcareous throughout their profile. They developed in moderately fine textured outwash under swamp grasses, sedges, and native prairie grasses that tolerate wetness.

In a typical profile, the surface layer is black to dark-gray, friable silty clay loam that feels gritty and is about 19 inches thick. It has granular structure. The subsoil extends to a depth of about 41 inches. It is dark-gray and olive-gray, friable clay loam that grades to loam in the lower part. The structure is mainly subangular blocky. The substratum is dark yellowish-brown and grayish-brown, loose sand and gravel.

The Talcot soils have high available moisture capacity. They are moderately slowly permeable. The supply of available nitrogen typically is low or medium, that of phosphorus is low or very low, and that of potassium is low. These soils are mildly to moderately alkaline throughout their profile.

Representative profile of a Talcot silty clay loam, 120 feet north and 444 feet west of the southeast corner of the NE¼ of section 2, T. 96 N., R. 38 W., on a nearly level slope, in a cultivated field:

Ap—0 to 8 inches, black (N 2/0) silty clay loam; cloddy but breaks to weak, fine, granular structure; friable to firm; moderately alkaline; calcareous; clear, smooth boundary.

A12—8 to 14 inches, mainly black (N 2/0) silty clay loam but a few very dark gray (N 3/0) peds in lower part; weak, fine, granular structure; friable; moderately alkaline; calcareous; gradual, smooth boundary.

A3—14 to 19 inches, black (N 2/0) and very dark gray (10YR 3/1) to dark-gray (5Y 4/1) silty clay loam; moderate, fine, granular structure; friable; moderately alkaline; calcareous; gradual, smooth boundary.

B21g—19 to 25 inches, mainly dark-gray (5Y 4/1) light clay loam but about 20 to 30 percent black (N 2/0) and very dark gray (N 3/0); weak, medium, subangular blocky structure that breaks to moderate, fine, granular; friable; common, very fine, tubular pores; few black and very dark gray worm casts; moderately alkaline; calcareous; gradual, smooth boundary.

B22g—25 to 30 inches, mainly dark-gray (5Y 4/1) light clay loam but a few very dark gray (N 3/0) peds in upper part and a few olive-gray (5Y 5/2) peds in the lower part; very weak, medium, subangular blocky structure; friable; common to many, very fine and few, fine, tubular pores; moderately alkaline; calcareous; clear, smooth boundary.

B23g—30 to 34 inches, mainly olive-gray (5Y 5/2) light clay loam but about 30 percent dark gray (5Y 4/1); few, fine, faint mottles of olive brown (2.5Y 5/4) and yellowish brown (10YR 5/6); very weak, medium, subangular blocky structure; friable; many, very fine, tubular pores; moderately alkaline; calcareous; gradual, smooth boundary.

B3g—34 to 41 inches, olive-gray (5Y 5/2) loam; very weak, medium, subangular blocky structure to massive (structureless); friable; many, very fine, tubular pores; common, dark, hard concretions of oxide; few fine concretions of lime; moderately alkaline; calcareous; clear, smooth boundary.

IIC1—41 to 48 inches, dark yellowish-brown (10YR 4/4) sand and gravel; single grain (structureless); loose; moderately alkaline; calcareous; gradual, smooth boundary.

IIC2—48 to 60 inches, grayish-brown (10YR 6/2), dark yellowish-brown (10YR 4/4), and yellowish-brown (10YR 5/4) sand and gravel; single grain (structureless); loose; moderately alkaline; calcareous.

The A horizon ranges from 12 to 20 inches in thickness. Typically, the color ranges from black (N 2/0 or 10YR 2/1) in the upper part to very dark gray (10YR 3/1 or N 3/0) in the lower part. The texture ranges from silty clay loam to clay loam. The B horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2) in color. In the upper part of this horizon are coatings and peds of very dark gray. The texture of the B horizon typically is light clay loam, but it ranges to loam in the lower part. Depth to the sand and gravel substratum typically is between 36 and 42 inches, but it ranges to 48 inches. The substratum consists mainly of sand and varying amounts of gravel, but in local areas it may consist mostly of sand.

Unlike the Biscay soils, Talcot soils are calcareous throughout their profile. Except for the underlying sand and gravel, Talcot soils resemble the Canisteo soils. The Talcot soils typically are not so rich in lime as the Harps soils, which do not overlie sand and gravel.

Talcot silty clay loam, deep (0 to 2 percent slopes) (Ta).—This nearly level soil is on stream benches or in glacial outwash areas. It occurs mainly with the well-drained Wadena, the somewhat poorly drained Cylinder, and the poorly drained Biscay soils.

Included with this soil in mapping were a few areas that have a very dark gray surface layer when dry. These included areas are mainly in sections 35 and 36 of Waterford Township and sections 1 and 2 of Lone Tree Township. In these areas the supply of available phosphorus and potassium is likely to be very low, and the supply of iron and other minor elements may be deficient.

Most areas of this soil are cultivated, but a few are in pasture. If this soil is artificially drained, it can be used for row crops much of the time. If management is good and fertility is maintained, crops grow well. Tile drains function well, but installation may be difficult because of caving in of the coarse-textured substratum. (Capability unit IIw-3)

Terril Series

The Terril series consists of deep, dark-colored, gently sloping to strongly sloping soils on the foot slopes of fans. These soils are moderately well drained. They formed mainly under native prairie grasses, but trees grew in a few areas. These soils occur throughout the county. They are generally between areas of Storden or Clarion soils above and the soils on benches or bottom lands below. Many areas of these soils are mapped in a complex with the Colo soils.

In a typical profile, the surface layer is black to very dark brown, friable loam about 30 inches thick. It has granular and subangular blocky structure. The subsoil is very dark brown and dark-brown friable loam. It has subangular blocky structure. The substratum generally is at a depth of about 39 inches. It is dark-brown or brown, heavy loam that has subangular blocky structure. Mottles of yellowish brown and grayish brown occur in many places.

The Terril soils have high available moisture capacity. They are moderately permeable. The supply of available nitrogen generally is low to medium, that of potassium generally is medium, and that of phosphorus generally is low. The surface layer normally is slightly acid in reaction.

Representative profile of a Terril loam, 321 feet west and 369 feet south of the northeast corner of section 30, T. 95 N., R. 35 W., on a west-facing slope of about 5 percent, in a cultivated field:

A1—0 to 7 inches, black (10YR 2/1) loam; slightly cloddy but breaks to weak to moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) loam; weak, medium to coarse, subangular blocky structure that breaks to weak to moderate, fine, granular; friable; slightly acid; gradual, smooth boundary.

A13—12 to 20 inches, very dark brown (10YR 2/2) loam with some black (10YR 2/1) peds; weak, medium and coarse, subangular blocky structure that breaks to weak, fine and very fine, subangular blocky and weak, fine, granular; friable; slightly acid; diffuse, smooth boundary.

A14—20 to 30 inches, very dark brown (10YR 2/2) light clay loam; weak, medium and coarse, subangular blocky structure that breaks to weak, fine, subangular blocky; friable; neutral; diffuse, smooth boundary.

B21—30 to 39 inches, very dark brown (10YR 2/2) and dark-brown (10YR 3/3) heavy loam; ped interiors mostly dark brown (10YR 3/3); weak, fine and medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C—39 to 50 inches, dark-brown (10YR 3/3) and brown (10YR 4/3) heavy loam; few very dark brown (10YR 2/2) streaks; few, fine, faint mottles of yellowish brown (10YR 5/4 to 5/6); very weak, fine and medium, subangular blocky structure; friable; neutral.

The A horizon ranges from 18 to 32 inches in thickness. The color of this horizon ranges from black (10YR 2/1) to very dark brown (10YR 2/2) in the upper part and from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) in the lower part. The B horizon is thin in many places, and in some places it is absent. Where present, this horizon is typically loam in texture but ranges to light clay loam. The color of the B horizon typically is dark brown or brown (10YR 3/3 or 4/3). The color may be dark grayish brown (10YR 4/2) in the upper 4 to 6 inches of the B horizon if chroma is higher and mottles are absent in the lower part. Very dark grayish-brown or dark-brown ped exteriors and peds are fairly common to a depth of 36 inches. Typically, however, color grades to brown (10YR 4/3) with depth. In places faint mottles occur in the lower part of the B horizon and in the C horizon. In the more sloping areas of this soil, loam or clay loam calcareous glacial till occurs in some places at depths between 40 and 50 inches.

The Terril soils have a thicker surface layer and are leached to a greater depth than Clarion soils. Terril soils formed in local alluvium, whereas the Clarion soils formed in glacial till.

Terril loam, 2 to 5 percent slopes (TeB).—This soil mainly is in areas that break from the uplands to benches and to bottom lands. It is generally downslope from Storden soils. In some places this soil is downslope from more sloping Terril soils. Areas of this soil are narrow and long, and the slopes are short. Included with this soil in mapping were some areas that are not so well drained. In these areas the subsoil and underlying material are more grayish brown than is typical for Terril soils. Also included were a few areas near Peterson that are covered by dark-brown, loamy, calcareous overwash as much as 3 feet thick.

If this soil is protected by contour tillage or terracing, it can be used for row crops much of the time. Because it commonly occurs in narrow areas adjacent to steep soils, it is used in many places for pasture. The hazard of erosion is slight, and where row crops are grown, contour farming is needed. Diversion terraces can be used in places to control runoff from higher lying areas. Gullies may form in shallow drainageways, and shaping and seeding these for waterways are needed. (Capability unit IIe–1)

Terril loam, 5 to 9 percent slopes (TeC).—This soil is in areas that break from uplands to benches and to bottom lands. It seldom is downslope from other Terril soils but generally is downslope from Storden soils.

This soil is suitable for cultivation. Because it generally is in narrow areas adjacent to steeper soils, it is used mainly for pasture. Crops grow well under good management. This soil is moderately susceptible to erosion. Where it is used for row crops, contour farming or terracing is needed. Diversion terraces can be used upslope in places to control runoff from higher areas. Gullies may form in drainageways, and shaping and seeding of these for waterways are needed. (Capability unit IIIe–1)

Terril loam, 9 to 15 percent slopes (TeD).—This soil occurs in small areas that seldom are more than a few acres in size. It is not extensive. Less sloping Terril soils generally are downslope from this soil. The surface layer of this soil is not so thick as that in the profile described as typical for the Terril series, and the subsoil generally is lighter brown. In many places calcareous glacial till is at a depth of 40 to 50 inches.

Because this soil is moderately steep and borders other steep soils, it is generally used for pasture. The hazard of erosion is moderate to high when this soil is cultivated. Crops grow fairly well, but where row crops are grown, terracing is needed to control erosion. In places gullies that cannot be crossed by farm machinery have formed. In these places shaping and seeding of the gullies for waterways are needed. (Capability unit IIIe–2)

Tripoli Series

The Tripoli series consists of nearly level, poorly drained soils in the uplands, chiefly in the central and northwestern parts of the county. These soils developed in a layer of gritty material less than 3 feet thick over calcareous glacial till. The native vegetation was sedges, swamp grasses, and prairie grasses that tolerate wetness.

In a typical profile, the surface layer is black, friable to firm clay loam about 19 inches thick. It has granular and subangular blocky structure. The subsoil developed partly in glacial till and partly in the overlying material. It is black in the upper few inches but is mainly dark grayish-brown, friable to firm clay loam to a depth of about 32 inches and has strong-brown, olive-brown, and grayish-brown mottles. Below 32 inches is light olive-brown and yellowish-brown, friable clay loam and a few pebbles. This layer has strong-brown, gray, and olive-gray mottles. The subsoil is calcareous below a depth of about 24 inches. It has subangular blocky structure. The substratum begins at a depth of about 40 inches. It is light olive-gray, friable to firm, calcareous clay loam that has yellowish-brown mottles.

The Tripoli soils have high available moisture capacity. They are moderately slowly permeable. The supply of available nitrogen generally is low or medium, that of available phosphorus is low, and that of available potassium is medium. The surface layer is about neutral in reaction.

Representative profile of a Tripoli clay loam, 550 feet west and 147 feet north of the southeast corner of the SW¼ of section 20, T. 96 N., R. 36 W., on a nearly level slope, in a cultivated field:

Ap—0 to 8 inches, black (N 2/0) clay loam; cloddy but breaks to weak to moderate, fine, granular structure; friable to firm; neutral; clear, smooth boundary.

A12—8 to 14 inches, black (N 2/0) clay loam; weak to moderate, fine, granular structure; friable; neutral; gradual, smooth boundary.

A3—14 to 19 inches, black (10YR 2/1) clay loam; few, fine, faint mottles of very dark gray (5Y 3/1); weak, fine, subangular blocky structure that breaks to weak to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

B21g—19 to 23 inches, black (10YR 2/1) clay loam; common, fine, faint mottles of very dark gray (10YR 3/1) and many, medium, distinct mottles of olive gray (5Y 4/2) and olive (5Y 4/3); weak, fine, subangular blocky structure; friable; common, medium, inped, tubular pores; few, fine, dark concretions of oxide; neutral; clear, smooth boundary.

I&IIB22g—23 to 32 inches, dark grayish-brown (2.5Y 4/2), olive-brown (2.5Y 4/4), and olive (5Y 4/3) clay loam, dark grayish brown (2.5Y 4/2) when kneaded; common, fine, distinct mottles of strong brown (7.5YR 5/8) and many, fine, distinct mottles of olive gray (5Y 5/2); weak, fine, subangular blocky structure; few pebbles; friable to firm; many black (10YR

2/1) worm casts that decrease in number with depth; few, soft concretions of oxide; abundant, fine and very fine pores and common, medium pores; mildly alkaline; calcareous; clear, smooth boundary.

IIB3—32 to 40 inches, mixed light olive-brown (2.5Y 5/4) and yellowish-brown (10YR 5/6) light clay loam; few, fine, distinct mottles of strong brown (7.5YR 5/8) and common, fine, distinct mottles of gray (5Y 5/1) or olive gray (5Y 5/2); few very dark gray (10YR 3/1) streaks; weak, fine and medium, subangular blocky structure; friable to firm; few pebbles; abundant fine pores; some carbonate concretions; moderately alkaline; calcareous; clear, smooth boundary.

IIC—40 to 52 inches, light olive-gray (5Y 6/2) light clay loam; common, medium, distinct mottles of yellowish brown (10YR 5/6); massive but breaks to weak, fine, subangular blocky structure; friable to firm; abundant, fine, tubular pores; common concretions of oxide; common soft concretions of carbonate; moderately alkaline; calcareous.

The A horizon ranges from 14 to 20 inches in thickness and from silty clay loam to clay loam in texture. The upper part of the B horizon ranges from black (10YR 2/1) or very dark gray (10YR 3/1) to dark gray (5Y 4/1) or olive gray (5Y 4/2) in color. The lower part of this horizon ranges from dark gray (5Y 4/1) or grayish brown (2.5Y 4/2) to olive (5Y 4/3) or olive brown (2.5Y 4/4). The color of the IIC horizon ranges from light olive gray to grayish brown or olive. Both the B horizon and underlying material are strongly mottled with yellowish brown, strong brown, olive, olive brown, and grayish brown. In places a faint stone line occurs between the overlying material and the glacial till, which generally is at a depth between 24 and 36 inches.

The Tripoli soils are less deep to glacial till than the Marcus soils and contain more sand. The subsoil of Tripoli soils is somewhat finer textured than that of the Webster soils. Also the colors in the lower part of the B horizon and the C horizon of Tripoli soils have higher chroma than those in Webster soils.

Tripoli clay loam (0 to 2 percent slopes) (Tr).—This soil is nearly level, but slopes range from slightly convex to slightly concave. It generally is adjacent to the somewhat poorly drained Nicollet or the well-drained Everly soils. Included with this soil in mapping were a few areas where the depth to calcareous glacial till is about 40 inches. Also included were small areas that are calcareous throughout their profile.

Most areas of this soil are cultivated, and row crops can be grown much of the time. Artificial drainage is needed, and tile drains function well. Good tilth is fairly easy to maintain, but if this soil is worked when wet, it becomes cloddy and hard when it dries. Preparing a good seedbed is easier where this soil is plowed in fall. If this soil is adequately drained and managed well, growth of crops is good. (Capability unit IIw-2)

Wabash Series

The Wabash series consists of deep, poorly drained or very poorly drained, nearly level soils in slight depressions or on low bottom lands along the Little Sioux River. These soils developed in fine-textured alluvium under native swamp grasses and sedges.

In a typical profile, the surface layer is black, friable to firm silty clay about 13 inches thick. It has granular and subangular blocky structure. The subsoil extends to a depth of about 36 inches. It is black, firm to very firm silty clay that has subangular blocky structure. The substratum is very dark gray, firm silty clay that has subangular blocky structure or is massive.

The Wabash soils have moderately high available moisture capacity. They are very slowly permeable. The supply of available nitrogen is low or medium, that of phosphorus is very low, and that of potassium generally is medium. The surface layer is neutral or slightly acid in reaction.

Representative profile of a Wabash silty clay, 240 feet west and 405 feet north of the southeast corner of the SW¼SE¼ of section 11, T. 95 N., R. 36 W., on a nearly level slope, in a cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay; cloddy but breaks to weak, fine, granular structure; friable to firm; slightly acid; gradual, smooth boundary.

A12—7 to 13 inches, black (N 2/0) silty clay; very weak, fine and medium, subangular blocky structure that breaks to moderate, very fine and fine, granular; friable to firm; neutral; diffuse, smooth boundary.

B21g—13 to 20 inches, black (N 2/0) silty clay; moderate, very fine, subangular blocky structure; firm; neutral; diffuse, smooth boundary.

B22g—20 to 29 inches, black (N 2/0) silty clay; moderate, very fine and fine, subangular blocky structure; firm to very firm; neutral; diffuse, smooth boundary.

B23g—29 to 36 inches, black (N 2/0) silty clay; weak to moderate, very fine and fine, subangular blocky structure; firm; neutral; diffuse, smooth boundary.

C1g—36 to 40 inches, very dark gray (N 3/0) silty clay; very weak, fine, subangular blocky structure; firm; neutral; diffuse, smooth boundary.

C2g—40 to 50 inches, very dark gray (5Y 3/1) silty clay; very weak, fine, subangular blocky structure or massive; firm; neutral.

The A horizon ranges from 12 to 20 inches in thickness. The B horizon ranges from black (10YR 2/1 or 5Y 2/1) to very dark gray (10YR 3/1 or N 3/0). Structure ranges from moderate or strong subangular blocky to angular blocky throughout much of this horizon. Colors that are very dark gray or darker are as deep as 40 inches or more. The C horizon occurs at a depth of 35 to 45 inches.

Wabash soils are finer textured, are more poorly drained, and have stronger structure than the Colo soils.

Wabash silty clay (0 to 2 percent slopes) (Wb).—This nearly level soil is on bottom lands or in slight depressions. It is not extensive, but the areas are fairly large in size. It occurs mainly with the Colo soils. In many places this soil is too wet for good growth of crops, and fieldwork is often delayed. Drainage with tile normally is not feasible, because the subsoil is very slowly permeable and adequate outlets are lacking. In many places the water table is near the surface and is nearly at the same level as the water in nearby streams. In these places tile drains do not function. In areas where tile drains can be used, spacing of the lines should be closer in this soil than in most other poorly drained soils. In some places drainage can be improved by using shallow ditches.

Where flooding is not too frequent and drainage is improved, this soil is suited to cultivated crops. The cultivated areas generally are used for row crops, for which they are well suited. Areas not suitable for cultivation can be used for pasture. The surface layer is clayey and difficult to work. If it is tilled when wet, it becomes cloddy. Because the subsoil is rich in clay, the movement of air and water is restricted. The frequency of flooding varies, depending on how far this soil is from the streams. (Capability unit IIIw-3)

Wacousta Series

The Wacousta series consists of very poorly drained soils in large depressions in the uplands. These depressions are the beds of former shallow lakes. These soils developed in silty, water-worked glacial sediment or local alluvium under native swamp grasses and sedges.

In a typical profile, the surface layer is black, friable to firm silty clay loam about 15 inches thick. It has granular and subangular blocky structure. The subsoil is olive-gray, friable silty clay loam with some streaks of yellowish brown and strong brown in old root channels. The calcareous substratum begins at a depth of about 23 inches. It is gray to olive-gray, friable silty clay loam that has mottles of olive, yellowish brown, and strong brown. The substratum has subangular blocky structure or is massive.

The Wacousta soils have high available moisture capacity. They are moderately or moderately slowly permeable. The supply of available nitrogen generally is medium or low, that of available phosphorus is low or very low, and that of potassium is low or medium. The surface layer generally is neutral or slightly acid in reaction.

Representative profile of Wacousta silty clay loam, 510 feet west and 80 feet south of the northeast corner of the NE¼ of section 4, T. 96 N., R. 35 W., in a nearly level depression in a cultivated field:

Ap—0 to 8 inches, black (N 2/0) light silty clay loam; weak, medium, subangular blocky structure that breaks to weak, fine, granular; friable to firm; slightly acid; gradual, smooth boundary.

A12—8 to 15 inches, black (N 2/0) silty clay loam, with some olive gray (5Y 4/2) in the lower part; weak, medium and coarse, subangular blocky structure; firm; neutral; clear, wavy boundary.

B2g—15 to 23 inches, olive-gray (5Y 4/2) heavy silty clay loam; a few yellowish-brown (10YR 5/8) and strong-brown (7.5YR 5/8) streaks in small, old root channels; very weak, fine and medium, subangular blocky structure; friable; few black (N 2/0) worm casts; moderately alkaline; noncalcareous; clear, smooth boundary.

C1g—23 to 30 inches, gray (5Y 5/1) or olive-gray (5Y 5/2) silty clay loam; common, fine, faint mottles of olive (5Y 5/3), few, fine, distinct mottles of yellowish brown (10YR 5/8), and few, fine, distinct mottles of strong brown (7.5YR 5/8) except for a layer between 25 and 28 inches which is strongly mottled with about 60 percent yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8); few very dark brown (10YR 2/2) streaks; weak, fine and medium, subangular blocky structure; friable; many, very fine and few, fine, tubular pores; moderately alkaline; calcareous; gradual, smooth boundary.

C2cag—30 to 48 inches, olive-gray (5Y 5/2) light silty clay loam; few, medium, distinct mottles of strong brown (7.5YR 5/6), common to few, fine, faint mottles of olive (5Y 4/3), and few, fine, faint mottles of dark yellowish brown (10YR 4/4); weak, fine and medium, subangular blocky structure in the upper part and massive in the lower part; common, fine, soft and hard concretions of carbonate; moderately alkaline; calcareous.

The A horizon ranges from heavy silt loam to light silty clay loam in texture and from 8 to 18 inches in thickness. The B2g horizon ranges from very dark gray (10YR 3/1) to olive gray (5Y 5/2) in color and has mottles of olive brown and strong brown. Depth to the calcareous C horizon ranges from 20 to 25 inches. In many places the C horizon is somewhat stratified. This horizon ranges from silt loam to silty clay loam in texture, and in many places it contains enough sand to feel gritty. Secondary carbonates occur in the B horizon or upper part of the C horizon, but the amount is only slightly more than the amount in the lower part of the C horizon.

The Wacousta soils have a thinner surface layer and solum than the Glencoe or Okoboji soils.

Wacousta silty clay loam (0 to 1 percent slopes) (Wa).—This soil occupies a large depression that was the bed of a large former shallow lake. It is not extensive. On the rim of the depression are narrow areas of the highly calcareous Harps soils. Included with this soil in mapping were a few areas that are calcareous throughout the profile.

This soil is very poorly drained. Crops may be damaged seriously by ponding after heavy rains. The subsoil is permeable enough for tile drains to function well where outlets are suitable. Water can be removed from the surface by open intakes to tile lines or by shallow ditches.

This soil can be used for row crops much of the time. Growth of crops is fairly good if drainage is adequate. Under good management, good tilth is easy to maintain. (Capability unit IIIw–1)

Wadena Series

The Wadena series consists of well-drained, nearly level to moderately steep soils in outwash areas and stream benches. These soils developed under native prairie grasses in medium-textured outwash that overlies sand or gravel. They are most extensive in the northwestern part of the county, but they also occur in the eastern and southwestern parts.

In a typical profile, the surface layer is very dark brown, friable loam about 11 inches thick. It has granular structure. The subsoil extends to a depth of about 35 inches. It is very dark grayish brown in the upper part and dark brown or brown in the lower part. The texture ranges from loam to sandy loam. The subsoil has very weak prismatic or subangular blocky structure. The underlying material is brown and dark yellowish-brown, loose, calcareous sand and gravel.

The available moisture capacity of the Wadena soils is medium to high, depending on the depth to sand or gravel. These soils are moderately permeable above the sand or gravel, but permeability of the sand and gravel is rapid to very rapid. The supply of nitrogen and phosphorus generally is low, and the supply of potassium is medium. The surface layer of the Wadena soils is medium acid to neutral in reaction.

Representative profile of a Wadena loam, 80 feet east of a point in the center of a road 0.1 mile south of the northwest corner of the SW¼ of section 9, T. 96 N., R. 37 W., on a slope of less than 1 percent, in a cultivated field:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when dry; cloddy but breaks to weak, fine, granular structure; friable; sand grains not coated; medium acid; gradual, smooth boundary.

A3—8 to 11 inches, very dark brown (10YR 2/2) loam; very dark grayish brown (10YR 3/2) with small spots of dark grayish brown (10YR 4/2) when dry; nearly massive in place but breaks readily to weak, fine, granular structure; friable; common, dark, spherical worm casts; few dark-brown spots approximately 0.5 centimeter in diameter of color from horizon below; horizontal parting in the upper part indicates a plowsole; medium acid; gradual, smooth boundary.

B1—11 to 15 inches, about 65 percent very dark grayish-brown (10YR 3/2) and about 35 percent very dark brown (10YR 2/2) loam; dark grayish brown (10YR 4/2) and brown (10YR 4/3) when dry; nearly massive but breaks to very weak, subangular blocky structure; cleavage more evident along horizontal and vertical planes than along diagonal ones; friable; medium acid; gradual, smooth boundary.

B2—15 to 22 inches, dark-brown (10YR 3/3) to brown (10YR 4/3) loam; brown (10YR 4/3) when kneaded; vertical cleavage indicates very weak, prismatic structure; horizontal cleavage very weak; friable to firm in place, friable when disturbed; smooth, patchy, dark-brown to very dark brown coats on sand grains and fine pebbles, on cleavage faces, and in some fine pores; these coats may be thin clay films but are not thick enough to be seen in cross section; very dark brown worm casts in the upper part; slightly acid; gradual to clear, smooth boundary.

I&IIB31—22 to 26 inches, dark-brown (10YR 3/3) to brown (10 YR 4/3) sandy loam; massive but has very weak vertical cleavage; friable; smooth, patchy dark-brown to very dark brown coats on fine pebbles in pores, and on cleavage faces as in horizon above; neutral; clear, smooth boundary.

IIB32—26 to 35 inches, dark-brown (10YR 3/3) sand; single grain; very friable but slightly coherent; smooth, patchy, dark-brown coats on coarse sand grains and fine pebbles may be clay films; upper half of horizon slightly more coherent and probably slightly finer textured than the lower half; mildly alkaline; calcareous; clear, smooth boundary.

IIC—35 to 55 inches, dark yellowish-brown (10YR 4/4) and brown (10YR 5/3) stratified sand and fine gravel; strata range from 3 to 10 inches in thickness; single grain; loose; films of carbonate about 0.1 to 0.5 millimeter thick cement small clusters of sand to the lower surface of many pebbles, but films and distinctly brownish colors diminish with depth below about 55 inches; strongly alkaline; calcareous.

A krotovina occurs in the B2 and B3 horizons. It is about 18 inches long and 12 inches across at the top but tapers to about 6 inches at the bottom. The soil material in the krotovina is darker colored and apparently is richer in organic matter than the typical soil material in these horizons.

The A horizon ranges from about 7 to 14 inches in thickness. In color, it ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The B horizon ranges from dark brown (10YR 3/3) or brown (10YR 4/3) to dark yellowish brown (10YR 4/4) with some grayish brown in the upper part. The texture of the B horizon typically is loam but ranges in places to sandy loam or sand in the lower part. The underlying material occurs between a depth of 22 and 42 inches. This material generally is sand mixed with gravel, but in places it is sand or loamy sand and a little gravel. In most places it is calcareous.

The Wadena soils have a finer textured subsoil than the Dickinson soils and a coarser textured substratum. Unlike the Waukegan soils, the Wadena soils have gravel in the substratum.

Wadena loam, deep, 0 to 2 percent slopes (WdA).—This nearly level, well-drained soil is in outwash areas and on stream benches. It generally occurs with the moderately deep Wadena, the Cylinder, or the Biscay soils. The depth to sand and gravel typically is 36 to 42 inches. Included with this soil in mapping were areas where the depth to gravel is slightly less than 36 inches and areas where it is as much as 48 inches.

This soil generally is cultivated. Row crops can be grown much of the time, and growth of crops is moderate to good under a high level of management. Some areas are slightly droughty in seasons when rainfall is average, but in most areas the available moisture capacity is adequate. Erosion is not a hazard. (Capability unit I–2)

Wadena loam, deep, 2 to 5 percent slopes (WdB).—This well-drained, gently undulating soil is in outwash areas and on stream benches. It generally occurs with other Wadena soils. Included with this soil in mapping were a few areas where the depth to sand and gravel is less than 36 inches and some where it is as much as 48 inches. Some areas are slightly droughty in seasons when rainfall is average, but in most areas the available moisture capacity is adequate.

Most areas of this soil are cultivated. Erosion is a slight hazard. If erosion is controlled by contour farming or terracing and a high level of fertility is maintained, row crops can be grown much of the time. Growth of crops is moderate to good if management is good. (Capability unit IIe–1)

Wadena loam, moderately deep, 0 to 2 percent slopes (WmA).—This is the most extensive Wadena soil in the county, and the areas generally are large. It is the main soil in the nearly level, broad outwash areas in the northwestern part of the county, but it also occurs on stream benches and glacial outwash areas in the rest of the county. It occurs chiefly with the somewhat poorly drained Cylinder and the poorly drained Biscay soils. In a few places this soil occupies 75 percent or more of a section. In other areas, however, the size varies and in places is only a few acres.

This soil is well drained and is often droughty, even in years when rainfall is normal. Row crops can be grown much of the time, but growth of crops is only moderate, even if management is good. This soil is well suited to irrigated crops, and sprinklers are used by a few farmers in the county. (Capability unit IIs–1)

Wadena loam, moderately deep, 2 to 5 percent slopes (WmB).—This gently sloping to gently undulating soil is mainly in outwash areas and on stream benches, but small areas are in glacial outwash in the uplands. It generally occurs with the Cylinder or other Wadena soils. The slopes vary in length but are usually short. In the uplands the profile of this soil is much the same as the profile on the outwash benches, but the coarse-textured underlying material is not so thick. On the average, this soil has a slightly thinner surface layer than the soil described as typical for the series, but other features are similar. In many places it is droughty, even in years when rainfall is normal. The hazard of erosion is slight.

Most areas of this soil are cultivated, but some are in permanent pasture. Row crops can be grown much of the time, but the growth of crops is only moderate. If row crops are grown, contour farming is needed to reduce runoff and erosion. In most places terracing is not feasible, because it would expose the droughty, coarse-textured under lying material in the terrace channels. The growth of crops is very poor on this material. (Capability unit IIe–2)

Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded (WmC2).—This soil generally occurs in outwash areas on breaks between one level and another or between these areas and bottom lands. In a few places it occurs as knobs or low hills. This soil generally occurs with the other Wadena soils or Cylinder soils. The Colo soils or the Colo-Terril complex of soils are on bottom lands. In the outwash areas this soil generally has short single slopes, but on the knobs and hills the slopes in most places are complex and gently rolling. The surface layer of this soil is only about 2 to 7 inches thick. It is somewhat lighter colored than that of the soil described as typical for the series because some of the subsoil material has been mixed into this layer. A few areas were included with this soil in mapping that have a surface layer 7 to 12 inches thick.

This soil is droughty and susceptible to moderate erosion. It is suited to cultivated crops and can be used for row crops part of the time. Growth of crops generally is poor. Contour farming is needed to reduce runoff and to control erosion. Terracing is likely to expose the droughty underlying material in the terrace channels. The growth of crops on this material is very poor. (Capability unit IIIe-3)

Wadena loam, moderately deep, 9 to 15 percent slopes, moderately eroded (WmD2).—This soil is mostly in outwash areas. It is on short sloping breaks between one level of outwash and another or between the outwash areas and bottom lands. It is generally with other Wadena soils, Colo soils, or the Colo-Terril complex of soils. The surface layer is only 2 to 7 inches thick and is somewhat lighter colored and thinner than that of the soil described as typical for the series. In some places the subsoil is more dark yellowish brown than normal, and in places the underlying sand and gravel is a few inches closer to the surface. One or two small areas were included with this soil in mapping where the depth to sand and gravel is more than 36 inches.

This soil is very droughty, and the hazard of erosion is high. Many areas are in cultivated crops, but some are in permanent pasture. Growth of crops is poor. This soil is better suited to semipermanent hay or pasture plants than to row crops, but an occasional year of row crops can be grown if erosion is controlled. (Capability unit IVe-2)

Waukegan Series

The Waukegan series consists of dark-colored, well-drained, nearly level to gently sloping soils in the uplands. These soils developed under native prairie grasses in loamy glacial sediment that overlies loamy sand or sandy loam at a depth of 24 to 30 inches. They are mainly in the northwestern part of the county, but they also occur in the north-central and east-central parts.

In a typical profile, the surface layer is black to very dark brown, friable to firm loam about 11 inches thick. It has granular structure. The subsoil is very dark brown to brown, friable loam to a depth of about 24 inches. From 24 to about 30 inches it is dark yellowish-brown sandy loam. The subsoil has subangular blocky structure. The substratum is dark yellowish-brown loamy sand.

The Waukegan soils have medium available moisture capacity. They are moderately permeable in the loam layers and moderately rapidly or rapidly permeable in the sandy loam and loamy sand layers. The supply of available nitrogen, phosphorus, and potassium generally is low. The surface layer generally is slightly acid or medium acid.

Representative profile of a Waukegan loam, 285 feet east and 27 feet south of the northwest corner of the SW¼ of section 4, T. 97 N., R. 38 W., on an east-facing slope of about 1 or 2 percent, in a cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; cloddy but breaks to weak, fine, granular structure; firm; common wormholes and worm casts; slightly acid; clear, smooth boundary.

A12—7 to 11 inches, very dark brown (10YR 2/2) loam; slightly cloddy but breaks to weak, fine, granular structure; friable to firm; many wormholes and worm casts; slightly acid; gradual, smooth boundary.

B1—11 to 16 inches, loam; ped exteriors are mainly very dark brown (10YR 2/2) and dark brown (10YR 3/3) in the upper part and dark brown (10YR 3/3) and brown (10YR 4/3) in the lower part; ped interiors are dark brown (10YR 3/3) and brown (10YR 4/3); weak, fine and very fine, subangular blocky and weak, fine, granular structure; friable; common, very fine and few, fine, tubular pores; medium acid; gradual, smooth boundary.

B21—16 to 24 inches, brown (10YR 4/3) loam; few very dark brown (10YR 2/2) peds and worm casts; very weak, fine and medium, subangular blocky structure; friable; many, very fine and few, fine, tubular pores; medium acid; gradual, smooth boundary.

IIB22—24 to 30 inches, dark yellowish-brown (10YR 4/4) sandy loam, yellowish brown (10YR 5/4 to 5/6) when dry; very weak, medium and coarse, subangular blocky structure; friable, slightly hard when dry; few to common, very fine, tubular pores; medium acid; gradual, smooth boundary.

IIC—30 to 55 inches, dark yellowish-brown (10YR 4/4) heavy loamy sand; mostly massive but tends to break to very weak, medium and coarse, subangular blocky structure; very friable, slightly hard when dry; medium acid.

Silt loam outwash material is at a depth of 60 to 80 inches.

The A horizon ranges from about 5 to 12 inches in thickness and from black (10YR 2/1) to very dark brown (10YR 2/2) in color. Depth to sandy loam or loamy sand ranges from 24 to 30 inches, and this material generally extends below a depth of 50 inches. Beneath this material is silty outwash, which, in turn, is underlain by glacial till, generally at a depth of 50 to 100 inches. The average depth to the till is about 80 to 90 inches. In a few places, the coarse-textured material directly overlies the till. Both the silty outwash and glacial till are calcareous.

Unlike the Wadena soils, Waukegan soils do not have gravel in the underlying layers. The Waukegan soils mainly have a loam subsoil, whereas the Dickinson soils have a sandy loam subsoil.

Waukegan loam, moderately deep, 0 to 2 percent slopes (WuA).—This nearly level soil is in the uplands. It generally occurs with the Ocheyedan, Dickinson, Everly, and other Waukegan soils. In places it is adjacent to areas of the Fostoria soils. A few small areas were included with this soil in mapping that are only about 18 inches deep to the underlying sandy loam.

This soil has medium available moisture capacity. It is droughty, especially in years when rainfall is below average. In years when rainfall is above average, growth of crops is good. Most areas of this soil are cultivated. If adequate fertility is maintained, row crops can be grown much of the time. (Capability unit IIs-1)

Waukegan loam, moderately deep, 2 to 5 percent slopes (WuB).—This soil has gentle slopes that range from short to fairly long. It is generally adjacent to other Waukegan soils, or to the Ocheyedan, Dickinson, Fostoria, or Everly soils. In many places the surface layer of this soil is a few inches thinner than that in the profile described as typical for the Waukegan series.

This soil has medium available moisture capacity. It is droughty, especially in years when rainfall is below average, but when rainfall is above average, growth of crops is good.

Because the hazard of erosion is slight, tillage should be on the contour. Most of the areas of this soil are used for cultivated crops. Row crops can be grown much of the time if erosion is controlled and fertility is maintained. (Capability unit IIe-2)

Webster Series

The Webster series consists of nearly level, poorly drained, dark-colored soils. These soils are mainly on the undulating till plain in the eastern part of the county, but some areas are in the uplands and outwash areas in the northwestern and north-central parts.

In a typical profile, the surface layer is black, friable to firm silty clay loam that feels gritty and is about 21 inches thick. It has granular and subangular blocky structure. The subsoil is dark-gray to olive-gray, friable, mottled silty clay loam that feels gritty. It has subangular blocky structure and is calcareous in the lower part. The substratum is gray to olive-gray, friable clay loam and heavy loam and is calcareous. It is massive or has very weak subangular blocky structure.

The Webster soils have high available moisture capacity. They are moderately slowly permeable. The supply of available nitrogen and potassium generally is low or medium, and the supply of available phosphorus is low or very low. The surface layer is about neutral in reaction.

Representative profile of a Webster silty clay loam, 297 feet west and 449 feet south of the northeast corner of the NW¼ of section 19, T. 94 N., R. 35 W., on a slope of about 1 percent, in a cultivated field:

Ap—0 to 8 inches, black (N 2/0) silty clay loam; cloddy but breaks to weak, fine, granular structure; firm; neutral; clear, smooth boundary.

A12—8 to 15 inches, black (N 2/0) silty clay loam; very weak, medium, subangular blocky structure that breaks to moderate, fine, granular and moderate, very fine, subangular blocky; friable; neutral; gradual, smooth boundary.

A13—15 to 21 inches, about 60 percent black (10YR 2/1) and about 40 percent very dark gray (5Y 3/1) silty clay loam; weak, medium, subangular blocky structure that breaks to weak, fine, granular and weak, very fine, subangular blocky; friable; neutral; gradual, smooth boundary.

B21g—21 to 29 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) silty clay loam; few, small, olive-gray (5Y 5/2) areas; few black (N 2/0) and very dark gray (N 3/0) worm casts; weak, fine and very fine, subangular blocky structure; friable; mildly alkaline; noncalcareous; clear, smooth boundary.

B3g—29 to 35 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; few, small, dark-gray (5Y 4/1) areas in the upper part; common, fine, distinct mottles of olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4); weak, medium to coarse, subangular blocky structure; friable; common to many, very fine, tubular pores; few, small, soft concretions of carbonate; few, fine, very dark brown concretions of soft oxide; moderately alkaline; calcareous; gradual, smooth boundary.

Clcag—35 to 42 inches, gray (5Y 5/1) clay loam; common, fine, distinct mottles of olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) and few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium to coarse, subangular blocky structure; friable; common to many, very fine, tubular pores; many small concretions of soft carbonate; few, fine, very dark brown concretions of soft oxide; moderately alkaline; calcareous; gradual, smooth boundary.

C2g—42 to 50 inches, olive-gray (5Y 5/2) light clay loam or heavy loam; common, fine, distinct mottles of yellowish brown (10YR 5/6), few, fine, distinct mottles of yellowish brown (10YR 5/8), and few, fine, distinct mottles of olive brown (2.5Y 4/4); very weak, medium, subangular blocky structure or massive; friable; few, small, soft concretions of carbonate; few, fine, dark concretions of soft oxide; moderately alkaline; calcareous; clear, smooth boundary.

C3—50 to 58 inches, gray (5Y 5/1), light olive-brown (2.5Y 5/4 and 5/6), and yellowish-brown (10YR 5/6 and 5/8) stratified clay loam and silt loam that has a 2-inch lens of loamy sand in the lower part; colors are in a very complex mottled pattern; a few, fine mottles of strong brown (7.5YR 5/8); massive; friable; common, fine, very dark brown concretions of soft oxide; moderately alkaline; calcareous.

The A horizon generally is black (N 2/0) but ranges to very dark gray (10YR 3/1) in the lower part. This layer typically is silty clay loam in texture but ranges to clay loam. Colors in the B horizon mainly are dark gray, gray, or olive gray but range to grayish brown and olive. Mottles are common in the B horizon and range widely in color. In texture, this horizon ranges from silty clay loam to clay loam. The C horizon generally is somewhat stratified and contains lenses of silt, sandy loam, or loamy sand. Friable to firm glacial till generally is at a depth between 40 and 60 inches, but in some places it is deeper. The depth to carbonates generally varies between 24 and 40 inches. Secondary carbonates may occur in the upper horizons, but the amount generally is not much more than the amount in the lower C horizon.

Unlike the Canisteo soils, Webster soils are not calcareous throughout their profile. The Webster soils have a somewhat finer textured subsoil and are darker colored in the lower subsoil and substratum than the Tripoli soils.

Webster silty clay loam (0 to 2 percent slopes) (Wy).—This nearly level soil is mainly on the undulating till plain in the eastern part of the county, but it also occurs in the uplands and glacial outwash areas in the north-central and northwestern parts (fig. 10). It is extensive, and the size and shape of the areas vary widely. Some areas are large and fairly broad, but most are long and fairly narrow. They range from few to many acres in size. This soil generally is with the Canisteo, the somewhat poorly drained Nicollet, or the well-drained Clarion soils. In some places, however, it occurs with the Fostoria, Ocheyedan, Waukegan, Guckeen, or Marna soils.

This soil is used mostly for crops, but tile drainage is needed. Row crops can be grown much of the time. Growth of crops is good where this soil is tile drained and properly managed. If this soil is plowed when wet, it tends to be cloddy and hard to work when it dries. Plowing in fall is a common practice because freezing and thawing break the clods into a better structure. (Capability unit IIw-2)

Use and Management of the Soils

This section is designed to help the landowner understand how soils behave and how they can be used. In it are discussed the use and management of soils for crops and pasture, for woodland, for wildlife, and for engineering works. Specific management is not suggested in this section for each soil. Suggestions for the use of each soil are given in the section "Descriptions of the Soils."

Use of Soils for Crops and Pasture

This subsection has three main parts. The first part explains the capability grouping of soils. In the second, the soils are placed in capability units, and the use and management of these are discussed. In the third part, predicted yields of the principal crops are given for each soil under a high level of management.

Capability Groups of Soils

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 are used for the ordinary field crops or sown pastures, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have special requirements for production. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation.

In the capability system, all soils are grouped at three levels, the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

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

- Class I. Soils have few limitations that restrict their use.
- Class II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices.
- Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.
- Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Class VII. Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.
- 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, or water supply, or to esthetic purposes. (None in Clay County.)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* is used in those areas where climate is the chief limitation to the production of common cultivated crops. Information on artificial drainage can be obtained through the local office of the Soil Conservation Service, from the Clay County extension director, or from the Iowa Drainage Guide (*4*).

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

***Figure 10.*—Profile of Webster silty clay loam. The dark-colored thick surface layer is typical.**

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

Management of soils by capability units

On the following pages the capability units, or groups of soils that have similar management requirements, are described; some limitations are given; and suitable management is briefly discussed. The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all soils of a given series appear in the unit. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of the survey. 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, well drained, moderately well drained and somewhat poorly drained, dark-colored soils that have a high available moisture capacity. They are in the Cylinder, Fostoria, Galva, Nicollet, and Primghar series. Movement of air and water through these soils is generally good. The organic-matter content is medium to high. These soils are generally in good tilth and are easy to work.

The soils in this unit are used mostly for cultivated crops, for which they are well suited. Corn and soybeans are the major crops, but these soils are also suited to grain sorghum and oats and to alfalfa, red clover, bromegrass, and other hay and pasture plants. Crops grow well on these soils. The soils in this unit can be used for row crops much of the time. Some of these soils are wet when rainfall is above average, and they benefit from tile drainage. Although erosion ordinarily is not a hazard, contour farming may be desirable on long slopes where row cropping is intensive. An occasional year of meadow improves tilth and helps to control weeds and insects.

Where corn is to be planted in spring, some farmers plow these soils the preceding fall. Although this plowing subjects the soils to blowing, blowing is reduced by leaving a roughened plowed surface and unplowed strips in vegetation.

Lime is needed on some soils in this unit, because reaction ranges from medium acid to neutral. In general, these soils are low in available nitrogen and phosphorus and range from low to high in available potassium. The response of plants to added fertilizer is good. Normally, nitrogen and phosphate are needed for corn that does not follow a legume.

CAPABILITY UNIT I-2

This unit consists of nearly level, well-drained, dark-colored soils that are moderately permeable and have a high available moisture capacity. They are in the Galva, Ladoga, Ocheyedan, and Wadena series. Tilth and aeration generally are good, and the soils are easy to work. These soils warm early in spring and can be worked fairly soon after rains.

Nearly all the acreage is used mainly for row crops, though areas are large enough to be farmed separately in only a few places. These soils are suited to all crops commonly grown in the county, especially corn and soybeans. Although erosion ordinarily is not a hazard, the Galva soils have long slopes in places, and contour farming is needed for row crops. The Wadena soils are only about 36 inches deep to sandy or gravelly material, and they are somewhat more droughty in dry years than the other soils in this unit. Their available moisture capacity is about medium.

If they are managed well and adequately fertilized, the soils in this unit can be used for row crops much of the time. An occasional year of meadow improves tilth and helps to control insects and diseases.

Lime is needed on some of the soils in this unit because they are slightly acid or medium acid. The supply of available nitrogen and phosphorus is generally low, and that of available potassium is medium or high. Fertilizer is needed where these soils are under intensive row cropping. Nitrogen and phosphate are needed where corn does not follow a legume. The response of crops to fertilizer is good.

CAPABILITY UNIT I-3

This unit consists of nearly level, somewhat poorly drained and moderately well drained, dark-colored soils in the Guckeen series. They have high available moisture capacity. These soils have a fine-textured subsoil in which permeability is slow or very slow. Some have a clayey substratum. These soils generally are in good tilth, but they become puddled if they are worked when wet, and they are cloddy and hard when they dry. They warm later in spring and dry more slowly after rains than the soils in capability units I-1 and I-2. In wet years some areas would benefit from tile drains. Tile does not function well in soils that have a silty clay substratum.

These soils are used mostly for crops, mainly row crops. They are well suited to corn and soybeans, but grain sorghum, oats, and the common hay and pasture plants are also grown. Crops grow well on these soils.

The soils in this unit can be used for row crops much of the time. An occasional year of meadow improves tilth and helps to control weeds and insects.

Lime is needed for some crops, because these soils are slightly acid, but the amount generally is small. The available nitrogen and phosphorus generally are low, and available potassium is low or medium. Fertilizer is needed where these soils are under intensive row cropping. Nitrogen and phosphate are needed where corn does not follow a legume. Small grains respond well to phosphate.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping and undulating, well-drained, dark-colored soils that have high available moisture capacity. They are in the Clarion, Everly, Ocheyedan, Sac, Terril, and Wadena series. Slopes range from 2 to 5 percent. These soils absorb rainfall readily, and permeability is moderate. They are generally in good tilth and are easy to work. The organic-matter content is medium to high.

The soils in this unit are used mainly for cultivated crops, but some are in permanent pasture. They are suited to corn, soybeans, oats, and grain sorghum, and to alfalfa, bromegrass, and other hay and pasture plants. Because they occur with steep soils that are used for permanent pasture, the Terril soils generally are used for pasture. The Clarion and Ocheyedan soils generally are in areas too small to be farmed separately, and they are farmed in the same way as adjacent soils. In places the Sac and the Everly soils occupy nearly all of a field.

The soils in this unit can be used for row crops much of the time if terracing and farming on the contour are used (fig. 11). Diversion terraces can be used in places to protect Terril soils. Because slopes of Clarion soils are irregular, laying out and building terraces in places is difficult. In most places, however, terraces are best for controlling erosion. Grassed waterways are needed in places for conducting runoff to a safe disposal area.

On terraced soils, row crops can be grown much of the time. Where only contour farming is used to control erosion, more close-growing crops and fewer row crops need to be grown.

The need for lime on the soils in this unit varies because reaction ranges from medium acid to neutral. These soils generally are low in available nitrogen and phosphorus, but available potassium ranges from low to high. Phosphate is needed for most crops, but the need for potash varies. Nitrogen ordinarily is needed for corn that does not follow a legume. Good tilth can be maintained on most of these soils by returning all crop residue, but moderately eroded areas benefit from added manure.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping, well-drained soils in the Wadena and Waukegan series. They are sandy or gravelly in the subsoil or underlying material. They are friable and easy to till. Permeability is moderate in the upper part of the profile and moderately rapid to very rapid in the underlying material. These soils have medium available moisture capacity and are droughty. They contain a small to medium amount of organic matter. They warm early in spring and can be tilled soon after rains. Slopes range from 2 to 5 percent, and the soils are slightly susceptible to erosion.

Most areas of these soils are used for crops, though areas are large enough to be farmed separately in only a few places. These soils are suited to corn, soybeans, grain sorghum, and oats and to alfalfa and other hay and pasture plants. Growth of crops generally is moderate because of droughtiness and low fertility. Stands of corn should be thinner on these soils than on the less droughty soils.

Where the soils in this unit are used for row crops, terracing or contour farming is needed. These practices help to control erosion and to conserve moisture. In building terraces, deep cuts should be avoided because the sandy or gravelly underlying material can hold only a small amount of water available to plants. On terraced soils, row crops can be grown much of the time. Where only contour farming is used to control erosion, more close-growing crops and fewer row crops need to be grown.

These soils generally are slightly acid or medium acid. They are low in available nitrogen and phosphorus and low or medium in potassium. Organic matter, either as barnyard manure or crop residue, lime, and fertilizer are

Figure 11.—**Parallel terraces on Clarion loam, 2 to 5 percent slopes. This soil is in capability unit IIe-1.**

needed. Adding large amounts of fertilizer is not economical, because the soils are droughty, but the response of crops to moderate amounts is fairly good.

CAPABILITY UNIT IIe-3

This unit consists of gently sloping, somewhat poorly drained to moderately well drained, dark-colored soils in the Guckeen series. These soils have a clayey subsoil; some have a clayey substratum. Slopes range from 2 to 5 percent. The available moisture capacity is high. These soils are fairly easy to work, but tilth generally is not so good as that of the soils in capability unit IIe-1. Permeability is slow or very slow in the clayey layers of these soils, which are firm and restricts the movement of water. In places this clayey material extends to a depth of 4 feet or more. These soils tend to warm somewhat more slowly in spring than the soils in capability unit IIe-1.

The soils of this unit are used mainly for row crops, for which they are well suited. They are suited to corn, soybeans, grain sorghum, and oats, and to alfalfa, bromegrass, and other hay and pasture plants. These soils can be used for row crops much of the time. Although a few places are somewhat wet in wet periods, tile drains are seldom used.

Where these soils are used for row crops, terracing or tilling on the contour is needed. Where cuts in building terraces expose the clayey subsoil, fertility can be restored by spreading topsoil and large amounts of manure over the cuts. On terraced soils, row crops can be grown much of the time. Where only contour farming is used to control erosion, more close-growing crops and fewer row crops need to be grown.

Lime is needed for some crops because most of these soils are slightly acid, but the amount generally is small. The available nitrogen and phosphorus generally are low, and the available potassium is low or medium. Fertilizer is needed on these soils under intensive row cropping. Crops respond well to added fertilizer. Nitrogen is needed where corn does not follow a legume.

CAPABILITY UNIT IIw-1

This unit consists of Calco, Colo, Spillville, and Terril soils. The Terril soils are in the Colo-Terril complex of soils. These are mainly nearly level soils on bottom lands, but the Colo-Terril complex is gently sloping. The Colo and Calco soils are poorly drained, the Terril soils are moderately well drained, and Spillville soils are moderately well drained to somewhat poorly drained. These soils have a thick, dark-colored surface layer of silty clay loam or loam. Permeability is moderate in the Spillville and Terril soils and moderately slow in the Calco and Colo soils. These soils are high in organic-matter content and available moisture capacity.

Most areas of this unit are used for crops, but some areas are in permanent pasture and some are wooded. The wooded areas are generally managed in the same way as the surrounding pasture. Corn, soybeans, grain sorghum, and small grains and hay and pasture plants are well suited. Row crops are grown much of the time. These soils generally are in areas large enough to be farmed separately, but the intermingled areas of Colo and Terril soils are small and are in narrow stream bottoms or drainageways. These areas are managed in the same way as the surrounding soils. The soils of this unit generally dry late in spring, and in some years planting is delayed. Tilth generally is good, but these soils become puddled if they are worked when wet, and they are cloddy and hard when they dry. In places where wetness is expected to delay tillage in spring, these soils are plowed the preceding fall.

A high water table, flooding, or both keep these soils wet most of the time. The frequency of flooding varies from place to place. Although the Spillville soils are flooded occasionally, they do not stay wet so long as the Calco and Colo soils. Ditches, dikes, and stream channel improvement can be used to help control flooding. Except on the Spillville soils, improved drainage is needed. Tile drains function well where the outlets are not covered by floodwater during periods of heavy rainfall. Crops grow better and the soils are easier to manage where drainage is improved, but many areas are farmed without drainage and without protection from flooding. Growth of crops ranges from medium to good, depending on drainage and the frequency of flooding. Runoff from higher lying soils runs across these soils in places. Diversion terraces can be built at the base of slopes to intercept this runoff and divert it to a safe disposal area. Streambank cutting occurs along the channels in places.

If adequate amounts of fertilizer are applied, these soils can be used for row crops much of the time. An occasional year of meadow improves tilth and helps to control weeds and insects. Some areas of these soils that now are wooded or in brushy pasture or bluegrass can be cleared, drained, and protected from flooding; then, they can be used for crops.

Lime generally is not needed, because these soils range from slightly acid to moderately alkaline. The available nitrogen generally is low or medium, available phosphorous generally is low or very low, and available potassium is very low or medium. Fertilizer is needed where these soils are under intensive row cropping. Where corn does not follow a legume, nitrogen is needed. Crops on these soils generally respond to added phosphate. Potash is needed, but generally in smaller amounts than nitrogen or phosphate.

CAPABILITY UNIT IIw-2

This unit consists of nearly level, poorly drained soils on uplands and outwash areas. These soils are in the Afton, Canisteo, Colo, Marcus, Tripoli, and Webster series. The Colo soils are gently sloping. These soils have a dark-colored silty clay loam or clay loam surface layer. Available moisture capacity is high, and permeability is moderately slow. The water table is often temporarily high, and runoff is slow. Unless drainage is improved, these soils generally are not suited to cultivation. They tend to warm somewhat more slowly in spring than better drained soils, and they dry more slowly after rains. In years when rainfall is heavy, planting may be delayed. The organic-matter content of these soils is high. Tilth is generally good, but these soils become puddled if they are worked when wet, and they are cloddy and hard when they dry.

Most areas of these soils are used for crops, mostly row crops, but there is some permanent pasture. Drained areas are well suited to corn and soybeans, but grain sorghum, oats, legumes, and grasses are also grown. Undrained areas ordinarily are suited to birdsfoot trefoil, bluegrass, and reed canarygrass. Growth of crops is good if drainage is adequate and management is good. The Marcus and

Tripoli soils generally are in large areas and, in some places, occupy entire fields. The Afton, Canisteo, Colo, and Webster soils generally are in fields with one or more other soils.

If the soils in this unit are managed well and adequately fertilized, they can be used for row crops much of the time. An occasional year of meadow improves tilth and fertility and helps to control weeds and insects. Drainage can be improved by installing title drains because they function well in these soils. In some places, especially in areas of the Afton and Colo soils, grassed waterways are needed for removing runoff. Other practices of erosion control are not needed. Because wetness may delay plowing in spring, these soils are generally plowed in fall. If plowing is in fall, freezing and thawing and wetting and drying improve tilth, and a better seedbed can be prepared. Fall plowing increases the hazard of soil blowing during winter, but blowing can be reduced by leaving crop residue on the surface or by alternating plowed and unplowed strips.

Lime generally is not needed, because these soils range from slightly acid to mildly alkaline. The available nitrogen normally is about medium, but it is low in places. The available phosphorus is low or very low, and available potassium generally is medium to high. To maintain good growth under intensive row cropping, fertilizer is required. Because these soils warm somewhat slowly in spring, corn responds to fertilizer added as a starter at planting time. Nitrogen is needed where corn does not follow a legume. Corn, small grains, and legumes respond well to added phosphate, but potash generally is not needed in large amounts. Larger amounts of phosphate and potash are needed on calcareous soils than on the noncalcareouse ones.

CAPABILITY UNIT IIw-3

This unit consists of nearly level, poorly drained, dark-colored soils in the Biscay and Talcot series. These soils overlie sand and gravel. They have a thick silty clay loam surface layer. Permeability is moderately slow above the sand and gravel, which is at a depth of 36 inches or more, but water moves more rapidly through the sand and gravel. The available moisture capacity is high. These soils are high in organic-matter content and generally are in good tilth. If they are worked when wet, these soils become puddled, and they are cloddy and hard when they dry. Runoff is slow, and in most places a temporary high water table makes them wet. Improved drainage generally is needed for satisfactory cultivation of these soils. Title drains function well but are difficult to install in places because of the sandy or gravelly substratum.

These soils are used mostly for crops, mainly row crops. Some areas are in permanent pasture. Corn and soybeans are the most common crops, but grain sorghum, oats, and all the common hay and pasture plants are also grown. Undrained areas are better suited to hay and pasture plants, though in places these areas are cultivated. Growth of crops is restricted on undrained areas, but it is good where these soils are adequately drained, fertilized, and managed well. Row crops can be grown on these soils much of the time. An occasional year of meadow improves tilth, and returning all crop residue helps to maintain the organic-matter content.

Grassed waterways are needed in some places, but other practices of erosion control are not needed. Open ditches are needed in places as outlets for tile drains. Because plowing in spring may be delayed by wetness, these soils generally are plowed in fall. Fall-plowed soils dry earlier in spring and are easier to work into a good seedbed. Leaving crop residue on the surface and alternating plowed and unplowed strips help to reduce soil blowing.

Lime is not needed, because these soils are generally neutral or mildly alkaline. The Biscay soils generally are low or medium in available nitrogen, generally low in available potassium, and low or very low in available phosphorus. The Talcot soils generally are low or medium in available nitrogen, low or very low in available phosphorus, and low in available potassium. Where row crops are grown frequently, fertilizer is needed to maintain fertility. Fertilizer added at planting time as a starter benefits most crops because these soils tend to warm somewhat slowly in spring. Where corn does not follow a legume, nitrogen is needed.

CAPABILITY UNIT IIw-4

Harps loam is the only soil in this unit. It is nearly level, poorly drained, and rich in lime. Where this soil is plowed and is dry, the surface layer appears to be distinctly grayer than that of surrounding soils. Permeability is moderate. The organic-matter content is moderately high to high. Artificial drainage is needed, and tile drains function well. Erosion is not a hazard. This soil generally occurs on the narrow rims of depressions that are occupied by the Glencoe or Okoboji soils or by Muck.

Most of this soil is used for crops. It is suited to corn, soybeans, and oats and to legumes, grasses, and most other pasture plants. If it is adequately fertilized, this soil can be used for row crops much of the time. Without fertilizer, the growth of corn on this soil commonly is poorer than it is on adjacent soils.

This soil is low in available nitrogen, very low in available phosphorus, and very low or low in available potassium. Low availability of these nutrients is caused by the high content of lime and poor drainage. Large amounts of phosphate are needed where this soil is under intensive row cropping. Nitrogen is especially needed for corn that does not follow a legume. Lime is not needed, but legumes respond well to phosphate. Because this soil is deficient in iron, the leaves of soybeans commonly turn yellow when the plants are only a few inches high. This deficiency can be overcome by spraying the leaves repeatedly with a solution of ferrous sulfate.

CAPABILITY UNIT IIw-5

This unit consists of nearly level, poorly drained, dark-colored soils of the Marna series. These soils have a heavy silty clay loam or silty clay surface layer and a silty clay or clay subsoil. Movement of air and water through these soils is poor. They absorb rainwater slowly, but their available moisture capacity is medium to high. The water table commonly is high.

These soils generally are in poor tilth. They become puddled if worked when wet, and they are cloddy and hard when they dry. Even where drainage is improved and they are worked within a favorable range of moisture content, these soils are seldom in good tilth. They are slow to dry in spring and after heavy rains. In most years when rainfall is heavy, planting is delayed.

The soils in this unit are used mostly for row crops. Corn, soybeans, grain sorghum, and oats and the most common hay and pasture plants are suited. Undrained areas can be used for pasture. Although natural fertility is high, the growth of plants varies, depending on drainage. This growth is moderate in most years but is poor in wet ones.

These soils can be used for row crops much of the time. An occasional year of meadow or a green-manure crop improves tilth.

Adequate drainage of these soils is difficult. Tile drains are only fairly effective, and the lines need to be spaced closer than those in most soils. If these soils are plowed in fall, tilth and workability are improved by freezing and thawing. In addition, the soils dry earlier in spring.

Lime is seldom needed, because these soils are slightly acid or mildly alkaline. Nitrogen and phosphate are needed if these soils are used intensively for row crops, and a smaller amount of potash is also needed. The calcareous Marna soil in this unit is more likely to be deficient in potassium.

CAPABILITY UNIT IIs-1

This unit consists of nearly level, well-drained soils in the Wadena and Waukegan series that are shallow to sand or gravel. The Wadena soils overlie sand and gravel, and the Waukegan soils overlie loamy sand or sandy loam. The texture generally is loam to a depth of 24 to 30 inches. These soils are medium to low in organic-matter content and are friable and easy to work. Permeability is moderate in the upper part of the profile and moderately rapid to very rapid in the lower part. The available moisture capacity is medium, and the soils are droughty.

The soils in this unit are generally used for cultivated crops. They can be used for row crops much of the time. They are suited to corn, soybeans, grain sorghum, and oats and to alfalfa, red clover, and other hay and pasture plants. Growth of plants generally is moderate because of droughtiness and low fertility. Stands of corn on these soils should be thinner than stands on less droughty soils.

These soils generally are slightly acid or medium acid. They are low in available nitrogen and phosphorus and low or medium in available potassium. Organic matter, either as barnyard manure or as crop residue, is needed in addition to fertilizer. Adding large amounts of fertilizer is not advisable, however, because the soils are droughty, but the response of crops to moderate amounts is fairly good.

CAPABILITY UNIT IIs-2

Cylinder loam, moderately deep, is the only soil in this unit. It is nearly level, is somewhat poorly drained, and overlies sand or gravel at a depth of 2 to 3 feet. This soil has a dark-colored surface layer that is friable and easy to work. The available moisture capacity is medium, and this soil tends to be droughty in dry years. In years of heavy rainfall, however, some areas are somewhat wet and would benefit from tile drains. The organic-matter content is fairly high. Erosion is not a hazard.

Most of this soil is used for crops. It is suited to corn, soybeans, grain sorghum, and oats, and to all hay and pasture plants common in the county. Growth of crops generally is moderate.

If it is adequately fertilized and all crop residue is returned, this soil can be used for row crops much of the time. An occasional year of meadow improves tilth and helps to control insects and diseases.

This soil generally is slightly acid or medium acid. The available nitrogen and potassium generally are low or medium, and available phosphorous generally is low. For corn that does not follow a legume, nitrogen is needed. The response of corn, oats, and legumes to phosphate is good. Adding large amounts of fertilizer is not advisable, however, because the soil is droughty.

CAPABILITY UNIT IIIe-1

This unit consists of moderately sloping to gently rolling, well-drained to somewhat poorly drained soils in the Clarion, Everly, Guckeen, Ocheyedan, Sac, Storden, and Terril series. These soils have a dark colored or moderately dark colored surface layer that normally is friable and easy to work. Slopes range from 5 to 12 percent, and most areas are moderately eroded. These soils generally have high available moisture capacity. Permeability is moderate. The movement of air and water is generally good, except in a small acreage of the Guckeen soils that have layers of silty clay or clay. The organic-matter content of most of the soils in this unit is medium, but it is generally low in some of the moderately eroded soils.

These soils are used mainly for crops, but a fairly large acreage is used for permanent pasture. Corn, soybeans, grain sorghum, oats, and all hay and pasture plants common in the county are suited. Growth of crops generally is moderate to good, but it may be poor on the moderately eroded soils.

Where erosion is controlled by terracing, row crops can be grown much of the time. Where only contour farming is used to control erosion, more close-growing crops and fewer row crops need to be grown.

Because slopes are short and irregular, building terraces on some of these soils may be difficult. In most places, however, terraces are best for controlling erosion. Where cuts are made into the clayey subsoil of Guckeen soils, the exposed areas should be covered with topsoil and manure. The Terril soils are on foot slopes and in many places can be protected by diversion terraces. In years of above-average rainfall some areas of Guckeen soils are wet, but artificial drainage is seldom installed. Grassed waterways are needed in many places to control runoff.

The soils in this unit range from medium acid to moderately alkaline in reaction, but most areas are slightly acid. Lime is never needed on the Storden soils and is seldom needed on the Clarion soils; it may be needed on other soils. Fertilizer is needed for good growth of crops. The supply of available plant nutrients varies, but generally these soils are low in available nitrogen and phosphorus and low to high in available potassium. The Storden soils are very low, however, in available nitrogen and phosphorus. Crops on the soils in this unit generally respond to added fertilizer. Where corn does not follow a legume, nitrogen is needed. Phosphate is generally needed for corn, oats, and legumes. The moderately eroded soils especially benefit from added barnyard manure, which improves tilth and adds organic matter.

CAPABILITY UNIT IIIe-2

This unit consists of strongly sloping and rolling, well-drained soils in the Clarion, Everly, Storden, and Terril series. All areas of these soils are fairly small. The surface layer is dark colored or moderately dark colored and loamy. It is friable and easy to work. Slopes range from 5 to 15 percent, and most areas are moderately eroded. These soils have high available moisture capacity. Permeability is moderate. The organic-matter content of most of these soils generally is low or medium, but in the uneroded Terril soils it is high. The soils in this unit warm early in spring and can be tilled fairly soon after rains.

Most areas of these soils are used for crops, but many areas are in permanent pasture. Medium fertility, fair to good tilth, and favorable moisture capacity make these soils suited to corn and oats and to alfalfa, bromegrass, and other hay and pasture plants. They are poorly suited to soybeans.

An occasional row crop can be grown where these soils are farmed on the contour and terraced. Building terraces on some of these soils is difficult because the slopes are irregular and short. Grassed waterways need to be established or improved in some places to control runoff.

The soils in this unit range from slightly acid to moderately alkaline. Lime is not needed on the Storden soils. If it is needed on other soils in this unit, the amount is generally small. These soils are generally low in available nitrogen and phosphorus and low or medium in available potassium. A few areas are very low in available nitrogen and phosphorus. All crops ordinarily respond to added phosphate and potash, and response to phosphate on the Storden soils is especially good. For corn that does not follow a legume, nitrogen is generally needed. All soils in this unit benefit from added manure, especially the Storden soils. Manure adds organic matter and improves tilth.

CAPABILITY UNIT IIIe-3

This unit consists of gently sloping and moderately sloping soils. These soils are in the Dickinson and Wadena series. Wadena soils are underlain by sand and gravel at a depth of 24 to 36 inches. The Dickinson soils are also underlain by sand and gravel, but at a depth generally more than 50 inches. These soils have a dark colored or moderately dark colored, loamy surface layer that is generally friable and easy to work. Slopes range from 2 to 9 percent, and some areas are moderately eroded. Permeability is moderate to moderately rapid in the upper part of the profile and moderately rapid to very rapid in the lower part. These soils absorb water readily, but because they cannot hold enough for good plant growth they are droughty. They are low to medium in organic-matter content and low in plant nutrients. All soils in this unit are susceptible to erosion, but the soils that have slopes of 5 to 9 percent are especially susceptible.

The soils of this unit are used mainly for crops, but a few areas are in permanent pasture. They are suited to corn, grain sorghum, and small grains and to alfalfa, bromegrass, and other hay and pasture plants. Growth of crops is generally poor to moderate, and even in years when rainfall is above average, it is not good. Where these soils are used for row crops, terracing or contour farming is needed to control erosion and conserve moisture. In terracing, deep cuts ought to be avoided because the underlying material has low available moisture capacity. Most areas of these soils are so small that they are managed in the same way as larger areas of surrounding soils.

Where they are terraced, these soils can be row cropped much of the time. Where only contour farming is used to control erosion, more close-growing crops and fewer row crops are needed.

The soils in this unit are slightly acid or medium acid. They are generally low in available nitrogen and phosphorus, medium in potassium, and all these plant nutrients need to be added for satisfactory growth of crops. Adding large amounts is not generally economical, however, because the soils are droughty, but the response of crops to moderate amounts is good. Adding barnyard manure increases the organic-matter content of these soils and improves tilth and fertility. All crop residue should be returned to the soils.

CAPABILITY UNIT IIIe-4

This unit consists of gently sloping and moderately sloping sandy and gravelly soils in the Dickinson and Salida series. The surface layer is moderately dark colored or dark colored. Salida soils are gravelly and somewhat difficult to till; Dickinson soils are sandy, friable, and easy to till. Slopes range from 2 to 9 percent. These soils have low available moisture capacity and are droughty. They absorb water rapidly but do not store much for plants. They are low in organic-matter content and in plant nutrients. Soil blowing is commonly severe, and erosion by water is a hazard, especially in the more sloping areas.

Most areas of these soils are used for crops, but some are in permanent pasture. Although these soils are droughty and have low fertility, they can be used for corn, soybeans, grain sorghum, and oats, and for alfalfa, bromegrass, and other hay and pasture plants. Corn is generally more profitable than soybeans. A thinner stand of corn is needed on these soils than on less droughty soils. Where row crops are grown, contour farming or terracing is needed. In building terraces on the Dickinson soils, deep cuts are to be avoided because the sandy underlying material is very droughty and has low fertility.

Where erosion is controlled, the Dickinson soils can be used for row crops much of the time. Because the Salida soils have so much gravel in the underlying layer, tilling these soils on the contour is preferable to terracing them. They can be used for row crops part of the time, but because of difficulty in tilling and poor plant growth, many farmers prefer to leave the Salida soils in hay or pasture most of the time.

The Dickinson soils are generally slightly acid or medium acid, and the Salida soils are generally calcareous at or near the surface. Lime is generally needed on the Dickinson soils, but it is not needed on the Salida soils. All the soils in this unit are very low or low in available nitrogen and phosphorus and low or medium in available potassium. Because these soils are droughty, adding large amounts of fertilizer is not economical, but crops respond well to small amounts. In some places soil blowing is a hazard, and sand blown against young plants damages them. Crop residue left on the surface helps to reduce blowing. Adding barnyard manure improves tilth and fertility and increases the organic-matter content.

CAPABILITY UNIT IIIw-1

This unit consists of poorly drained or very poorly drained soils in the Glencoe, Okoboji, Rolfe, Sperry, and Wacousta series. These soils are in potholes, or landlocked depressions, that collect water, and they are frequently ponded in spring or after heavy rains. The surface layer of the Glencoe and Okoboji soils is thick and very black, but that of the other soils is thinner. The Sperry and Rolfe soils have a leached subsurface layer that grades to a clayey subsoil. This clayey subsoil is slowly or very slowly perme-

The wildlife of Clay County provide many opportunities for recreation. Many kinds of wildlife are also beneficial because they eat harmful insects and rodents. Many kinds of birds eat insects; hawks, owls, and other avian predators help keep the number of rodents tolerable; and shrews, skunks, foxes, and snakes also feed on rodents.

Pheasant, Hungarian partridge, cottontail rabbit, jackrabbit, squirrel, and deer are the game species that provide much of the hunting in the county. The distribution of pheasants, partridges, and rabbits is fairly uniform throughout the county. The Marcus and Primghar soils in soil association 3, however, are used intensively for row crops, and the cover needed for shelter and nesting is limited. Cover is somewhat limited in the nearly level areas of the other soil associations. Squirrels and deer occur in greatest numbers in soil association 7, which consists mainly of Storden and Clarion soils, and in association 6, which consists of Colo, Spillville, and Wabash soils and Alluvial land. In these associations the kinds of trees, food supply, and cover favor these animals. Opossums, raccoons, weasels, badgers, foxes, and skunks occur in variable numbers throughout the county.

Soil association 1 is most favorable for muskrats and minks, though these animals inhabit areas of Marsh and are along the streams and drainage ditches throughout the county (fig. 12). The Clarion, Webster, and Nicollet are the major soils in this association, but Canisteo and Storden soils also occur. Many of the drainage ditches in this association serve as outlets for tile drainage systems and provide water most, if not all, of the year.

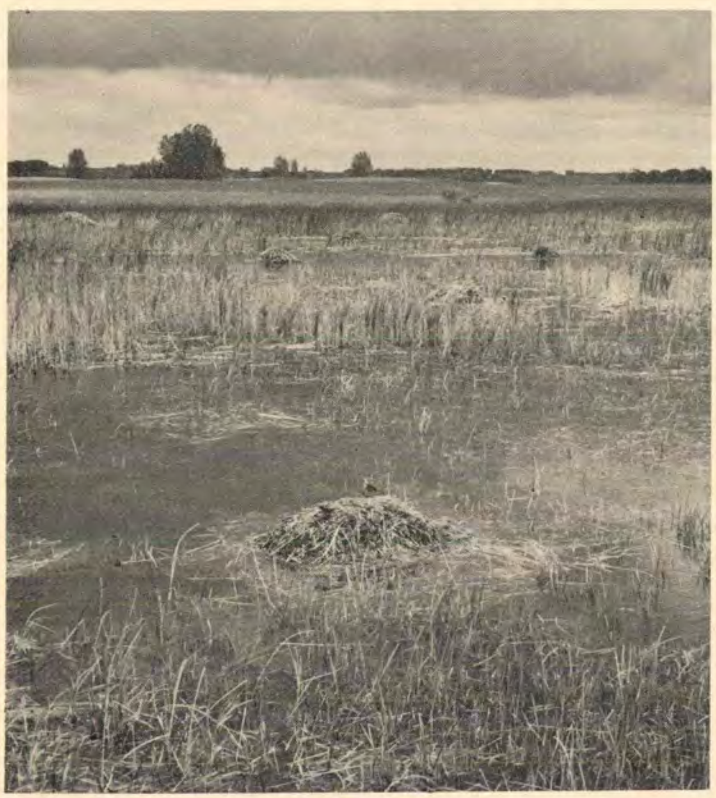

***Figure 12.*—Muskrat houses in an area of Marsh. Marsh provides a natural habitat for waterfowl and other wetland wildlife.**

The many small, shallow lakes and marshes in soil a sociation 1 include Dan Green Slough, Barringer Sloug Trumbull Lake, Mud Lake, Round Lake, Elk Lake, a parts of Lost Island Lake and Pickerel Lake. Also in t association are many smaller undrained depressions th support marsh vegetation and that hold water part, if n all, of the year. These areas are used by muskrats a minks and are also used intensively by migrating wat fowl for feeding and nesting. Mallard, teal, and other duc nest and raise their young in these areas.

The Little Sioux River and Lost Island and Trumb Lakes provide sport fishing. A few farm ponds have be stocked with fish. Farm ponds provide excellent fishing properly managed. The Storden soils provide good co struction material for ponds, and frequently suitable sit are available. The Clarion, Everly, and many other so also provide suitable material but seldom have good sit for ponds. Soil associations 1, 2, and 7 have more good sit than the other associations, though suitable sites and m terial occur in some of the others.

The soils, topography, and vegetation favor the develo ment of facilities for many kinds of recreation in Cl County. Many areas that are of little value for farming c be used for developing these facilities. In Wanata Sta Park, near Peterson, the steep Clarion soils provide hikin nature study, and bridle trails. The adjacent Terril so on foot slopes provide sites for picnicking. Other develo ments that have been made recently on these and simil soils include facilities for winter sports and for moto cycle racing. In soil association 1 several marshy areas ha been developed as wildlife refuges and as public shooti areas. Many other areas are suitable for developing the refuges and selling shooting rights.

Many areas that cannot be used for crops are well suite to the production of useful wildlife. On most farms a odd areas that can be developed as habitat for wildli The Salida, Storden, or Clarion soils are most likely have areas of this kind. Also suitable as wildlife habit are small, steep, eroded, or gravelly parts of croplan gravel pits; railroad rights-of-way; or tracts of land c off from the rest of a field by a stream or drainage ditc Even on soils that are suitable for use as cropland, wildli can be produced as a secondary source of income or f recreation.

Use of Soils for Woodland

Only a small percentage of Clay County is wooded. Mo areas of woodland border the Little Sioux River, but few small woodlots are on farms. Trees and shrubs a commonly planted around farmsteads. They are general planted to provide protection from wind or in landsca gardening.

Most of the wooded areas produce little merchantab timber. Much of the woodland in the county is graze and is managed primarily as pasture. In steep areas tre are generally left, but where these areas adjoin pasture th trees have little more use than as shade for livestock o as wildlife habitat.

The amount of woodland in the county has change little in recent years. Some woodland, mostly alon streams, has been cleared for use as cropland. Woodlot of vacant farmsteads generally are cleared, the building are removed, and the areas are used as cropland.

The small demand for timber of the quality and volume produced in the county accounts for the lack of interest in woodland. The chief concern of farmers is in planting trees and shrubs for windbreaks. Technical assistance in managing woodland and planting for windbreaks is available to landowners through the local office of the Soil Conservation Service and from the State Conservation Commission.

Forest types

The forest types in Clay County occur in two kinds of natural landscape. One is in the gently rolling to steep uplands, and the other is on the nearly level bottom lands.

Oak-hickory type.—This type occurs on gently rolling to steep uplands, chiefly along the Little Sioux River in the southern part of the county. It is mainly on steep breaks from the uplands to the bottom lands. The stand is growing mainly on Clarion soils that have a fine-textured subsoil and on the Storden soils. It also is on nearly level areas of the Ladoga soils and small, nearly level to gently sloping areas of the Galva, Sac, and Nicollet soils. These nearly level to gently sloping soils are generally adjacent to steeper ones. A large percentage of this type of woodland is on north- and east-facing slopes. Oak and hickory dominate in the stand, but white elm, red elm, basswood, hackberry, wild black cherry, and green ash also occur. The species of oak are mainly bur oak and some white oak and northern red oak. The species of hickory are the shagbark and bitternut.

Soft maple-elm-cottonwood type.—This type occurs on nearly level bottom lands, mainly on Alluvial land or on the Colo soils. It is mostly along the Little Sioux River, but areas also occur in the lower reaches of the larger tributaries. The stand consists mainly of elm, soft maple, and cottonwood, but willow, oak, hickory, green ash, and black walnut occur in places. Willow and cottonwood generally are near the streams that overflow frequently and cause prolonged wetness.

Planting suitability groups

The soils in Clay County have been placed in four groups according to their suitability for planting trees in woodlands, in windbreaks, and for Christmas trees. Hardwoods generally grow poorly on old fields that formerly were cultivated, severely eroded soils, or soils depleted of fertility. Pines grow better on these poor sites. Plantings for wildlife habitat should include plants that provide both food and cover. Trees and shrubs in plantings for wildlife habitat generally are not suitable on soils that are flooded regularly. The four groups are described in the following paragraphs, and the trees suitable for planting are listed. To determine the kinds of trees that are suitable for each purpose, the reader should refer to local and State literature. Because it is not suitable for woodland, Marsh was not placed in a planting suitability group.

PLANTING SUITABILITY GROUP 1

This group includes soils on uplands that range from nearly level to steep. Some of these soils are on benches and foot slopes, but they have characteristics similar to those of soils on uplands. The soils in this group are mainly deep, medium textured or moderately fine textured, and moderately to moderately slowly permeable. The Guckeen soils, however, are fine textured in some layers and are moderately slowly or slowly permeable.

The soils in this group are the most favorable in the county for the growth of trees. They are the Clarion, Cylinder loam, deep, Everly, Fostoria, Galva, Guckeen, Ladoga, Nicollet, Ocheyedan, Primghar, Sac, Storden, Terril, and Wadena loam, deep, soils.

Trees suitable for planting where slopes are less than 14 percent and on north-facing and east-facing slopes of more than 14 percent are green ash, hackberry, cottonwood, red oak, white oak, black walnut, Scotch pine, Austrian pine, European larch, Douglas-fir, basswood, hard maple, eastern redcedar, eastern white pine, ponderosa pine, and Norway spruce. Some of the Storden and Clarion soils have west- and south-facing slopes of more than 14 percent. Trees suitable for planting on these slopes are limited to hackberry, cottonwood, green ash, ponderosa pine, Austrian pine, Scotch pine, and eastern redcedar.

PLANTING SUITABILITY GROUP 2

The soils in this group are nearly level and are naturally poorly drained or very poorly drained. They are mainly deep, moderately fine textured, and moderately slowly permeable, but the Marna soils are fine textured and slowly permeable.

The soils in this group are the Afton, Biscay, Canisteo, Glencoe, Harps, Marcus, Marna, Muck, Okoboji, Rolfe, Sperry, Talcot, Tripoli, Wacousta, and Webster soils.

Trees suitable for planting on the soils in this group are green ash, hackberry, cottonwood, soft maple, eastern redcedar, European larch, Norway spruce, and Scotch pine. Muck is very poorly drained and resembles some of the soils in this group in some other characteristics. Cottonwood and willow are suitable for planting on Muck.

PLANTING SUITABILITY GROUP 3

The soils in this group are mainly medium textured or moderately coarse textured to a depth of about 24 to 30 inches and overlie sand, gravel, or mixed sand and gravel. They are the Dickinson, Hagener, and Salida soils; the moderately deep Cylinder, Wadena, and Waukegan loams; and Sandy lake beaches. The Salida and Hagener soils and Sandy lake beaches are not so deep to coarse material. The soils in this group dominantly have slopes of less than 14 percent, but the Salida soils are steeper in places.

Trees suitable for planting on the soils in this group are red oak, white oak, green ash, hackberry, cottonwood, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir.

PLANTING SUITABILITY GROUP 4

The soils in this group vary widely in texture and permeability. They are nearly level soils on bottom lands, and all receive water in addition to rainwater, either as overflow from streams or as runoff. In this group are the Calco, Colo, Spillville, and Wabash soils, and Alluvial land, channeled, a land type that is similar to these soils.

Trees suitable for planting on the soils of this group are cottonwood, hackberry, green ash, and soft maple.

Use of Soils for Engineering

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

The information in this soil survey can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, or other construction materials.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that will be useful in designing and maintaining specified engineering practices and structures.

TABLE 3.—*Estimated engineering*

Soil series and map symbol	Depth from surface	Classification		
		USDA textures	Unified	AASHO
	Inches			
Afton (Af).	0–26	Silty clay loam	OH or CH	A–7–6 or A–7–5
	26–51	Silty clay loam	CH	A–7–6
	51–65	Clay loam	CH to CL	A–6 or A–7–6
Alluvial land, channeled (Au).[1]				
Biscay, deep (Bs).	0–11	Silty clay loam	CL to OH	A–7–6 or A–7–5
	11–40	Clay loam and heavy loam	CL	A–6 or A–7–6
	40–48	Sand and gravel	SP–SM	A–1 or A–2
Calco (Ca).	0–36	Silty clay loam	OL or CH	A–7–6 or A–7–5
	36–50	Clay loam	CL	A–7–6
Canisteo (Ce).	0–19	Silty clay loam	OH to CL	A–7–6 or A–7–5
	19–39	Silty clay loam	CL	A–6 or A–7–6
	39–48	Loam	CL	A–6 or A–7–6
Canisteo, gypsic variant (Cg).	0–26	Silty clay loam	OH to CL	A–7–6 or A–7–5
	26–32	Silty clay loam	CL	A–6 or A–7–6
	32–48	Clay loam	CL	A–6 or A–7–6
Clarion:				
Loam (ClB, ClC2, ClD2, CmC2, CmD2). (For properties of Storden soils in mapping units CmC2 and CmD2, refer to the Storden series.)	0–14	Loam	CL	A–4 or A–6
	14–34	Clay loam	CL	A–6
	34–48	Loam	CL	A–6
Loam, heavy subsoil variant (ClF).	0–12	Loam	ML–CL or CL	A–4 to A–6
	12–33	Clay loam	CL	A–6 to A–7–6
	33–52	Clay loam	CL	A–6
Colo (Co, CoB, Cs, CtB, CtC). (For properties of Terril soils in mapping units CtB and CtC, refer to the Terril series.)	0–36	Silty clay loam	OL or CH	A–7–6
	36–52	Silty clay loam	CH	A–7–6
Cylinder, deep (Cu).	0–15	Loam	ML–CL	A–4 or A–6
	15–38	Loam	CL	A–4 or A–6
	38–50	Sand and gravel	SP–SM	A–1 or A–2
Cylinder, moderately deep (Cy).	0–18	Loam	CL or ML–CL	A–4 to A–6
	18–28	Loam to clay loam	SC to CL	A–6
	28–58	Sand and gravel	SP–SM	A–1 or A–2

See footnote at end of table.

6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The engineering interpretations reported here can be useful for many purposes. It should be emphasized, however, that they may not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depth of the layers reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Information regarding the behavior and properties of the soils in Clay County can be obtained from the detailed soil map at the back of the survey and from tables 3, 4, and 5 in this section. The information in the tables was obtained and evaluated from field experience, field performance, and the result of tests such as that shown in table 5. The data contained in table 5, and other assistance as well, were furnished by the Iowa State Highway Commission.

Some terms used by the soil scientist may have special meaning in soil science and may be unfamiliar or have a different meaning to engineers. Many of these terms are defined in the Glossary at the back of this survey.

properties of soils

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 200				
			Inches per hour	*Inches per inch of soil*	*pH value*	
----------	100	90–98	0. 2–0. 8	0. 21	6. 6–7. 3	High.
----------	100	90–98	0. 2–0. 8	. 19	7. 4–7. 8	High.
100	95–100	60–80	0. 2–0 .8	. 16	7. 8–8. 4	Moderate to high.
----------	100	75–85	0. 8–2. 5	. 21	6. 6–7. 3	Moderate to high.
100	95–100	75–85	0. 2–0. 8	. 17	6. 6–8. 4	Moderate to high.
70–90	65–75	3–15	>10	. 02	7. 4–8. 4	Low.
----------	100	80–90	0. 2–0. 8	. 21	7. 4–8. 4	High.
----------	100	70–80	0. 2–0. 8	. 18	7. 4–7. 8	Moderate to high.
100	95–100	70–90	0. 8–2. 5	. 21	7. 9–8. 4	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	7. 9–8. 4	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	7. 9–8. 4	Moderate.
100	95–100	70–90	0. 8–2. 5	. 21	7. 4–7. 8	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	7. 9–8. 4	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	7. 9–8. 4	Moderate.
98–100	96–100	60–80	0. 8–2. 5	. 19	6. 1–6. 5	Moderate.
94–99	88–98	55–75	0. 8–2. 5	. 17	6. 6–7. 3	Moderate.
94–99	85–95	55–75	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
98–100	95–100	60–80	0. 8–2. 5	. 21	5. 6–6. 5	Moderate.
98–100	90–98	60–80	0. 8–2. 5	. 17	5. 6–6. 5	Moderate to high.
93–100	90–98	60–80	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
----------	100	80–90	0. 2–0. 8	. 21	6. 6–7. 3	High.
----------	100	75–90	0. 2–0. 8	. 19	6. 6–7. 3	High.
100	95–100	60–70	0. 8–2. 5	. 18	6. 1–6. 5	Moderate.
100	95–100	55–65	0. 8–2. 5	. 16	6. 1–7. 3	Moderate.
70–90	35–45	3–20	>10	. 03	6. 6–8. 4	Low.
100	95–100	55–70	0. 8–2. 5	. 18	6. 1–6. 5	Moderate.
98–100	90–100	45–60	0. 8–2. 5	. 16	6. 6–7. 3	Moderate.
70–90	60–80	3–10	>10	. 03	6. 6–8. 4	Low.

295-993—69——5

TABLE 3.—*Estimated engineering*

Soil series and map symbol	Depth from surface	Classification		
		USDA textures	Unified	AASHO
	Inches			
Dickinson:				
Fine sandy loam (DcA, DcB, DcC2).	0–7	Fine sandy loam	SM–SC or SC	A–4 or A–2
	7–20	Sandy loam	SM to SC	A–4
	20–60	Loamy sand	SM	A–2–4
Fine sandy loam, benches (DkA, DkB, DkC2, DkD2, DkE2).	0–6	Fine sandy loam	SM–SC	A–4 or A–2
	6–30	Sandy loam	SM–SC or SC	A–4
	30–60	Loamy sand	SM	A–2–4
Loam (DlA, DlB).	0–14	Loam	ML to CL or SM	A–4 or A–6
	14–30	Fine sandy loam	SM to SC	A–4
	30–45	Loamy sand	SM	A–2–4
Everly (EcB, EcC2, EsD2). (For properties of Storden soil in mapping unit EsD2, refer to the Storden series.)	0–12	Clay loam	ML–CL	A–6
	12–26	Clay loam	CL	A–6 to A–7–6
	26–60	Loam	CL	A–6 to A–7–6
Fostoria:				
Clay loam (Fo).	0–14	Clay loam	CL	A–6
	14–29	Clay loam	CL	A–6
	29–46	Sandy clay loam	SC	A–6
	46–53	Sandy loam or sandy clay loam	SM or SM–SC	A–2–4 to A–4
Loam (Fs).	0–19	Loam	ML or CL	A–4 or A–6
	19–34	Loam	ML or CL	A–6
	34–50	Silt loam	ML–CL or CL	A–6 to A–7–6
Galva:				
Silty clay loam (GaA).	0–12	Silty clay loam	ML or ML–CL	A–7–6 or A–7–5
	12–39	Silty clay loam	ML–CL	A–7–6
	39–57	Silt loam	ML–CL	A–6 to A–7–6
Silty clay loam, benches (GbA).	0–12	Silty clay loam	ML or ML–CL	A–7–6 or A–7–5
	12–48	Silty clay loam	ML–CL	A–7–6
	48–55	Sandy loam mixed with some gravel.	SP–SM or SM	A–2
	55–60	Sand and gravel	SP–SM	A–1 or A–2
Glencoe:				
Silty clay loam (Ge).	0–25	Silty clay loam	OH to CH	A–7–6 or A–7–5
	25–46	Silty clay loam	CH to CL	A–7–6 or A–7–5
Silty clay loam, gravelly substratum (Gg).	0–7	Silty clay loam	CL to OH	A–6, A–7–6, or A–7–5
	7–43	Clay loam	CL	A–6, A–7–6 or A–7–5
	43–60	Sand and gravel	SP–SM	A–1 or A–2
Guckeen:				
Silty clay loam (GkA, GkB, GkC2).	0–6	Silty clay loam	CL to CH	A–7–6
	6–28	Silty clay	CH	A–7–6
	28–36	Silty clay loam	CL to CH	A–7–6
	36–50	Loam and silt loam	CL	A–6
Clay loam, silty clay substratum (GuA, GuB).	0–16	Clay loam	CL to CH	A–6 or A–7–6
	16–34	Silty clay	CH	A–7–6
	34–60	Silty clay	CH	A–7–6
Hagener (HaC2).	0–13	Loamy sand	SM	A–2
	13–48	Sand	SP	A–3
Harps (Hr).	0–14	Loam	OL to CL	A–6 or A–7–6
	14–24	Clay loam	CL	A–6 or A–7–6
	24–50	Loam	CL to ML	A–6
Ladoga (LaA).	0–14	Silt loam	ML or ML–CL	A–6 or A–7–6
	14–36	Silty clay loam	ML–CL	A–7–6
	36–48	Silty clay loam	ML–CL	A–7–6

See footnote at end of table.

properties of soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 200				
			Inches per hour	*Inches per inch of soil*	*pH value*	
------	100	35–45	2. 5–5. 0	. 10	6. 1–6. 5	Low.
------	100	35–50	2. 5–5. 0	. 06	6. 1–6. 5	Low.
------	100	15–30	5. 0–10. 0	. 06	6. 1–6. 5	Low.
100	96–100	35–45	2. 5–5. 0	. 10	6. 1–6. 5	Low.
100	96–100	35–50	2. 5–5. 0	. 06	6. 1–6. 5	Low.
100	96–100	15–30	5. 0–10. 0	. 04	6. 1–6. 5	Low.
------	100	50–60	0. 8–2. 5	. 16	5. 6–6. 0	Moderate.
------	100	35–50	2. 5–5. 0	. 13	5. 6–6. 0	Low.
100	98–100	15–30	5. 0–10. 0	. 05	5. 6–6. 0	Low.
100	95–100	65–80	0. 8–2. 5	. 21	5. 6–6. 0	Moderate.
98–100	95–100	70–90	0. 8–2. 5	. 18	5. 6–6. 5	Moderate.
90–100	85–95	65–80	0. 8–2. 5	. 16	7. 8–8. 4	Moderate.
100	98–100	65–85	0. 8–2. 5	. 20	5. 6–6. 0	Moderate.
100	98–100	65–80	0. 8–2. 5	. 17	5. 6–6. 0	Moderate.
100	95–99	35–55	0. 8–2. 5	. 13	5. 6–6. 0	Moderate to low.
100	95–99	20–40	2. 5–5. 0	. 06	5. 6–6. 0	Low.
100	98–100	65–85	0. 8–2. 5	. 19	6. 6–7. 3	Moderate.
100	98–100	60–80	0. 8–2. 5	. 17	6. 6–7. 8	Moderate.
------	100	75–95	0. 8–2. 5	. 18	7. 9–8. 4	Moderate.
------	100	90–98	0. 8–2. 5	. 21	6. 1–6. 5	Moderate to high.
------	100	90–98	0. 8–2. 5	. 19	6. 1–6. 5	Moderate to high.
------	100	90–95	0. 8–2. 5	. 18	6. 6–7. 3	Moderate.
------	100	90–98	0. 8–2. 5	. 21	5. 6–6. 0	Moderate to high.
------	100	87–97	0. 8–2. 5	. 19	6. 0–6. 5	Moderate to high.
75–95	35–45	10–25	0. 8–2. 5	. 06	6. 1–6. 5	Low.
70–90	35–45	3–15	0. 8–2. 5	. 02	6. 6–7. 3	Low.
------	100	80–90	0. 2–0. 8	. 21	6. 6–7. 8	High.
------	100	80–90	0. 2–0. 8	. 19	6. 6–8. 4	High.
------	100	75–85	0. 2–0. 8	. 21	6. 6–7. 3	Moderate to high.
100	95–100	75–85	0. 2–0. 8	. 17	6. 6–7. 3	Moderate to high.
70–90	65–75	5–25	>10	. 04	6. 6–7. 8	Low.
100	98–100	80–90	0. 8–2. 5	. 21	6. 1–6. 5	Moderate to high.
------	100	90–100	0. 05–0. 2	. 17	6. 5–7. 0	High.
------	100	90–100	0. 2–0. 8	. 19	7. 9–8. 4	Moderate to high.
100	98–100	60–80	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
------	100	65–85	0. 8–2. 5	. 18	6. 6–7. 3	Moderate to high.
------	100	85–100	<0. 05	. 17	6. 6–8. 4	High.
------	100	85–100	<0. 05	. 16	7. 9–8. 4	High.
------	100	10–20	5. 0–10. 0	. 06	5. 6–6. 5	Low.
------	100	5–15	5. 0–10. 0	. 02	6. 6–7. 3	Low.
100	98–100	65–80	0. 8–2. 5	. 18	7. 9–8. 4	Moderate to high.
100	98–100	65–80	0. 8–2. 5	. 17	7. 9–8. 4	Moderate to high.
95–100	92–100	60–75	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
------	100	90–98	0. 8–2. 5	. 21	6. 6–7. 3	Moderate.
------	100	90–98	0. 8–2. 5	. 19	6. 6–7. 3	Moderate to high.
------	100	90–98	0. 8–2. 5	. 16	6. 6–7. 3	Moderate to high.

TABLE 3.—*Estimated engineering*

Soil series and map symbol	Depth from surface	Classification		
		USDA textures	Unified	AASHO
	Inches			
Marcus (Ma).	0–17	Silty clay loam	OH or CL–CH	A–7–6 or A–7–5
	17–29	Silty clay loam	CH	A–7–6
	29–50	Silt loam	CL	A–7–6
Marna (Mc, Me).	0–17	Silty clay	OH–CH	A–7–6
	17–50	Silty clay	CH	A–7–6
Marsh (Mh).	----------	Peat	Pt	Muck
Muck:				
Moderately shallow (Mm).	0–28	Muck	Pt	Muck
	28–50	Silt loam to silty clay loam	ML–CL or CL	A–7–6
Moderately shallow, calcareous (Mr).	0–29	Muck	Pt	Muck
	29–48	Mucky silt loam	OL	A–7–6
Shallow (Ms).	0–12	Muck	Pt	Muck
	12–50	Silty clay loam and silt loam	ML to CL	A–7–6
Nicollet:				
Clay loam (Nc).	0–19	Clay loam	CL	A–4 or A–6
	19–45	Clay loam	CL	A–6
Loam (No).	0–14	Loam	CL or ML–CL	A–4 or A–6
	14–31	Clay loam	CL	A–6 or A–7–6
	31–48	Loam	CL	A–6
Ocheyedan (OcA, OcB, OcC2).	0–21	Loam	ML to CL	A–4 or A–6
	21–34	Sandy clay loam and fine sandy loam.	SC or CL	A–4 or A–6
	34–48	Silt loam	ML to CL	A–6
Okoboji (Ok).	0–14	Silt loam	OH to CL	A–7–6 or A–7–5
	14–45	Silty clay loam	CH to CL	A–7–6 or A–7–5
	45–50	Silty clay loam	CH to CL	A–7–6
Primghar:				
Silty clay loam (Pr).	0–16	Silty clay loam	MH or CH	A–7–6
	16–30	Silty clay loam	CL or CH	A–7–6
	30–47	Silt loam	ML to CL	A–7–6
	47–84	Clay loam	CL	A–6
Silty clay loam, benches (Ps).	0–19	Silty clay loam	MH or CH	A–7–6 or A–7–5
	19–49	Silty clay loam	CL or CH	A–7–6
	49–56	Sandy loam to loamy sand and gravel.	SP–SM	A–1 or A–2
Rolfe (Ro).	0–14	Silt loam	OH or CL	A–6
	14–28	Clay or silty clay	CH	A–7–6
	28–50	Clay loam	CL	A–6
Sac (SaB, SaC, SaC2).	0–11	Silty clay loam	ML or ML–CL	A–7–5 or A–7–6
	11–28	Silty clay loam	ML–CL	A–7–6
	28–57	Clay loam	CL	A–6 to A–7–6
Salida (SgB, SgC2, SgD2, SgE2, SlF2).	0–7	Gravelly sandy loam	SM–SC or SM	A–1 or A–2
	7–11	Loamy sand mixed with gravel	SM	A–1 or A–2
	11–44	Sand and gravel	SP–SM	A–1–, A–1–b or A–2
Sandy lake beaches (Sn).	0–11	Sandy loam or loamy sand	SM or SM–SC	A–2 to A–4
	11–45	Sand and gravel	SP–SM	A–1 or A–2

properties of soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 200				
			Inches per hour	*Inches per inch of soil*	*pH value*	
--------------	100	90–98	0. 2–0. 8	. 21	6. 1–6. 5	High.
--------------	100	90–98	0. 2–0. 8	. 19	6. 6–7. 3	High.
100	95–100	80–92	0. 2–0. 8	. 17	7. 9–8. 4	High.
--------------	100	90–100	0. 5–0. 2	. 18	6. 6–8. 4	High.
--------------	100	90–100	<0. 05	. 17	6. 6–8. 4	High.
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--------------	100	95–100	5. 0–10. 0	. 25	6. 6–7. 3	Moderate.
--------------	100	85–95	0. 8–2. 5	. 20	7. 4–8. 4	Moderate to high.
--------------	100	95–100	5. 0–10. 0	. 25	7. 9–8. 4	Moderate.
--------------	100	85–95	0. 8–2. 5	. 20	7. 9–8. 4	Moderate.
--------------	--------------	100	2. 5–5. 0	. 25	6. 6–7. 3	Moderate.
--------------	100	95–100	0. 2–2. 5	. 20	6. 6–8. 4	High.
100	90–100	65–80	0. 8–2. 5	. 18	6. 1–6. 5	Moderate.
97–100	85–95	60–80	0. 8–2. 5	. 17	6. 6–8. 4	Moderate.
100	95–100	60–80	0. 8–2. 5	. 19	6. 1–7. 3	Moderate.
100	88–98	60–80	0. 8–2. 5	. 17	6. 6–7. 3	Moderate.
95–100	85–95	60–80	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
100	95–100	65–80	0. 8–2. 5	. 19	6. 1–7. 3	Moderate.
100	95–100	35–55	0. 8–2. 5	. 14	6. 6–7. 3	Moderate
100	95–100	75–90	0. 8–2. 5	. 18	7. 9–8. 4	Moderate.
--------------	100	80–90	0. 8–2. 5	. 23	6. 6–7. 3	Moderate to high.
--------------	100	80–90	0. 2–0. 8	. 20	7. 4–7. 8	High.
--------------	100	75–90	0. 2–0. 8	. 19	7. 4–8. 4	High.
--------------	100	94–100	0. 8–2. 5	. 21	5. 6–6. 0	High.
--------------	100	94–100	0. 8–2. 5	. 19	6. 1–7. 3	High.
--------------	100	90–100	0. 2–0. 8	. 19	6. 6–8. 4	High.
96–100	90–97	60–80	0. 8–2. 5	. 16	7. 9–8. 4	Moderate to high.
--------------	100	90–98	0. 8–2. 5	. 21	5. 6–6. 5	High.
--------------	100	85–95	0. 2–2. 5	. 19	6. 6–7. 3	High.
80–95	60–80	10–25	5. 0–10. 0	. 06	7. 4–8. 4	Low.
100	98–100	70–90	0. 8–2. 5	. 21	5. 1–6. 0	Moderate.
100	98–100	70–90	0. 05–0. 2	. 17	6. 1–6. 5	High.
100	90–100	60–80	0. 2–0. 8	. 17	6. 6–8. 4	Moderate.
--------------	100	90–98	0. 8–2. 5	. 21	5. 6–6. 0	Moderate to high.
--------------	100	90–98	0. 8–2. 5	. 19	5. 6–6. 5	Moderate to high
97–100	90–97	65–80	0. 8–2. 5	. 16	7. 4–8. 4	Moderate.
80–90	70–80	20–30	2. 5–5. 0	. 10	6. 6–7. 3	Low.
80–90	70–80	15–25	5. 0–10. 0	. 06	6. 6–7. 3	Low.
75–90	50–70	5–20	>10	. 03	7. 4–8. 4	Low.
100	98–100	20–40	2. 5–5. 0	. 06	6. 6–7. 8	Low.
80–95	70–80	5–20	>10	. 02	7. 4–7. 8	Low.

TABLE 3.—*Estimated engineering*

Soil series and map symbol	Depth from surface	Classification		
		USDA textures	Unified	AASHO
	Inches			
Sperry (So).	0–18	Silty clay loam	OH or ML to CL	A–7–6 or A–7–5
	18–36	Silty clay	CH	A–7–6
	36–50	Silty clay loam	CH	A–7–6
Spillville (Sp).	0–28	Loam	OL or ML to CL	A–4 or A–6
	28–50	Loam	CL	A–4 or A–6
Storden (StD2, StE2, StF2, StG2).	0–6	Loam	CL	A–4 or A–6
	6–36	Loam	CL	A–6
Talcot (Ta).	0–19	Silty clay loam	CL to OH	A–7–6 or A–7–5
	19–34	Clay loam	CL	A–6 or A–7–6
	34–41	Loam	CL	A–6 or A–7–6
	41–60	Sand and gravel	SP–SM	A–1–b or A–2
Terril (TeB, TeC, TeD).	0–30	Loam and clay loam	OL or CL	A–6
	30–50	Loam	CL	A–6 or A–7–6
Tripoli (Tr).	0–19	Clay loam	OH to CL	A–7–6 or A–7–5
	19–52	Clay loam	CL	A–6 to A–7–6
Wabash (Wb).	0–36	Silty clay	OH to CH	A–7–6
	36–50	Silty clay	CH	A–7–6
Wacousta (Wa).	0–15	Silty clay loam	OL or ML	A–6 to A–7–6
	15–48	Silty clay loam	CL to CH	A–6 to A–7–6
Wadena:				
Loam, deep (WdA, WdB).	0–12	Loam	ML to CL	A–4 to A–6
	12–38	Loam	ML to CL or SM	A–6
	38–50	Sand and gravel	SP–SM	A–1–b or A–2
Loam, moderately deep (WmA, WmB, WmC2, WmD2).	0–11	Loam	ML–CL	A–4 to A–6
	11–26	Loam	SC–CL	A–6
	26–55	Sand and gravel	SP–SM	A–1–b or A–2
Waukegan (WuA, WuB).	0–11	Loam	ML–CL	A–4 or A–6
	11–24	Loam	ML to CL	A–4 or A–6
	24–30	Sandy loam	SM to SM–SC	A–2–4 or A–4
	30–55	Loamy sand	SM	A–2–4
Webster (Wy).	0–21	Silty clay loam	OH to CL	A–7–6 or A–7–5
	21–35	Silty clay loam	CL	A–6 or A–7–6
	35–50	Clay loam	CL	A–6 or A–7–6

[1] Properties too variable to be estimated.

properties of soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 200				
			Inches per hour	*Inches per inch of soil*	*pH value*	
	100	90–98	0. 8–2. 5	. 21	6. 1–6. 5	Moderate to high.
	100	90–98	<0. 05	. 17	6. 6–7. 3	High.
	100	85–95	0. 2–0. 8	. 18	6. 6–7. 3	High.
100	95–100	70–85	0. 8–2. 5	. 19	6. 6–7. 3	Moderate.
100	95–100	65–80	0. 8–2. 5	. 17	6. 6–7. 3	Moderate.
95–100	85–95	50–70	0. 8–2. 5	. 17	7. 9–8. 4	Moderate.
95–100	85–95	50–70	0. 8–2. 5	. 16	7. 9–8. 4	Moderate.
	100	70–85	0. 8–2. 5	. 21	7. 4–8. 4	Moderate to high.
100	95–100	65–80	0. 2–0. 8	. 17	7. 4–8. 4	Moderate to high.
100	90–100	65–80	0. 2–0. 8	. 15	7. 9–8. 4	Moderate to high.
80–90	65–75	3–15	>10	. 03	7. 9–8. 4	Low.
100	90–100	65–80	0. 8–2. 5	. 19	6. 1–7. 3	Moderate.
100	90–100	65–80	0. 8–2. 5	. 17	6. 6–7. 3	Moderate.
100	95–100	60–80	0. 8–2. 5	. 19	6. 1–7. 3	Moderate to high.
95–100	90–98	55–75	0. 5–2. 0	. 17	6. 6–8. 4	Moderate to high.
	100	90–97	<0. 05	. 18	6. 1–7. 3	High.
	100	85–95	<0. 05	. 17	6. 6–7. 3	High.
	100	80–95	0. 8–2. 5	. 23	6. 1–7. 3	Moderate to high.
100	98–100	70–90	0. 2–0. 8	. 19	7. 9–8. 4	High.
98–100	98–100	55–65	0. 8–2. 5	. 18	6. 6–7. 3	Moderate.
98–100	95–99	40–55	0. 8–2. 5	. 16	6. 6–7. 3	Moderate.
70–90	60–80	3–15	>10	. 03	7. 4–8. 4	Low.
100	95–100	55–70	0. 8–2. 5	. 17	5. 6–6. 0	Moderate.
98–100	90–100	45–60	0. 8–2. 5	. 15	5. 6–7. 3	Moderate.
70–90	60–80	3–10	>10	. 03	7. 4–8. 4	Low.
	100	55–65	0. 8–2. 5	. 17	6. 1–6. 5	Moderate.
	100	55–65	0. 8–2. 5	. 15	5. 6–6. 0	Moderate.
100	98–100	20–40	2. 5–5. 0	. 10	5. 6–6. 0	Low.
100	98–100	10–25	5. 0–10. 0	. 05	5. 6–6. 0	Low.
100	95–100	70–90	0. 8–2. 5	. 21	6. 6–7. 8	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	6. 6–8. 4	Moderate to high.
100	95–100	60–80	0. 2–0. 8	. 17	7. 9–8. 4	Moderate.

Soil series and map symbol	Topsoi
Afton (Af)	Fair
Alluvial land, channeled (Au).	Mostly poor; variab
Biscay (Bs)	Fair
Calco (Ca)	Fair
Canisteo (Ce, Cg)	Fair

Soil series and symbol	Suitability as a source of—				
	Topsoil	Sand	Gravel	Road fill	Ir
Clarion: Loam (ClB, ClC2, ClD2, CmC2, CmD2). (For interpretations of Storden soils in mapping units CmC2 and CmD2, refer to the Storden series.)	Good	Not suitable	Not suitable	Good; good bearing capacity and shear strength; good workability; good compaction.	Go
Loam, heavy subsoil variant (ClF).	Good to the depth of the loam surface layer.	Not suitable	Not suitable	Good; good bearing capacity and shear strength; good workability; easily compacted to high density; moderate shrink-swell potential.	Go
Colo (Co, CoB, Cs, CtB, CtC). (For interpretations of Terril soils in mapping units CtB and CtC, refer to the Terril series.)	Fair	Not suitable	Not suitable	Very poor; poor bearing capacity and shear strength; seasonal high water table; high compressibility; rich in organic matter to a depth of about 3 feet or more.	Po
Cylinder: Deep (Cu)	Good	Suitable below a depth of 3 feet; mixed sand and gravel.	Suitable below a depth of 3 feet; generally mixed sand and gravel.	Fair to a depth of 3 feet, good to excellent below; good bearing capacity and shear strength; slight compressibility.	Po
Moderately deep (Cy)	Good	Suitable below a depth of 2 to 3 feet; generally mixed sand and gravel; quality variable.	Suitable below a depth of 2 to 3 feet; generally mixed sand and gravel; quality variable.	Good to excellent below a depth of 2 to 3 feet; good bearing capacity and shear strength; slight compressibility.	Po

interpretations of soils—Continued

Soil features that affect suitability for—Continued					Degree of limitation for—	
Farm pond—Con. Embankments	Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Foundations of low buildings	Septic tank disposal fields
Good stability; good for impervious cores when compacted; occasional stones or boulders; moderate shrink-swell potential.	Well drained; drainage not needed.	Medium intake rate; high available water capacity; gravity system not suitable on strong slopes.	Complex slopes in places; features favorable except for occasional stones or boulders.	Nearly level to strongly sloping; easy to establish plants; occasional stones or boulders.	Slight; good shear strength; medium compressibility; deep to water table.	Slight except for slopes; moderate permeability; water table generally below a depth of 4 feet.
Good stability; good for impervious cores; occasional stones or boulders; good resistance to piping.	Well drained; drainage not needed.	Steep slopes.	Steep slopes; nonarable.	Steep slopes; nonarable.	Slight; good bearing capacity and shear strength; low compressibility; moderate shrink-swell potential.	Slight except for slopes; steep slopes hinder layout and installation.
Rich in organic matter to a depth of 3 feet or more; fair to poor stability; poor workability; poor embankment foundation.	Poorly drained; moderately slow permeability; tile functions well; outlets submerged in some places; subject to flooding.	Medium intake rate; high available water capacity; subject to flooding.	Nearly level or gently sloping; terraces not needed.	Nearly level; waterways not needed.	Severe; seasonal high water table; subject to flooding; high compressibility with uneven consolidation.	Severe; seasona high water table; subject to flooding; moderately slow permeability.
Good stability, especially in substratum; substratum pervious when compacted.	Somewhat poorly drained; tile drains not generally needed; sand and gravel at a depth of 3 feet or more.	Medium available water capacity; medium intake rate.	Nearly level; terraces not needed.	Nearly level; features favorable.	Slight; good bearing capacity and shear strength; slight compressibility in the substratum.	Slight to moderate; occasional high water table; contamination of streams or water supplies possible.
Good stability, especially below a depth of 2 feet; substratum pervious when compacted.	Somewhat poorly drained; tile drains generally not needed; sand and gravel at a depth of 2 to 3 feet.	Low available water capacity; rapid permeability in substratum limits effective irrigation to a depth of 2 to 3 feet.	Nearly level; terraces not needed.	Nearly level; features favorable.	Slight; good bearing capacity; slight compressibility; low shrink-swell potential.	Slight; contamination of streams or water supplies possible.

TABLE 4.—*Engineering*

Soil series and symbol	Suitability as a source of—					Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill	Impermeable material	Highway location	Farm pond: Reservoir areas
Dickinson:							
Fine sandy loam (DcA, DcB, DcC2).	Fair to good.	Substratum suitable for road subgrade but not for subbase; high in fines.	Not suitable	Good; fair bearing capacity; slight compressibility; good workability and compaction characteristics.	Poor; semipervious when compacted.	Erodibility in embankments and cuts; some heavy seepage in deep cuts.	Rapid permeability in substratum; compaction or sealing material needed; few suitable sites.
Fine sandy loam, benches (DkA, DkB, DkC2, DkD2, DkE2).	Fair to good.	Fair; generally underlain below a depth of 4 feet or more by sand mixed with some gravel.	Fair to poor; generally underlain below a depth of 4 feet by sand mixed with some gravel.	Good; fair bearing capacity; slight compressibility; good workability and compaction characteristics.	Poor; semipervious when compacted.	Erodibility in embankments.	Rapid permeability in substratum; compaction or sealing material needed; few suitable sites.
Loam (DlA, DlB)	Good	Substratum suitable for road subgrade but not for subbase; high in fines.	Not suitable	Good; good bearing capacity; slight compressibility; generally low shrink-swell potential; good workability and compaction.	Poor; semipervious when compacted.	Erodibility in embankments and cuts; some heavy seepage in deep cuts.	Rapid permeability in substratum; compaction or sealing material needed; few suitable sites.
Everly (EcB, EcC2, EsD2). (For interpretations of the Storden soil in mapping unit EsD2, refer to the Storden series.)	Fair	Not suitable	Not suitable	Good; good shear strength and bearing capacity; good workability and compaction characteristics; moderate shrink-swell potential.	Good; impervious when compacted.	Features favorable; good for embankment material.	Moderate permeability but slow when disturbed and compacted; generally low seepage; occasional pockets of sand or gravel.
Fostoria:							
Clay loam (Fo)	Fair	Not suitable	Not suitable	Fair; fair to good bearing capacity; fair workability and compaction.	Poor to fair; semipervious to impervious when compacted.	Nearly level; fair for borrow material; occasional high water table.	Nearly level; no suitable sites.

interpretations of soils—Continued

Soil features that affect suitability for—Continued					Degree of limitation for—	
Farm pond—Con. Embankments	Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Foundations of low buildings	Septic tank disposal fields
Fair stability; good workability and compaction; erodible on slopes; poor resistance to piping.	Somewhat excessively drained; drainage not needed.	Low available water capacity; rapid intake rate; requires frequent irrigation; erodibility.	Erodibility; sandy substratum; difficult to establish plants in channels.	Erodibility; low available water capacity; difficult to establish plants.	Slight; low shrink-swell potential; fair bearing capacity; consolidation rapid and possibly uneven; subject to liquifying and piping.	Slight; contamination of streams or water supplies possible.
Fair stability; slight compressibility; moderate permeability when compacted.	Somewhat excessively drained; drainage not needed.	Low available water capacity; rapid intake rate; requires frequent irrigation; erodibility.	Erodibility; sandy substratum; difficult to establish plants in channels.	Erodibility; sandy substratum; low available water capacity; difficult to establish plants.	Slight; low shrink-swell potential; fair bearing capacity; consolidation rapid and possibly uneven; becomes unstable and liquifies when saturated.	Slight; contamination of streams and water supplies possible.
Fair stability; good workability and compaction; erodibility on slopes; poor resistance to piping.	Somewhat excessively drained; drainage not needed.	Low available water capacity; rapid intake rate; requires frequent irrigation; erodibility.	Erodibility; difficult to establish plants in channels.	Erodibility; low available water capacity; difficult to establish plants.	Slight; low shrink-swell potential; fair bearing capacity; consolidation rapid and possibly uneven.	Slight; contamination of streams or water supplies possible.
Good stability; good for impervious cores when compacted; occasional stones or boulders; moderate shrink-swell potential; good resistance to piping.	Well drained; drainage not needed.	High available water capacity; medium intake rate; rapid runoff; erodibility.	Features favorable; occasional stones or boulders.	Features favorable; occasional stones or boulders.	Slight; good shear strength and bearing capacity; moderate shrink-swell potential; deep to water table.	Slight; moderate permeability; water table generally below a depth of 4 feet.
Fair to good stability; fair to good compaction and workability.	Somewhat poorly drained; tile drains generally not needed; sandy substratum.	High available water capacity; medium intake rate.	Nearly level; terraces not needed.	Nearly level; waterways not needed.	Slight; generally good bearing capacity and shear strength; slight compressibility; occasional high water table.	Slight to moderate; occasional high water table.

TABLE 4.—*Engineering*

Soil series and symbol	Suitability as a source of—					Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill	Impermeable material	Highway location	Farm pond: Reservoir areas
Fostoria—Continued							
Loam (Fs)	Good	Not suitable	Not suitable	Fair; fair to poor bearing capacity; fair workability and compaction.	Poor to fair; semipervious when compacted.	Nearly level; fair for borrow material; occasional high water table.	Nearly level; no suitable sites.
Galva:							
Silty clay loam (GaA).	Fair	Not suitable	Not suitable	Fair; fair to poor shear strength and bearing capacity; medium to high compressibility and compaction characteristics.	Fair; semipervious to impervious when compacted.	Nearly level; fair embankment material.	Nearly level; low permeability when disturbed and compacted; few suitable sites.
Silty clay loam, benches (GbA).	Fair	Suitable below a depth of 3½ feet; generally mixed sand and gravel.	Suitable below a depth of 3½ feet; generally mixed sand and gravel.	Fair above a depth of 3½ feet; fair to poor bearing capacity and shear strength; good below 3½ feet; good shear strength and slight compressibility.	Fair above a depth of 3½ feet; poor below 3½ feet.	Nearly level; good borrow material below a depth of 3½ feet.	Porous substratum; not suitable.
Glencoe:							
Silty clay loam (Ge).	Fair	Not suitable	Not suitable	Very poor; rich in organic matter to a depth of 2 to 3 feet; fair to poor shear strength; poor bearing capacity; high compressibility.	Very poor; rich in organic matter to a depth of 2 to 3 feet.	Frequent high water table; subject to ponding; wet, plastic material.	Frequent high water table; some areas suitable for dugout ponds.
Silty clay loam, gravelly substratum (Gg).	Fair	Suitable below a depth of 36 inches or more; generally mixed sand and gravel; high water table may hinder excavation.	Suitable below a depth of 36 inches or more; generally mixed sand and gravel; high water table may hinder excavation.	Poor above a depth of 3 feet; good to excellent below; rich in organic matter to a depth of about 2 feet or more.	Poor; upper part rich in organic matter; substratum pervious when compacted.	Seasonal high water table; some ponding after heavy rains or in wet periods.	Coarse, porous substratum.

interpretations of soils—Continued

Soil features that affect suitability for—Continued					Degree of limitation for—	
Farm pond—Con. Embankments	Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Foundations of low buildings	Septic tank disposal fields
Fair stability, workability, and compaction.	Somewhat poorly drained; tile drains generally not needed; tile functions well.	High available water capacity; medium intake rate.	Not needed	Nearly level; waterways not needed.	Slight to moderate; fair to poor bearing capacity and shear strength; medium to high compressibility; occasional high water table.	Slight to moderate; occasional high water table.
Fair stability, workability, and compaction; medium compressibility.	Well drained	High available water capacity; medium intake rate.	Nearly level; features favorable.	Nearly level; features favorable.	Moderate; generally poor bearing capacity and shear strength; medium compressibility; moderate shrink-swell potential.	Slight; moderate permeability; deep to water table.
Fair stability; fair workability and compaction to a depth of 3½ feet; good stability below 3½ feet; pervious.	Well drained; drainage not needed.	Medium to high available water capacity; medium intake rate.	Nearly level; features favorable.	Nearly level; features favorable.	Slight; slight compressibility and good bearing capacity in substratum.	Slight; moderate permeability in the upper part, rapid below a depth of 3½ feet; contamination of streams and water supplies possible.
Rich in organic matter to a depth of 2 to 3 feet; fair to poor stability; poor compaction; high compressibility.	Very poorly drained; moderately slow permeability; tile functions fairly well; French drains, open ditches, or surface intake needed; outlets may require deep cuts.	Very poorly drained; irrigation seldom needed.	Depressions; terraces not needed.	Depressions; waterways not needed.	Severe; frequent high water table; subject to ponding; high compressibility and uneven consolidation; poor bearing capacity.	Severe; frequent high water table; subject to ponding; moderately slow to slow permeability.
Rich in organic matter to a depth of about 2 feet; substratum stable but pervious.	Very poorly drained; moderately slow permeability above the coarse substratum; tile functions well; the sand and gravel in the substratum may cause installation difficulties.	Medium to high available water capacity; medium intake rate.	Nearly level; terraces not needed.	Nearly level; waterways generally needed.	Severe; seasonal high water table; some ponding after heavy rains or in wet periods.	Severe; seasonal high water table; some ponding after heavy rains and in wet periods.

TABLE 4.—*Engineering*

Soil series and symbol	Suitability as a source of—					Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill	Impermeable material	Highway location	Farm pond: Reservoir areas
Guckeen: Silty clay loam (GkA, GkB, GkC2).	Fair	Not suitable	Not suitable	Very poor above a depth of 3 feet; high shrink-swell potential and compressibility; good below a depth of 3 feet; good bearing capacity and compaction characteristics.	Fair; impervious when compacted but subject to cracking and volume change.	Seasonal high water table; very plastic above 3 feet; good borrow material below a depth of 3 feet.	Nearly level; no suitable sites.
Clay loam, silty clay substratum (GuA, GuB).	Fair	Not suitable	Not suitable	Very poor; fair to poor shear strength and bearing capacity; high shrink-swell potential; high compressibility.	Fair; impervious when compacted but subject to cracking and volume change.	Seasonal high water table; very plastic material.	Nearly level; very slow permeability; no suitable sites.
Hagener (HaC2)	Very poor	Not suitable for concrete; fair for road subbase.	Not suitable	Good; good bearing capacity; low shrink-swell potential; subject to liquifying and piping; high erodibility on embankments.	Very poor; pervious material.	High erodibility on embankments; may liquify if moved when wet.	Rapid permeability.
Harps (Hr)	Poor; high in calcium carbonate.	Not suitable	Not suitable	Very poor; seasonal high water table; high shrink-swell potential; fair bearing capacity and shear strength.	Fair; impervious below a depth of 1½ feet when compacted.	Seasonal high water table.	Nearly level; seasonal high water table; no suitable sites.
Ladoga (LaA)	Fair	Not suitable	Not suitable	Fair; fair to poor bearing capacity and shear strength; medium to high compressibility; fair to poor workability and compaction characteristics.	Fair; semipervious to impervious when compacted.	Fair for embankments; other features favorable.	Nearly level; few suitable sites; permeability moderate but low when scarified and compacted.

interpretations of soils—Continued

Soil features that affect suitability for—Continued					Degree of limitation for—	
Farm pond—Con. Embankments	Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Foundations of low buildings	Septic tank disposal fields
Fair stability above a depth of 3 feet, good stability below; moderate to high shrink-swell potential; excellent resistance to piping.	Somewhat poorly to moderately well drained; some areas benefited from tile drains; tile functions well.	High available water capacity; slow intake rate.	Clayey subsoil; difficult to establish plants in terrace channels without adding topsoil.	Clayey subsoil; difficult to establish plants in channels without adding topsoil.	Slight; substratum has good bearing capacity, moderate shrink-swell potential, and slight compressibility; seasonal high water table.	Slight to moderate; poor below a depth of 3½ feet; seasonal high water table.
Fair stability on level slopes; poor compaction; high shrink-swell potential; excellent resistance to piping.	Somewhat poor to moderately good; some areas benefited from tile drains; tile may not function well.	High available water capacity; slow intake rate.	Clayey subsoil; difficult to establish plants in terrace channels without adding topsoil.	Clayey subsoil; difficult to establish plants without adding topsoil.	Moderate; fair to poor bearing capacity; high shrink-swell potential; high compressibility; seasonal high water table.	Severe; slow permeability.
Fair stability; slight compressibility; pervious; poor resistance to piping.	Excessively drained; drainage not needed.	Low available water capacity; rapid intake rate; frequent irrigation needed; subject to erosion.	Sandy subsoil and substratum; high erodibility; difficult to establish plants.	High erodibility; difficult to establish and maintain plants.	Slight to none; good bearing capacity and shear strength; low shrink-swell potential; slight compressibility; subject to liquifying and piping.	Slight; contamination of streams and water supplies possible.
Not ordinarily used.	Poorly drained; tile functions well.	High available water capacity; medium intake rate; seasonal high water table.	Not needed.	Seasonal high water table; wetness hinders construction.	Severe; fair shear strength; fair bearing capacity; seasonal high water table; moderate to high shrink-swell potential.	Severe; moderate permeability; seasonal high water table; generally adjacent to very wet soils in depressions.
Fair stability; fair to poor compaction and workability; medium compressibility; poor resistance to piping.	Well drained; drainage not needed.	High available water capacity; medium intake rate.	Nearly level; features favorable.	Nearly level; features favorable.	Slight to moderate; fair to poor bearing capacity and shear strength; medium to high compressibility; moderate to high shrink-swell potential.	Slight; moderate permeability; deep to water table.

TABLE 4.—*Engineering*

Soil series and symbol	Suitability as a source of—					Soil features that affect suitability for—	
	Topsoil	Sand	Gravel	Road fill	Impermeable material	Highway location	Farm pond: Reservoir areas
Marcus (Ma)	Fair	Not suitable	Not suitable	Very poor; fair to poor bearing capacity; rich in organic matter to a depth of about 2 feet; high shrink-swell potential; frequent high water table.	Poor; rich in organic matter to a depth of 2 feet; semipervious to impervious below 2 feet when compacted.	Seasonal high water table; rich in organic matter to a depth of about 2 feet.	Nearly level; seasonal high water table; some areas suitable for dugout ponds.
Marna (Mc, Me)	Poor	Not suitable	Not suitable	Very poor; very plastic material.	Fair; impervious when compacted; subject to cracking and volume change.	Seasonal high water table; very plastic; rich in organic matter to a depth of 1½ feet.	Nearly level; slow permeability; seasonal high water table; no suitable sites for conventional ponds.
Muck:							
Moderately shallow (Mm)	Good if mixed with mineral soil.	Not suitable	Not suitable	Not suitable; rich in organic matter; frequent high water table.	Not suitable	Not suitable for borrow material; frequent high water table; subject to ponding.	Occurs in depressions; some areas suitable for dugout ponds.
Moderately shallow, calcareous (Mr).	Poor; highly calcareous; low in plant nutrients.	Not suitable	Not suitable	Not suitable; rich in organic matter; frequent high water table.	Not suitable	Not suitable for borrow material; frequent high water table; subject to ponding.	Occurs in depressions; some areas suitable for dugout ponds.
Shallow (Ms)	Fair to good if mixed with mineral soil.	Not suitable	Not suitable	Not suitable to a depth of about 1½ feet; very poor bearing capacity; high compressibility.	Very poor; muck to a depth of about 1 or 1½ feet; very pervious.	Seasonal high water table; subject to ponding; very poor as borrow material.	Seasonal high water table; some areas suitable for dugout ponds.

of soils—Continued

	Soil features that affect suitability for—Continued				Degree of limitation for—	
on. ts	Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Foundations of low buildings	Septic tank disposal fields
- om-	Poorly drained; tile functions well.	High available water capacity; medium to slow intake rate; seasonal high water table.	Nearly level; terraces not needed.	Seasonal high water table; wetness hinders construction.	Severe; fair to poor bearing capacity; high compressibility; seasonal high water table; high shrink-swell potential.	Severe; moderately slow permeability; seasonal high water table.
on c- om- and	Poorly drained; slow permeability; tile does not function well; close spacing of tile needed; surface drains beneficial in places.	Medium to high available water capacity; intake rate generally slow.	Nearly level; terraces not needed.	Seasonal high water table; wetness hinders construction in places.	Severe; fair to poor bearing capacity; seasonal high water table; high shrink-swell potential.	Severe; seasonal high water table; slow permeability.
-----	Very poorly drained; generally moderate permeability in mineral part; open intake or surface ditches needed in ponded areas.	High available water capacity; rapid intake rate in muck part, medium in mineral part.	Depressions; terraces not needed.	Depressions; waterways not needed.	Severe; frequent high water table; subject to ponding.	Severe; frequent high water table; subject to ponding.
-----	Very poorly drained; generally moderate permeability in mineral part; open intake or surface ditches needed.	High available water capacity; rapid intake rate in muck part, medium in mineral part.	Depressions; terraces not needed.	Depressions; waterways not needed.	Severe; frequent high water table; subject to ponding.	Severe; frequent high water table; subject to ponding.
o 1½ ta- ; et; ily	Very poorly drained; moderately slow permeability; tile functions well but deep cuts needed in places for outlets; open intake or surface ditches also needed in places.	Very poorly drained; irrigation not needed.	Depressions; terraces not needed.	Depressions; waterways not needed.	Very severe; muck extends to a depth of about 1 or 1½ feet; poor bearing capacity and shear strength; seasonal water table near the surface.	Severe; seasonal water table near the surface; moderately slow permeability.

TA

[Tests performed by Iowa State Highway Commission in cooperation with U.S. Department of Commerce,

Soil name and location	Parent material	Iowa report No. AAD9–	Depth	Horizon	Ma de
Dick[illegible]nson fine sandy loam:			*Inches*		*Lb.*
30[illegible] feet S. and 264 feet E. of the NW. cor. of [illegible]he NW¼ of sec. 15, T. 97 N., R. 38 W.	Stratified or wind-blown materials.	8415	0–7	Ap	
		8416	14–20	B2	
		8417	30–60	C	
1,[illegible]32 feet S. and 82 feet E. of the NW. cor. of [illegible]f NW¼ of sec. 21, T. 97 N., R. 37 W.	Stratified or wind-blown materials over glacial outwash.	8418	0–6	Ap	
		8419	22–30	B22	
		8420	30–42	C	
Prim[illegible]ghar silty clay loam:					
36[illegible] feet S. and 320 feet W. of NE. cor., NW¼ [illegible]NE¼ of sec. 14, T. 95 N., R. 38 W.	Loess overlying glacial till.	10472	0–7	Ap	
		10473	21–30	B22	
		10474	47–60	IIC3	
Sac [illegible]lty clay loam:					
30[illegible] feet W. and 135 yards N. of SE. cor. [illegible]NE¼SE¼ of sec. 16, T. 95 N., R. 38 W.	Loess overlying glacial till.	10475	0–7	Ap	
		10476	11–18	B1	
		10477	44–57	IIC	
Wau[illegible]egan loam:					
80[illegible]feet E. and 0.1 mile S. of NW. cor., SW¼ [illegible]f sec. 9, T. 96 N., R. 37 W.	Glacial outwash.	10466	0–8	Ap	
		10467	15–22	B21	
		10468	35–55	IIC	

[illegible] Based on AASHO Designation: T 99–57, Method A (2).
[illegible] Mechanical analyses according to the American Association of State Highway Officials Designation T 88-proc[illegible]dure frequently may differ somewhat from results that would have been obtained by the soil survey proced vatio[illegible]n Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the tions[illegible]are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SC the f[illegible]ne material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is exc of gr[illegible]in-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes

upla[illegible]nds. On the more sloping hillsides, the loess is thinner and [illegible] may be absent in places. In these places till is at the surf[illegible]ace.

T[illegible]he nearly level soils that formed in loess on uplands, such[illegible] as the Primghar and Marcus, are classified A–7 and OH [illegible] or CL or CH. The upper foot or so of these soils is orga[illegible]nic and therefore difficult to compact to good density. The [illegible] subsoil is more plastic and has high shrink-swell potent[illegible]al. Where soils, such as the Sac, formed in loess over till [illegible]n sloping hillsides, less topsoil has developed and the subs[illegible]oil is less plastic. The soils formed in loess are readily eroc[illegible]ed where runoff is rapid, and sodding, paving, or buil[illegible]ding of check dams is needed in gutters and ditches.

I[illegible] soils formed in loess over till, a seasonally high water tabl[illegible] may be perched above the till. In the more level soils or s[illegible]ils in depressions, a shallow perched water table occurs abov[illegible]e a plastic B horizon in places. In these areas the density [illegible]of the loess in place is fairly low, and the moisture content [illegible] is high. The high moisture content causes instability of e[illegible]mbankments unless the moisture is carefully controlled at t[illegible]e time of compaction.

T[illegible]he soils that formed in loamy till, such as the Clarion, Nic[illegible]llet, and Storden, range from loam to clay loam in texture and are classified A–4 or A–6 a soils are in or adjacent to road grade mally is placed in the upper part of t that are unstable. Pockets and lenses o interspersed throughout the till and bearing.

Where the road grade is only a fe and the surface layer is silty, frost hea the till is drained or the soil above i granular backfill or clayey till. Poorl formed in glacial till and glacial se Webster, are classified A–7 and OH to a high moisture content and low densi good subgrade bearing capacity cann material in these soils, this material least 3 feet below the top of the subg in the county that are highly organic soil of low density should also be p

Soils that formed in loam and clay wash benches are fine textured and a A–6 and ML or CL. These soils, such *test data*

Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*2*)]

Mechanical analysis [2]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—						AASHO	Unified [3]
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.	0.05 mm.	0.005 mm.	0.002 mm.	0.001 mm.				
---------	100	84	37	32	15	11	9	23	7	A–4(0)	SM–SC
---------	100	89	45	39	18	15	12	21	7	A–4(2)	SM–SC
---------	100	73	17	13	8	8	7	[4] NP	[4] NP	A–2–4(0)	SM
---------	100	93	39	34	17	12	10	22	6	A–4(1)	SM–SC
---------	100	93	37	33	18	14	12	23	10	A–4(0)	SC
---------	100	90	23	19	12	11	10	NP	NP	A–2–4(0)	SM
---------	----------	100	98	92	42	31	24	54	21	A–7–5(15)	MH
---------	----------	100	99	93	40	31	25	49	26	A–7–6(16)	CL
[5] 99	97	92	70	66	35	27	21	37	19	A–6(11)	CL
---------	100	99	97	89	40	31	25	48	18	A–7–5(13)	ML
---------	100	99	96	92	41	33	27	48	21	A–7–6(14)	ML–CL
[6] 97	94	89	76	71	40	31	25	43	23	A–7–6(14)	CL
100	99	84	62	55	23	16	10	37	12	A–6(6)	ML–CL
[5] 99	97	77	47	43	23	19	15	36	16	A–6(4)	SC
[6] 83	72	26	5	4	1	.5	.2	NP	NP	A–1–b(0)	SP–SM

[3] Based on the Unified Soil Classification System (*17*). The Soil Conservation Service and Bureau of Public Roads have agreed to con sider that all soils having plasticity indexes within two points of the A-line are to be given a borderline classification. An example of borderline classification so obtained is "ML–CL."

[4] NP = Nonplastic.

[5] 100 percent passes a ¾-inch sieve.

[6] 99 percent passes a ¾-inch sieve; 100 percent passes a 1½-inch sieve.

Cylinder, are underlain by stratified sand and gravel. The sand and gravel are classified A–1 or A–2 and SP–SM. The gently sloping Wadena soils generally have a thin surface layer, but sand and gravel in the underlying layers can be used as borrow material and placed in the upper part of the subgrade. Frost heaving may result, however, unless the level areas are properly drained.

Soils on bottom lands in the county developed in alluvium. The Colo soils formed in alluvium and are classified A–7 and OL or CH. These soils are silty clay loam and have a thick, organic surface layer that may consolidate erratically under embankment loads. The Colo soils have a high moisture content and low density in place.

The clayey Wabash soils are classified A–7 and OH to CH and may produce differential settlement under embankment loads. Embankment overloading and temporary or delayed paving normally serve as corrective measures in assuring a smooth grade where roads are built on these soils.

The clayey Marna and Guckeen soils formed in lacustrine deposits and are classified A–6 or A–7 and CL to CH. These soils are on uplands and glacial outwash benches. They are generally in small areas and, in most places, ca be bypassed in highway construction. If these soils mus be crossed by a road grade, excavation to a firm subsoi may be needed, and backfilling with granular material ma be desirable.

Formation and Classification of Soils

This section consists of three main parts. In the firs part, the factors of soil formation are listed and discusse as they relate to the formation of soils in the county. Th second part discusses the formation of horizons and th processes of their formation. In the third part, each so series represented in the county is placed in its respectiv family, subgroup, and order of the current system for clas sifying soils and is also placed in its respective great so group of the classification system used in 1938 and late revised.

For further information about the current system fo classifying soils, refer to "Soil Classification, a Compr hensive System" (*14*).

ʼactors of Soil Formation

Soil is produced when soil-forming processes act on ıaterials deposited or accumulated by geologic forces. The haracteristics of the soil at any given point are determined ŋy (1) the physical and mineralogical composition of the ›arent materials; (2) the climate under which the soil ıaterial has accumulated and existed since accumulation; 3) the plant and animal life on and in the soil; (4) the reief, or lay of the land; and (5) the length of time the orces of soil formation have acted on the soil material.

Climate and living organisms, chiefly vegetation, are the ctive factors of soil formation. They act on the parent maerial that has accumulated through the weathering of ocks and slowly change it into a natural body with genetially related horizons. The effects of climate and vegetaion are conditioned by relief. The parent material also afects the kind of profile that can be formed, and, in extreme ases, determines it almost entirely. Finally, time is needed or changing the parent material into a soil. It may be ıuch or little, but some time is always required for horizon ifferentiation. Usually, a long time is required for the deelopment of distinct soil horizons.

The factors of soil formation are so closely interrelated n their effects on the soil that few generalizations can be ıade regarding the effect of any one factor unless condiions are specified for the other four. Many of the processes f soil formation are not fully known.

ʼarent material

The soils of Clay County developed in glacial till, glaial outwash, loess, alluvium, organic deposits, eolian sand, nd lacustrine sediments. The bedrock underlying these ıaterials is so deep that it has had no influence on the forıation of the soils.

The soils of the county have been affected by three stages f glaciation—the Nebraskan, the Kansan, and the Wisonsin. In this county the till from the Kansan and Neraskan stages is deeply buried and is not visible.

The eastern part of the county was covered by the Des Ioines lobe of late Wisconsin glaciation (*6*). It was forıerly believed that the Des Moines lobe was in two subtages, the Cary and the Mankato (*6*, *8*). According to ıis view, the eastern part of the county would lie ıainly within the Cary substage, but only a mile or two of he eastern part would be covered by the Mankato, which s the last or most recent substage. In more recent investiations, however, the evidence indicates that most, if not ll, of the Des Moines lobe is of Cary age (*9*). It has been etermined by radiocarbon dates that the Cary substage ccurred about 13,000 years ago. The evidence for the geoɔgic youth of the Cary substage is the lack of deep weathring, the unleached calcareous till at a shallow depth, and he poorly developed surface drainage and many closed epressions.

In most of the western two-thirds of the county the ʼazewell substage of the Wisconsin glaciation deposited urface drift. Radiocarbon dates of wood obtained at the ase of the till near Cherokee indicate that this substage ccurred about 20,000 years ago (*19*). Loess that is between 0 and 60 inches thick, except on steep, eroded slopes, ıantles much of the area. An exception is areas in the Evrly-Nicollet-Tripoli soil association. In these areas the ill is covered by a thin, gritty, loesslike material of uncertain origin but presumed to be windblown. In the Ocheyedan-Fostoria-Webster soil association the Tazewell till is covered 50 to about 100 inches deep by sediments that range from moderately fine to coarse in texture.

GLACIAL TILL is exposed in the eastern part of the county and in sloping areas in the western part where the loess mantle has been removed by erosion. The major soils that developed in glacial till are the Storden and Clarion. The Salida soils developed on sandy and gravelly knobs of moraines. The Webster soils developed in glacial till and in glacial sediments or reworked till overlying glacial till (*18*). The Everly, Nicollet, and Tripoli soils developed in glacial till and a thin, gritty layer of uncertain origin on the till. The Glencoe, Okoboji, Wacousta, and Rolfe soils developed in reworked glacial till and local alluvium.

GLACIAL OUTWASH, or material deposited by meltwater from glaciers, makes up extensive deposits of sand and gravel on benches along the Little Sioux and Ocheyedan Rivers in the northwestern part of the county. Similar deposits that are less extensive and shallower occur along other streams and near moraines in the eastern part of the county. The Cylinder, Wadena, Biscay, and Talcot soils developed in glacial outwash and overlie sand and gravel. The Ocheyedan and Fostoria soils developed in glacial outwash or sediments of similar texture in the upper part but of finer texture in the lower part.

LOESS consists mainly of particles of silt and clay deposited by wind. Loess covers extensive areas of the county, mainly in the western part and west of the Little Sioux River. The soils that developed in loess are the Galva, Sac, Ladoga, Marcus, Primghar, and Sperry.

ALLUVIUM consists of sediments deposited by streams. The miscellaneous land type, Alluvial land, is made up of recent alluvium and the Colo, Spillville, and Wabash soils of somewhat older alluvium. The Terril soils developed in local alluvium that recently was washed from adjacent soils.

ORGANIC DEPOSITS consist of plant material that has accumulated in old lakebeds or swamps that supported a thick growth of water-loving plants. The dead, partly decomposed plants accumulated in a fairly thick layer under water and ordinarily overlie glacial material. Muck soils formed in this organic material.

EOLIAN SAND consists of sand that is assumed to have been deposited by wind. The fine sand was probably blown from the river flood plains or from benches. The Hagener soils developed in this material. They occur mainly as sandy ridges on benches in the northwestern part of the county, but some areas are in the uplands southeast of Spencer. The Dickinson soils developed in this sandy material that most likely was deposited by water, though there is some indication that, in some parts of the county, much of this material was deposited or reworked by wind.

LACUSTRINE SEDIMENTS are in deposits of variable thickness. Some deposits are 4 to 5 feet thick or more; others are thinner and overlie medium-textured to moderately fine textured glacial drift or glacial sediment at a depth of 3 to 4 feet or less. The Marna and Guckeen soils developed wholly or partially in water-laid lacustrine sediments.

Climate

Climate influences the formation of soils in many ways. Rainfall affects the amount of leaching in soils and influences the kind and amount of vegetation that grows on soils. Temperature affects the growth of plants, the activity of micro-organisms, and the rapidity of chemical reactions. The major differences among soils within the county, however, are attributed to factors other than climate.

Available information indicates that the soils in Clay County have been developing under a midcontinental, subhumid climate for the last 5,000 years. Between 5,000 and 16,000 years ago the climate was conducive to forest vegetation (*8*). Lane assumes that the successions of vegetation in post-Mankato time, from about 11,000 years ago to the present, has been caused by changes in climate (*5*). From these successions of vegetation, he infers that there have been three shifts in climate. These shifts were (1) a warming condition that produced a change from coniferous to deciduous trees, (2) a gradual desiccation prior to the appearance of grasses, and (3) continued drying that produced a climate more favorable to grasses. The recent work by Walker and Brush on climate (*16*) corroborates the findings of Lane. Some soils of Clay County, however, do not have characteristics that indicate they were ever forested.

Plant and animal life

Plants and animals have greatly influenced the development of soils in Clay County. Micro-organisms have helped in the decay of organic matter. The native vegetation of Clay County at the time of settlement was mainly tall prairie grasses, but a few areas, mainly along the Little Sioux River, were in trees. Ruhe and Scholtes (*8*) report that for the last 5,000 years the environment in Iowa was conducive to prairie plants. From 5,000 to 16,000 years ago, however, the cooler, more moist climate that existed was more favorable to trees. The effect of this period of forest vegetation is not reflected in the formation of the Primghar, Sac, Nicollet, or other dark-colored soils that formed more recently under prairie vegetation.

Most of the soils of Clay County formed under prairie grasses. The formation of Clarion loam, heavy subsoil variant, and the Ladoga soil has been influenced by trees during at least part of the time. These soils may have developed first under grasses and later under encroaching trees. The vegetation in the potholes and other depressions was sedges, cattails, rushes, and similar plants.

Under similar conditions, soils that formed under grass are darker colored than those that formed under trees. Soils that formed under trees are more acid and have a thinner surface layer than soils that formed under grass. Soils that formed under vegetation consisting of mixed grass and trees have properties that are intermediate between those of soils formed under grass and those of soils formed under trees.

Relief

Relief is important in soil formation mainly because it affects drainage and erosion. Less water soaks into a soil that has steeper slopes, and there is less leaching of the carbonates and less movement of clay from the surface soil to the subsoil. Soil erosion generally increases as steepness increases. In the nearly level or depressed areas, the soils are wet and frequently have a gray or mottled subsoil that results from poor aeration and restricted drainage. Webster soils are an example.

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The relief of the eastern part of the county is immature geologically, as shown by the large number of potholes and other depressions and by the absence of well-developed upland streams. The western part of the county is somewhat more dissected in some areas, but relief is also fairly immature. Areas adjacent to the major streams are dissected, but streams have not extended their channels much at the head. Most of Clay County is nearly level to rolling. A large percentage of the soils in the nearly level areas are poorly drained. Most of the soils, such as Clarion or Sac, that are gently sloping or strongly sloping are well drained.

The thickness and color of the A horizon and the thickness of the solum are also related to slope; for example, the thickness and color of the A horizon of the Storden, Clarion, and Nicollet soils are directly related to the topography. Thickness of the A horizon increases, and the color becomes darker as the slope decreases. Typically, the Storden soils have steep slopes, the Clarion soils have intermediate slopes, and the Nicollet soils are nearly level. Likewise, the thickness of the solum increases from the thinner Storden to the thicker Clarion and Nicollet soils.

Time

The radiocarbon technique for determining the age of carbonaceous material found in loess and glacial till has made it possible to determine the approximate ages of soils and of Pleistocene geologic deposits in Iowa. The age of the Cary substage of the late Wisconsin glaciation, according to studies by Ruhe and Scholtes (*8,9*), has been determined to be about 13,000 years. Soils that formed in Cary till include the Clarion, Webster, and Nicollet.

The Tazewell loess, in which most soils of the uplands in the western part of the county were formed, was being deposited from some time prior to 17,000 to approximately 15,000 years ago (*7*). Soils that formed in Tazewell loess include the Galva, Sac, Primghar, and Marcus.

The soils that formed in glacial outwash, such as the Wadena and Biscay, are less than about 13,000 years old. Soils that developed in alluvium range in age from recently deposited material that makes up Alluvial land to sediments that have been in place longer in which Colo and Wabash soils developed. These sediments are not more than 13,000 years old and are probably much younger.

Soils such as Clarion, Storden, and other sloping soils are subject to geologic erosion, which continues to expose deeper material. These soils therefore range in age from the time their parent materials were deposited to recent time.

Formation of Horizons

In Clay County morphology is expressed by faint soil horizons in most soils. The Storden, Clarion, Webster, Marcus, and Sac soils have faint horizons; the Rolfe soils, prominent horizons; the Ladoga and a few other soils, intermediate horizons. Some soils have a marked difference between the texture of the solum and an underlying IIC horizon. Examples are the Wadena, Cylinder, and Biscay soils.

Horizon differentiation in soils is the result of one or more of the following processes: (1) accumulation of organic matter; (2) leaching of calcium carbonate and other bases; (3) formation and translocation of silicate clay minerals; (4) reduction and transfer of iron; and (5) accumulation of calcium carbonates. In most of the soils of the county two or more of these processes have been active in the formation of horizons.

Most soils in Clay County have some accumulation of organic matter in the upper part that forms an A1 horizon. The A1 horizons of soils formed in organic deposits in the county have a high organic-matter content. Some of the mineral soils that have a high content of organic matter are the Glencoe, Okoboji, Webster, and Colo. These soils have a thick A1 horizon. The Hagener and Salida soils are low in organic-matter content and have a faint, thin A1 horizon. Many soils in the county have a moderate content of organic matter.

Leaching of calcium carbonates and other bases has occurred in many soils in the county. Leaching generally occurs before and during the translocation of silicate clay minerals. Many of the soils in Clay County, including the Clarion, Nicollet, and Webster, have been leached of calcium carbonate to a shallow depth, but little clay has been moved downward in their profiles. The Rolfe and Ladoga soils generally are more strongly leached throughout their profiles and have a distinct accumulation of silicate clay in the B horizon.

The translocation of silicate clay minerals has contributed to the prominent horizonation in the Rolfe soils and to the somewhat less prominent horizonation in the Ladoga soils. The B horizons of these soils have more clay than the A horizons and often have dark-colored clay coatings on the ped surfaces and along root channels. The eluviated A2 horizon has platy structure, has less clay, and normally is lighter colored than the B horizon. The leaching of bases and the translocation of clay in these soils have been more important processes in horizon differentiation than the accumulation of organic matter.

The horizonation is faintly expressed in the Harps and Canisteo soils. Carbonates have accumulated in the surface layer and subsoil. The calcium carbonate equivalent of the Harps soils is 10 to 40 percent.

Gleying, or the process of reduction and transfer of iron (*10*), is evident in the poorly drained and very poorly drained soils. The Glencoe, Webster, Biscay, Colo, Marcus, and Harps soils have gleyed (Bg) horizons. The Bg horizons are gray, which indicates the reduction and loss of iron. In some soils there are reddish-brown concretions of iron.

Classification of Soils

Soils are classified so that we can more readily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*12*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*11, 14*). Therefore, readers interested in developments of this system should search for the latest literature available. In this subsection some of the classes in the current system and the great soil groups in the older system are given for each soil series in table 6. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different climates.

Table 6 shows the three soil orders in Clay County—Mollisols, Alfisols, and Histosols. Mollisols have a thick, soft, friable surface layer that has been darkened by organic matter. Alfisols have clay-enriched B horizons that are high in base saturation. Histosols are highly organic, and their classification has not been completed beyond the order.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUPS: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans interfering with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 6 because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Hapludolls.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils where used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. An example is *fine-loamy, mixed, mesic family* of Typic Hapludolls.

SERIES: The series consists of a group of soils that formed from a particular kind of parent material and

TABLE 6.—*Soil series classified according to the current system of classification*[1] *and the revised 1938 system*

Series	Current classification			1938 classification
	Family	Subgroup	Order	Great soil group
Afton	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Calco	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils intergrading to Alluvial soils.
Canisteo	Fine-loamy, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols	Humic Gley soils.
Clarion	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils intergrading to Alluvial soils.
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic.	Aquic Hapludolls	Mollisols	Brunizems.
Dickinson	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Everly	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Fostoria	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols	Brunizems.
Galva	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Glencoe	Fine-loamy, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Guckeen	Fine, montmorillonitic, mixed, mesic	Aquic Hapludolls	Mollisols	Humic Gley soils.
Hagener	Sandy, mixed, mesic	Entic Hapludolls	Mollisols	Regosols.
Harps	Fine-carbonatic, mesic	Typic Calciaquolls	Mollisols	Humic Gley soils.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols	Gray-Brown Podzolic soils intergrad ng to Brunizems.
Marcus	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols	Humic Gley soils.
Marna	Fine, montmorillonitic, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Muck	(2)	(2)	Histosols	Bog soils.
Nicollet	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols	Brunizems.
Ocheyedan	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Okoboji	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Primghar	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols	Brunizems.
Rolfe	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols	Planosols.
Sac	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols	Brunizems intergrading to Regosols.
Sperry	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols	Planosols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems intergrading to Alluvial soils.
Storden	Fine-loamy, mixed, mesic	Entic Hapludolls	Mollisols	Regosols.
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Tripoli	Fine-loamy, mixed, noncalcareous, me-ic	Typic Haplaquolls	Mollisols	Humic Gley soils.
Wabash	Fine, montmorillonitic, noncalcareous, mesic.	Vertic Haplaquolls	Mollisols	Humic Gley soils.
Wacousta	Fine-silty, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols	Humic Gley soils.
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Waukegan	Fine-silty over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Webster	Fine-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols	Humic Gley soils.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.
[2] Families and subgroups have not been developed for the Histosolsorder.

having genetic 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, structure, reaction, consistence, and mineralogical and chemical composition.

New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at National, State, and regional levels of responsibility for soil classification results in a judgment that the new series should be established. Most of the soil series described in this survey have been established earlier, but eight had tentative status when the survey was sent to the printer. They are the Cylinder, Everly, Fostoria, Galva, Harps, Ocheyedan, Primghar, and Sac series.

General Nature of the County

This section was written for those who are not familiar with Clay County. It discusses briefly the history, climate, and relief and drainage of the county and gives some agricultural statistics.

History

The first permanent white settlers in Clay County were Christian Kirchner, who settled in section 32 of Peterson Township, and Ambros S. Mead, who settled in section 34. These men settled in July 1856, and in the fall several other families moved in.

Clay County originally was part of Woodbury County. At an election held on October 12, 1858, Clay County was organized, and district, county, and township officers were elected. At this time nearly all the inhabitants lived in the southwestern corner of the county. They selected Peterson as the county seat. By 1871 many people had arrived in the county, and the northern part was rapidly being settled. Spencer now had a larger population than Peterson, and in October of 1871 the residents of the county voted to move the county seat to Spencer.

The population of the county was 4,248 in 1880. It had grown to about 15,600 by 1920 (*1*), but since then the rate of growth has been fairly slow. According to the U.S. Census, 18,504 persons were residing in the county in 1960. Spencer had about 1,000 residents in 1880; in 1960 it had about 8,800. The population of Peterson in 1960 was 565.

Climate [4]

Clay County has a subhumid midcontinental climate. Changes are frequent and generally distinct because the county is near the path of two prevailing storm tracks, one from the northwest and the other from the southwest. Summers are warm with occasional hot periods, and winters are cold, but long periods of intense cold or heat are rare. Summers are sunny and have prevailing southerly winds. The winters are somewhat more cloudy, and the prevailing winds are northwesterly. The climatological data from Spencer are summarized in table 7. These data are fairly representative for the county, though summer showers and minimum temperatures are somewhat variable. On calm

[4] By PAUL J. WAITE, State climatologist, U.S. Weather Bureau.

TABLE 7.—*Climatological*

[Elevation

Month	Temperature in °F.							Mean heating degree-days [2]
	Mean			Extreme				
				Record highest		Record lowest		
	Daily maximum	Daily minimum	Monthly	Degrees	Year	Degrees	Year	
January	26.0	6.2	16.1	66	1944	−30	1936	1,516
February	30.2	9.5	19.9	63	1954	−31	1936	1,274
March	40.8	21.1	31.0	82	[3] 1943	−28	1948	1,054
April	59.2	34.7	45.5	91	1960	8	1936	585
May	71.4	46.4	58.9	109	1934	23	1946	265
June	80.6	57.0	68.8	106	1933	32	1945	69
July	86.5	61.0	73.8	113	1936	41	1947	28
August	84.1	59.2	71.7	108	1936	34	1950	31
September	75.6	49.1	62.4	100	1939	21	1942	165
October	64.0	37.9	51.0	91	[3] 1953	10	1949	443
November	43.8	22.8	33.3	78	1931	−17	1959	951
December	31.1	12.1	21.6	65	1939	−28	1951	1,345
Year	57.8	34.8	46.2	113	1936	−31	1936	7,726

[1] Based on a 30-year record, from 1931 through 1960.
[2] Degree-days are computed by recording for each day the significant mean departure from a selected temperature base, and adding these departures for the month and year. A base of 65° F. is used for heating degree-days, as this is the lowest mean daily temperature at which no heat is required in homes.

clear nights the lowlands normally are a few degrees cooler than the uplands or urban areas.

During the five warm months—May through September—the county receives about two-thirds of its annual precipitation, mostly as showers. About 40 thundershowers occur each year, mainly during this period. Occasionally excessive rainfall, high winds, hail, or even tornadoes occur. On the average Clay County has about one tornado every 2 years, but none has been damaging nor has moved a long distance. The most damaging tornado on record occurred on September 21, 1894. This tornado caused little damage in Clay County, but in northern Iowa it killed 53 people and did considerable damage.

Some very damaging hailstorms have occurred in Clay County, but losses from hail generally have been less than in the rest of northwestern Iowa. Winds as much as 50 miles an hour at a height of 15 feet occur about once every 2 years; as much as 80 miles, about once in 50 years; and as much as 90 miles, about once in 100 years.

Rainfall is excessive, mainly in spring and summer, and causes local flooding. The heaviest rainfall ever recorded was 5.45 inches in about 12 hours. It began about 5 p.m. on September 17, 1926. The probability of a recurrence of this amount in 12 hours is about once in 85 years. Rainfall is heaviest during May and June. Measurable rainfall occurs on about 95 days each year and, on the average, 60 days has 0.1 inch or more. Except during early growth, corn requires about 1 inch of rain each week; therefore, dry spells during the growing season are of some concern. The probability of receiving 1 inch or more of rain in June is about two in five, but this probability decreases to about one in four during July and August. Drought is most likely to occur late in July or in August, which is after the peak of rainfall and after soil moisture has been depleted. Extreme drought, such as that in 1934 and 1936, is rare.

On the average, snowfall is 32 inches each year, but it was only 4.5 inches during the winter of 1895–96 and was 75.6 during the winter of 1961–62. The heaviest snowfall in 1 day was 12 inches on February 9, 1939, and again on February 18, 1961. On 1 or more days, snowfall of 7 inches or more will occur in 3 of every 5 years, and about 1 year in 6 will have 1 day with 10 inches or more. The average date of the first snowfall of 1 inch or more, which is the least that affects highway travel, is November 27.

The continental climate of Clay County causes wide seasonal variations in temperature. In about half of the winters the coldest temperature is about −24° F.; the average warmest in summer is about 99°. Zero or colder is recorded on about 29 days each year, and 90° or higher on about 10 days. At Spencer, the coldest temperature, −38°, was recorded on January 12, 1912; the warmest, 113°, was recorded on July 17, 1936. The average length of the freeze-free season, temperatures above 32°, is 143 days, or from about May 10 to about September 30.

Sunshine varies from about 48 percent of the possible days in December to about 75 percent in July. Solar radiation is about four times as much in July as it is in December. The relative humidity varies inversely as the temperature, or from about 78 percent at sunrise to about 50 to 55 percent by midafternoon.

Relief and Drainage

The relief of the eastern part of the county is dominated by the Bemis and Altamont end moraines. This part has the characteristic morainic knobs, hills, and ridges and the

ummary at Spencer, Iowa[1]

l, 331 feet]

Precipitation in inches									Mean number of days with—				
			Snow, sleet							Temperatures			
										Maximum		Minimum	
Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precipitation of 0.10 inch or more	90° and above	32° and below	32° and below	0° and below
0. 75	0. 88	1944	7. 6	32. 0	1932	11. 0	1937	3	0	21	31	12
. 88	1. 35	1951	7. 7	31. 6	1936	12. 0	1939	2	0	15	28	5
1. 55	1. 26	1951	7. 2	19. 0	1933	10. 1	1951	4	0	8	28	0
2. 24	2. 78	1947	1. 6	13. 0	1945	7. 0	1945	5	0	0	19	0
3. 89	3. 76	1959	. 2	4. 0	1938	3. 0	1938	7	0	0	2	0
4. 96	4. 15	1934	0	0	--------	--------	--------	7	6	0	2	0
3. 30	2. 50	1933	0	0	--------	--------	--------	10	2	0	0	0
3. 67	4. 10	1939	0	0	--------	--------	--------	6	2	0	0	0
2. 91	3. 53	1938	(4)	1. 0	1942	1. 0	1942	7	0	0	3	0
1. 63	1. 98	1931	. 2	7. 0	1937	6. 0	1937	3	0	0	9	0
1. 32	1. 93	1946	4. 7	13. 5	1940	8. 0	1943	3	0	3	28	0
. 82	1. 25	1931	5. 7	14. 5	1935	7. 0	1934	3	0	24	30	12
27. 92	4. 15	1934	34. 9	32. 0	1932	12. 0	1939	60	10	71	180	29

[3] Also on earlier dates, months, or years.
[4] Trace.

many landlocked depressions and potholes. Two fairly large marshy areas in this part are the Dan Green and the Barringer Sloughs. Trumbull Lake, Lost Island Lake, and other small lakes are in this part. The relief is stronger and the surface rougher along the eastern edge of the county near the Clay-Palo Alto County line. In this area a few of the morainic hills rise 100 feet or more above the stream valleys.

East of the Little Sioux River and south of Elk Creek the moraine is also fairly rough, but as it extends northwestward from the east-central part of the county toward Langdon it is less rough. Relief in some areas of the southeastern part of the county more nearly resembles that resulting from a ground moraine. These areas are undulating to rolling.

The soils in the Marcus-Primghar soil association, and those on benches along the Little Sioux and Ocheyedan Rivers, are nearly level. Some breaks between the benches and areas cut by streams have stronger relief. The rest of the county is nearly level to gently sloping and has a network of drainage channels. Near the major streams and drainageways, however, slopes range from moderate to very steep. The steepest areas are mainly along the Little Sioux River, Elk Creek, and Willow Creek.

Clay County is drained mainly by the Little Sioux River and its tributaries. The river enters the county in the northwest, flows southeastward through Gillett Grove Township, and then flows southwestward to the county line. South of the county line it turns westward and crosses back through the southwestern part of the county. It leaves the county about 1.5 miles north of the southwest corner. The main tributaries of the Little Sioux River are the Ocheyedan River and Prairie, Willow, Montgomery, Elk, Big Meadow, and Little Meadow Creeks. A small area in the southeast corner of the county is drained southeastward into the Des Moines River.

In the eastern part of the county the channels of some of the smaller streams have been straightened and deepened. In addition, some manmade ditches provide surface drainage and outlets for tile drainage systems.

Agriculture

In the following paragraphs the principal crops grown in the county are discussed, and the acreage of each crop grown in 1964 is shown in a list. Also discussed are the main kinds of livestock raised or fattened, and the number of each kind in 1964 is listed. Finally, the type, size, and tenure of farms in 1964 are given. All of the data are from the Iowa Annual Farm Census (*15*).

Crops

Corn, soybeans, oats, and hay are the principal crops grown in the county. Corn is grown on the largest acreage. Grain, especially corn and soybeans, is the main cash crop, but much of the corn and small grains is fed on the farm to hogs, cattle, and sheep. A few farmers grow popcorn as a cash crop. Cropland not harvested or pastured was 49,543 acres in 1964, which is a large increase since 1959. Little timber is cut in the county for commercial use. Land in lots, roads, buildings, and trees and idle land was 22,888 acres in 1964, or about the same as in 1959. The number of acres used for the principal crops and for pasture in 1964 are shown in the list that follows:

	Acres
Corn for all purposes	120, 023
Oats for grain	17, 804
Soybeans for beans	76, 193
Popcorn	588
Sorghum	184
All hay	25, 140
Pasture	44, 089

Livestock

The raising of livestock, especially hogs, and the fattening of beef cattle are the main enterprises on many farms in the county. Much of the income of farmers is from the sale of these animals. The number of chickens declined considerably since 1959, and the number of turkeys was not reported in 1964. The number of the principal kinds of livestock raised and sold in the county in 1964 are shown in the list that follows:

	Number
Grain-fed cattle sold	51, 521
Grain-fed sheep and lambs sold	18, 899
Sows farrowed	18, 599
Beef cows 2 years old and older	7, 142
Milk cows 2 years old and older	3, 926
Chickens	158, 109

Type, size, and tenure of farms

In recent years the number of farms in Clay County has decreased and the size of farms has increased. In 1964 there were 1,505 farms in the county, a decrease of 275 since 1955. The average size of farms has increased from 200 acres in 1955 to 237 acres in 1964. Most farms are of the cash-grain or livestock type, and a few are of the dairy, poultry, or general type.

The percentage of farms operated by tenants in 1964 was about 61; full or part owners operated the remaining 39 percent. The number of persons living on farms in the county in 1965 was 5,757.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Bench. A high, shelflike position.

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

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

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

Loose.—Noncoherent; soil will not hold together in a mass.

Friable.—When moist, soil crushes easily under gentle pressure between thumb and forefinger, but resistance is distinctly noticeable.

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

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

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

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

Cemented.—Soil is hard and brittle; little affected by moistening.

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

Drift (geology). Material of any sort deposited by geologic processes in one place after having been removed from another; includes drift materials deposited by glaciers and by streams and lakes associated with them.

Horizon, soil. A layer of soil, approximately parallel to the surface that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clays, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching. The removal of soluble materials from the soils or other materials by percolating water.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *Fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Outwash (glacial). A broad term that includes all the material swept out, sorted, and deposited beyond the glacial ice front by streams of melt water.

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

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

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

Solum. The upper part of a soil profile, above the parent material in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

Substratum. Any layer lying beneath the solum, or true soil.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (structural). An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Till, glacial. Material deposited directly by glacial ice with little or no transportation by water.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

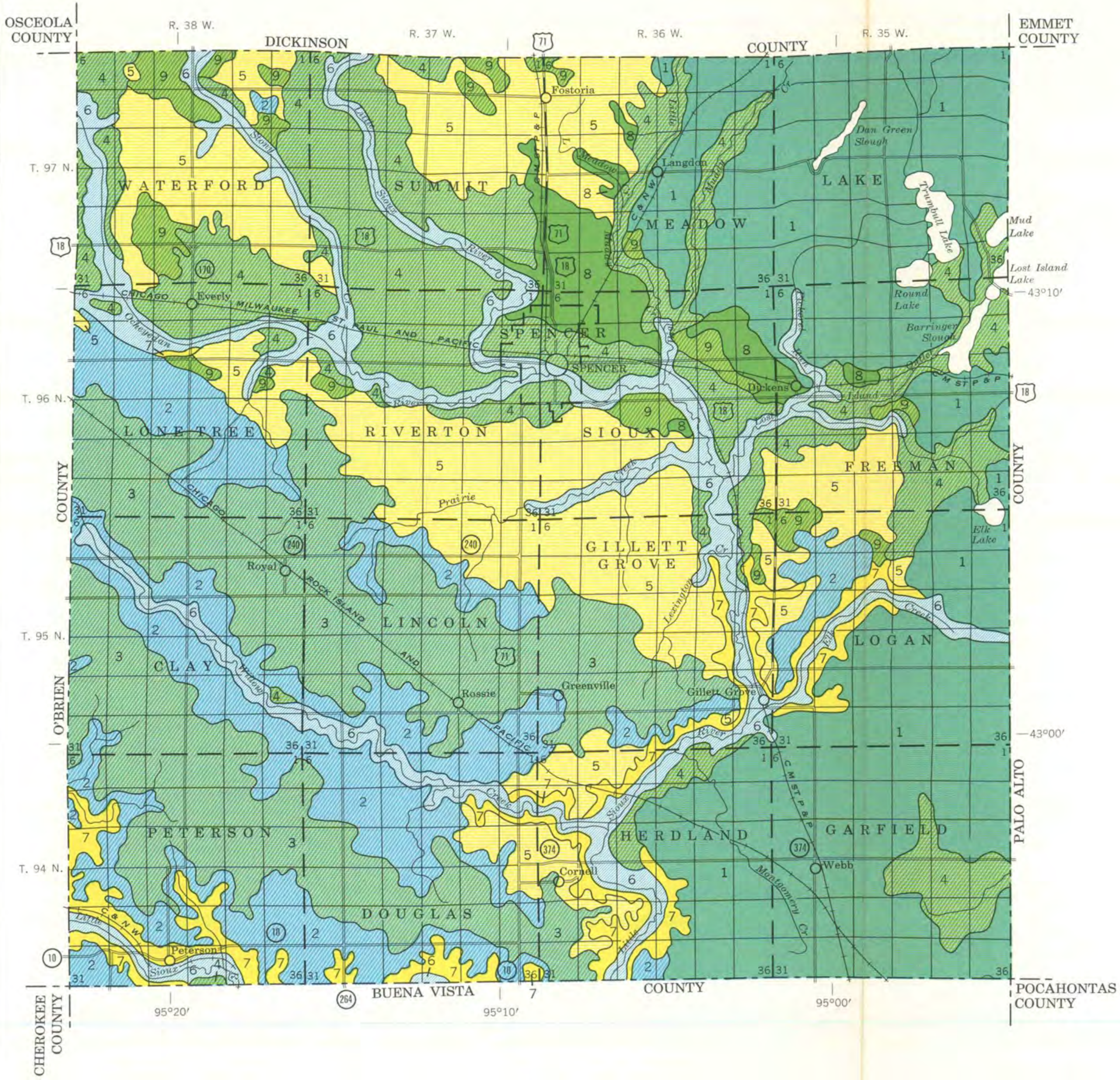
For a full description of a mapping unit, read both the description of the mapping unit and the soil series to which the mapping unit belongs. Discussion of the planting suitability groups is given on page 61. Other information is given in tables as follows:

Acreage and extent, table 1, p. 9.
Predicted yields, table 2, p. 58.

Engineering uses of the soils, tables 3, 4, and 5, pp. 62 through 93.

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Planting suitability group Number
Af	Afton silty clay loam	11	IIw-2	50	2
Au	Alluvial land, channeled	11	Vw-1	56	4
Bs	Biscay silty clay loam, deep	12	IIw-3	51	2
Ca	Calco silty clay loam	12	IIw-1	50	4
Ce	Canisteo silty clay loam	13	IIw-2	50	2
Cg	Canisteo silty clay loam, gypsic variant	13	IIw-2	50	2
ClB	Clarion loam, 2 to 5 percent slopes	14	IIe-1	48	1
ClC2	Clarion loam, 5 to 9 percent slopes, moderately eroded	14	IIIe-1	52	1
ClD2	Clarion loam, 9 to 15 percent slopes, moderately eroded	15	IIIe-2	52	1
ClF	Clarion loam, heavy subsoil variant, 20 to 40 percent slopes	15	VIIe-1	57	1
CmC2	Clarion-Storden complex, 5 to 9 percent slopes, moderately eroded	15	IIIe-1	52	1
CmD2	Clarion-Storden complex, 9 to 15 percent slopes, moderately eroded	15	IIIe-2	52	1
Co	Colo silty clay loam	16	IIw-1	50	4
CoB	Colo silty clay loam, 2 to 4 percent slopes	16	IIw-2	50	4
Cs	Colo silty clay loam, channeled	16	Vw-1	56	4
CtB	Colo-Terril complex, 2 to 5 percent slopes	16			
	Colo soil	--	IIw-1	50	4
	Terril soil	--	IIw-1	50	1
CtC	Colo-Terril complex, 5 to 9 percent slopes	17			
	Colo soil	--	IIIw-4	55	4
	Terril soil	--	IIIw-4	55	1
Cu	Cylinder loam, deep	17	I-1	48	1
Cy	Cylinder loam, moderately deep	18	IIs-2	52	3
DcA	Dickinson fine sandy loam, 0 to 2 percent slopes	18	IIIs-1	55	3
DcB	Dickinson fine sandy loam, 2 to 5 percent slopes	18	IIIe-4	53	3
DcC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded	19	IIIe-4	53	3
DkA	Dickinson fine sandy loam, benches, 0 to 2 percent slopes	19	IIIs-1	55	3
DkB	Dickinson fine sandy loam, benches, 2 to 5 percent slopes	19	IIIe-3	53	3
DkC2	Dickinson fine sandy loam, benches, 5 to 9 percent slopes, moderately eroded	19	IIIe-3	53	3
DkD2	Dickinson fine sandy loam, benches, 9 to 15 percent slopes, moderately eroded	19	IVe-2	55	3
DkE2	Dickinson fine sandy loam, benches, 15 to 20 percent slopes, moderately eroded	19	VIe-2	56	3
DlA	Dickinson loam, 0 to 2 percent slopes	19	IIIs-1	55	3
DlB	Dickinson loam, 2 to 5 percent slopes	20	IIIe-3	53	3
EcB	Everly clay loam, 2 to 5 percent slopes	20	IIe-1	48	1
EcC2	Everly clay loam, 5 to 9 percent slopes, moderately eroded	20	IIIe-1	52	1
EsD2	Everly-Storden complex, 9 to 15 percent slopes, moderately eroded	21	IIIe-2	52	1
Fo	Fostoria clay loam	21	I-1	48	1
Fs	Fostoria loam	22	I-1	48	1
GaA	Galva silty clay loam, 1 to 3 percent slopes	22	I-2	48	1
GbA	Galva silty clay loam, benches, 0 to 2 percent slopes	22	I-1	48	1
Ge	Glencoe silty clay loam	23	IIIw-1	53	2
Gg	Glencoe silty clay loam, gravelly substratum	23	IIIw-1	53	2
GkA	Guckeen silty clay loam, 0 to 2 percent slopes	24	I-3	48	1
GkB	Guckeen silty clay loam, 2 to 5 percent slopes	24	IIe-3	50	1
GkC2	Guckeen silty clay loam, 5 to 9 percent slopes, moderately eroded	25	IIIe-1	52	1
GuA	Guckeen clay loam, silty clay substratum, 0 to 2 percent slopes	25	I-3	48	1
GuB	Guckeen clay loam, silty clay substratum, 2 to 5 percent slopes	25	IIe-3	50	1
HaC2	Hagener loamy sand, 4 to 8 percent slopes, moderately eroded	25	IVs-1	56	3
Hr	Harps loam	26	IIw-4	51	2
LaA	Ladoga silt loam, 1 to 3 percent slopes	27	I-2	48	1
Ma	Marcus silty clay loam	28	IIw-2	50	2
Mc	Marna silty clay	28	IIw-5	51	2
Me	Marna silty clay loam, calcareous variant	28	IIw-5	51	2
Mh	Marsh	29	VIIw-1	57	--
Mm	Muck, moderately shallow	29	IIIw-2	54	2
Mr	Muck, moderately shallow, calcareous	29	IIIw-2	54	2
Ms	Muck, shallow	30	IIIw-2	54	2
Nc	Nicollet clay loam	30	I-1	48	1
No	Nicollet loam	30	I-1	48	1
OcA	Ocheyedan loam, 0 to 2 percent slopes	31	I-2	48	1
OcB	Ocheyedan loam, 2 to 5 percent slopes	31	IIe-1	48	1
OcC2	Ocheyedan loam, 5 to 12 percent slopes, moderately eroded	31	IIIe-1	52	1
Ok	Okoboji silt loam	32	IIIw-1	53	2
Pr	Primghar silty clay loam	33	I-1	48	1
Ps	Primghar silty clay loam, benches	33	I-1	48	1
Ro	Rolfe silt loam	34	IIIw-1	53	2
SaB	Sac silty clay loam, 2 to 5 percent slopes	35	IIe-1	48	1
SaC	Sac silty clay loam, 5 to 9 percent slopes	35	IIIe-1	52	1
SaC2	Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	35	IIIe-1	52	1
SgB	Salida gravelly sandy loam, 2 to 5 percent slopes	36	IIIe-4	53	3
SgC2	Salida gravelly sandy loam, 5 to 9 percent slopes, moderately eroded	36	IIIe-4	53	3
SgD2	Salida gravelly sandy loam, 9 to 15 percent slopes, moderately eroded	36	IVe-2	55	3
SgE2	Salida gravelly sandy loam, 15 to 20 percent slopes, moderately eroded	37	VIe-2	56	3
SlF2	Salida sandy loam, 20 to 30 percent slopes, moderately eroded	37	VIIe-2	57	3
Sn	Sandy lake beaches	37	VIs-1	57	3
So	Sperry silty clay loam	38	IIIw-1	53	2
Sp	Spillville loam	38	IIw-1	50	4
StD2	Storden loam, 5 to 15 percent slopes, moderately eroded	39	IIIe-2	52	1
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	39	IVe-1	55	1
StF2	Storden loam, 20 to 30 percent slopes, moderately eroded	39	VIe-1	56	1
StG2	Storden loam, 30 to 50 percent slopes, moderately eroded	39	VIIe-1	57	1
Ta	Talcot silty clay loam, deep	40	IIw-3	51	2
TeB	Terril loam, 2 to 5 percent slopes	41	IIe-1	48	1
TeC	Terril loam, 5 to 9 percent slopes	41	IIIe-1	52	1
TeD	Terril loam, 9 to 15 percent slopes	41	IIIe-2	52	1
Tr	Tripoli clay loam	42	IIw-2	50	2
Wa	Wacousta silty clay loam	43	IIIw-1	53	2
Wb	Wabash silty clay	42	IIIw-3	54	4
WdA	Wadena loam, deep, 0 to 2 percent slopes	44	I-2	48	1
WdB	Wadena loam, deep, 2 to 5 percent slopes	44	IIe-1	48	1
WmA	Wadena loam, moderately deep, 0 to 2 percent slopes	44	IIs-1	52	3
WmB	Wadena loam, moderately deep, 2 to 5 percent slopes	44	IIe-2	49	3
WmC2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	44	IIIe-3	53	3
WmD2	Wadena loam, moderately deep, 9 to 15 percent slopes, moderately eroded	45	IVe-2	55	3
WuA	Waukegan loam, moderately deep, 0 to 2 percent slopes	45	IIs-1	52	3
WuB	Waukegan loam, moderately deep, 2 to 5 percent slopes	45	IIe-2	49	3
Wy	Webster silty clay loam	46	IIw-2	50	2

295-993 O - 69 (Face maps)



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
IOWA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
CLAY COUNTY, IOWA

N

SCALE IN MILES

1 0 1 2 3 4

SOIL ASSOCIATIONS

1 — Clarion-Nicollet-Webster association: Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to strongly sloping soils on uplands

2 — Marcus-Primghar-Sac association: Well-drained to poorly drained, moderately fine textured, nearly level to moderately sloping soils on uplands

3 — Marcus-Primghar association: Poorly drained and somewhat poorly drained, moderately fine textured, nearly level soils on uplands

4 — Wadena-Cylinder-Biscay association: Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to strongly sloping soils on benches

5 — Everly-Nicollet-Tripoli association: Well-drained to poorly drained, moderately fine textured, nearly level to sloping soils on uplands

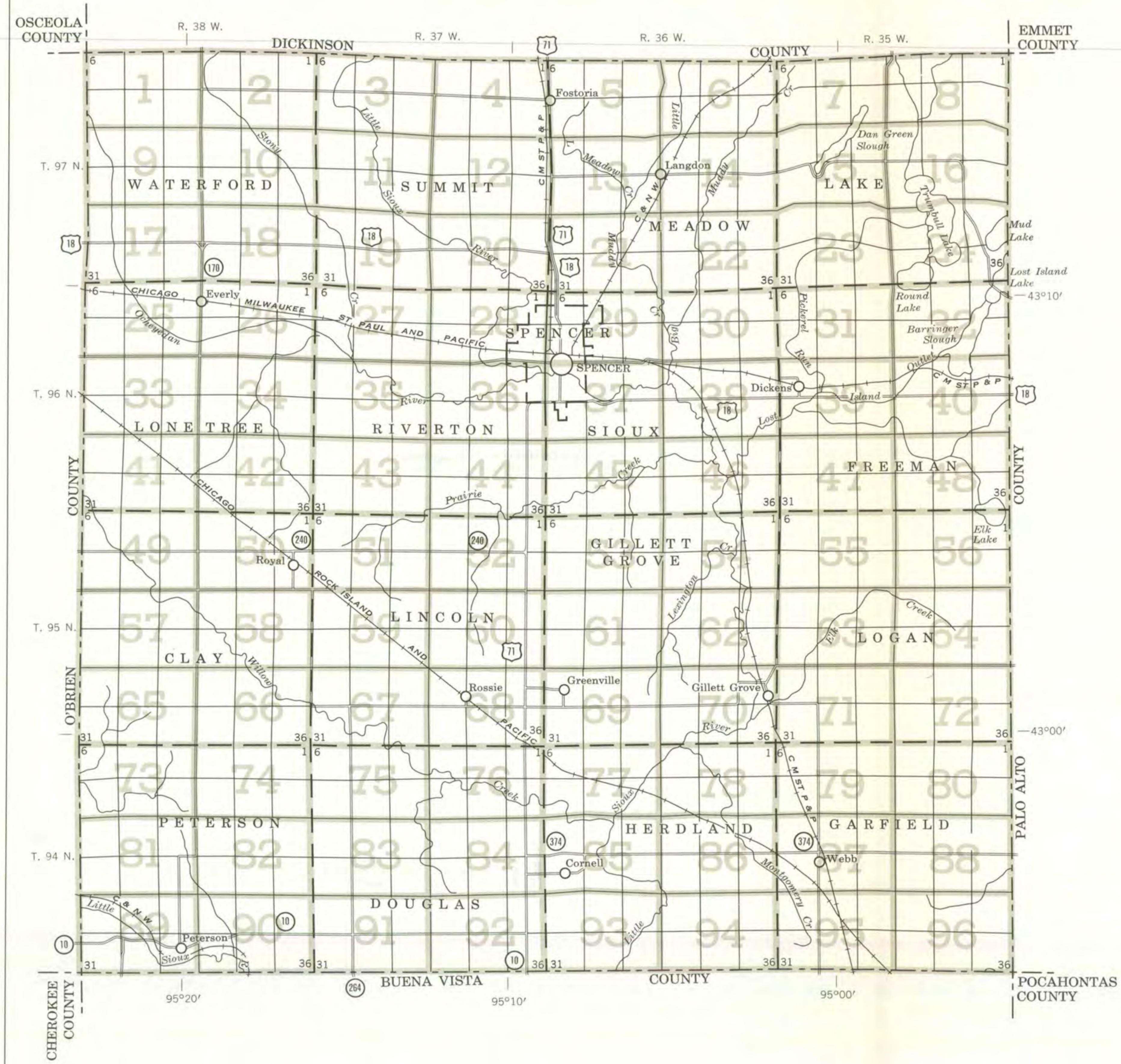
6 — Colo-Spillville-Wabash association: Moderately well drained to very poorly drained, medium-textured to fine-textured, nearly level soils on bottom lands

7 — Storden association: Well-drained, medium-textured, sloping to steep soils on uplands

8 — Ocheyedan-Webster-Guckeen-Marna association: Well-drained to poorly drained, medium-textured to fine-textured, nearly level to gently sloping soils on uplands and benches

9 — Ocheyedan-Fostoria-Webster association: Well-drained to poorly drained, medium-textured to moderately fine textured, nearly level to moderately sloping soils on uplands

April 1968



INDEX TO MAP SHEETS
CLAY COUNTY, IOWA

N

SCALE IN MILES

1 0 1 2 3 4

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, F, or G shows the slope. Symbols without a slope letter are those of nearly level soils or land types. A final number, 2, in the symbol, shows that the soil is moderately eroded.

SYMBOL	NAME
Af	Afton silty clay loam
Au	Alluvial land, channeled
Bs	Biscay silty clay loam, deep
Ca	Calco silty clay loam
Ce	Canisteo silty clay loam
Cg	Canisteo silty clay loam, gypsic variant
ClB	Clarion loam, 2 to 5 percent slopes
ClC2	Clarion loam, 5 to 9 percent slopes, moderately eroded
ClD2	Clarion loam, 9 to 15 percent slopes, moderately eroded
ClF	Clarion loam, heavy subsoil variant, 20 to 40 percent slopes
CmC2	Clarion–Storden complex, 5 to 9 percent slopes, moderately eroded
CmD2	Clarion–Storden complex, 9 to 15 percent slopes, moderately eroded
Co	Colo silty clay loam
CoB	Colo silty clay loam, 2 to 4 percent slopes
Cs	Colo silty clay loam, channeled
CtB	Colo–Terril complex, 2 to 5 percent slopes
CtC	Colo–Terril complex, 5 to 9 percent slopes
Cu	Cylinder loam, deep
Cy	Cylinder loam, moderately deep
DcA	Dickinson fine sandy loam, 0 to 2 percent slopes
DcB	Dickinson fine sandy loam, 2 to 5 percent slopes
DcC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded
DkA	Dickinson fine sandy loam, benches, 0 to 2 percent slopes
DkB	Dickinson fine sandy loam, benches, 2 to 5 percent slopes
DkC2	Dickinson fine sandy loam, benches, 5 to 9 percent slopes, moderately eroded
DkD2	Dickinson fine sandy loam, benches, 9 to 15 percent slopes, moderately eroded
DkE2	Dickinson fine sandy loam, benches, 15 to 20 percent slopes, moderately eroded
DlA	Dickinson loam, 0 to 2 percent slopes
DlB	Dickinson loam, 2 to 5 percent slopes
EcB	Everly clay loam, 2 to 5 percent slopes
EcC2	Everly clay loam, 5 to 9 percent slopes, moderately eroded
EsD2	Everly–Storden complex, 9 to 15 percent slopes, moderately eroded
Fo	Fostoria clay loam
Fs	Fostoria loam
GaA	Galva silty clay loam, 1 to 3 percent slopes
GbA	Galva silty clay loam, benches, 0 to 2 percent slopes
Ge	Glencoe silty clay loam
Gg	Glencoe silty clay loam, gravelly substratum
GkA	Guckeen silty clay loam, 0 to 2 percent slopes
GkB	Guckeen silty clay loam, 2 to 5 percent slopes
GkC2	Guckeen silty clay loam, 5 to 9 percent slopes, moderately eroded
GuA	Guckeen clay loam, silty clay substratum, 0 to 2 percent slopes
GuB	Guckeen clay loam, silty clay substratum, 2 to 5 percent slopes
HaC2	Hagener loamy sand, 4 to 8 percent slopes, moderately eroded
Hr	Harps loam
LaA	Ladoga silt loam, 1 to 3 percent slopes
Ma	Marcus silty clay loam
Mc	Marna silty clay
Me	Marna silty clay loam, calcareous variant
Mh	Marsh
Mm	Muck, moderately shallow
Mr	Muck, moderately shallow, calcareous
Ms	Muck, shallow
Nc	Nicollet clay loam
No	Nicollet loam
OcA	Ocheyedan loam, 0 to 2 percent slopes
OcB	Ocheyedan loam, 2 to 5 percent slopes
OcC2	Ocheyedan loam, 5 to 12 percent slopes, moderately eroded
Ok	Okoboji silt loam
Pr	Primghar silty clay loam
Ps	Primghar silty clay loam, benches
Ro	Rolfe silt loam
SaB	Sac silty clay loam, 2 to 5 percent slopes
SaC	Sac silty clay loam, 5 to 9 percent slopes
SaC2	Sac silty clay loam, 5 to 9 percent slopes, moderately eroded
SgB	Salida gravelly sandy loam, 2 to 5 percent slopes
SgC2	Salida gravelly sandy loam, 5 to 9 percent slopes, moderately eroded
SgD2	Salida gravelly sandy loam, 9 to 15 percent slopes, moderately eroded
SgE2	Salida gravelly sandy loam, 15 to 20 percent slopes, moderately eroded
SlF2	Salida sandy loam, 20 to 30 percent slopes, moderately eroded
Sn	Sandy lake beaches
So	Sperry silty clay loam
Sp	Spillville loam
StD2	Storden loam, 5 to 15 percent slopes, moderately eroded
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded
StF2	Storden loam, 20 to 30 percent slopes, moderately eroded
StG2	Storden loam, 30 to 50 percent slopes, moderately eroded
Ta	Talcot silty clay loam, deep
TeB	Terril loam, 2 to 5 percent slopes
TeC	Terril loam, 5 to 9 percent slopes
TeD	Terril loam, 9 to 15 percent slopes
Tr	Tripoli clay loam
Wa	Wacousta silty clay loam
Wb	Wabash silty clay
WdA	Wadena loam, deep, 0 to 2 percent slopes
WdB	Wadena loam, deep, 2 to 5 percent slopes
WmA	Wadena loam, moderately deep, 0 to 2 percent slopes
WmB	Wadena loam, moderately deep, 2 to 5 percent slopes
WmC2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded
WmD2	Wadena loam, moderately deep, 9 to 15 percent slopes, moderately eroded
WuA	Waukegan loam, moderately deep, 0 to 2 percent slopes
WuB	Waukegan loam, moderately deep, 2 to 5 percent slopes
Wy	Webster silty clay loam

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries
- Mine dump
- Pits, gravel or other
- Power line
- Pipeline
- Cemetery
- Dams
- Levee
- Tanks
- Well, oil or gas

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches (CANAL)

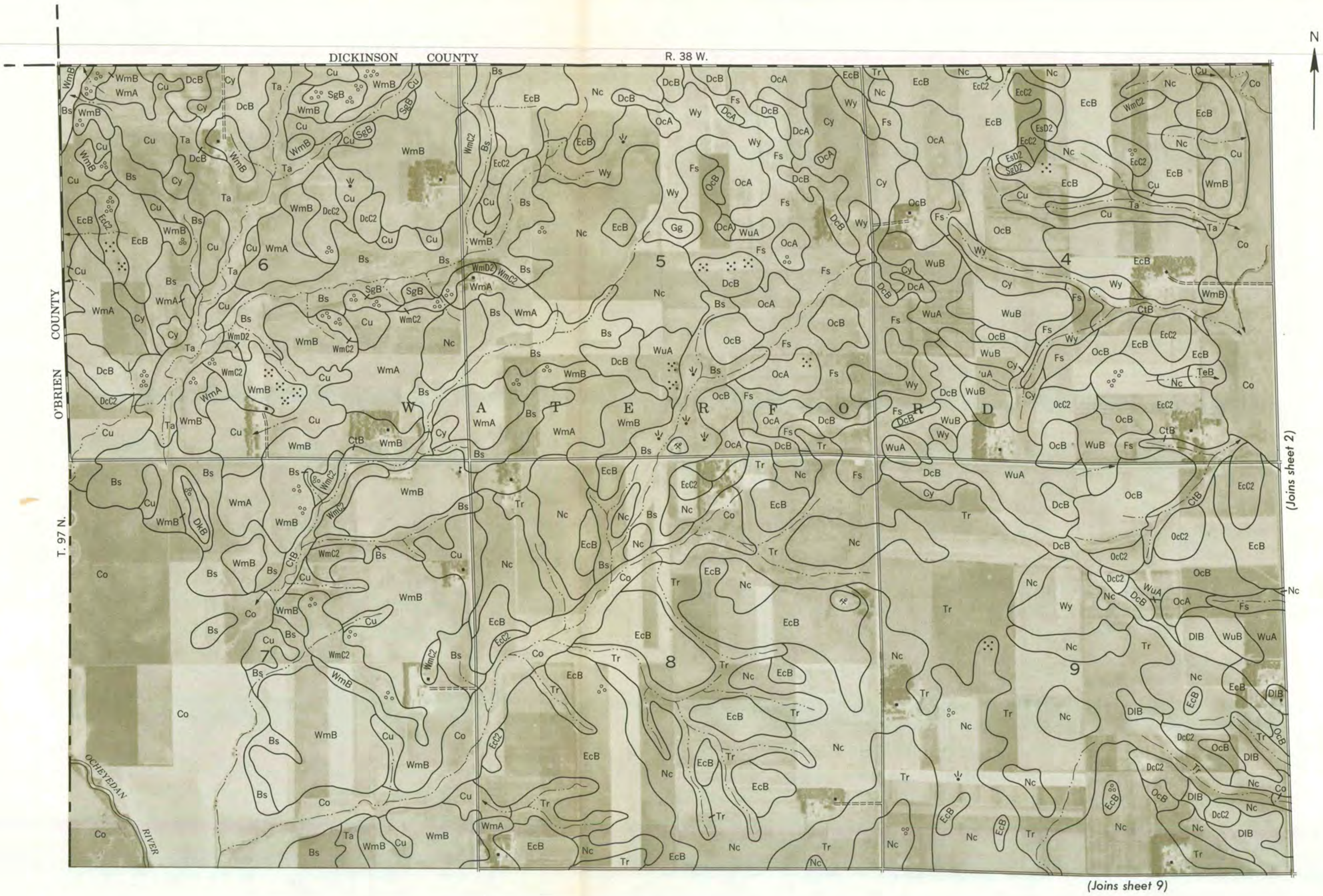
Lakes and ponds
- Perennial (water, w)
- Intermittent

- Wells, water (flowing)
- Spring
- Marsh or swamp
- Wet spot
- Mucky seepy land
- Alluvial fan
- Drainage end

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Small area of Rolfe, Sperry, or Cullo soils or clay spot 20 to 30 inches deep
- Small area of Glencoe soils, contains water part of time
- Calcareous spot, well drained

Soil map constructed 1967 by Cartographic Division, Soil Conservation Service, USDA, from 1962 aerial photographs. Controlled mosaic based on Iowa plane coordinate system, north zone, Lambert conformal conic projection, 1927 North American datum.



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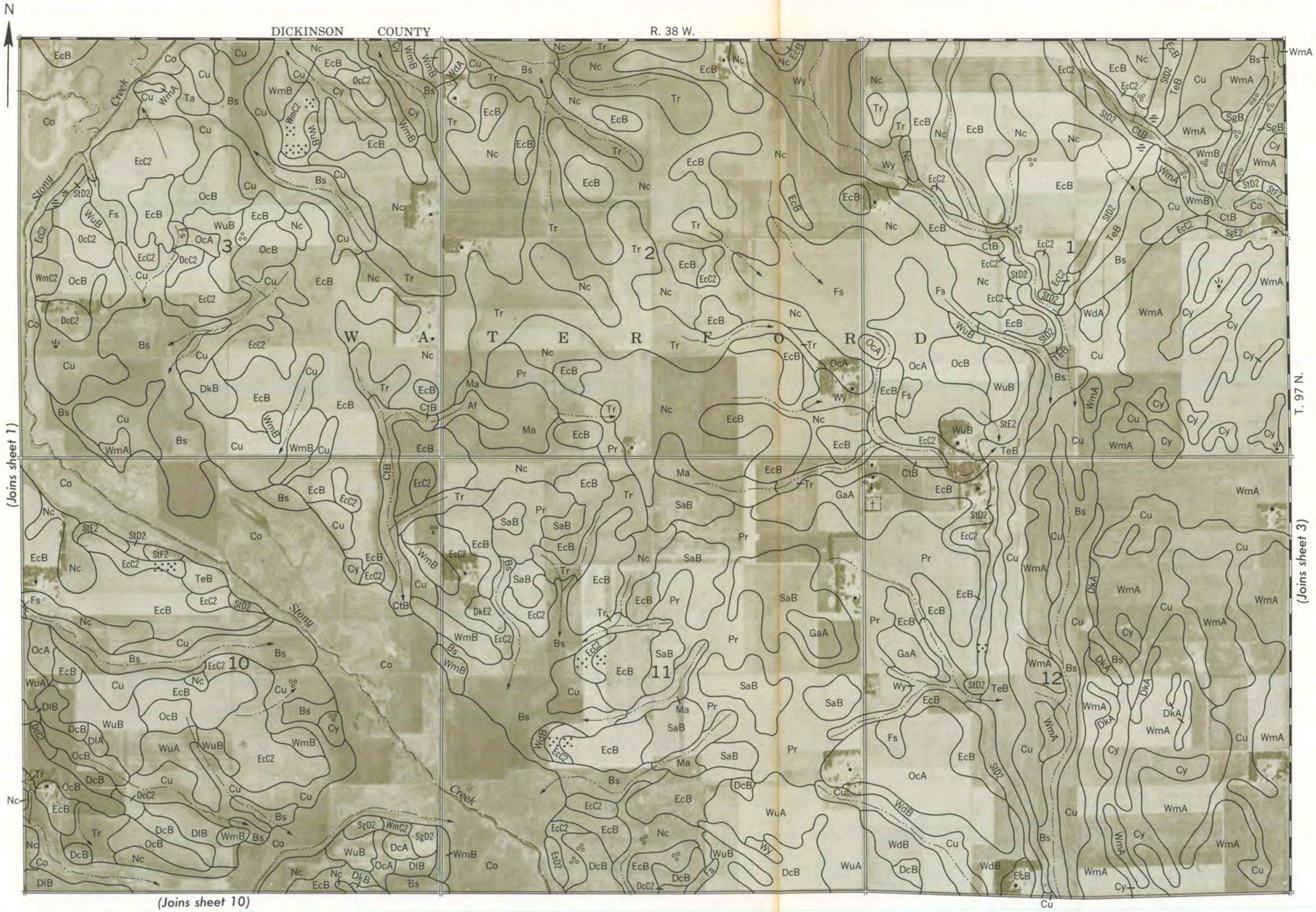
CLAY COUNTY, IOWA NO. 1

Land division corners are approximately positioned on this map.

CLAY COUNTY, IOWA — SHEET NUMBER 2



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CLAY COUNTY, IOWA NO. 2

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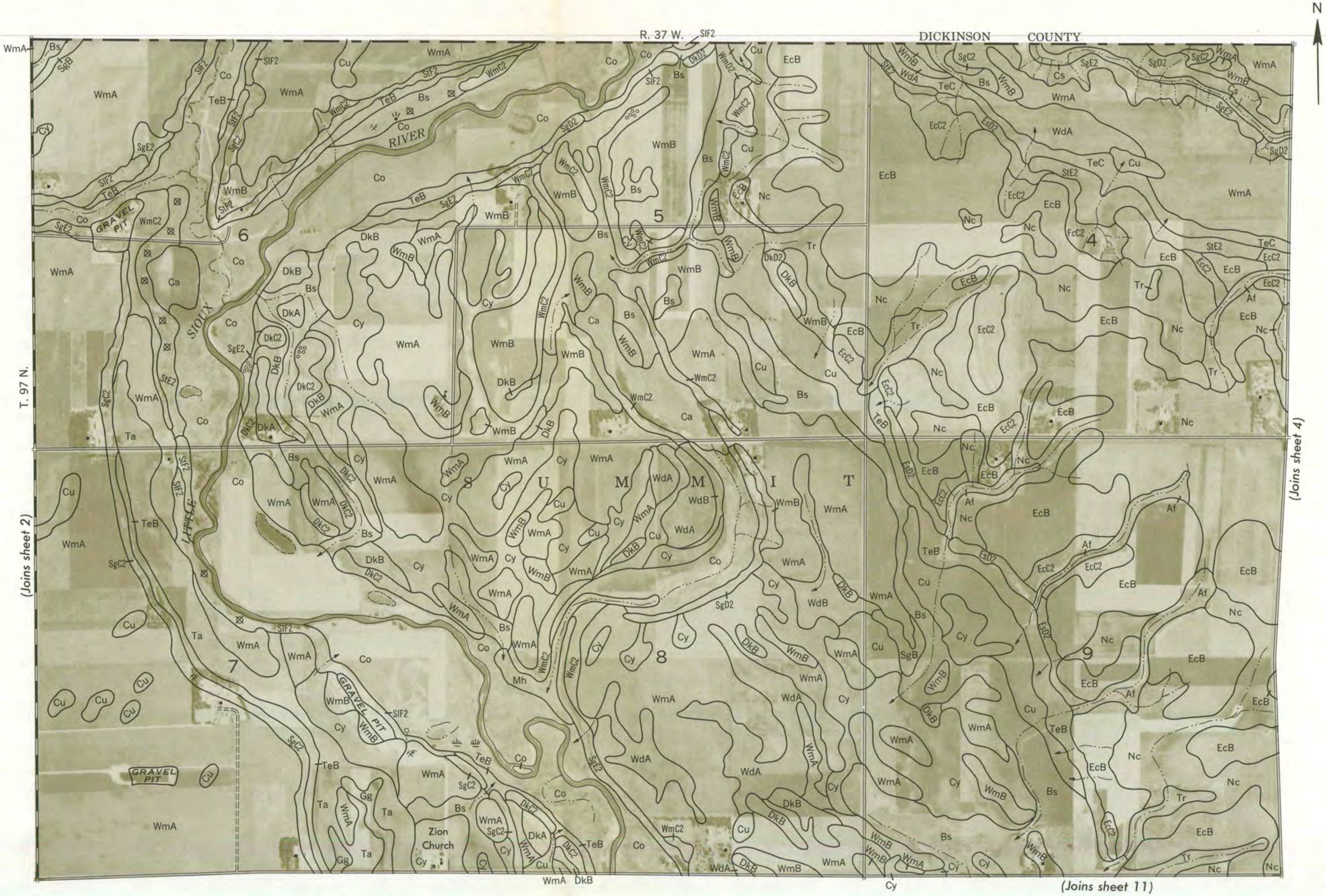
CLAY COUNTY, IOWA NO. 3



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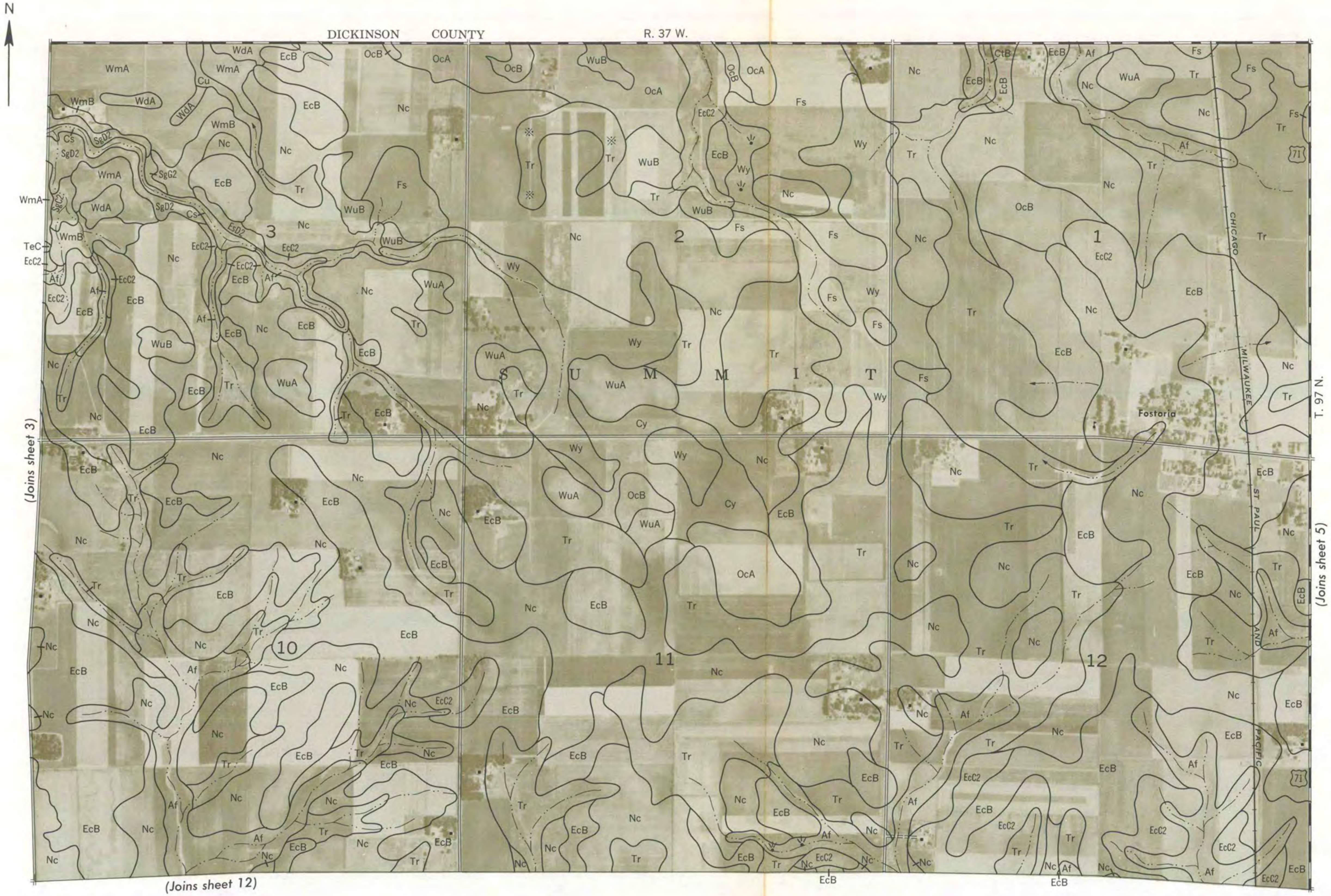

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Land division corners are approximately positioned on this map

CLAY COUNTY, IOWA NO. 5

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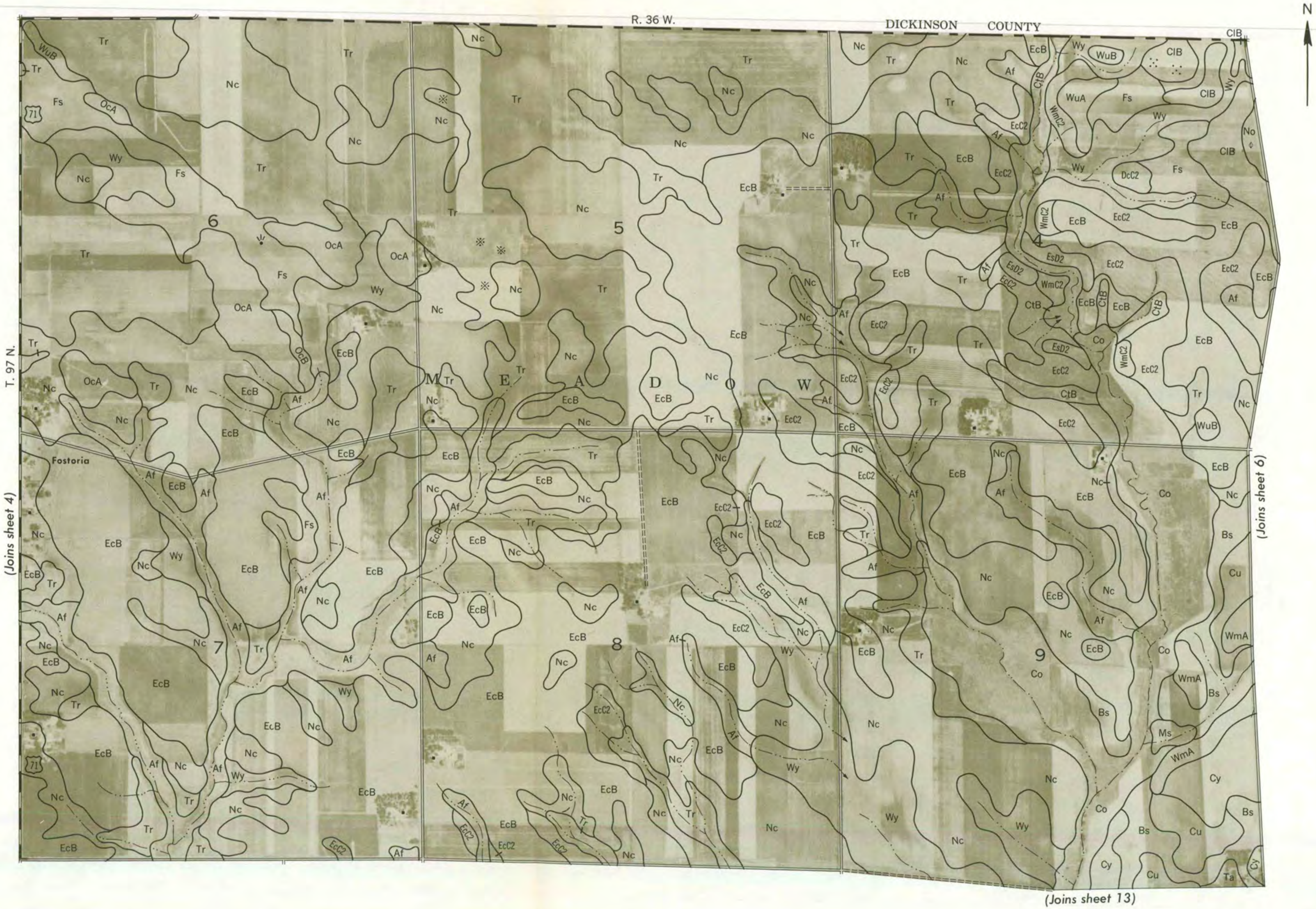

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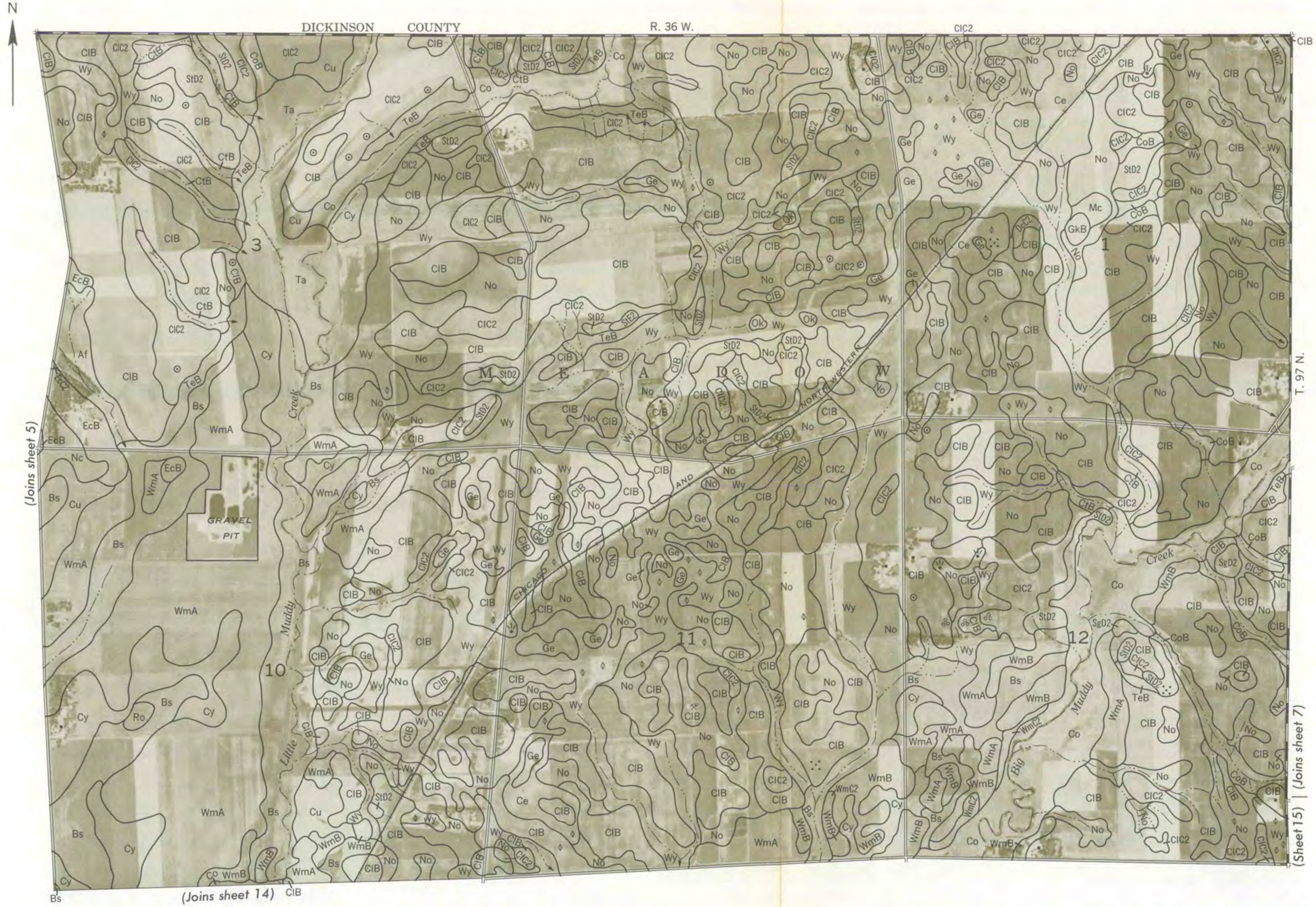

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CLAY COUNTY, IOWA NO. 6

Land division corners are approximately positioned on this map.

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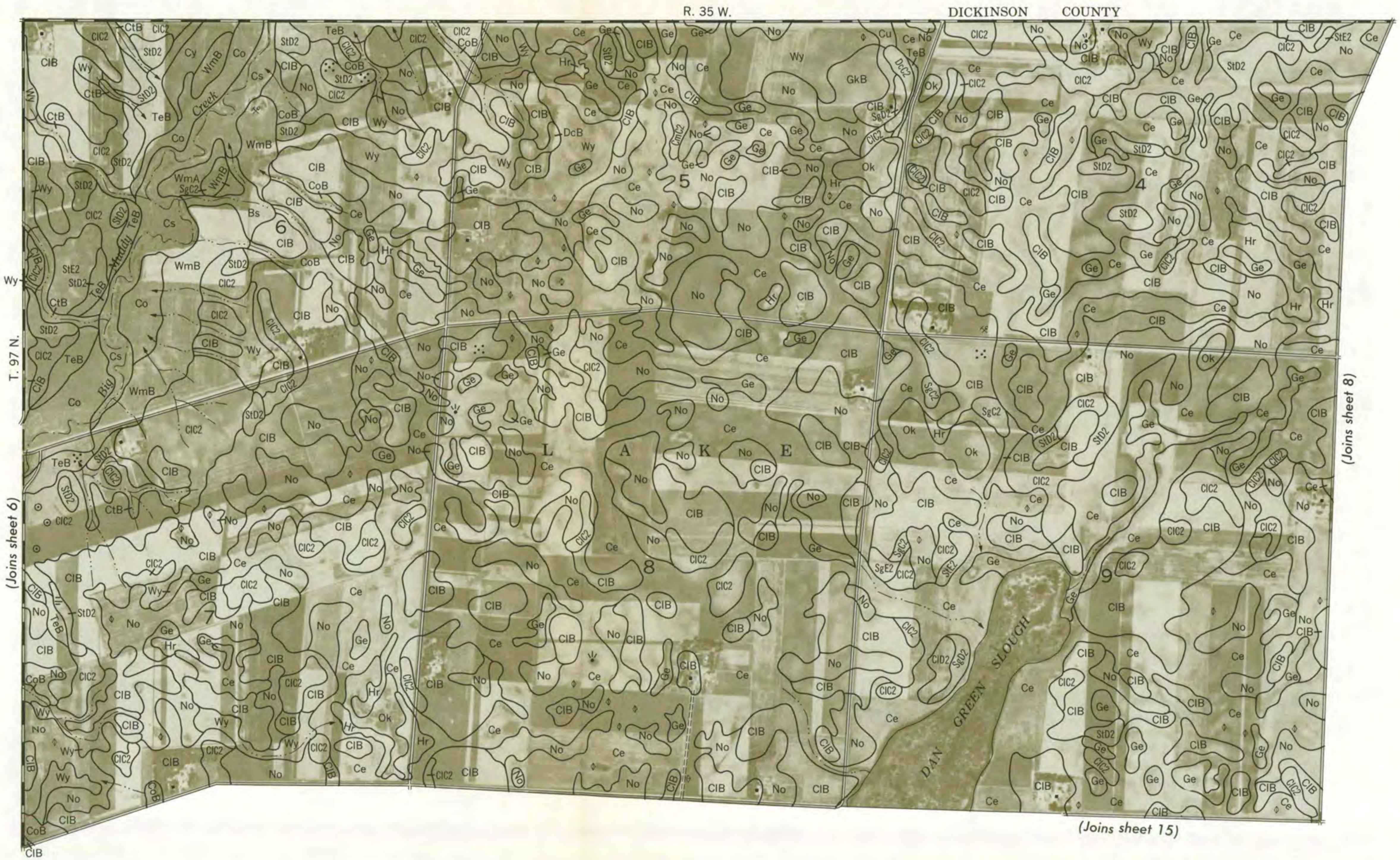

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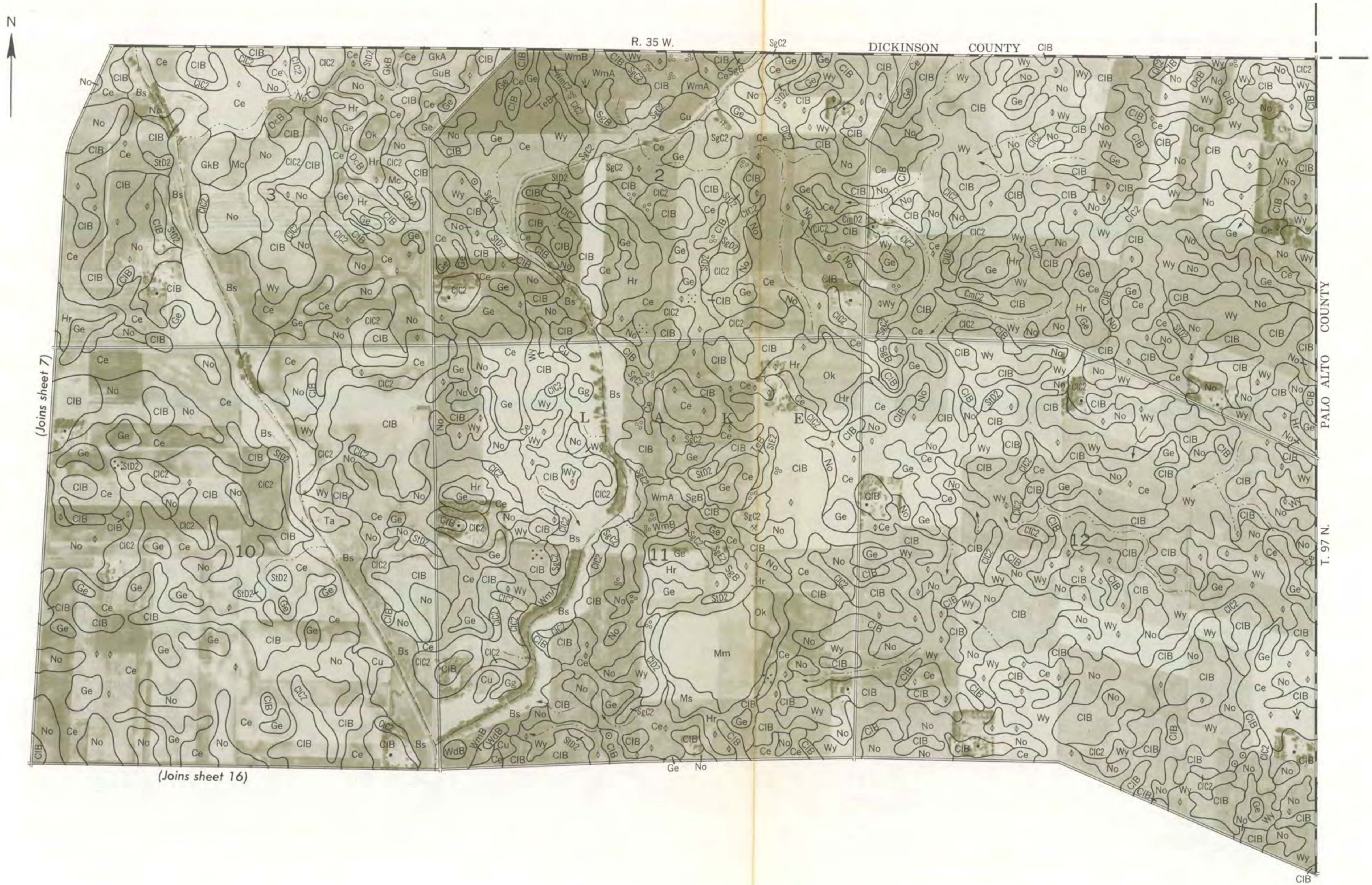

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CLAY COUNTY, IOWA NO. 8

Land division corners are approximately positioned on this map.

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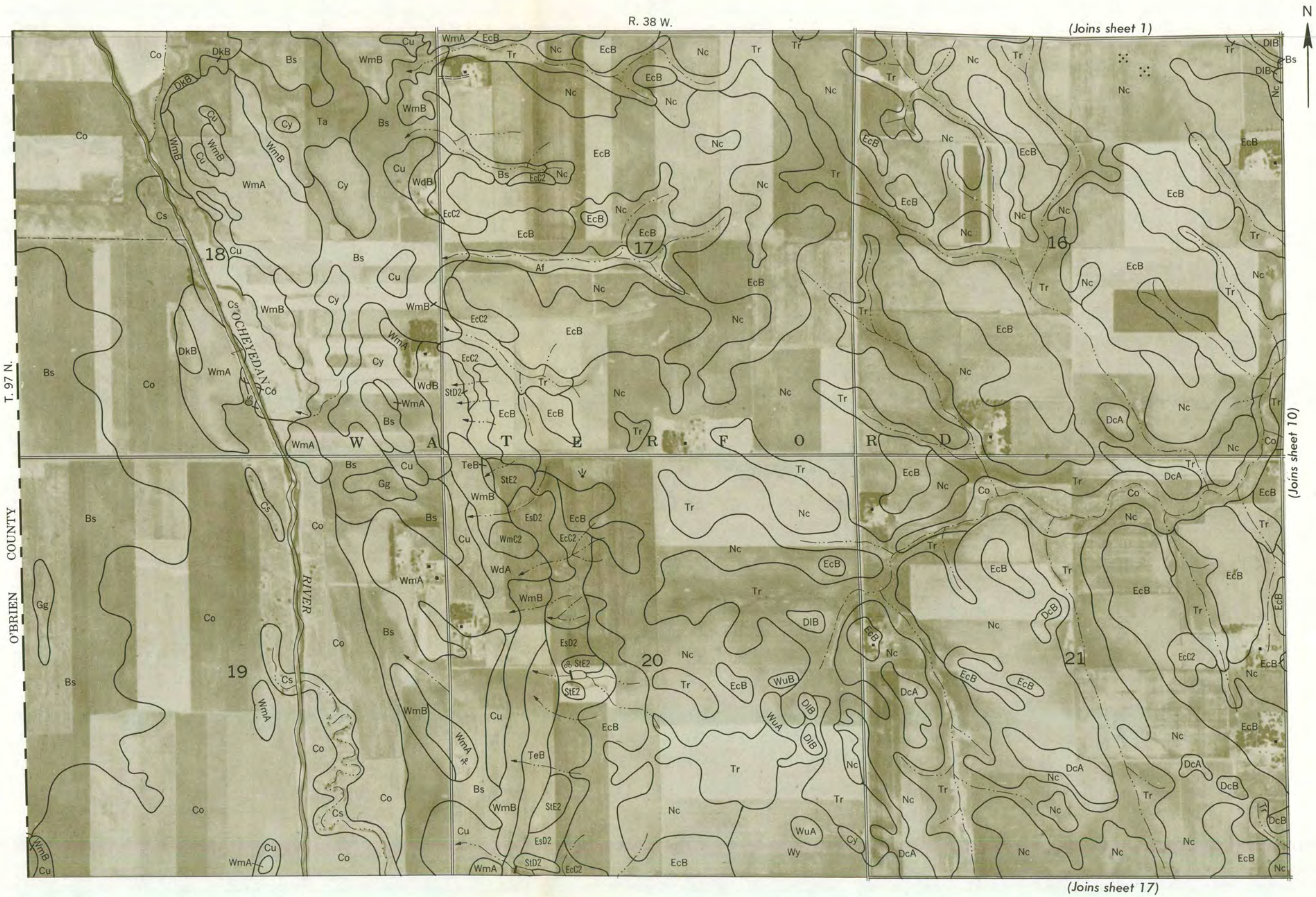

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Land division corners are approximately positioned on this map.

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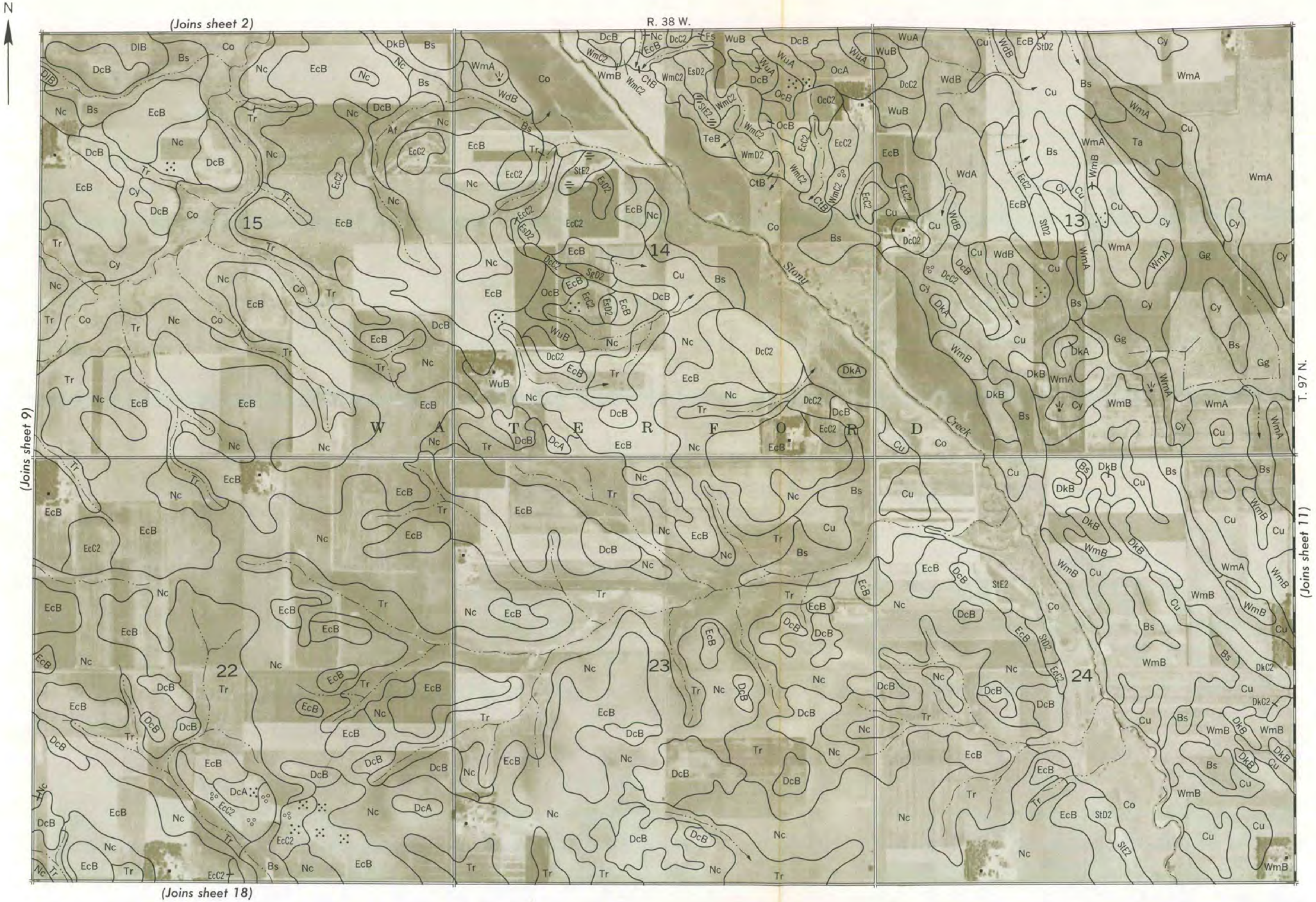

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CLAY COUNTY, IOWA NO. 10

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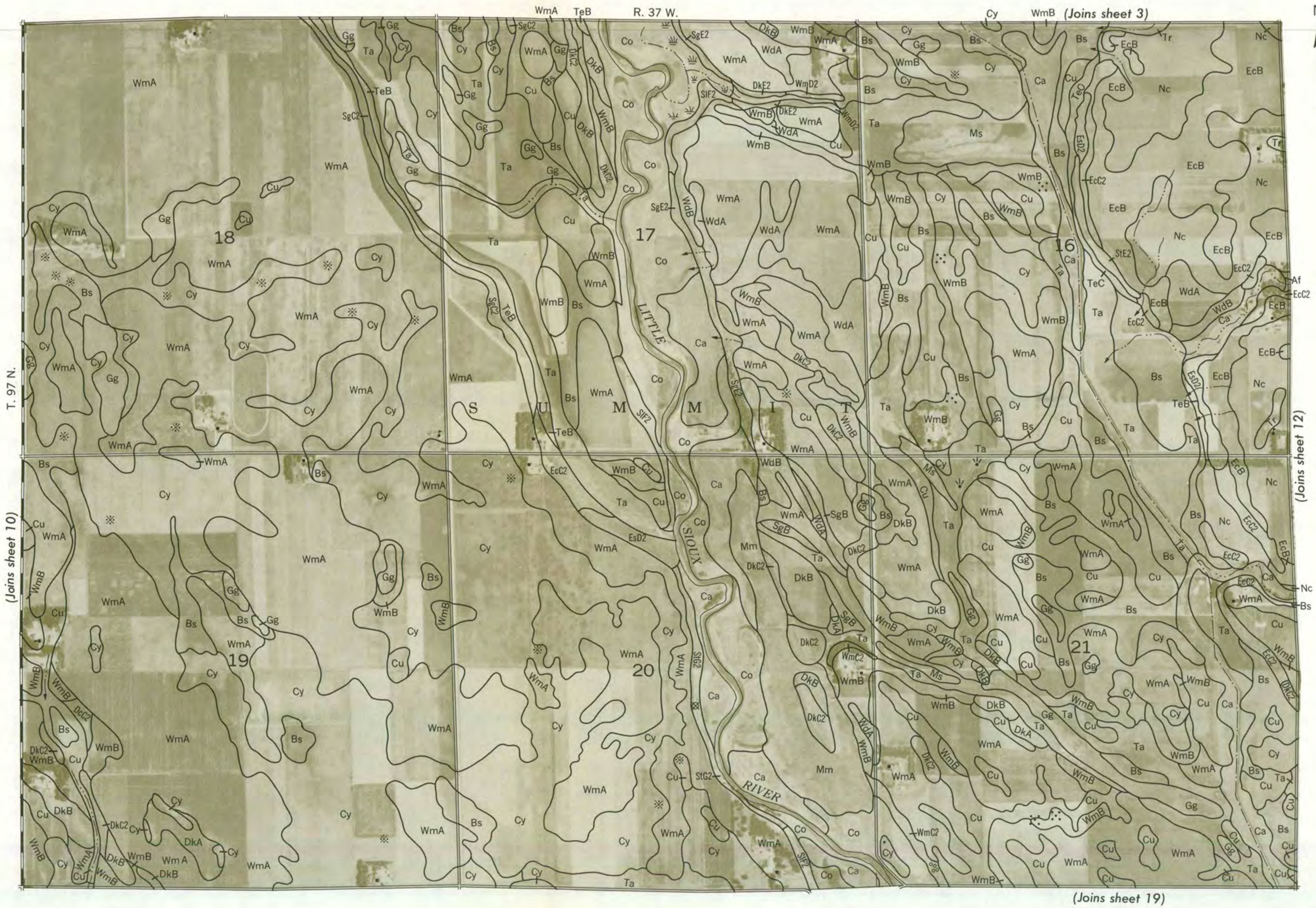
CLAY COUNTY, IOWA NO. 11



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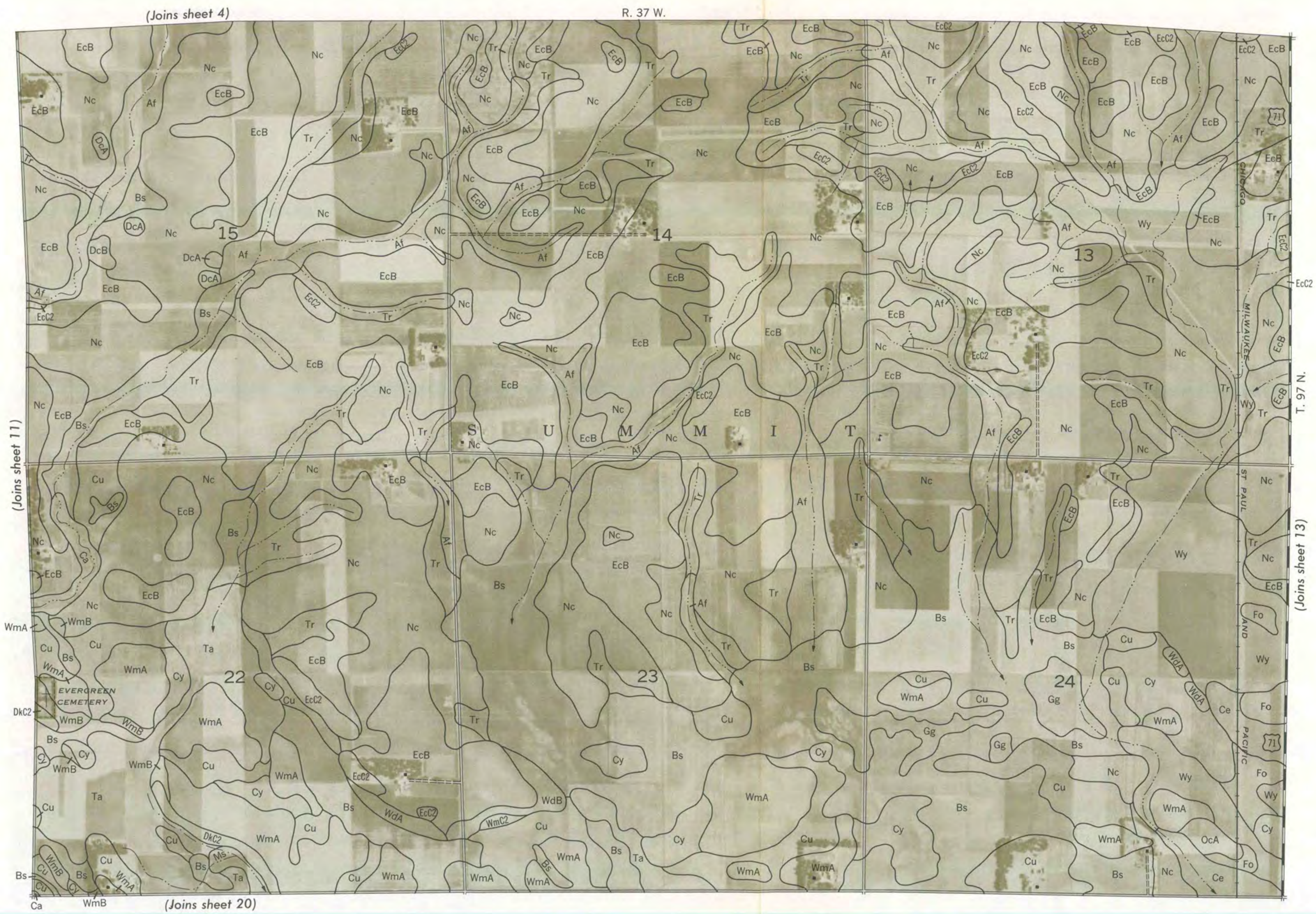

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CLAY COUNTY, IOWA NO. 12

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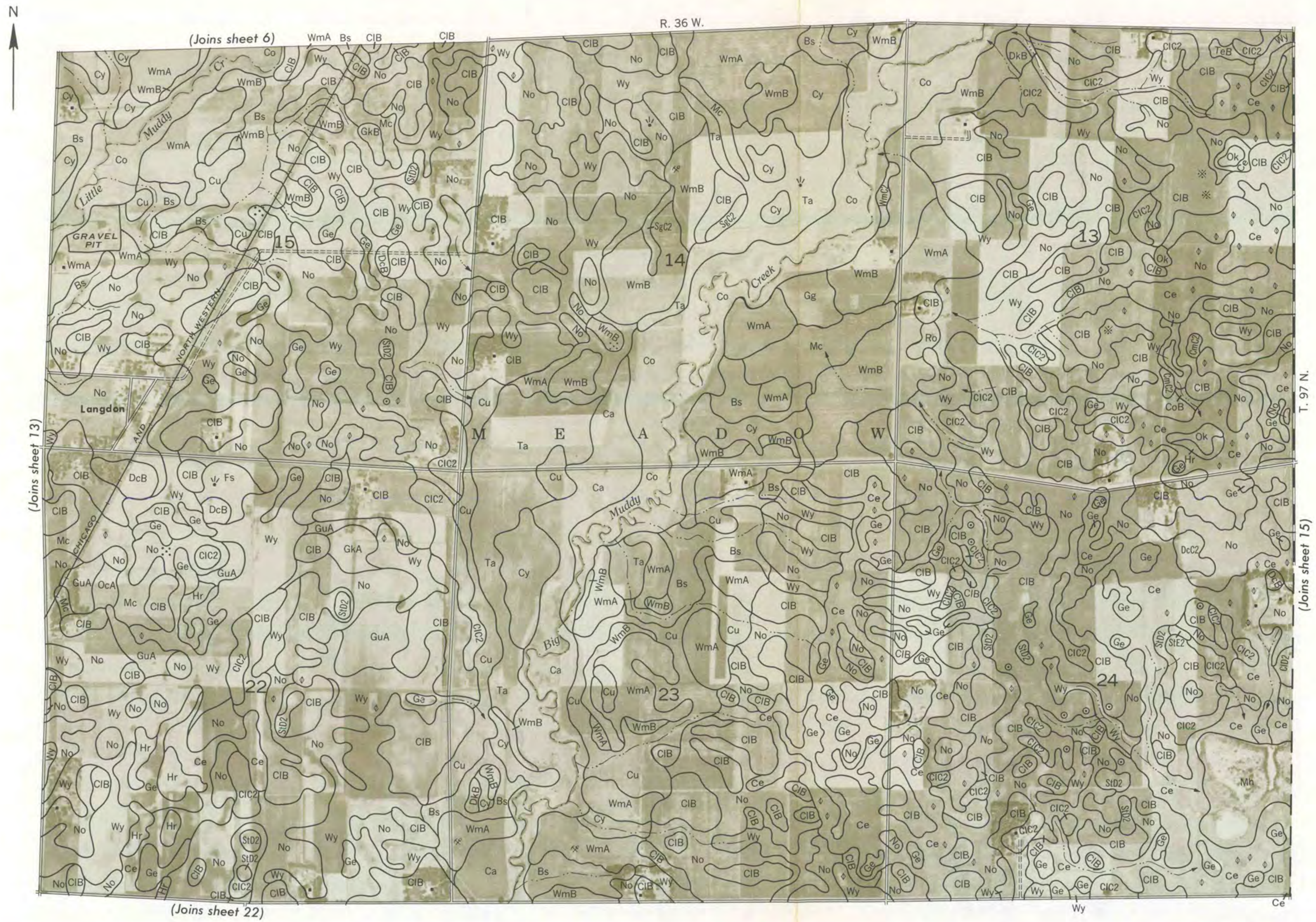

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CLAY COUNTY, IOWA NO. 14

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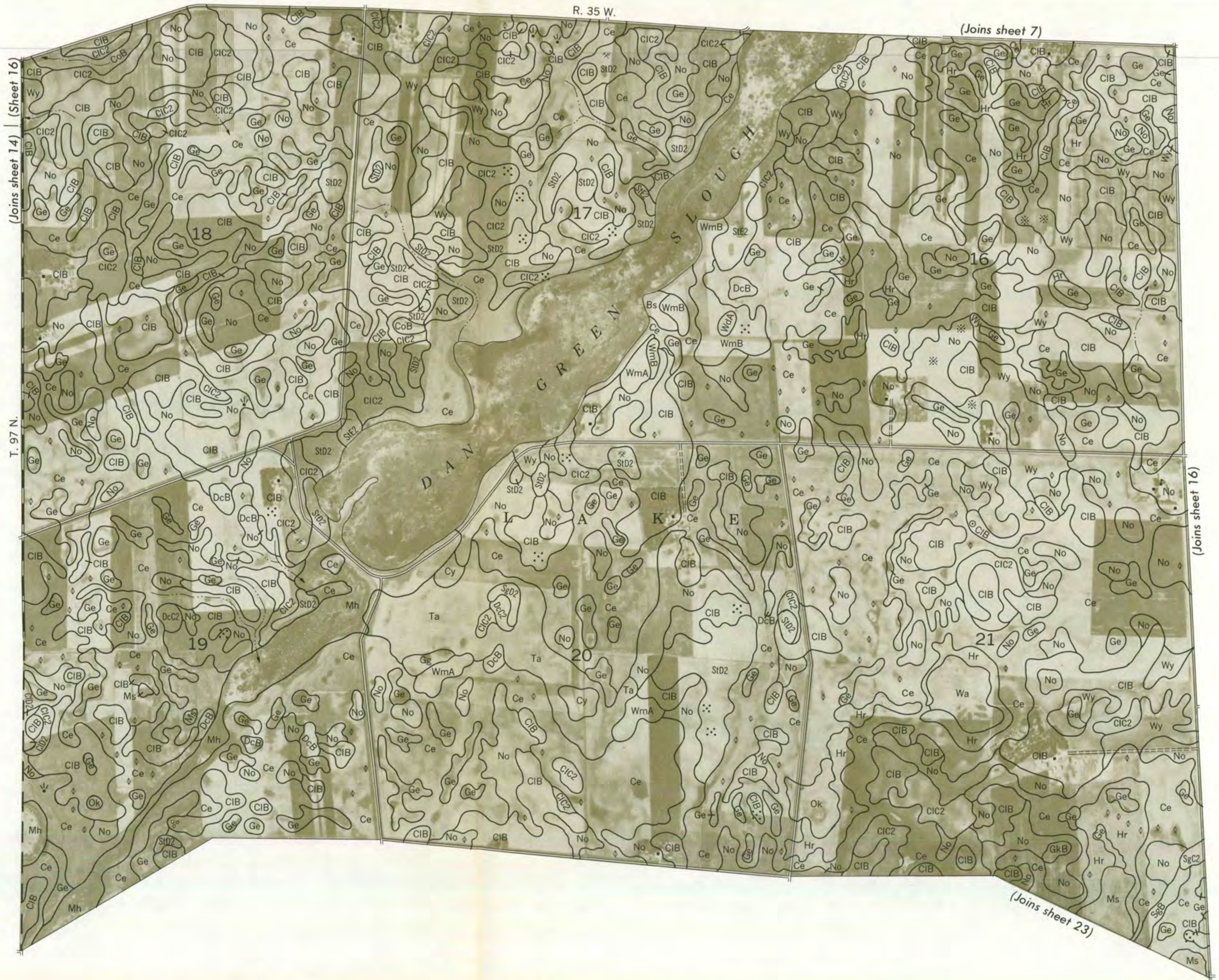
CLAY COUNTY, IOWA NO. 15



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CLAY COUNTY, IOWA — SHEET NUMBER 16

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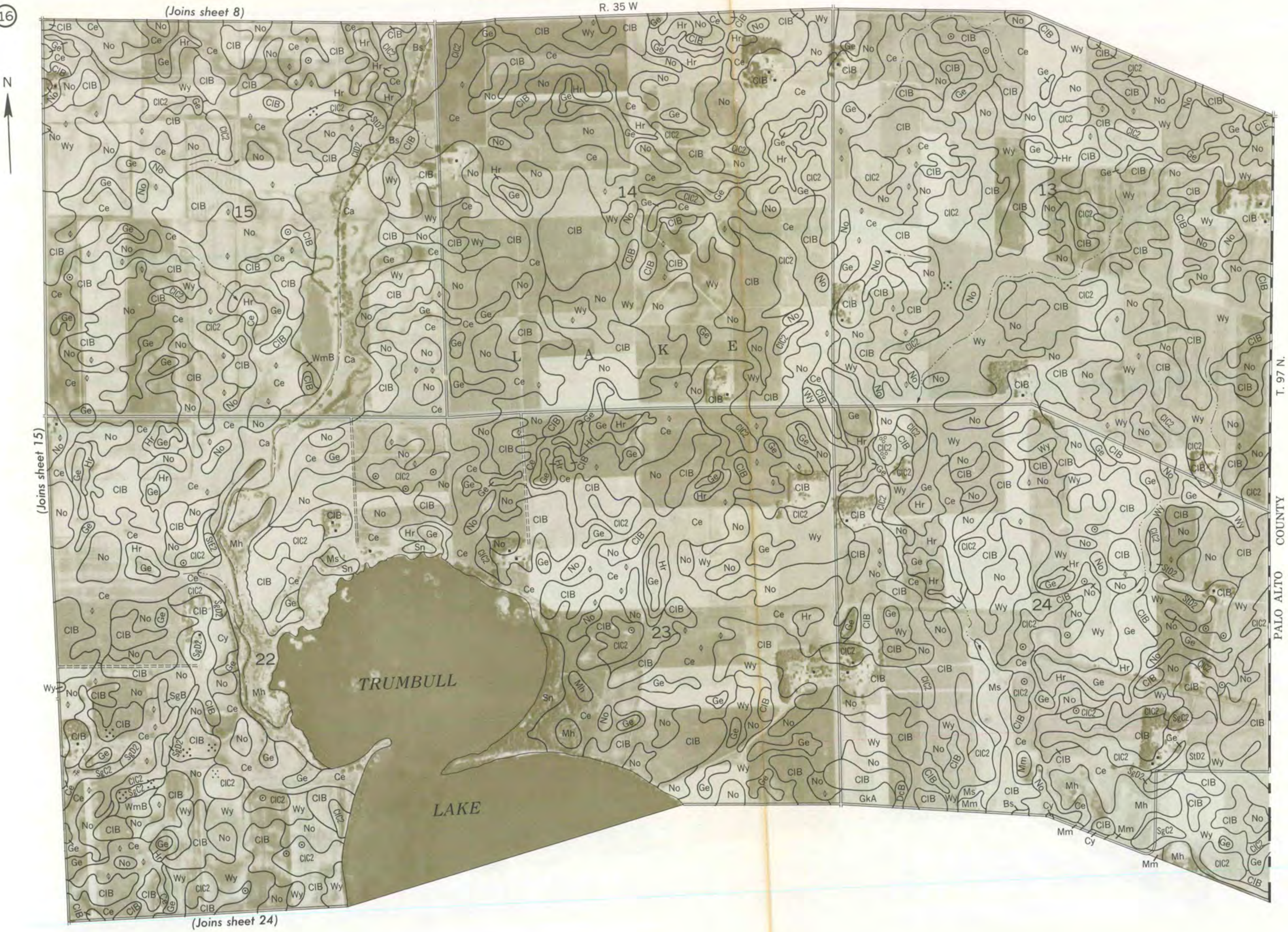

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CLAY COUNTY, IOWA NO. 16

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CLAY COUNTY, IOWA NO. 17

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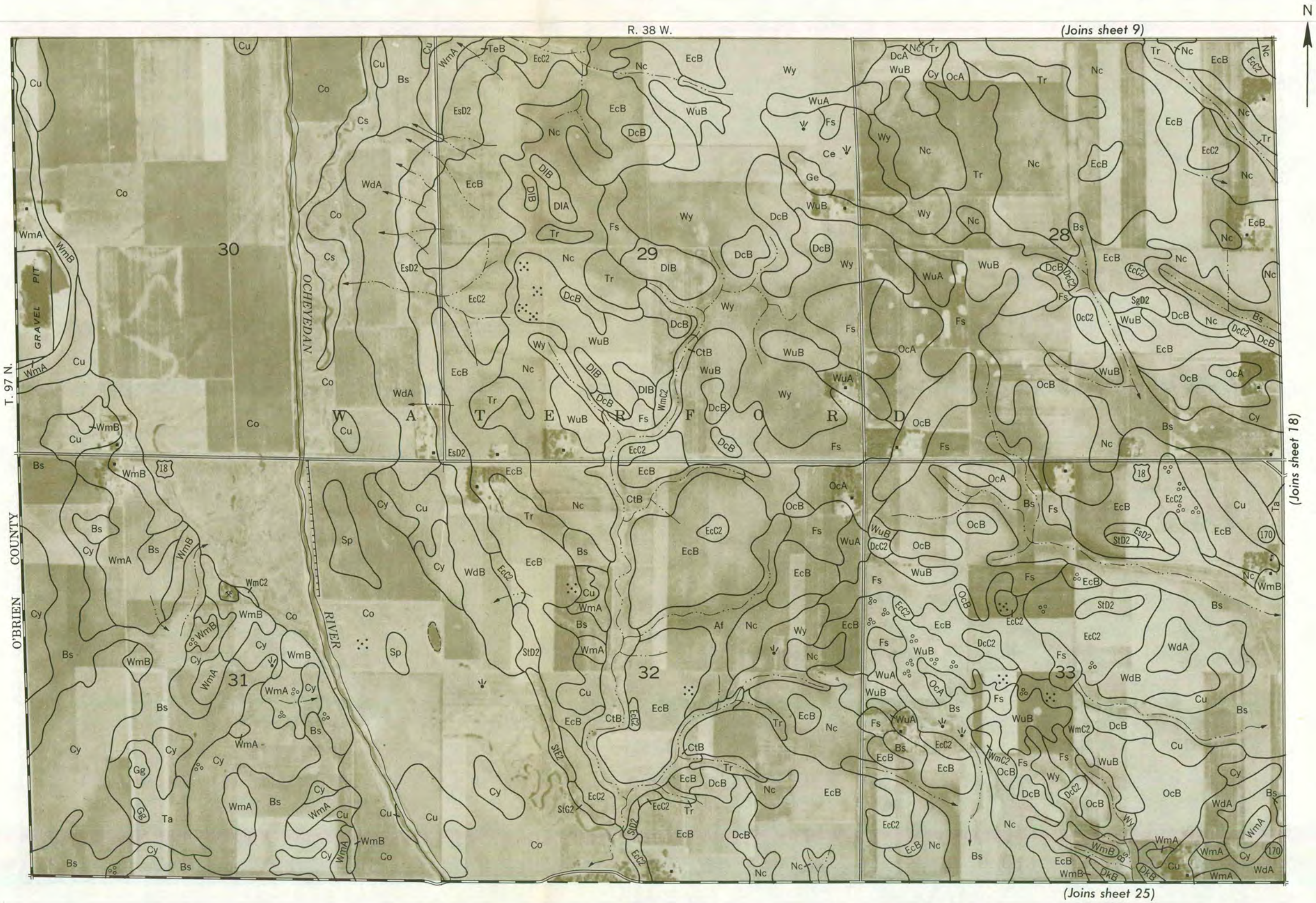

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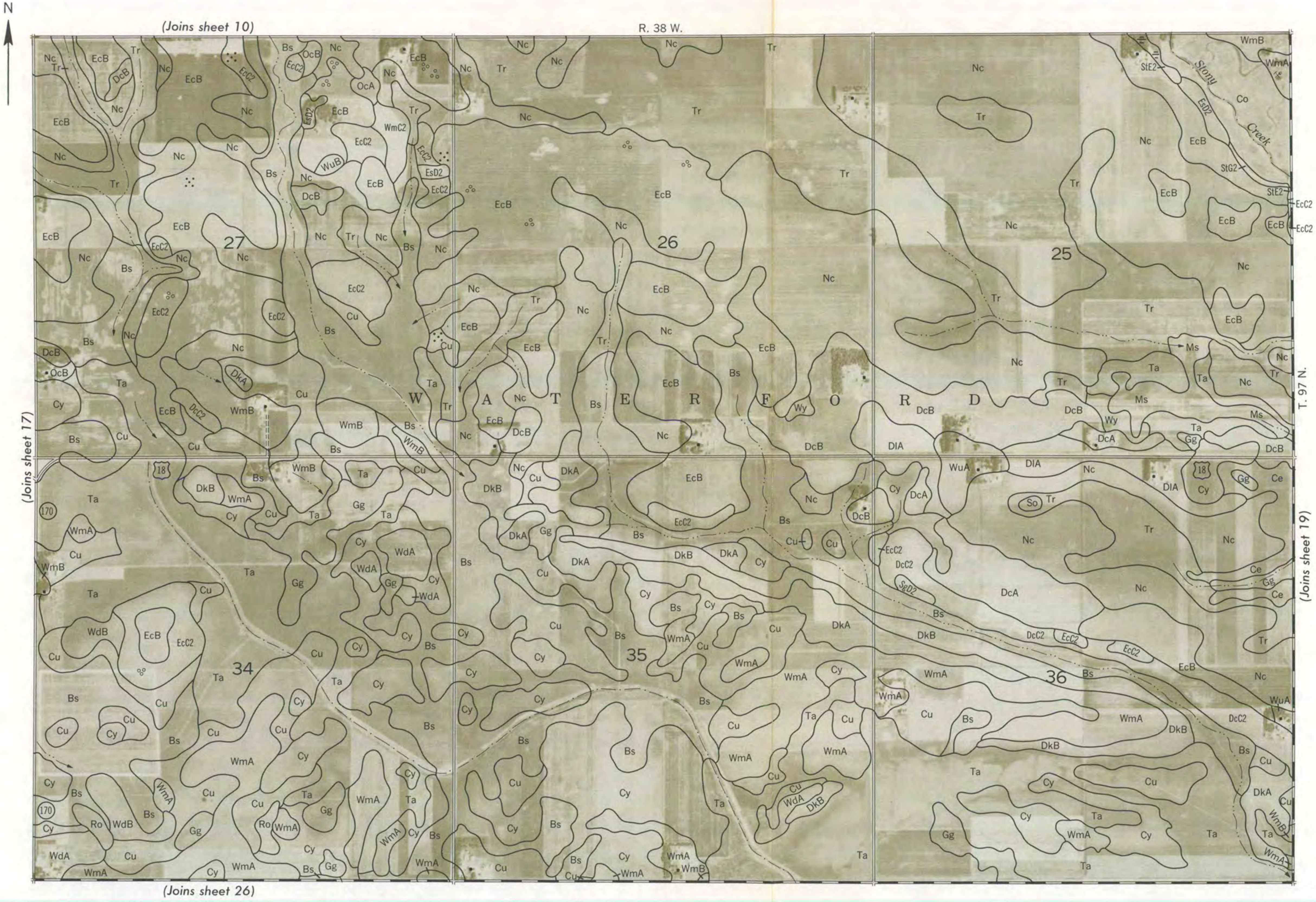

Scale 1:15840

0 ½ Mile

0 3000 Feet

CLAY COUNTY, IOWA NO. 18

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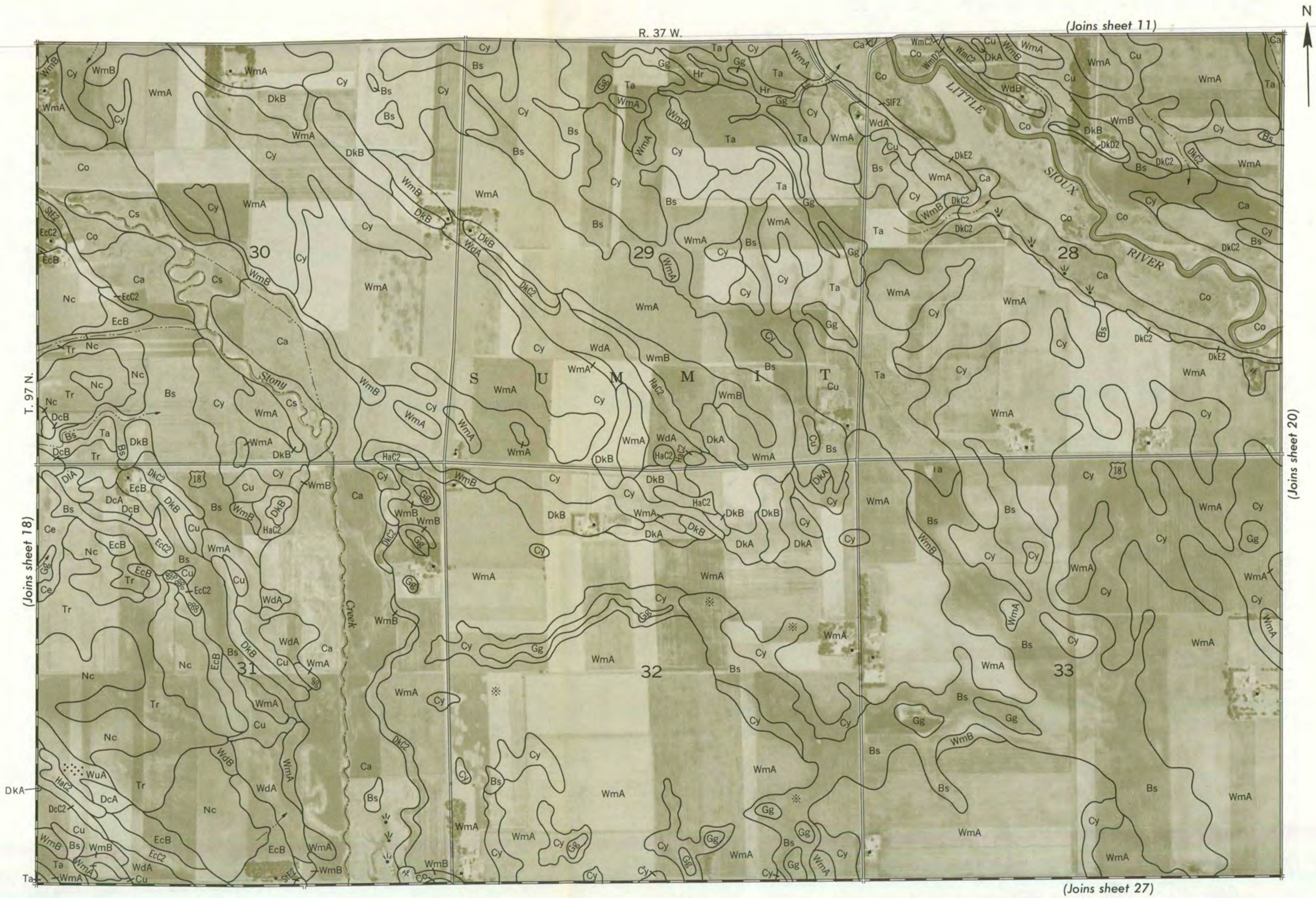
Land division corners are approximately positioned on this map.

CLAY COUNTY, IOWA NO. 19



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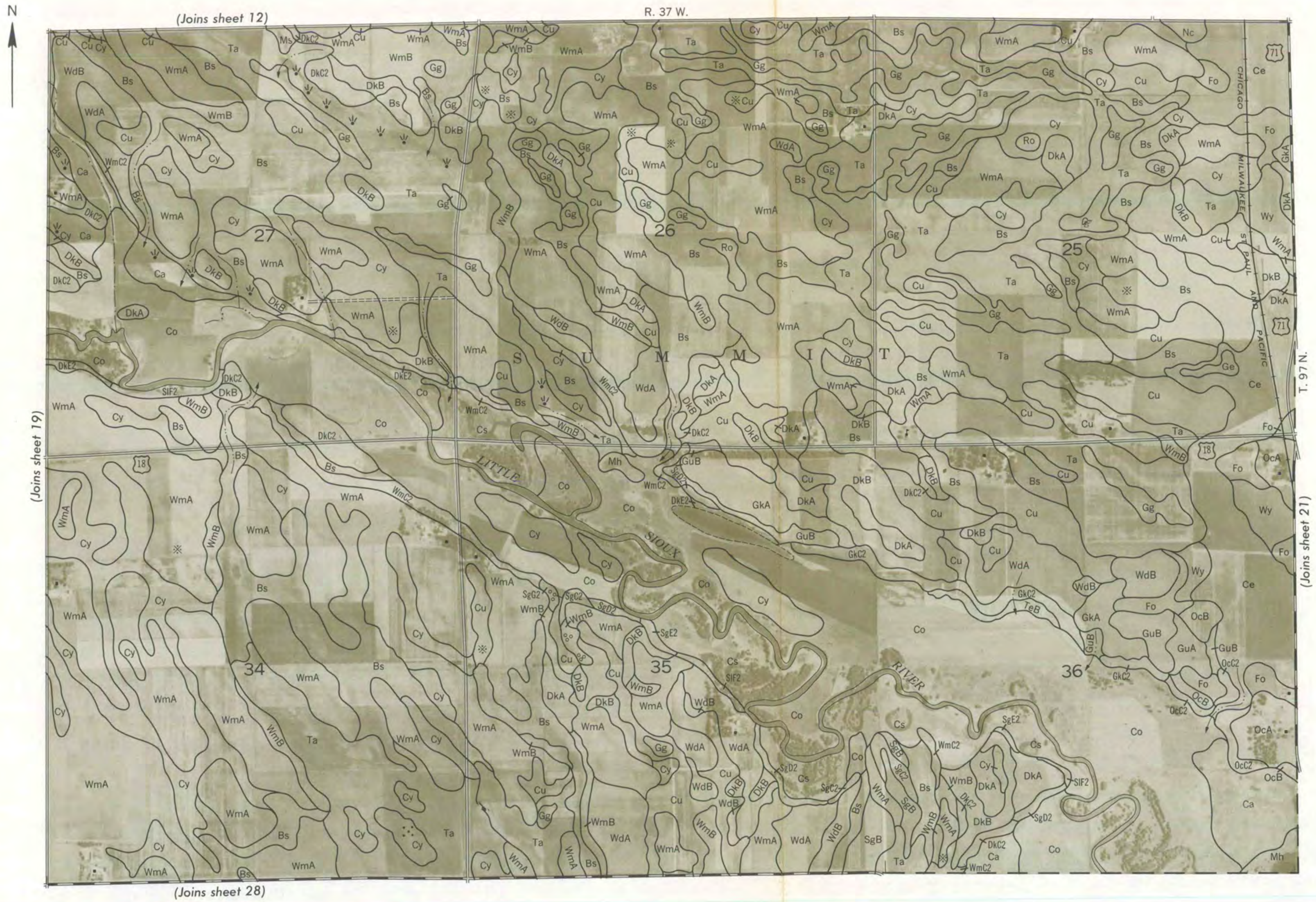

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CLAY COUNTY, IOWA NO. 20

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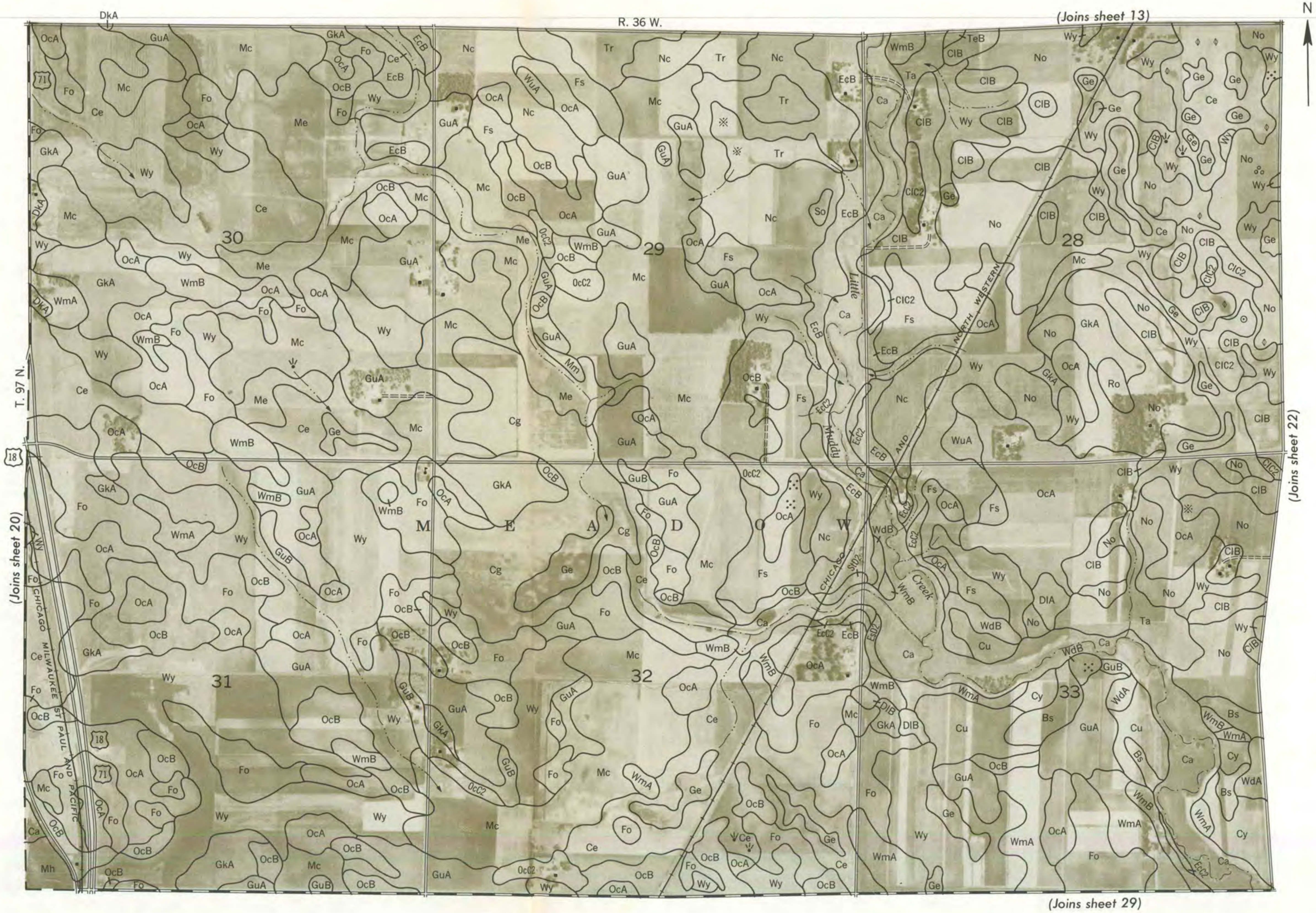
CLAY COUNTY, IOWA NO. 21



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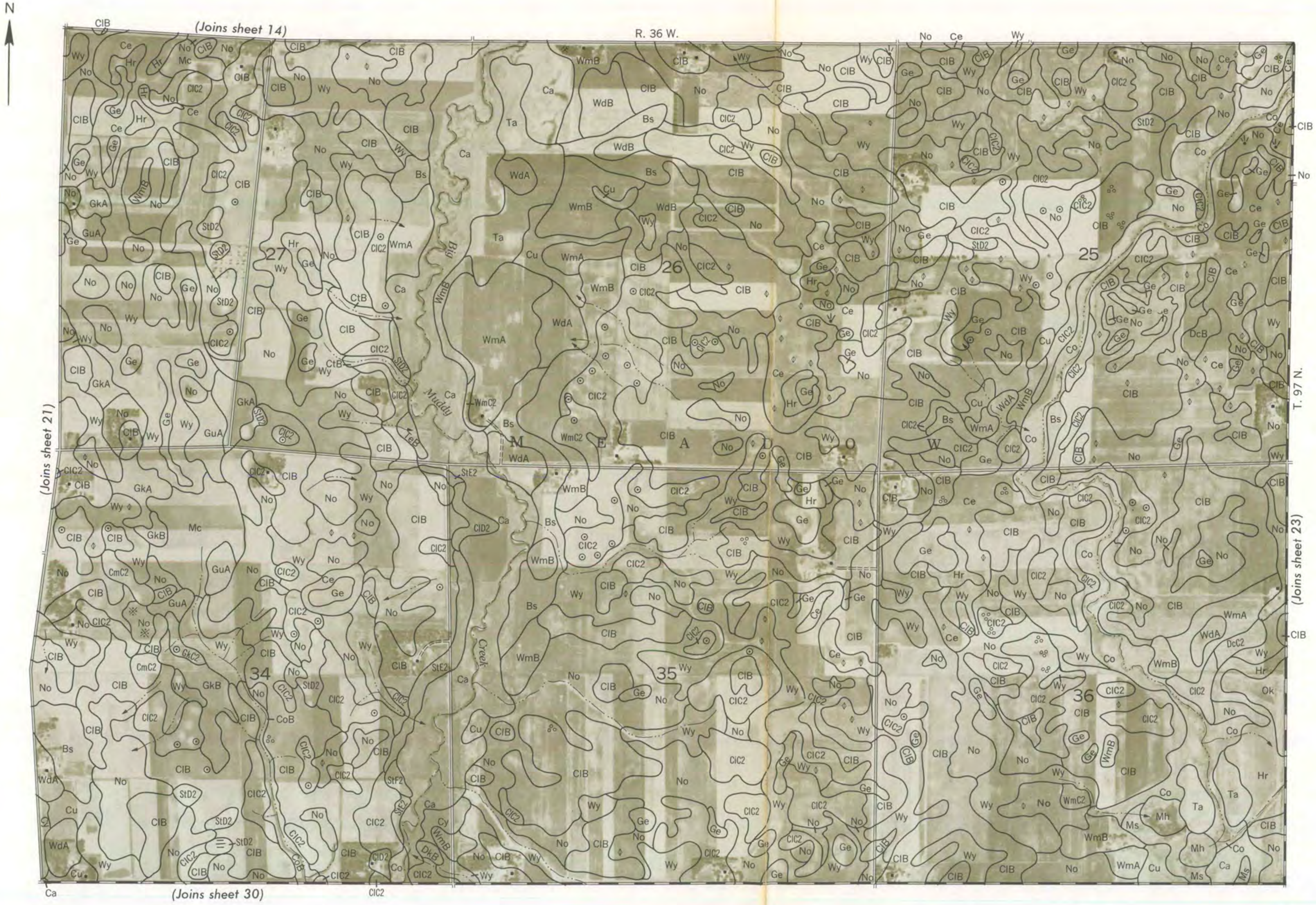
CLAY COUNTY, IOWA — SHEET NUMBER 22



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CLAY COUNTY, IOWA NO. 22

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N

0 ½ Mile Scale 1:15840 0 3000 Feet

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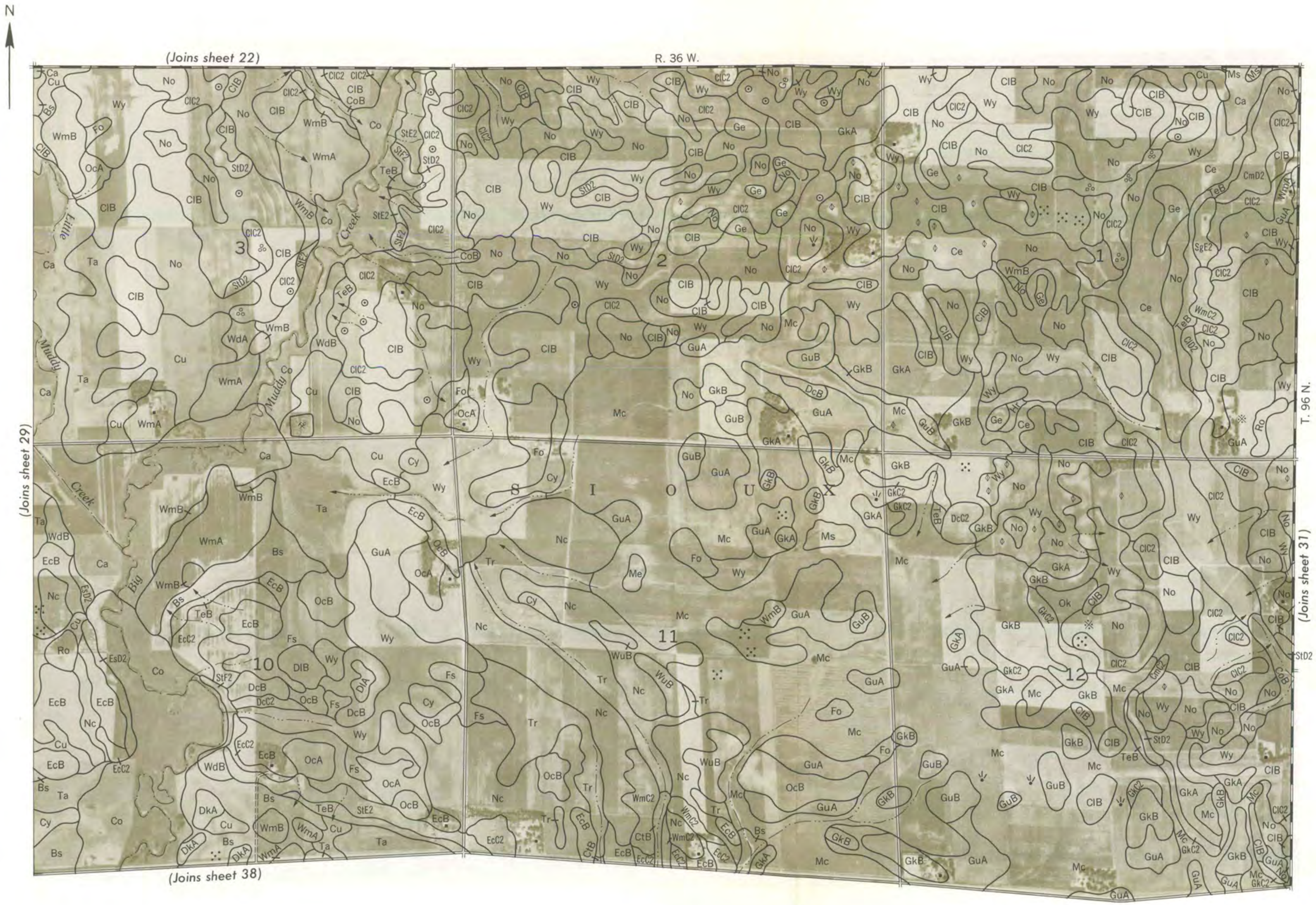
Land division corners are approximately positioned on this map.

CLAY COUNTY, IOWA NO. 23

CLAY COUNTY, IOWA — SHEET NUMBER 30



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CLAY COUNTY, IOWA NO. 30

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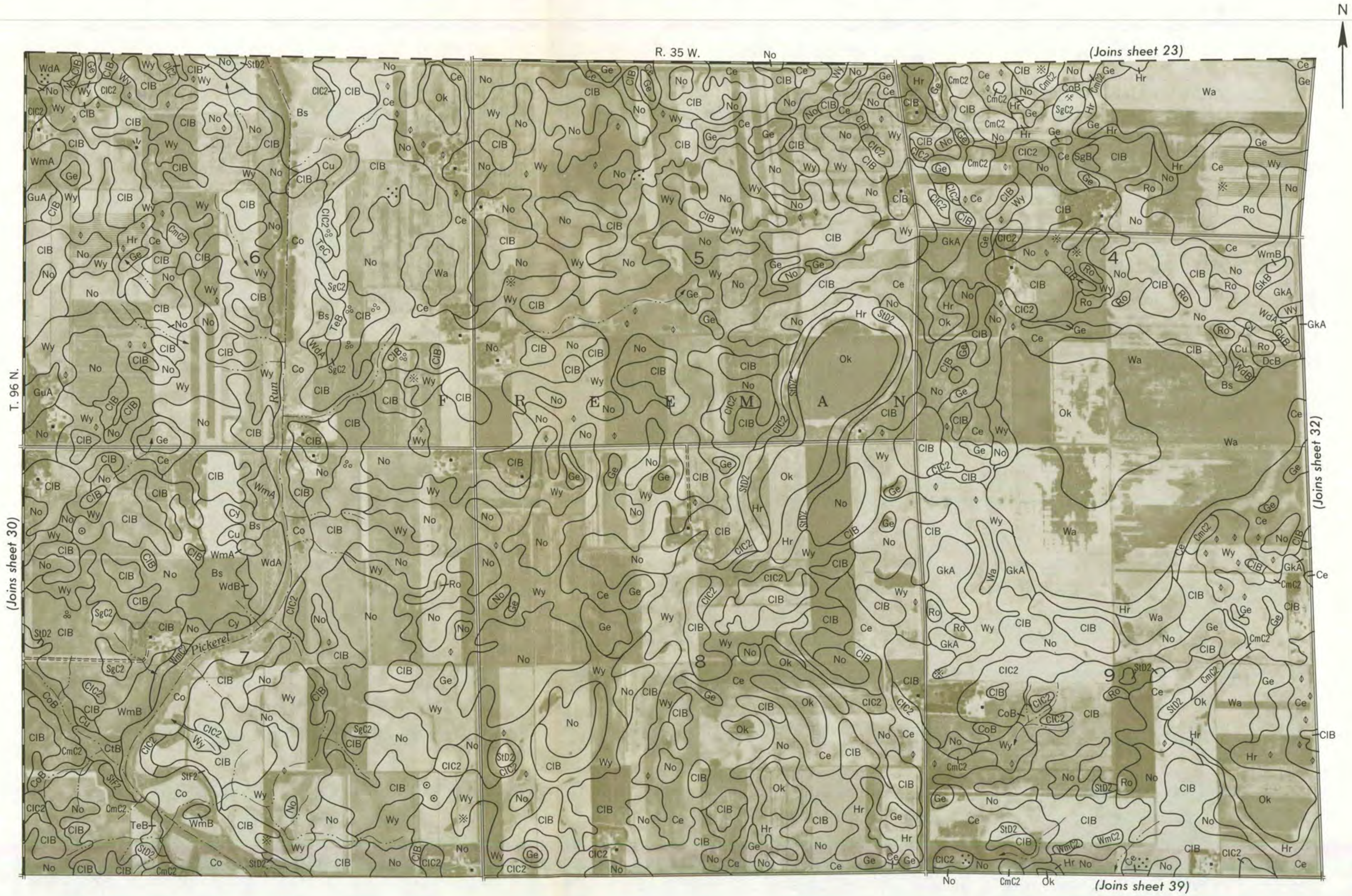
CLAY COUNTY, IOWA NO. 31



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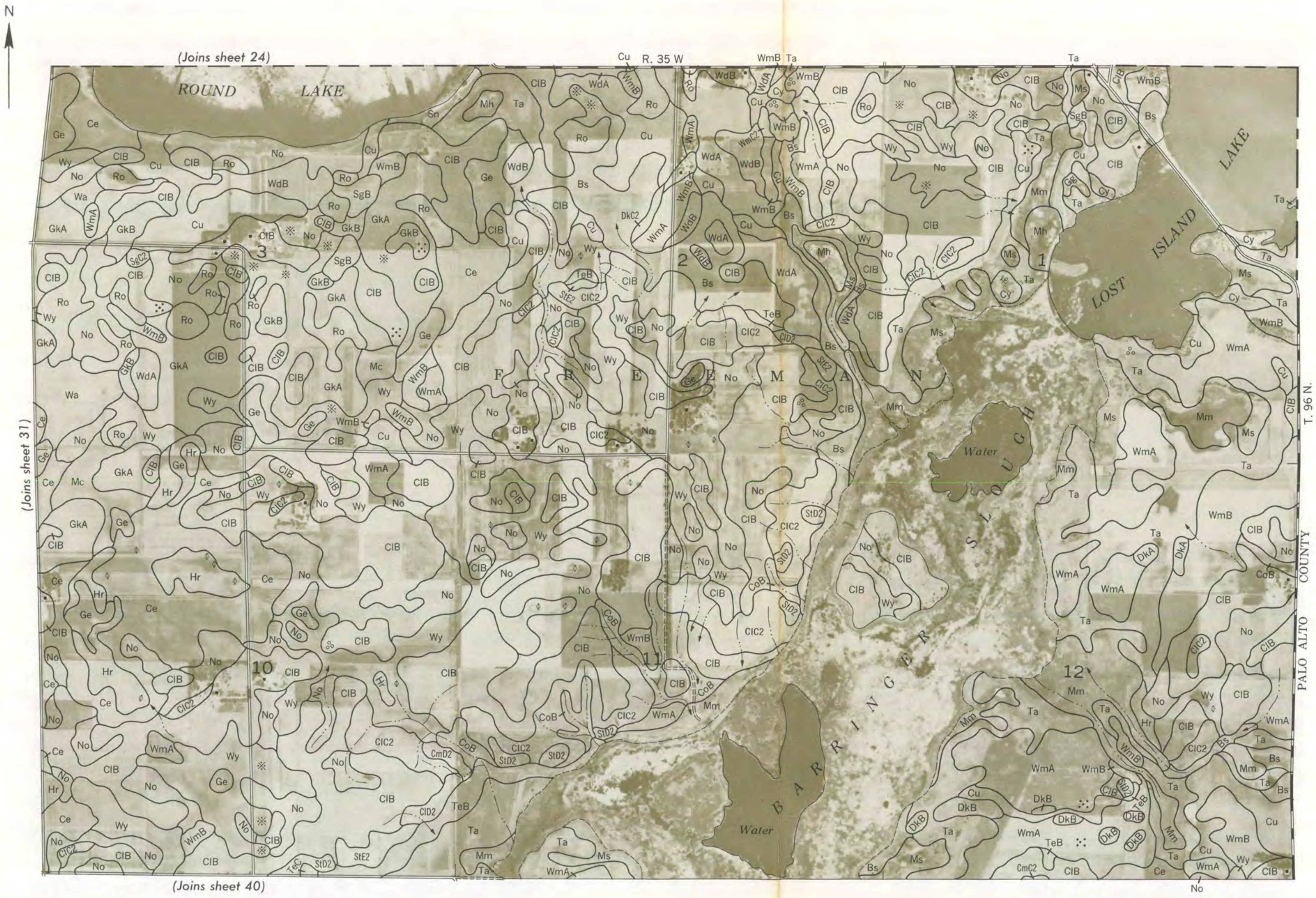

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CLAY COUNTY, IOWA NO. 32

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