Issued November 21, 1914.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION,
C. F. CURTISS, DIRECTOR.

SOIL SURVEY OF BREMER COUNTY, IOWA.

BY

MARK BALDWIN AND E. B. WATSON, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND F. B. HOWE, OF THE IOWA AGRICULTURAL EXPERIMENT STATION.

THOMAS D. RICE, INSPECTOR NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1913.]

WASHINGTON:
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1914.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., May 7, 1914.

SIR: In the extension of the soil survey in the State of Iowa, work was undertaken in Bremer County during the field season of 1913. This work was done in cooperation with the Iowa Agricultural Experiment Station, and the selection of the area was made after conference with the State officials.

I have the honor to transmit herewith the manuscript report and map covering this work, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1913, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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SOIL SURVEY OF BREMER COUNTY, IOWA.

By MARK BALDWIN and E. B. WATSON, of the U. S. Department of Agriculture, and F. B. HOWE, of the Iowa Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

Bremer County, Iowa, is situated in the northeastern part of the State, 42 miles south of the Minnesota State line, and about 48 miles west of the Mississippi River. It is bounded on the north by Chickasaw County, on the east by Fayette County, on the south by Black-

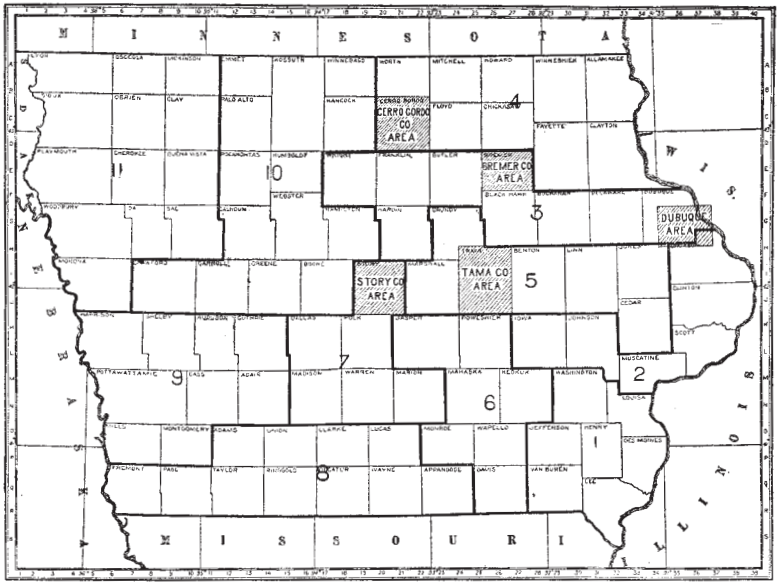

FIG. 1.—Sketch map showing areas surveyed in Iowa.

hawk County, and on the west by Butler County. Bremer County forms a rectangle 24 miles long from east to west and 18 miles wide from north to south. It has an area of 434 square miles, or 277,760 acres.

The topography of the county as a whole is gently undulating to rolling. Nowhere is the surface entirely level; on the other hand, the maximum local relief probably does not exceed 150 feet. The highest point in the county is about 2½ miles northeast of Sumner, where an elevation of 1,128 feet above sea level is attained. The lowest point, where the Cedar River crosses the south boundary line, is some 250 feet lower.

Variations from the general undulating or gently rolling topography of the county are found adjacent to the valleys of the larger

streams where the surface is more rolling and is broken by the small tributary valleys. An area between Waverly and Denver and extending about 2 miles north and east of Waverly is very rolling, much of the country being known locally as the "clay hills" or "big-woods" country, the latter name being applied because of the extensive forest growth. Low mounds of silt, fine sand, or sand, generally lenticular in shape, are encountered throughout the county. The silt mounds in the vicinity of Denver and of Waverly are known as "paha," and are marked by their graceful contours.

The three principal streams of the county, the Cedar, the Shell Rock, and the Wapsipinicon Rivers, flow through approximately parallel valleys in a general south-southeasterly direction. The main tributaries of these streams follow the same general course and are so spaced that the interstream areas are nowhere more than 6 miles in width, with an average of perhaps 3 miles. Thus the laterals are intermittent streams of small size.

The Cedar River, the county's largest stream, crosses the northern boundary line about a mile from the western boundary of the county. At this place the valley is not more than a mile in width. On each side of the stream are terraces 20 to 30 feet above the water level, bordered by the upland till plain which rises some 50 feet higher. About 2 miles north of Plainfield the bordering hills diverge and at Horton, near the mouth of Dry Run and Horton Creek, they are 4 miles apart, being separated by broad terraces. Two and one-half miles below Plainfield the valley again narrows to a width of 1 mile, and just north of Waverly it is less than one-half mile wide. In the neighborhood of Janesville the hills again diverge, and at the county line the terraces are nearly 1½ miles in width. The valley of the Shell Rock River crosses the southwestern corner of the county for a distance of about 5 miles. This valley averages about 1½ miles in width, and throughout its extent the stream is separated from the upland by terraces. The Wapsipinicon River enters the county from the north in a valley about 1½ miles wide. At Frederika the bordering hills on the east are rocky and descend rather abruptly almost to the water's edge. South of Frederika the valley is about 2 miles wide, and this width is maintained throughout the remainder of the course of the stream in the county. The terraces of the Wapsipinicon River are not so distinct as those of the Cedar and Shell Rock Rivers. In many cases the upland slopes gently down to the terraces or the bottom lands and the terraces merge as gradually into the flood plain.

Of the tributary streams in Bremer County, seven are bordered by terraces of sufficient size to be shown on the soil map. East of the Wapsipinicon are the Little Wapsipinicon River, Buck Creek, and the East Fork Wapsipinicon River. Between the Wapsipinicon and

Cedar Rivers are Crains Creek, Quarter Section Run, Horton Creek, and Dry Run.

The first white settlement of the territory now included in Bremer County was made in 1845. The settlers established homes near the "big-woods" country, about 2 miles southwest of the town of Denver. Immigration proceeded very slowly during the next five years, and in 1850 it is estimated that there were not more than 25 or 30 inhabitants of the county, all or nearly all of whom lived in or near the "big woods." These early settlers were Americans of English, Scotch, and Irish descent, from the Northern States, east of the Mississippi River.

The county was organized in 1853, the county seat being established at Waverly. The period of most rapid settlement of Bremer County was between 1850 and 1870. In those 20 years the population increased to 12,528. Many of the settlers were immigrants from northern Europe. It is estimated that in 1880, with a population of 14,081, fully 50 per cent of the inhabitants of Bremer County were foreign born. The county, according to the census of 1910, has a population of 15,843, an increase of 1,762 over that of 1880, and a decrease from the 16,305 reported in 1900.

At present about 40 per cent of the inhabitants of Bremer County live in the towns and villages. Waverly, the county seat, has a population of 3,205, according to the 1910 census; Sumner, in the eastern part of the county, has 1,404 inhabitants. Other towns of more than 200 inhabitants are Tripoli, Janesville, Readlyn, Denver, and Plainfield.

The Chicago Great Western Railroad operates 53 miles of track in Bremer County, with stations at Waverly, Bremer, Tripoli, Sumner, and Readlyn. The Illinois Central runs north and south through the county, passing Plainfield, Waverly, and Janesville. The Chicago, Rock Island & Pacific traverses the southwest corner of the county, and has a branch to Waverly. Waverly is one of the terminals of the Waterloo, Cedar Falls & Northern Electric Line.

The county roads are kept graded, and in places are surfaced with sand or gravel. Systematic road building is in progress throughout the county.

CLIMATE.

The climate of Bremer County is marked by wide variations in temperature. During the summer extreme temperatures of over 100° F. are recorded, and at times during the winter extremes of 20° or 30° below zero occur. The ground commonly freezes to a depth of 3 feet.

The average date of the first killing frost in the fall is October 8, and of the last in the spring May 8. The earliest killing frost in

the fall recorded during a period of nine years, from 1904 to 1912, inclusive, occurred on September 25. The latest date of killing frost in the spring recorded is May 20.

The growing season in Bremer County averages about five months. The varieties of corn commonly grown approach maturity early enough in a normal season to escape injury by frost. The alternate freezing and thawing of the ground during the winter and early spring and occasional sudden freezes following heavy rains damage clover, at times almost entirely destroying the crop throughout the county. The farmers do not attempt to grow winter wheat to any extent, and rye is the only grain seeded in the fall.

There is an average annual precipitation of about 31 inches. As a rule this is sufficiently well distributed to supply growing crops, although periods of drought during the summer sometimes result in injury to corn crops and particularly to pastures. Occasional wind and hail storms cause some damage to crops, but this is usually local and seldom results in total loss.

The average monthly and annual temperature and precipitation as recorded at the Weather Bureau station at Waverly, Bremer County, are given in the following table:

Normal monthly and annual temperature and precipitation at Waverly, Iowa.[1]

Month.	Temperature.	Precipitation.	Month.	Temperature.	Precipitation.
	°F.	*Inches.*		°F.	*Inches.*
January	17.9	0.99	August	70.8	2.96
February	17.5	1.14	September	62.5	2.94
March	32.8	1.95	October	52.0	2.31
April	47.0	2.69	November	35.1	1.40
May	60.0	4.70	December	21.6	1.18
June	67.5	4.25			
July	72.4	4.54	Year	46.4	31.05

[1] The means given in this table cover a period of 15 years, including 1910. The records of this station for later years are incomplete.

AGRICULTURE.

Agriculture is and always has been the dominant industry of Bremer County. At present more than half the population is rural, and many of the inhabitants of the towns are owners of farm property. Nearly all of the factories of the county are supplied with raw material by the farms of the county.

Agriculture may be said to have commenced in Bremer County in 1845. Corn was the first crop grown. Flax and hemp were important crops to the early settlers in that they supplied material for clothing. Sheep raising was a difficult matter at that time because of the depredations of prairie wolves.

Between 1850 and 1870 the better drained areas of farm land were brought under cultivation. By 1880 the total acreage of improved farm land was 212,565; and the average size of the farms was 130 acres. At that time 80.6 per cent of the total number were cultivated by the owners. Spring wheat was for some time the most important crop grown, but in the late seventies and early eighties the production of this cereal declined and corn and oats became the county's most important crops.

The census for 1910 reports 267,528 acres in farms, of which 229,505 were improved. The average size of the farms is given as 135.9 acres.

Land in Bremer County has advanced rapidly in price during the last 30 years. A number of farms have sold recently for $200 an acre, and very little farm land is valued at less than $125 an acre. The 1910 census reports an average value of $66.60 [1] an acre. Values are based largely upon the quality of the soil, the improvements on the farm, and the proximity to the towns. The Carrington loam is recognized as the county's most valuable general farming soil. The total value of land and improvements, including buildings, is given in the 1910 census as $23,051,591.

Corn is the principal crop of Bremer County. The 1910 census reports a production of 2,162,238 bushels from 60,827 acres. The field corn grown in the county is chiefly of yellow dent varieties, although some white corn is produced. Part of the corn is drilled in and part planted in check rows. Very little hand labor is used in connection with the production of a corn crop. Riding cultivators are used by most farmers, and in harvesting the crop corn binders are in common use.

The small grains are planted, harvested, and thrashed by the use of modern farm machinery. The oat crop is second only to corn in importance. The 1910 census reports 53,015 acres in oats, with a production of 1,423,671 bushels. A yield of 4,573 bushels of wheat from 305 acres is reported, while 4,280 acres is devoted to barley, with a yield of 87,255 bushels. The yield of buckwheat is given as 691 bushels from 60 acres, and that of rye, 9,914 bushels from 726 acres.

A production of 134,857 bushels of potatoes from 1,572 acres is reported in the census for 1910, while 1,473 acres are devoted to other vegetables. Sweet corn is grown to some extent in this county, mainly to supply the canning factories at Waverly and Tripoli.

Since the building of the beet-sugar factory at Waverly, the farmers of Bremer County have had excellent opportunity for the mar-

[1] Assessed value, and therefore lower than prices obtained in open market, except at forced sale.

keting of sugar beets. But of the 5,000 acres of beets required to supply this factory, only about 400 acres were devoted to sugar beets in Bremer County in 1912. This is due, not to the inferiority of the Bremer County soils for the production of beets, but to the hesitancy of the farmers to grow this crop, chiefly because of the great amount of hand labor required. The land for the production of beets is fall plowed, and as soon as the frost is out of the ground in the spring it is harrowed. After the preparation of the seed bed the beet seed is drilled in, the rows being 16 to 18 inches apart. The quantity of seed used ranges from 20 to 25 pounds to the acre. After the beets are up, they are thinned and carefully weeded and cultivated, operations requiring much hand labor, although riding cultivators are used for some of the work. The pulling and topping in September and October also require hand labor. It can thus be seen that the sugar-beet crop is a rather expensive one to produce, the cost averaging about $35 an acre, but under good management it is a profitable field crop. Yields of 20 tons to the acre are reported, with an average of about 12 tons. The price paid at the Waverly factory is $5 a ton. It is known that sugar beets have been grown and have given satisfactory yields on three types of soil in Bremer County, the Carrington loam, the Carrington sandy loam, and the Knox silt loam, but observation and experiment are not thus far sufficient to determine the relative value of these soils for the production of the crop, although it is generally recognized that the Carrington loam is naturally the best of the three.

Dairying, first taken up 25 or 30 years ago, is becoming an important phase of the agriculture of Bremer County. Cooperative creameries are numerous, being located in all of the towns and villages. No single breed of dairy cattle is used for the production of milk, the herds being variously made up of grade cattle, Holstein, Jerseys, and some of the dual-purpose breeds. The number of silos is increasing in all parts of the county as the value of silage for feed, especially for the dairy cattle, is more generally recognized. The value of domestic animals, poultry, and bees in Bremer County is given in the census for 1910 as $3,254,716.

The same general type of farming is followed on all the soils of the county except on those too poorly drained for cultivation, such areas being used for the production of hay and for pasture. The 1910 census reports the production of 28,522 tons of wild grass hay. Millet or Hungarian grasses produced 352 tons; clover, 470 tons; alfalfa, 14 tons, and other tame grasses, 8,704 tons of hay. Grains cut green for hay yielded 543 tons. A total area of 6,779 acres was sown for forage.

No systematic rotation of crops, as a rule, is followed in Bremer County. Commercial fertilizers are unimportant in the agricultural

practice, but the importance of careful conservation and application of organic manures is being more and more recognized by the farmers.

Fall plowing begins as soon as possible after the oats are harvested, often as early as the middle of August. Three to five horses are required, the larger number being used with gang plows. Steam or gasoline tractors are not extensively used in general farm work; the small size of the fields does not warrant the use of such machinery.

The proportion of farms operated by the owners decreased during the past 20 years. In 1910 it is reported as 70 per cent of the total. This largely is due to the land owners moving into the towns and leaving their lands in the hands of tenants. Cash rental averages $4 to $5 an acre, land nearer town renting for a higher price than that more remote.

The expenditure for farm labor in Bremer County in 1909 was $148,034, according to the census of 1910. The wages generally paid are $35 a month, with board and washing. During harvest season hands are paid $2 and $2.50 a day, with board.

SOILS.

The soils of Bremer County, Iowa, fall into four general classes. The first class includes the soils composed of glacial drift of the Iowan glaciation, unmodified except for the weathering which forms the soils of the Carrington and Miami series. The second class comprises the reworked soils having their source of material in the glacial drift, but now occupying the flood plains of the streams and the river terraces. This includes the Bremer and Cass series and Meadow. The Fargo loam may also be considered in this division, although the material in this soil has been only partially reworked, and the soil is intermediate between this class and the first class. The residual limestone soil encountered in only one small area, but occurring in numerous outcrops too small to be shown separately on the map, forms the third class, while the fourth class includes those soils whose origin is not above dispute, the silty and sandy soils of the Marshall and Knox series.

Bremer County is covered with till to a depth apparently averaging over 100 feet. In some areas it is very thin, and in a few places it is absent, as on the bluffs along the Cedar River. In other places it is 250 feet or more in depth, as where an old river channel has been filled. This layer of material consists almost entirely of two parts, the lower being the Kansan and the upper the Iowan drift. The great bulk of the till belongs to the lower part, the Kansan. The drift covers the whole county, with the exception of a very few

areas of rock outcrop. To the Kansan glaciation is largely due the topography of the county; its drift material filled the old valleys, and the ice planed off the ridges, making the general surface almost level. This Kansan till plain was in turn eroded, although the erosion evidently did not proceed to an advanced stage. However, a regular dendritic system was developed which served to drain every part of the surface. The Kansan drift is seen in numerous cuts, and it appears at the surface in a few places, but these areas are small and the map accompanying this report does not show a soil derived definitely from this drift material.

The upper drift sheet is a mere veneer in comparison with the sheet below. It averages 15 to 20 feet in depth, and in a part of the county it is absent. This is the area between Waverly and Denver, which is covered by the loess deposit. The Iowan drift was deposited over the lower drift without sensibly mixing with or disturbing it, and as its mantle was comparatively uniform, it preserved in a general way the topographic features of the lower drift sheet, modifying them probably by making the deposits somewhat deeper in the valleys than on the hills, but after all leaving them so that they are still apparent.

The physical composition of the Iowan drift, while subject to local variation, is generally quite uniform throughout the county. The surface material is chiefly clay, silt, and sand, mixed in such proportions as to form a loam over most of the county. In a number of areas the sand or fine sand is sufficiently prominent to give the soil the texture of a sandy loam or fine sandy loam. Likewise, in a few areas the proportion of clay is so great as to make the soil a clay loam.

Stones and bowlders are scattered over the drift sheet, being particularly numerous in the small drainage channels of intermittent streams. Some of the bowlders are quite large, ranging up to 15 or 20 feet in diameter. They are all igneous and metamorphic rocks, and the great majority are granites and gneisses.

Since its deposition the surface of the Iowan drift sheet has been subjected to the various agencies of weathering. Over a large part of the county prairie grasses established themselves, extended their root systems far into the soil, and on decaying left various organic compounds, forming humus. The accumulation of this black organic matter in the surface material of the Iowan drift gives rise to the black or dark-brown Carrington soil.

In the neighborhood of the Wapsipinicon River near the north county line, in well-drained and forested areas, organic matter did not accumulate so rapidly and extends less deeply into the soil. Thus the surface soil of these areas is lighter colored, containing much less humus than the Carrington soils. They are included in

the Miami series, of which two types are mapped in Bremer County, the Miami loam and the Miami sandy loam.

Into the little valleys of the intermittent streams of the county material from the surrounding soils has been slipping and washing for centuries. This accumulation of soil material has given rise to a black, mellow, poorly drained loam, mapped as the Fargo loam.

In a few small undrained or poorly drained depressions standing water and swampy conditions have favored the rank growth of water-loving plants. The presence of water and the cold winter climate have prevented the complete oxidation of the organic matter accumulating in such places, and as a result small areas of Muck have formed.

The remaining soil types, with a single exception, are derived from reworked materials of the glacial drift. These soils, which are clearly derived from glacial material laid down by running water, are included in the Bremer, Plainfield, and Cass series or mapped as Meadow. The Bremer and Plainfield series occupy the stream terraces, the former being distinguished from the latter by a higher organic content, resulting from conditions similar to those which give rise to the distinction between the Carrington and the Miami soils. The Cass soils are black to dark brown and occupy the flood plains of the permanent streams. Meadow is a term applied to the poorly drained or frequently overflowed bottom lands not under cultivation.

Northeast and east of Waverly, between Waverly and Denver, and extending southeastward from Denver to Crains Creek are areas of silty and sandy soils, occurring as upland deposits upon glacial till. These areas occur in various forms, but the most distinctive feature is the occurrence of low lenticular hills of silt or loess known as "paha." There are, however, large areas, of irregular shape, covering hundreds of acres and marked by a very rolling topography, known locally as the "clay hills." The uniformity of the texture of these deposits indicates the assorting action of wind or water, or perhaps both, and owing to this fact together with other points of similarity the soil is correlated with the Knox and Marshall soils of the Glacial and Loessial province. The Knox soils are yellowish brown or gray in the surface 12 inches, while the Marshall soils are black to dark brown, the difference being due to a higher percentage of organic matter in the latter series.

The glacial drift of Bremer County is underlain by shales and limestones of Ordovician, Silurian, and Devonian age. The Ordovician rock does not appear near the surface in any part of the county, and the outcrop of Silurian and Devonian limestones is not extensive. Their influence on the soil is limited to small areas along

the Cedar and Shell Rock Rivers and on the banks of the Wapsipinicon, near Frederika. One area, just southeast of Waverly, was mapped in which the limestone is within 2 to 5 feet of the surface and has influenced the character of the soil to some extent, although the material is largely glacial drift. This area is mapped as the Crawford silt loam.

The following table gives the names and the actual and relative extent of the various soils mapped in Bremer County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington loam	169,664	62.8	Bremer fine sandy loam	1,600	0.5
Poorly drained phase	4,800		Cass loam	1,536	.5
Meadow	21,824	7.9	Plainfield loam	1,088	.4
Fargo loam	18,304	6.6	Marshall silt loam	896	.3
Carrington sandy loam	16,960	6.1	Carrington clay loam	512	.2
Bremer loam	14,912	5.4	Knox fine sandy loam	512	.2
Bremer sandy loam	8,192	2.9	Cass sandy loam	512	.2
Miami loam	4,160	1.5	Crawford silt loam	256	.1
Knox silt loam	3,584	1.3	Miami sandy loam	64	.1
Carrington fine sandy loam	3,200	1.1	Muck	64	.1
Bremer coarse sandy loam	2,944	1.0			
Marshall sand	2,176	.8	Total	277,760	

CARRINGTON SERIES.

The types included in the Carrington series have dark-brown to black soils and light-brown to yellowish subsoils. They are derived almost exclusively from glacial till material. Their topography is gently undulating to rolling, with occasional nearly flat areas. The soils in this series are found in the glaciated region from the Ohio River westward.

CARRINGTON CLAY LOAM.

The surface soil of the Carrington clay loam is a black clay loam from 8 to 12 inches deep. It contains a high percentage of organic matter, and is underlain by a tenacious clay loam subsoil, which varies in color from yellow to drab or dark gray. The surface soil does not contain so high a percentage of clay as the subsoil and is much more friable. Bowlders of various sizes are found in the soil and subsoil and are frequently scattered over the surface. This is a heavy soil and its cultivation is difficult. It has poor natural drainage and is in need of tiling, but when proper drains are installed the water passes off readily. The soil is retentive of moisture and is not easily affected by drought.

The Carrington clay loam is comparatively unimportant in Bremer County. It occurs in small areas scattered over the more level sections of the Iowan drift.

It occupies poorly drained flats at the heads of the shallow drainage channels and is always surrounded by the better drained Carrington loam. Although its drainage is poor, the soil is not marshy. This soil is derived directly from the Iowan drift, but it may have received some wash from the surrounding land. Its poorly drained condition has favored the accumulation of a large amount of organic matter, and this gives it its black color.

The Carrington clay loam, like the surrounding loam, was originally prairie, but it supported taller and coarser grasses than the loam. The type is generally used for hay or pasture, and as the areas are, as a rule, only 5 to 20 acres in extent this gives the cultivated fields a patchy appearance. Where properly drained this is an excellent soil for heavy farm crops, producing better yields of corn than are secured on the Carrington loam.

The better practice is to tile drain and cultivate the areas of this soil, not only because it can be made to produce profitable crops but because the areas can then be cultivated in connection with fields, thus avoiding the difficulty of cultivating small, irregular fields with the large, heavy farm machinery commonly used.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Carrington clay loam:

Mechanical analyses of Carrington clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330501	Soil	0.6	7.0	8.4	14.2	7.4	40.1	22.4
330502	Subsoil	1.6	9.3	11.4	22.5	8.5	22.2	24.4

CARRINGTON LOAM.

The surface soil of the Carrington loam varies in depth from 10 to 18 inches. It consists of a dark-brown to black, mellow loam of a high organic-matter content. The percentage of silt, fine sand, and sand is sufficiently high to render the soil friable and free from stickiness, even when wet. The subsoil is a brownish-yellow to light-yellow sandy or silty clay loam, which grades downward into the unmodified glacial till of the Iowan drift. Some bowlders, stones, and gravel occur in the soil and subsoil and on the surface. In some places the bowlders were sufficiently numerous to necessitate their removal, but at present they have been so thoroughly cleared from the fields that they no longer interfere with cultivation.

The Carrington loam is the predominant soil type of Bremer County. It occupies the greater part of the upland till plain of the Iowan drift. Its continuity across the county is broken only by the

valleys of the larger streams and by small areas of other upland soil types. Throughout its area it is remarkably uniform, both in structure and texture; but its gradations into adjoining types are in places so gradual that the soil boundaries are necessarily arbitrary. In the more rolling areas where erosion has been more active the soil is usually lighter in color and contains a higher percentage of sand and fine sand than does the typical Carrington loam. This especially is true of the long valley slopes of Buck Creek and the Wapsipinicon River. A few knolls of sandy or gravelly material, too small to be shown as distinct types on the soil map, are included with the Carrington loam.

The general topography of the areas of Carrington loam is gently undulating to rolling. Those portions of the interstream areas which are more remote from the valleys are the most nearly level. A gradual transition from this surface configuration to the more rolling topography near the larger streams is the general rule. The elevation of most of the upland is 1,000 to 1,100 feet above sea level. The natural drainage is good over practically all of the type. The more distinct, poorly drained areas are recognized as a separate phase.

The Carrington loam is derived directly from unstratified glacial till. The black surface soil has been formed by the alteration of the upper portion of the till through the agencies of weathering and the growth and decay of vegetation. This alteration has consisted to some extent of the leaching of soluble salts, notably calcium carbonate, from the surface soil and the carrying away by surface wash of some of the finer soil particles; but the most important feature is the incorporation of organic matter. This organic matter, or humus, represents the remains of prairie grasses and other vegetation that covered this region for many hundreds of years.

While the Carrington loam is typically a prairie soil, there are a number of areas of this type in Bremer County which were originally forested, mainly with oak, aspen, walnut, butternut, maple, and ash. These areas are confined almost entirely to the well-drained locations near the larger streams.

Not only is the Carrington loam the most widely distributed soil of Bremer County, but it is the best type for general farming. Although a medium heavy soil, requiring a heavy farm equipment, it contains sufficient organic matter and sand to make it readily reducible to good tilth. The present agricultural wealth of the county is based chiefly upon the productivity of this soil, and the substantial, well-kept farm buildings are an evidence of the prosperity of the farmers.

Crop yields are quite variable on the Carrington loam. The production of corn ranges from 30 to 80 bushels per acre, averaging

about 45 bushels; oats average 30 to 40 bushels an acre, wheat probably 20 bushels, and barley 35 bushels. The average yield of timothy hay is about 1 ton per acre. Red clover is grown to some extent but often freezes out in winter. Buckwheat, millet, and sorghum are grown on a small scale. Since the establishment of the beet-sugar factory at Waverly some farmers have grown sugar beets on the Carrington loam. The yields have been generally good, averaging 12 tons to the acre and running as high as 20 tons. While this type is not primarily a fruit soil, apples and small fruits, such as blackberries, raspberries, currants, and gooseberries, are grown on a small scale.

While the Carrington loam is naturally a very fertile soil, there is at the same time the possibility of exhausting its fertility. It is maintained by many farmers that its productiveness is constantly increasing. This is perhaps true in many cases and is due to various causes, the most important of which is the installation of tile drainage on the more nearly level areas. Another factor is the improvement of cultural operations; and another, the careful selection of seed. The more successful and progressive farmers save all of the stable manure produced on the farm and apply it to the fields. Many of them have come to recognize the usefulness of manure spreaders.

Land of the Carrington loam is valued at $150 to $200 an acre, ranking with the highest priced general farming soils in the United States. Rents vary from $4 to $5 an acre, the distance from town being the chief factor in determining the price.

Carrington loam, poorly drained phase.—The poorly drained phase of the Carrington loam to a depth of 18 inches is a black, heavy loam containing a high percentage of organic matter. The subsoil is a yellow sandy or silty clay loam, often carrying some gravel and pebbles.

This phase of the Carrington loam occupies the nearly level areas on the divides between the streams of Bremer County.

Like the typical Carrington loam, this soil is the product of the weathering of unstratified glacial drift. The more nearly level topography has resulted in poorer drainage conditions and the accumulation of a greater amount of vegetable matter, and has prevented the washing away of the finer soil particles. Thus, in general, the poorly drained phase differs from the typical Carrington loam in having a greater depth of black surface soil, a somewhat heavier texture, and poorer natural drainage, all of these distinctions having been brought about by its more nearly level topography. In many places the texture approaches that of a clay loam, but when thoroughly drained and moderately dry the soil is fairly friable and works up into very good tilth under proper cultivation.

At present a large part of the area of this soil is uncultivated, and is used only for the production of hay and for pasturage. Until the soil is well drained field crops are backward, but with thorough tiling the agricultural value of this phase becomes fully equal to that of the typical Carrington loam. The phase is richer in organic matter, and is capable of producing good yields of corn longer than the main type.

CARRINGTON SANDY LOAM.

To a depth of 15 to 18 inches the Carrington sandy loam is a dark-brown sandy loam. It is loose and friable and easily worked. The sand content usually increases slightly with depth, and the subsoil is a yellow, very sandy loam, in most cases, however, carrying sufficient clay to give it a sticky character. Occasionally some gravelly material, consisting mainly of rounded pebbles, is encountered in the subsoil, and in a few places bowlders are scattered over the surface. The sand grains are principally quartz. The bowlders are practically all of igneous and metamorphic origin.

The Carrington sandy loam is the most extensive of the upland sandy soils of Bremer County. It occurs principally in the southwestern part of the county in areas a square mile or more in extent, and in numerous smaller areas, on the east side of the Cedar and Shell Rock Rivers, and in the neighborhood of the "paha" and the large loess deposit between Waverly and Denver. Small areas also occur throughout other parts of the county, generally near the stream valleys, but occasionally well out upon the interstream uplands of the Iowan drift plain.

The soil type, like the Carrington loam, is of glacial origin, but the definite processes which led to the concentration of sandy material are not clearly understood. The presence of large bowlders on the surface in some of the areas and the lack of evidence of the assorting action of wind or water indicate that at least a part of the material of this type is purely ice-deposited drift. Some small areas appear to owe their texture to the action of water, in the form of sheet wash, carrying away the finer soil particles. It is possible that in some cases the sandy texture is due exclusively to the action of wind or water.

The topography is undulating to rolling. The drainage is good, and in many cases excessive. Near the larger streams the areas of Carrington sandy loam originally supported a forest growth consisting mainly of red, scarlet, and bur oak, sugar maple, linden, and hickory. Farther away from the streams the native vegetation of the type consisted largely of prairie grasses, which did not, however, make so rank a growth as on the Carrington loam. Oxidation, because of better drainage and aeration, proceeded more rapidly on

the sandy soils than on the heavier types, and the accumulation of humus was, therefore, much slower.

The same general type of farming is followed on the Carrington sandy loam as on the Carrington loam. Because of the loose, porous nature of the soil and subsoil, crops on this type are more subject to injury by drought. In seasons of heavy, well-distributed rainfall crops about equal those on the heavier soil types, but on the average the yields are lower. Corn produces from 25 to 50 bushels per acre, and oats from 25 to 40 bushels during favorable seasons. Sugar beets are said to yield from 6 to 10 tons to the acre. Potatoes of good quality are produced on this type, and in favorable seasons cantaloupes, watermelons, and cucumbers do well.

While not naturally so strong a soil as the Carrington loam, the Carrington sandy loam possesses some advantages over that type. It is a warmer soil and matures crops much earlier; it is more easily worked, and weeds are not so troublesome as on the heavier type. To increase its efficiency the addition of organic matter is needed in most cases. The application of stable manure and the turning under of green crops not only increase the amount of plant food in the soil, but also improve its texture and increase the water-holding capacity.

The average results of mechanical analyses of samples of the soil and subsoil of the Carrington sandy loam are given in the following table:

Mechanical analyses of Carrington sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330503, 330505.....	Soil.....	0.8	15.8	19.1	23.1	4.9	23.4	12.9
330504, 330506.....	Subsoil.....	1.2	17.7	18.7	21.7	6.2	21.4	13.1

CARRINGTON FINE SANDY LOAM.

To a depth of about 14 inches the soil of the Carrington fine sandy loam is a brown to dark-brown fine sandy loam, carrying sufficient organic matter in some cases to impart a decidedly loamy, mellow texture. The subsoil is typically a yellow to brownish-yellow fine sandy loam or sandy loam. In places strata of loose, incoherent material, mainly sand, are encountered, with alternating strata of sticky fine sandy loam or sandy loam.

Topographically this type is closely associated with the sandy loam of the same series. Like that soil, it occurs mainly upon the uplands along the larger stream valleys. The largest development of the

type is 4 miles north of Waverly. It extends eastward from the east bank of the Cedar River and includes an area of about 2 square miles. Other areas are mapped in the vicinity of the Wapsipinicon River, the Shell Rock River, Quarter Section Run, and on the valley slopes of some of the smaller streams of the county. A number of small mounds or ridges, rising 8 to 20 feet above the general upland level, well out upon the Iowan drift plain, are included in this type. The percentage of fine sand in such areas is somewhat greater than in the typical soil. These outlying, detached areas are surrounded by Carrington loam and, like that soil, were originally prairie land. The type as it occurs along the stream courses was originally forested mainly with red, white, scarlet, and bur oak, sugar maple, elm, and linden.

The Carrington fine sandy loam is derived from material of the glacial drift. The exact processes by which it was distributed and deposited are somewhat obscure. No doubt the greater part of the type represents material laid down by the ice sheet. It seems equally certain that the agencies of wind and water have been working in some cases toward the greater concentration of sand and fine sand.

The Carrington fine sandy loam can be used successfully in the production of potatoes, beets, cabbage, cantaloupes, watermelons, cucumbers, and other vegetables. The areas adjacent to streams are adapted to fruit, and are suited especially to apples, plums, raspberries, strawberries, and blackberries.

The type is used for the production of general farm crops, being farmed in the same manner as the Carrington loam. Yields in seasons of well-distributed rainfall are about equal to those on the heavier soil, but this type is more easily affected by drought. This is especially true of the sandier phases. The loose, porous texture of the soil and subsoil permits the water to drain away quickly. This characteristic has a compensating value, however, in that it renders the soil more easily cultivated, and weeds are not so troublesome and are more easily destroyed than on the heavier types. The lighter colored and sandier areas of the Carrington fine sandy loam are in need of organic matter.

Miami Series.

The Miami series includes types having brown, light-brown, or gray soils underlain by yellowish and brown subsoils. The soils of this series are derived mainly from more or less calcareous glacial till. The subsoil is sometimes mottled. This is one of the most important series of the glaciated region lying west of the Ohio River.

MIAMI LOAM.

The surface soil of the Miami loam is 8 to 10 inches deep. It is a light-brown to gray loam, containing a noticeable amount of sand and fine sand, the grains of which are mainly quartz. The subsoil is more variable both in texture and color than the surface soil, but it is typically a yellow or brownish-yellow sandy clay loam. Mottlings of red and gray are often present in the subsoil. Pockets of yellow to reddish-yellow sand are encountered in some places at depths ranging from 2 to 3 feet.

Stones and bowlders are scattered over the surface of the type. The bowlders are mainly igneous and metamorphic rocks.

Like the Carrington loam, the Miami loam is the product of weathering of unstratified glacial till. The difference between the two soils is principally in organic-matter content and depth of the surface soil. The Miami loam is, or originally was, forested, while the Carrington loam was mainly prairie. The fact that the latter condition was more favorable to the accumulation of humus accounts for the deep, black surface soil, the timbered areas generally being marked by a shallower, lighter colored surface soil.

The natural vegetation of the Miami loam consists of a mesophytic forest growth, including red, scarlet, white and bur oak, shellbark hickory, sugar maple, and aspen, with an undergrowth of hazel bushes.

Owing to their topographic position near the Wapsipinicon River and the East Fork of Wapsipinicon, the areas of Miami loam are well drained, a condition which interferes with the rapid accumulation of organic matter but is favorable to forest growth.

Perhaps not more than half of the acreage of the Miami loam is farmed. Much of the type is quite rolling, and in general only the more nearly level areas are cleared.

The agricultural practices are the same as on the Carrington loam; the same crops are grown and yields in good seasons are almost equal to yields on that type. It is, however, recognized that the higher organic-matter content of the Carrington loam makes it the more valuable soil of the two for general farming. The Miami loam is more likely to bake during hot, dry weather, and crops suffer from drought. This fact makes it important that careful attention be given the preservation of good tilth.

To maintain and increase the efficiency of the Miami loam the most important requirement is the incorporation of organic matter by the application of large amounts of stable manure and by turning under green crops, preferably the legumes. Red clover does well on this type, and its use in crop rotation to furnish organic

matter and nitrogen is advantageous. Alfalfa has been grown on the Miami loam in this county and did well until it was winter-killed. The type is well adapted to small fruits and apples.

MIAMI SANDY LOAM.

The Miami sandy loam, to a depth of 8 inches, is a light-brown to gray, loose loamy sand or sandy loam, containing a high percentage of fine sand. The subsoil is a reddish-brown or yellowish-brown sandy loam which becomes heavier with depth, generally passing into a sandy clay at about 30 inches. In places pockets of sand or gravel are encountered.

This is one of the minor soil types of the county, only two areas being mapped. Both of these occur on the banks of the Wapsipinicon River in association with areas of Miami loam.

The Miami sandy loam is derived from material of the glacial drift. The topography is rolling and the soil is so thoroughly drained that crops suffer during a protracted dry season. The rather heavy character of the subsoil, however, assists the retention of moisture to some extent.

The Miami sandy loam was originally forested, the predominant growth being red and scarlet oak.

The addition of stable manure, and the rotation of crops to include a legume for turning under at intervals of three or four years are necessary to increase the efficiency of this soil. At present the crop yields on this type are below the average for the county.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Miami sandy loam are given:

Mechanical analyses of Miami sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330539	Soil	0.3	11.2	24.4	31.2	7.0	19.2	6.3
330540	Subsoil	1.7	8.8	11.7	16.6	6.7	36.6	17.6

MARSHALL SERIES.

The Marshall series includes the dark-colored upland loessial soils covering wide areas in the prairie region of the central West. The surface soils are dark brown to black and the subsoil somewhat lighter. The topography is level to rolling.

MARSHALL SILT LOAM.

The Marshall silt loam, to a depth of 12 or 14 inches, is a dark-brown silt loam of high organic-matter content. The proportion of

silt is very high and the soil is quite friable and free from stickiness even when damp. The dry soil has a soft, velvety feel. The subsoil is a brownish-yellow silty loam, differing from the surface soil in having a smaller proportion of organic matter. The texture throughout the type is very uniform, the only variation noted being the presence of very fine sand in some small areas. This type is free from bowlders and pebbles such as are found in the Carrington and Miami soils. A few fragments of limestone were noted in the subsoil.

But one area of the Marshall silt loam was mapped. It occurs as a ridge extending southeastward from Denver to the valley of Crains Creek, a continuation of the large area of Knox silt loam west of Quarter Section Run. This ridge has an average elevation of about 40 feet above the general level of the upland till plain. South of Denver it has a width of about three-fourths mile, but gradually becomes narrower toward Crains Creek and is only about a hundred yards wide where it finally merges with the valley slopes of that stream. In its wider portion the topography is rolling, but the narrower part has the character of a single elongated ridge, sloping on each side down to the general level of the till plain.

The Marshall silt loam is derived from glacial material, which has probably been reworked by wind or water, or by both agencies. The absence of glacial stones and bowlders, the remarkable uniformity of texture, and the elevated, ridge-shaped topography of the type indicate that it is not derived directly from the ice-laid drift.

The drainage is good, and this characteristic, in connection with the high organic-matter content of the surface soil, makes cultivation of this type possible over a wide range of moisture conditions. It is a very valuable general farming soil, adapted to the production of corn, oats, rye, wheat, barley, and hay. Yields are about equal to those on the better drained portions of the Carrington loam. It gives good crops of clover and alfalfa, and is fairly well suited to apples and small fruits. Potatoes, sugar beets, and other vegetables can be grown successfully.

MARSHALL SAND.

The surface soil of the Marshall sand is a brown to dark-brown medium sand, containing a fair amount of organic matter. It has a depth of about 15 inches. The subsoil is a yellow or yellowish-brown sand of loose structure. In places the soil is light brown or gray in color.

The Marshall sand is a minor type. It occurs in a few places on the east side of the Cedar, Shell Rock, and Wapsipinicon Rivers and Crains Creek. It has a rolling topography, and in some areas occupies dune-shaped hills. These dunes are not now affected by wind

action, except slightly in the cultivated fields. Drainage is usually excessive, owing to the open, porous texture of the soil and subsoil.

The Marshall sand is composed of reworked glacial material laid down by water and subsequently influenced by wind action. It was originally forested with a fairly heavy growth of scrub oak and some hickory. It is a very poor farming soil. After a few years' cultivation corn can not be profitably grown. It is probably best adapted to rye, which yields 10 to 12 bushels per acre.

The results of mechanical analyses of samples of the soil and subsoil of the Marshall sand are given in the following table:

Mechanical analyses of Marshall sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330519	Soil	4.6	43.3	22.4	16.0	2.8	5.6	5.0
330520	Subsoil	7.0	49.3	21.5	13.5	2.2	3.0	3.7

KNOX SERIES.

The Knox series includes light-brown soils derived from loessial or other wind-blown deposits. The subsoil, as well as the soil, is derived from loess and is somewhat lighter colored. The topography is gently undulating to rolling and the drainage is well established. This is one of the important grain-growing soils of the central prairie States.

KNOX SILT LOAM.

The surface soil of the Knox silt loam is a yellowish-brown silt loam 12 to 15 inches in depth. The subsoil is a yellow silt loam. This soil as found in Bremer County is not as uniform either in color or texture as in other sections where it occurs in large areas. In the largest area the surface soil is a heavy loam, the subsurface material in places being a silty clay loam. On the borders of this area and in the smaller areas, the "paha," the surface is a light loam and in places a very fine sandy loam. The color also varies from gray to yellowish brown in the larger area and to a dark brown in some of the small areas, which were probably prairie, while the large area was forested. The subsoil is more nearly uniform than the surface soil. It has a yellow color and is a silt in texture, but sometimes varies to a very find sand. This soil has a lower humus content than the prairie soils, and this consists of the gray humus that develops in forests rather than the black humus that is developed in areas of grassland.

The Knox silt loam is encountered in one large area between Waverly and Denver, and in several small areas in this part of the

county. The large area is quite rolling, having a modified erosional topography. The hills probably have been formed by a mantle of silt being laid down on the Kansan till which had a mature erosional topography. This, of course, modified and reduced the variation in the topography to a great extent. Recent erosion is not a large factor in the topography. The "paha" are smooth, elongated, rounded hills.

Most of this soil was originally forested, and constituted what was known as the "big woods." Oak, hickory, hard maple, basswood, and a few cedar made up the timber growth. Some of the detached "paha" near Waverly apparently were prairie, although this is not certain.

The development of agriculture on this type has been very backward. The poor appearance of the farm buildings and the neglected condition of the farms are in great contrast to the evidences of thrift and prosperity seen on the Carrington loam. This backward condition is not due to the soil, for it is a valuable type with great possibilities, but rather to its settlement and development. It was the "big woods" region, and many of the settlers on the adjoining prairie bought tracts of 10 to 20 acres of this land to secure posts and fuel. Many of these tracts are undeveloped, largely because of the small size of the holdings. In addition a class of settlers from forested regions farther east and south acquired tracts of this land, because of the congenial surroundings and the game to be found, and were slow in clearing and developing the resources of the area. The system of agriculture is practically the same as that followed on the prairie. But conditions are so different here that an entirely different system of farming is required. This soil is particularly suited to the production of fruit, but no commercial orchards are found on it. Alfalfa and clover do well. The type is well suited to dairying and sheep raising, and the production of sugar beets should prove profitable. Only a small part of the type is suitable for cultivated crops, and this requires plowing and cultivating with special reference to the prevention of erosion. Erosion, while it does not affect the farms on the Iowan drift, is particularly injurious to this type.

KNOX FINE SANDY LOAM.

The Knox fine sandy loam to a depth of 15 inches is a yellowish-gray fine sandy loam or very fine sandy loam. This is underlain usually by a yellow silt loam. A phase of the type is underlain by the Kansan till, which in this case consists of a yellow loam to clay loam containing large quantities of gravel and small stones. In places a red clay loam is encountered. The soil is friable and easily worked.

This soil is found in association with the loess which overlies the Kansan till in the area near Denver and is intermediate between the sandy soils having a sand subsoil and the true silt soil. It is subject to some variation. It has a rolling topography and good drainage. The type is eroded in places because of its slope and the fact that the subsoil is so much heavier than the surface material.

The Knox fine sandy loam is derived from reworked glacial material deposited at the close of the glacial period. It was formed by the fine and very fine sands being laid down over the silt or over the Kansan till directly.

The Knox fine sandy loam was originally forested but now is largely cleared and farmed. It is a fairly productive soil.

BREMER SERIES.

In the Bremer series are included types with dark-brown to black soils and yellow or light-brown, heavy subsoils, derived from high terrace deposits in the glacial region of the North-Central States. The series differs from the Waukesha in the absence of limestone fragments and from the Sioux and Hempstead series in the absence of beds of gravel in the lower subsoil.

BREMER LOAM.

The soil of the Bremer loam is typically a black, friable loam ranging from 14 to 20 inches in depth. Locally, the percentage of fine and medium sand is quite large, and the type merges so gradually into the lighter textured soils of the same series that its boundaries must be arbitrarily drawn. The subsoil is a somewhat tenacious clay or sandy clay, usually chocolate brown in color. It is probable that the type is everywhere underlain at some depth by stratified sand or gravel. This bed of stratified material is reached in some places within 3 feet of the surface, but usually it is deeper. The material is yellow in color and mixed with a small quantity of clay or silt, sufficient in most cases to impart a feeble coherence when damp. The color is due to a mineral stain, probably iron oxide. The sand and gravel particles are mainly quartz.

The surface of the Bremer loam is free from large stones and bowlders, but usually a few small pebbles and some gravel are present.

The type is derived from material of the glacial drift, reworked by running water and deposited after the close of the glacial period. It occupies the stream terraces and is mainly above the reach of flood waters of the present streams. The topography is level to very gently undulating, and the drainage, except in some small areas, is good. The heavy subsoil intervening between the surface soil and the gravel or sand substratum prevents excessive drainage in most cases.

A poorly drained phase of the Bremer loam occupies depressions on the terraces of the Wapsipinicon River. One very small area occurs on a terrace of the Cedar River, 2½ miles southeast of Plainfield. This phase is quite variable in its physical characteristics. The surface soil is a black, mucky loam or sandy loam extending to a depth of 9 to 20 inches. The subsoil is a sandy clay or clay loam, dark brown to black in color. In places the surface soil is underlain by a bed of almost pure sand. This phase of the Bremer loam is not under cultivation and is used only for the production of hay and for pasturage.

The Bremer loam is developed in the valleys of the Cedar, Shell Rock, and Wapsipinicon Rivers, and to some extent along the smaller streams. The boundaries of the area along the Wapsipincon are not clearly defined. The terraces often merge so gradually into the upland that it is difficult to draw a definite line of separation. It is also difficult to distinguish between the terraces and the bottom land. Usually the Bremer loam is not subject to overflow, but no doubt some parts of the type are inundated during high floods. The Bremer loam was partly forest and partly prairie land. Most of the timber, consisting largely of oak, elm, walnut, hickory, box elder, and maple has been removed and the soil is under cultivation.

The Bremer loam is one of the county's most valuable general farming soils. It has about the same range of crop adaptation as the Carrington loam, and while it is usually somewhat better drained than that type, it does not suffer from drought except in very dry seasons. The production of corn ranges from 35 to 70 or more bushels per acre, and of oats from 30 to 40 bushels. The soil requires a heavy farm equipment. Three to five horses are used in breaking the ground. The farmers on this type of soil are prosperous; farm buildings are large and substantial, and the general equipment is good. Land of this type is valued at $150 to $200 an acre.

BREMER SANDY LOAM.

The surface soil of the Bremer sandy loam is a brown sandy loam 12 to 15 inches deep. This is underlain by a yellowish-brown sandy loam to loamy sand, which usually grades into a bed of stratified sand or gravel at a depth of 3 to 4 feet.

This type occupies the terraces of the Shell Rock, Cedar, Wapsipinicon, and Little Wapsipinicon Rivers and Buck Creek. It is associated with the other soils of the Bremer series. The topography is level to gently undulating, and drainage is good to excessive.

The material of the Bremer sandy loam is derived from glacial drift. It was transported and partially assorted by post-glacial waters and laid down in the stream valleys. In most cases the

streams have cut their channels so far below the areas of this type that it is not now subject to overflow. Most of the sand is quartz of different colors.

Owing to its sandy texture the Bremer sandy loam is easily cultivated and kept free from weeds, but it is not as retentive of moisture as the heavier types. It is used for the same general purposes as the Bremer loam. Crop yields vary considerably from season to season because of the somewhat droughty nature of the soil. In seasons of ample and well-distributed rainfall yields are almost equal to those on the Bremer loam, but crops are much more easily affected by dry weather. This type is well suited to melons, cucumbers, and cantaloupes, and to potatoes and early vegetables. Excellent tomatoes are grown on this soil near Waverly.

The lighter colored areas of the Bremer sandy loam are especially in need of organic matter, which is best supplied by applying manure or by turning under green crops.

BREMER FINE SANDY LOAM.

The soil of the Bremer fine sandy loam consists of a brown to dark-brown fine sandy loam. It is 12 to 18 inches deep, with an average depth of about 15 inches. The subsoil is a yellowish-brown fine sandy loam to loamy fine sand. This type is alluvial in origin and like most alluvial soils is quite variable in texture and color. In many of the lower areas, which have been subject to poor drainage conditions, the soil is almost black, is somewhat mucky, and has a heavier texture than the typical soil. The areas along the Cedar and Shell Rock Rivers often contain large quantities of very fine sand. The type is nearly always underlain by stratified sand or gravel at depths of 3 to 10 feet.

The Bremer fine sandy loam is developed on the terraces in the valleys of the Shell Rock, Cedar, and Wapsipinicon Rivers, and Crains Creek. It is closely associated with the Bremer loam and Bremer sandy loam, and the boundaries between the soils are in many cases arbitrary. Typically it is above the reach of flood water, but some of the lower areas are subject to occasional overflow.

The Bremer fine sandy loam is alluvial in origin. The material is composed of sediments brought down from the areas of glacial drift. The original vegetation of the better drained areas was chiefly soft maple, white ash, box elder, elm, birch, and aspen, with an undergrowth of sumac and hazel. The poorer drained areas supported a luxuriant growth of grasses and sedges of numerous species. Some of the areas of this soil are still forested, but most of the type is cleared and under cultivation.

The topography is level to undulating, and the surface is free from stones and bowlders.

The Bremer fine sandy loam is easily handled. The texture of the soil permits its cultivation over a wide range of moisture conditions, but it is sufficiently loamy to be fairly retentive of moisture. It is used mainly for pasture and for the production of hay, oats, and corn. Rye and barley do well on this soil. Except in very dry seasons yields are about equal to those on the Bremer loam.

This type offers excellent opportunities for specialized and intensive agriculture. The better drained areas are well adapted to the production of early vegetables and melons. The soil is capable of producing potatoes of excellent quality.

BREMER COARSE SANDY LOAM.

The Bremer coarse sandy loam, to a depth of 15 inches, is a brown sandy loam containing considerable coarse sand and some gravel. The subsoil is a yellowish-brown coarse sandy loam or coarse sand, carrying some gravel, and grading into a bed of yellow stratified sand or gravel at about 36 inches. The sand and gravel in this type are mainly quartz of different varieties, with a scant intermingling of the feldspathic and ferromagnesian minerals. The surface soil does not contain as large a percentage of organic matter as do the other soils of the Bremer series.

The Bremer coarse sandy loam is developed principally on the terraces of the Shell Rock and Cedar Rivers, being especially prominent along these streams in the southwestern part of the county. A few very small areas are mapped along Buck Creek in the eastern part of the county.

Like the other members of the Bremer series, the Bremer coarse sandy loam is derived from water-worked material of the glacial drift. Its coarser texture indicates that it was deposited by more swiftly flowing waters than were the other types of the series. The topography is usually almost level, but some of the areas are developed as low ridges. Drainage is excessive, and crops suffer from drought in dry seasons. Most of the type is used for general farming. Crop yields are extremely variable from season to season because of the droughty nature of the soil.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Bremer coarse sandy loam:

Mechanical analyses of Bremer coarse sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330507	Soil	6.2	19.4	17.9	23.4	5.9	16.8	10.9
330508	Subsoil	5.9	21.7	18.7	27.3	5.9	12.0	8.5

PLAINFIELD SERIES.

The Plainfield series includes types whose surface soils range in color from brown to grayish yellow and whose subsoils are usually yellow to pale yellow. These soils are derived from deep glacial drift in the West Central States.

PLAINFIELD LOAM.

The Plainfield loam, to a depth of 8 to 10 inches, is a brown to light-brown loam. In some areas the surface soil carries a rather high percentage of sand and fine sand, sufficient to justify the classification of such areas as fine sandy loam. They are, however, not large enough to be shown on the soil map as distinct types. The subsoil is a mottled gray and light reddish brown or yellowish-brown sandy loam, containing a noticeable amount of gravel and coarse sand. At depths ranging between 24 and 40 inches stratified sand or gravel is usually encountered.

This type is not widely developed in Bremer County. With the exception of one area in the valley of lower Horton Creek, it is confined to the terraces of the Wapsipinicon and East Fork Wapsipinicon Rivers.

Like the soils of the Bremer series, the Plainfield loam is of alluvial origin. The material was laid down by running water at some period succeeding the withdrawal of the Iowan ice sheet. It differs from the Bremer loam in carrying a much smaller percentage of organic matter, so that it does not have the black or dark-brown color of that soil. This type was originally forested with trees of various species, including white, bur, red, and scarlet oak, shellbark hickory, and aspen. The native vegetation has been largely removed, and the soil is cropped to corn and small grains. Corn yields 25 to 60 bushels to the acre, and oats average something less than 30 bushels.

Owing to their topographic position on the river terraces and to the substratum of sand or gravel, the areas of this soil are well drained, and in some cases the drainage is excessive. For this reason the soil is in need of organic matter, both to improve its capacity for retaining moisture and to add needed plant food.

The results of mechanical analyses of samples of the soil and subsoil of the Plainfield loam are given in the following table:

Mechanical analyses of Plainfield loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330537	Soil	1.4	10.5	12.7	17.3	6.1	35.9	16.1
330538	Subsoil	.7	8.9	17.4	26.0	9.5	23.1	14.7

Cass Series.

The Cass soils occur in association with the Sarpy, occupying, however, areas having somewhat less perfect drainage. The soils of this series differ from the Sarpy in that the color of the surface material is characteristically dark brown to black instead of brown. They have lighter textured, lighter colored subsoils. They are subject to overflow where not protected by levees, but dry out with the subsidence of overflow water. These soils are most extensively developed in the bottoms along the Mississippi and Missouri Rivers and their tributaries.

CASS LOAM.

The surface soil of the Cass loam, to a depth of 15 to 18 inches, is a black or dark-brown loam. There are minor variations in the texture and color of the type. In some areas the soil is a heavy silty loam, in others the texture approaches a sandy loam or fine sandy loam. The subsoil is more variable than the surface material. Typically it is a brown to yellowish-brown clay loam. Small areas occur in which the surface soil is immediately underlain by sand. Usually stratified sand or gravel is encountered within 3 feet of the surface.

The type occurs in the valley of the Wapsipinicon River and on the flood plains of some of the smaller streams of the county. The topography is level, and in places the drainage is poor. All or nearly all of the areas are subject to overflow.

The Cass loam is alluvial in origin, having been built up by deposition of material washed from the glacial drift and carried by running water into the stream valleys. The better drained areas of the type were originally forested with ash, box elder, elm, soft maple, and birch. The lower, wetter areas supported a heavy growth of prairie grasses.

The Cass loam is an excellent corn and oats soil and is used chiefly for the production of those crops. Corn yields from 40 to 70 bushels per acre, and oats from 30 to 50 bushels. Hay is produced on the poorer drained areas, yields of 1 to 1½ tons to the acre being secured. Potatoes and onions do well. Little or no attention is paid to crop rotation. The general management of the type is similar to that of the upland soils.

CASS SANDY LOAM.

The Cass sandy loam is a variable type. The surface soil to a depth of 10 to 18 inches is a brown to dark-brown sandy loam. This grades into a yellowish-brown loamy sand, sandy loam, or sandy clay. In places a bed of stratified sand or gravel is encountered within a depth of 3 feet, but this material usually occurs at a greater depth. The areas of this type are usually marked by low ridges or

mounds of brown sand. These small sandy areas are not of sufficient size to be indicated on the soil map.

The type is free from stones and bowlders, but numerous water-worn pebbles, mainly quartz, are scattered over the surface. The topography is nearly level and drainage is good. There is usually sufficient subirrigation to prevent crops on this type from suffering from drought.

The Cass sandy loam is not widely developed in Bremer County. It occurs in the river valleys in association with the Cass loam or as elevated areas in the Meadow land. The most extensive areas are mapped in the valley of the Wapsipinicon River east of Tripoli and near the southern county line.

This soil is alluvial in origin and is composed of glacial material washed down and deposited in the stream valleys by running water. In times of flood all or most of the type is subject to overflow. The original vegetation of the Cass sandy loam consists mainly of oak, hickory, soft maple, birch, and box elder.

The areas under cultivation are used for general farming. Yields of corn range from 30 to 60 bushels to the acre, oats average perhaps 35 bushels. Barley and wheat do well.

This soil has practically the same range in crop adaptation as the Bremer sandy loam, except that it is not quite so subject to drought. It is well adapted to early vegetables, tomatoes, potatoes, and beets.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Cass sandy loam are given:

Mechanical analyses of Cass sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330541	Soil	0.4	10.6	20.3	30.1	4.3	21.7	12.2
330542	Subsoil	.4	12.0	22.6	21.2	5.1	16.7	11.4

FARGO SERIES.

In the Fargo series are included types with dark-brown to black surface soils and mottled yellow and gray subsoils. These types are composed of glacial material reworked and laid down in lakes. So far they have been mapped mainly in Minnesota and the Dakotas, but may be encountered wherever the beds of glacial lakes are found.

FARGO LOAM.

The Fargo loam to a depth of 10 to 16 inches is a black, friable, mucky silt loam, underlain by a sticky clay which is usually mottled yellow and gray. This soil varies in the percentage of organic

matter present in the surface 12 inches. The presence of true Muck in small patches of a few square rods is not unusual, and, on the other hand, there are some large areas of this type in which drainage is fairly well established. Here the soil loses its mucky character, and the subsoil is brown to drab in color. In the smaller areas large bowlders are usually encountered either on the surface or partly buried in the soil. The greater part of this soil has not been plowed, and the surface often has a peculiar tufted or lumpy appearance, the tufts, about a foot in height, being formed by the growth of certain water-loving grasses and sedges.

This is one of the minor types of the county; it is widely distributed in small areas occupying the flatter drainage channels in areas of the Carrington loam. They usually occur along the very smallest branches of the drainage system, but occasionally they are found on the larger streams, occupying colluvial slopes and merging into the true alluvium. The topography is flat to gently sloping, and the drainage is usually poor.

This is a colluvial soil formed by the material washing and slipping from the surrounding Carrington loam, being caught in the poorly drained watercourses. In a few places on the smaller streams narrow strips of true alluvium are encountered bordering the stream, but the colluvial and the alluvial materials blend so gradually into each other and the alluvium is in such narrow strips that the two can not be satisfactorily separated. The vegetation on this type when the country was settled consisted of tall, rank grasses and sedges. These have been largely replaced by better grasses, the land having been used almost exclusively for pasture.

The first requisite in the reclamation of this soil is proper drainage with tile. This should be profitable even though the areas were kept in pasture. But with proper drainage the soil is well suited to the crops usually grown on the adjoining loam. It is probable, however, that until the sod became thoroughly rotted and the wild nature worked out of the soil by several years' cultivation, crops would not be very satisfactory, but the few fields of this type in cultivation indicate a great productiveness of the soil.

The results of mechanical analyses of samples of the soil and subsoil of the Fargo loam are given in the following table:

Mechanical analyses of Fargo loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
330527	Soil	0.4	3.3	4.9	11.9	7.4	55.0	16.9
330528	Subsoil	1.4	5.2	7.3	14.2	7.4	18.8	45.6

Crawford Series.

The Crawford series comprises residual limestone soils of the prairie regions. The types have dark-brown to dark reddish brown surface soils and reddish-brown to red subsoils. Usually the surface is undulating to rolling. But one type, the silt loam, is mapped in Bremer County.

Crawford silt loam.[1]

The soil of the Crawford silt loam to a depth of 12 inches is a light-brown silt loam or a fine sandy loam. The subsoil is a yellow, granular loam to clay loam. It contains some glacial gravel and some broken limestone. The limestone in places is encountered at depths of 2 to 5 feet. Small limestone sinks are of frequent occurrence.

This is a residual limestone soil having in places a very thin mantle of till, while in other places a silt or sandy loam occurs. The limestone from which it is derived, according to Norton, of the Iowa Geological Survey, is the Cedar Valley stage of the Devonian system.

The soil is mapped in the south-central part of the county. It is developed in numerous other small areas, too small to map separately, on the outcroppings of the bluffs bordering the old flood plains of the rivers. The type is forested and is used only for pasture.

Miscellaneous.

Muck.

The physical characteristics of the Muck mapped in this county are uniform to a depth of 2 or 3 feet. The material is black or very dark brown in color. In texture it is loose and friable when dry, but slightly plastic and spongy when wet. The mineral matter in the Muck is mainly silt and clay washed in from adjoining areas of the Carrington loam. The material underlying the Muck is variable. In most cases it is a clay loam or clay, but occasionally pockets of sand are encountered.

But three small areas of Muck are mapped in this county. Other areas, too small to be shown separately on the map, are included with the Fargo loam and Meadow, but the total acreage of this type in Bremer County would not exceed a half section.

Muck is the product of the decomposition and disintegration of vegetable matter deposited in poorly drained areas and mixed with a

[1] It is recognized that this soil is not typical Crawford material, as it differs from the latter type in color of soil and subsoil. Only a small area occurs in Bremer County and the similarity in origin seems to make it advisable for the present to group it with the Crawford series.

small quantity of mineral matter. It occurs where there has been sufficient standing water to prevent the complete oxidation of the remains of the water-loving plants which grow in such locations. The natural drainage of Bremer County as a whole is sufficiently well developed to prevent the formation of Muck, except in very small isolated areas.

Practically all of the Muck areas are too poorly drained for cultivation, and support a rank growth of wild water-loving grasses. They are utilized to some extent for pasture and hay.

With proper drainage and the application of stable manure or lime, or both, the Muck areas can be made to produce good yields of corn. This soil is especially adapted to celery, onions, and cabbage.

MEADOW.

Meadow includes those low-lying areas in the larger stream valleys which are subject to overflow or are so broken by bayous and swampy depressions as to be unfit for cultivation to any extent.

The soil material of the Meadow is quite variable, and in places especially subject to overflow changes from time to time. The texture varies from gravel through about all the different grades of material to clay loam. Perhaps the greater part of the type is a black loam or sandy loam underlain by sand or gravel at depths varying from 10 to 36 inches.

Two general phases of Meadow are encountered in Bremer County. The more typical soil, developed along all of the larger streams, is fairly well drained in small areas, but is characteristically dissected by stream channels, now abandoned except in times of high water. In many places these well-drained areas of Meadow support a growth of native trees, including elm, soft maple, box elder, bur oak, red oak, birch, and willow. Birch is especially prominent in the valley of the Wapsipinicon River.

The second phase of Meadow occurs almost entirely in the valley of the Wapsipinicon River. It includes the poorly drained, treeless areas overgrown with wild water-loving grasses and sedges. Hay cut from these areas averages about 1¼ tons to the acre.

SUMMARY.

Bremer County is situated in the northeastern part of Iowa. It has an area of 434 square miles or 277,760 acres. The topography is gently undulating to rolling. The regional drainage is good.

The climate is marked by a wide range in temperature, with a maximum over 100° F. and a minimum below —30°. The mean annual precipitation is 31.05 inches, of which 80 per cent falls between April 1 and November 1.

The population in 1909 was 15,843.

The county has three railroad systems, and few farms are more than 5 miles from a shipping point.

Corn and oats are the most important crops. Hay is made from both tame and wild grasses. Some barley, rye, and wheat are grown, together with potatoes, sugar beets, and other vegetables. Dairying and hog raising are the most important live-stock industries. Cooperative creameries are found in all parts of the county.

The value of farm land ranges from $125 to $225 an acre.

The soils of Bremer County are largely derived from unstratified material of the glacial drift. Six soil types of this origin are mapped. Twelve types represent glacial material reworked by wind or water, and one type is derived from the weathering of limestone. In texture the soils range from clay loam to sand. A large part of the soil of the county is a loam. The amount of organic matter in the heavier types is usually sufficient to impart a mellow texture and to permit cultivation under a fairly wide range of moisture conditions.

The Carrington loam is the most important soil in the county, covering 62.8 per cent of its total area. It produces good yields of the general farm crops, and is particularly adapted to corn and oats. A poorly drained phase of the type is used for pasture.

The Carrington clay loam usually occupies depressions surrounded by the Carrington loam. Its agricultural value is similar to that of the Carrington loam, but it is more difficult to keep in good tilth.

The Carrington sandy loam is in general a less fertile soil than the Carrington loam, but it is adapted to a wide range of crops. It is used for general farming, and is well adapted to the production of potatoes, melons, and other vegetables.

The Carrington fine sandy loam is associated with the Carrington loam and Carrington sandy loam, and lies between these types in agricultural value.

The Miami loam is an excellent general farming soil, adapted to corn, oats, barley, rye, wheat, and clover. Alfalfa has been grown successfully on it. Only a part of it is cleared.

The Miami sandy loam is used for general farming. Owing to its loose texture and lack of humus this soil is droughty.

The Marshall silt loam is one of the best general farming soils in Bremer County, ranking in value with the Carrington loam.

The Marshall sand has a rolling topography and is excessively drained. Crops make a rapid growth, but yields are light. The type seems best adapted to rye.

The Knox silt loam and fine sandy loam are used for general farming. The silt loam is a good fruit soil.

The Bremer loam is usually a well-drained terrace soil. It is easily cultivated, well supplied with humus, and is one of the best general farming soils in the county.

The Bremer fine sandy loam, sandy loam, and coarse sandy loam occupy stream terraces. The drainage of these types is good to excessive. They are used for general farm crops, which yield well, except in very dry seasons. They are adapted to the production of melons, cantaloupes, and cucumbers.

The Plainfield loam is a stream-terrace soil of minor importance. The land is used for the production of corn and oats, of which good yields are secured.

The Cass loam is a mellow, easily worked soil. It is an excellent type for general farming. Good yields of corn, oats, and hay are secured from this type.

The Cass sandy loam is a fairly good corn and oats soil, but is more subject to drought than the Cass loam.

The Fargo loam occupies the small drainage channels and slopes of the intermittent streams of the county. The areas of this soil are poorly drained and used for the production of hay.

The Crawford silt loam is a minor type. Only two areas were mapped. These are wooded and used for pasture.

Small areas of Muck exist. They are undrained and used at present only for the production of wild hay.

Meadow occurs along the stream bottoms. Some areas are forested. The type is used for the production of hay and for pasture.

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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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