IOWA GEOLOGICAL SURVEY
IOWA CITY, IOWA
SAMUEL J. TUTHILL, Director and State Geologist

WATER-SUPPLY BULLETIN NO. 9

GEOLOGY AND GROUND-WATER RESOURCES OF CERRO GORDO COUNTY, IOWA

by

H. G. HERSHEY
Iowa Geological Survey

K. D. WAHL and W. L. STEINHILBER
U. S. Geological Survey

Prepared Cooperatively
by the United States Geological Survey
and Iowa Geological Survey

Published by the
STATE OF IOWA
Des Moines
1970

State of Iowa
1970

GEOLOGY AND GROUND-WATER RESOURCES OF CERRO GORDO COUNTY, IOWA

by

H. G. HERSHEY
Iowa Geological Survey

K. D. WAHL and W. L. STEINHILBER
U. S. Geological Survey

Prepared Cooperatively
by the United States Geological Survey
and Iowa Geological Survey

Published by the
STATE OF IOWA
Des Moines
1970

CONTENTS

ILLUSTRATIONS

TABLES

GEOLOGY AND GROUND-WATER RESOURCES OF CERRO GORDO COUNTY, IOWA

by H. G. HERSHEY, K. D. WAHL and W. L. STEINHILBER

ABSTRACT

The basic geologic framework underlying Cerro Gordo County consists of an igneous or metamorphic Precambrian basement complex overlain by, in ascending order, consolidated sedimentary rocks of Precambrian, Cambrian, Ordovician, Devonian, Mississippian, and Cretaceous age, and unconsolidated sand, gravel, and clay of Quaternary age. Structurally the county is in the northern part of the Iowan Basin, and the sedimentary units of Cambrian through Devonian age dip southward at 9 to 14 feet per mile. Three major glacial advances, the Nebraskan, Kansan, and Wisconsin, covered all or part of the county during the Pleistocene Epoch and left behind glacial drift consisting of 0 to 125 feet of till and related outwash deposits. Deposits of Holocene age, aside from surficial soil, are thin and scattered.

Ground water occurs in the sedimentary units of Cambrian through Mississippian age and in the glacial drift and outwash deposits of Quaternary age. The chief aquifers, in ascending order, are the deep Cambrian sandstones, Jordan aquifer, St. Peter Sandstone, Devonian and Mississippian limestones and dolomites, and the Pleistocene glacial drift and related interglacial deposits. Units between the St. Peter Sandstone and the Devonian limestones, the Platteville, Decorah, Galena, and Maquoketa Formations, are of low permeability and are considered to be an aquiclude in comparison to the overlying and underlying units.

The deep Cambrian sandstones will yield about 60 gpm (gallons per minute) to an individual well; the Jordan aquifer about 1,200 gpm; the St. Peter Sandstone 30 to 200 gpm; the Devonian limestones and dolomites 120 to 200 gpm; and the glacial outwash or shallow bedrock generally will yield 10 gpm or more. The Jordan aquifer supplies large quantities of water for municipal and industrial use at Mason City. Pumping tests on wells tapping the Jordan in that area show that the aquifer has a transmissibility of about 35,000 gallons per day per foot and a storage coefficient of 2×10^{-4}. Pumping in the Mason City

area from 1912 to 1969 has produced about 200 feet of drawdown in the areas of maximum withdrawal.

Ground water in Cerro Gordo County is of suitable chemical quality for domestic, industrial, or municipal use. The total dissolved solids ranges from 152 mg/l (milligrams per liter) in water from the shallow bedrock to 885 mg/l in water from the deep Cambrian sandstones. Water from the Jordan, which is the most productive aquifer in the county, generally contains less than 500 mg/l dissolved solids.

Ground water is the major source of water supplies throughout Cerro Gordo County. The majority of wells in the county are used for domestic and stock supplies, but the largest withdrawals of water are for municipal and industrial supplies. Municipal pumpage in the county in 1968 was about 1.5 billion gallons; industrial pumpage was about 1.8 billion gallons and most of the water was obtained from the Jordan aquifer. If future development of water from the Jordan aquifer is to be to the best economical advantage, careful consideration should be given to the location, capacity, and pumping schedules of proposed wells and nearby existing wells so that local overdevelopment or excessive interference do not occur.

INTRODUCTION

Purpose and Scope

Ground water is one of the principal natural resources of Cerro Gordo County. All private domestic water supplies and, with one exception, public water supplies in the county are obtained from ground-water sources. Most industrial supplies are obtained from ground-water sources and others are augmented with ground water. Present ground-water withdrawals are concentrated at Mason City causing declining water levels and a significant cone of drawdown in that area. Those declines and the consequential lowering of pumping levels are of concern to water users throughout the area.

The purposes of this report are to delineate and describe aquifers in Cerro Gordo County, evaluate the availability and quality of water in the aquifers, supply data on ground-water utilization, and determine the rate of growth and the magnitude of the cone of drawdown in the Mason City area. This information will provide a knowledge of alternate sources of supply and an understanding of the effect of withdrawals on water levels, which are essential points to be considered in planning future water developments in Mason City and throughout Cerro Gordo County. Specific problems in regard to quantity and quality probably will arise in the future requiring more detailed studies in particular areas.

Description of the Area

Cerro Gordo County is in the north-central part of Iowa (fig. 1) and includes 16 townships or about 576 square miles. The population in 1960 was 49,894 of which about 80 percent was in urban areas. The population of the county has been steadily increasing and during the 1930 to '60 period has shown an increase of 14 percent between 1930 and '40, 5 percent between 1940 and '50, and 8 percent between 1950 and '60. Mason City, the county seat, has a population of 30,642 and eight other incorporated towns have a combined population of 9,338.

Cerro Gordo County has a variable subhumid midcontinental climate and a mean annual precipitation of 30.52 inches at Mason City. About 74 percent of the precipitation occurs during the warm season (April through September) and 54 percent during the season of greatest crop growth (May through August). The climatic conditions are therefore highly favorable

Figure 1.—Index map of Iowa showing area of this report and status of other recent ground-water investigations.

for agriculture and irrigation generally is not needed for most crops.

Corn is the dominant agricultural crop; although oats, wheat, barley, flax, and soybeans are also grown. Peat lands in the western part of the county generally are planted to potatoes, onions, or sugar beets. In addition many of the farms raise livestock and on some the feeding and fattening of livestock for market are major operations.

Mason City is a major trading center for most of north-central Iowa and several large agriculture processing plants, including a sugar refinery, packing plant, and a milk-processing plant are located there. Mason City is favorably located with respect to natural rock materials suitable for the manufacture of Portland cement, brick, and tile (Gwynne, 1943, p. 289-295). As a result, two large cement plants and a brick and tile company have located nearby.

The city of Clear Lake, second largest municipality in the county, is located at the east end of Clear Lake, the third largest natural lake in the State. Clear Lake and its environs have a substantial year-round population which, in the summer months, is augmented by vacationists who are attracted by the water-based recreational facilities in the area.

Cerro Gordo County is in the Central Lowland physiographic province of the Interior Plains Division (Fenneman, 1938). The western part of the county is in the Western Lake physiographic section, and the remainder of the county is in the Dissected Till Plains section.

The Western Lake physiographic section is underlain by Pleistocene deposits of Wisconsin (Cary) age. Land forms are typically morainal and characterized by erratically arranged rounded knobs, ridges, and tortuous marshy depressions (fig. 2A). The depressions range in size from a fraction of an acre

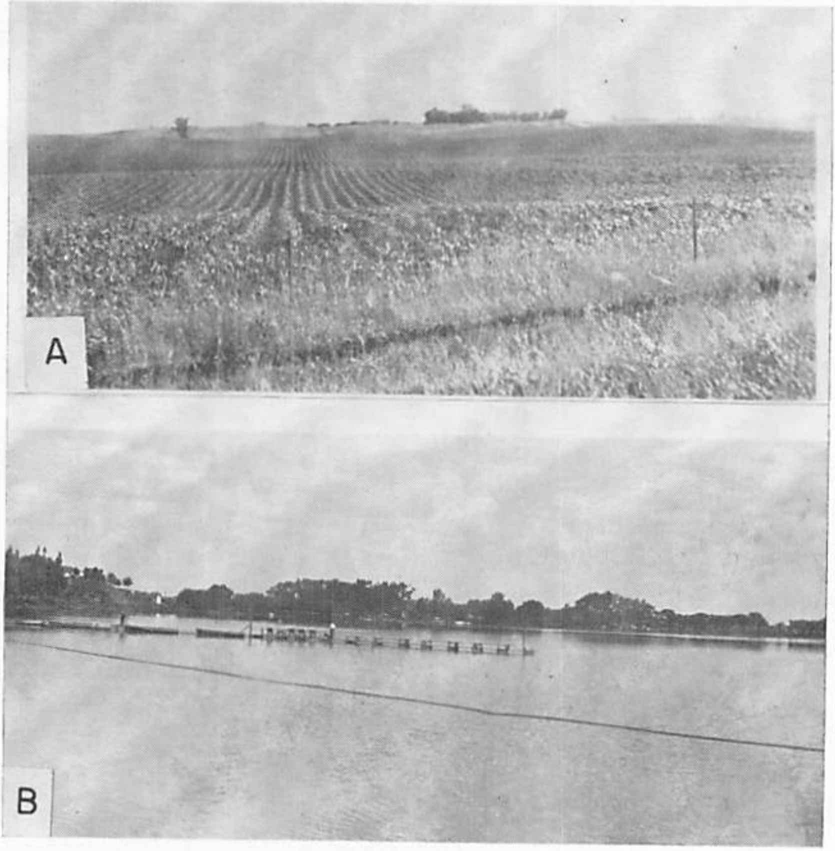
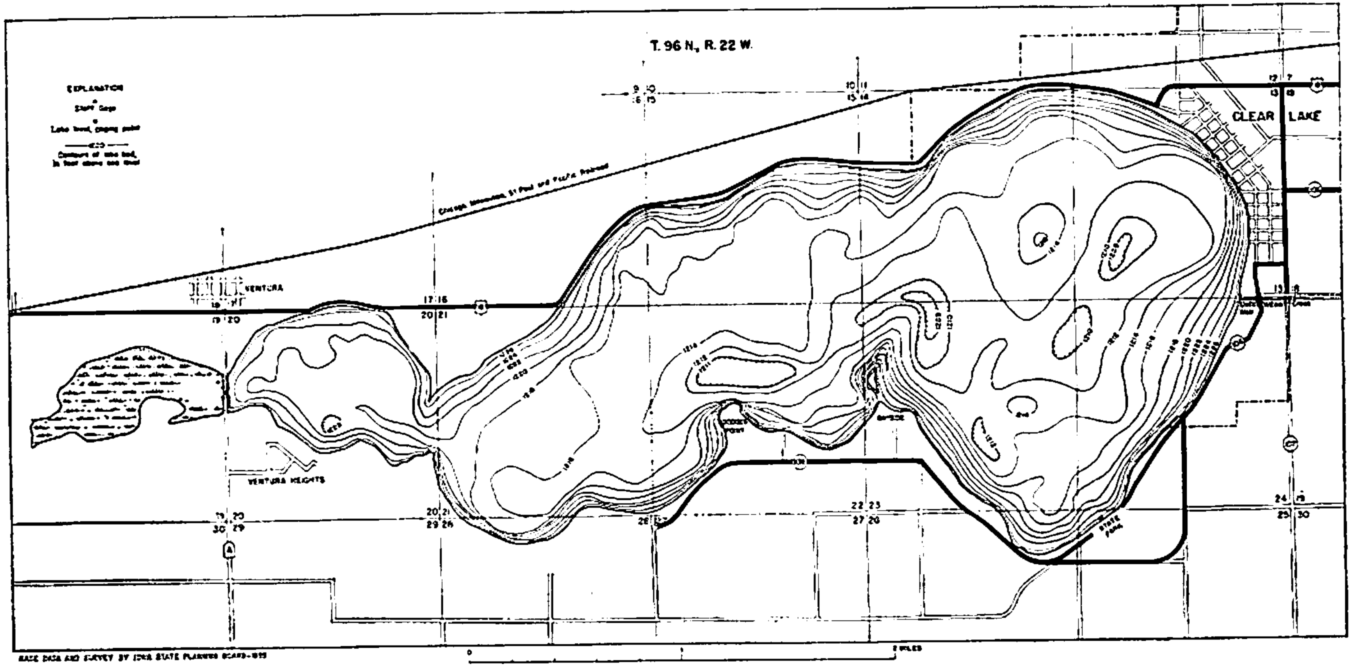


Figure 2A.—Gently rolling surface of the Wisconsin (Cary) drift area.
B.—Northern shore of Clear Lake showing rolling character of the surrounding landscape.



BASE DATA AND SURVEY BY IOWA STATE PLANNING BOARD—1935

Figure 3.—Map of Clear Lake showing altitude of the lake bottom, 1935.

to as large as 10 acres, and commonly are sharply depressed below the adjacent terrain. Some larger depressions have been drained artifically to permit cultivation. The marginal moraine, defining the eastern edge of the Western Lake section, runs almost due north-south about 6 miles from the western county line (pl. 1).

The drainage pattern in the Western Lake section is poorly developed and the surface features have changed little since the retreat of the last glacial ice sheet. A prominent feature of the section is Clear Lake which occupies a large natural depression or kettle surrounded by low rounded knobs and ridges (fig. 2B). The Clear Lake drainage area comprises about 22.6 square miles, including the area of the lake (Larimer, 1957, p. 80), and dis-

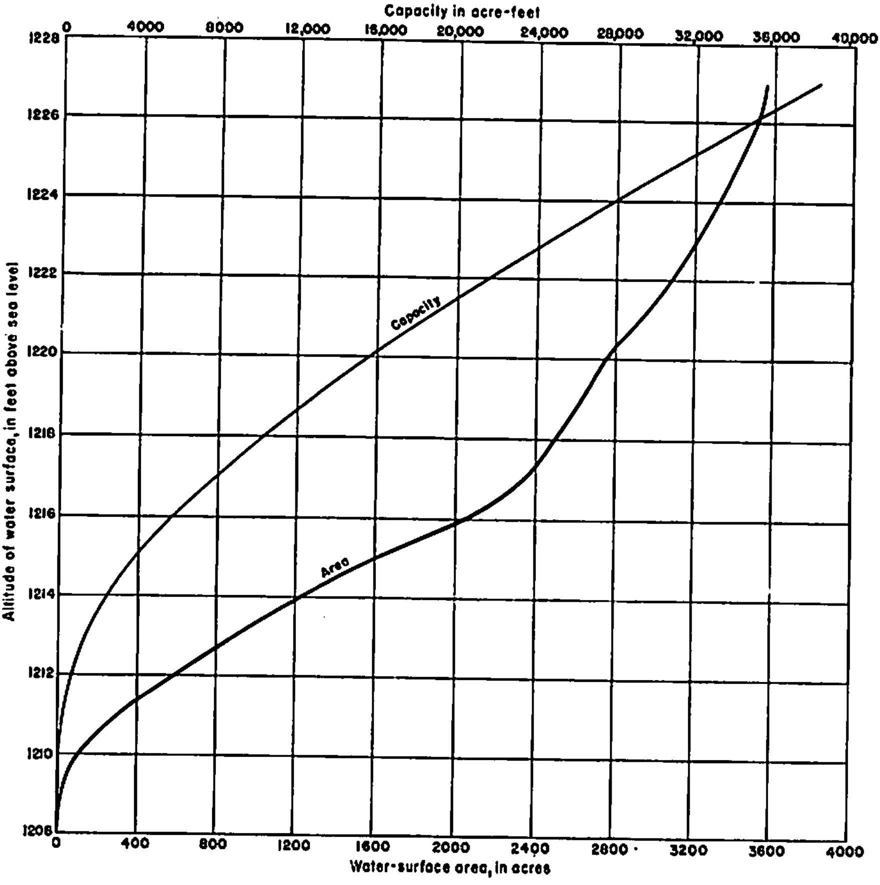


Figure 4.—Area and capacity curves for Clear Lake.

charges through a concrete outlet weir at the eastern end into a tributary of Willow Creek. The eastern end of the lake is confined by a 4- to 6-foot embankment which probably has resulted from ice action. Ice is often piled up along this shore by prevailing winds, and material from the lake bottom is scraped and shoved onto the embankment by the ice. Clear Lake, when full, is approximately 4¾ miles long and 2¼ miles in maximum width (fig. 3). The lake area, as determined from aerial photographs in 1943, was about 3,550 acres and the water-holding capacity was approximately 38,200 acre-feet. The average depth was about 10.5 feet and the maximum depth about 18.5

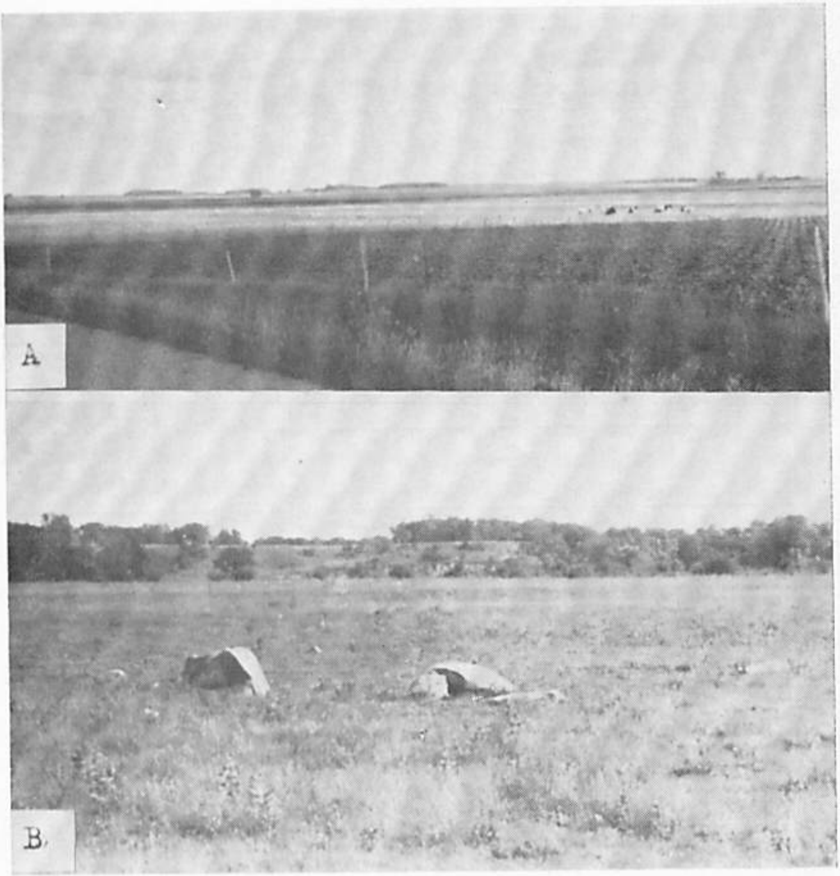


Figure 5A.—Gently undulating plain typical of the Dissected Till Plains physiographic section in south-central Cerro Gordo County.

B.—Glacial boulders near the Winnebago River in north-central Cerro Gordo County.

feet. The depth of the lake at various points can be determined from figure 3 by comparison with the altitude of the outlet weir (1,226.8 feet above sea level). Records of water levels in the lake, however, indicate long periods when the lake level was below the altitude of the outlet weir (fig. 22). The area and capacity of Clear Lake when the water level is below overflow stage can be determined from figure 4.

The Dissected Till Plains physiographic section of Cerro Gordo County consists of a gently undulating plain modified slightly by irregularities near major streams (fig. 5A and B). Low hills in upland areas are well rounded and merge gradually into the landscape. A characteristic feature of the streams, particularly in the lower reaches, is the vertical or nearly vertical banks. Such banks occur commonly along both Winnebago and Shell

Figure 6A.—Winnebago River in north-central Cerro Gordo County showing the slightly indented character of the channel.

B.—Abandoned channel of Winnebago River near Mason City.

Rock Rivers. As indicated by Calvin (1897), Winnebago River flows in a relatively shallow channel in unconsolidated glacial deposits (fig. 6A and B). This channel, however, is located in a wide valley in the consolidated bedrock which is only partly filled with glacial material. The valley of Shell Rock River, on the other hand, does not seem to be related to the underlying bedrock surface.

Previous Investigations

The geology of Cerro Gordo County, particularly the stratigraphy of the Devonian, has been studied for many years. One of the earliest descriptions of the county was by White (1870, p. 249-253). That report was followed by a description of the Devonian rocks and fossils by Hall and Whitfield (1873) and a description of the glacial drift by Upham (1881, p. 298-299). The general geology of the county was first described in a report by Calvin (1897).

Stratigraphic studies of the Devonian were made by Calvin (1883), Webster (1889), Keyes (1893), Fenton (1919 and 1920), Fenton and Fenton (1924), Belanski (1927-28 and 1931), Stainbrook (1935, 1941, 1944, and 1950), and by Cooper and others (1942). Recent work by Dorheim and Koch on the Devonian in Iowa, in part published in an International Symposium on the Devonian (Collinson and others, 1967, p. 933-971), describes the Devonian rocks in Iowa, redefines the Devonian-Mississippian boundary, and resulted in a revision of previous geologic mapping.

The glacial drift in Cerro Gordo County has been described by Kay and Apfel (1929), Kay and Miller (1941), and by Kay and Graham (1943). A recent report, which may have significance in Cerro Gordo County, by Ruhe and others (1968) describes a study of the Iowan drift problem in northeastern Iowa.

A report by Yoho (1967) on the basement complex in Iowa includes data for three deep wells in Cerro Gordo County. That report indicates that the basement complex at Mason City is at an altitude of 348 to 600 feet below mean sea level and consists chiefly of diabase and basalt.

A report by Norton (1897) describes the principles of groundwater occurrence and ground water in Iowa. That report includes logs of wells in the Mason City area. Ground-water conditions, public water supplies, and deep wells in Cerro Gordo County were discussed in detail in a report by Norton and others (1912,

p. 759-768). Logs of subsequent deep wells were described by Norton (1928, p. 90, 256-261) and by Lees (1935, p. 377-379).

Additional ground-water data for north-central Iowa, although without reference to Cerro Gordo County, are in a report on the Iowa-Cedar River basin by Tester (1936). Chemical analyses of ground water and some well descriptions for Cerro Gordo County are also included in reports by the State Planning Board (1938, p. 30-31) and State Department of Health (1964, p. 45-46).

Collection of data for a detailed report on the geology and ground-water resources of Cerro Gordo County was begun by H. Garland Hershey during the fall of 1937, and detailed field work was carried on in 1941-42 by T. W. Robinson and A. P. Gerardi. A report on the hydrologic phases of the investigation was prepared by Robinson in 1942 and revised and expanded by Jeffords in 1949. That unpublished report plus data accumulated since 1949 serve as a basis for this report. The only data collected specifically for this report was an update of pumpage information for deep wells producing from the Jordan aquifer.

Well-Numbering System

The public-land survey divisions form the basis for the well-numbering system used in this report. Each well number consists of three parts, separated by hyphens, representing first the township, second the range, and third the section. A letter and number following the section number indicate the 40-acre tract in which the well is located as designated on figure 7, and the order in which they were inventoried within that tract. As an example, on figure 7 the location of well 97-22-21J1 is in the NE¼ of the SE¼ of section 21, T. 97 N., R. 22 W.

The locations of wells and springs inventoried for this report are shown on plate 1 and figure 10. The wells and springs are shown in their respective positions and the wells are identified by the last part of the well number.

Acknowledgments

Residents of the county supplied invaluable information regarding local ground-water conditions and data for their wells. Acknowledgment is also made for the fine cooperation of the management of industrial plants in Mason City and officials of the public water-supply systems in the county who generously furnished well records and pumpage data. C. B. Patchen, for-

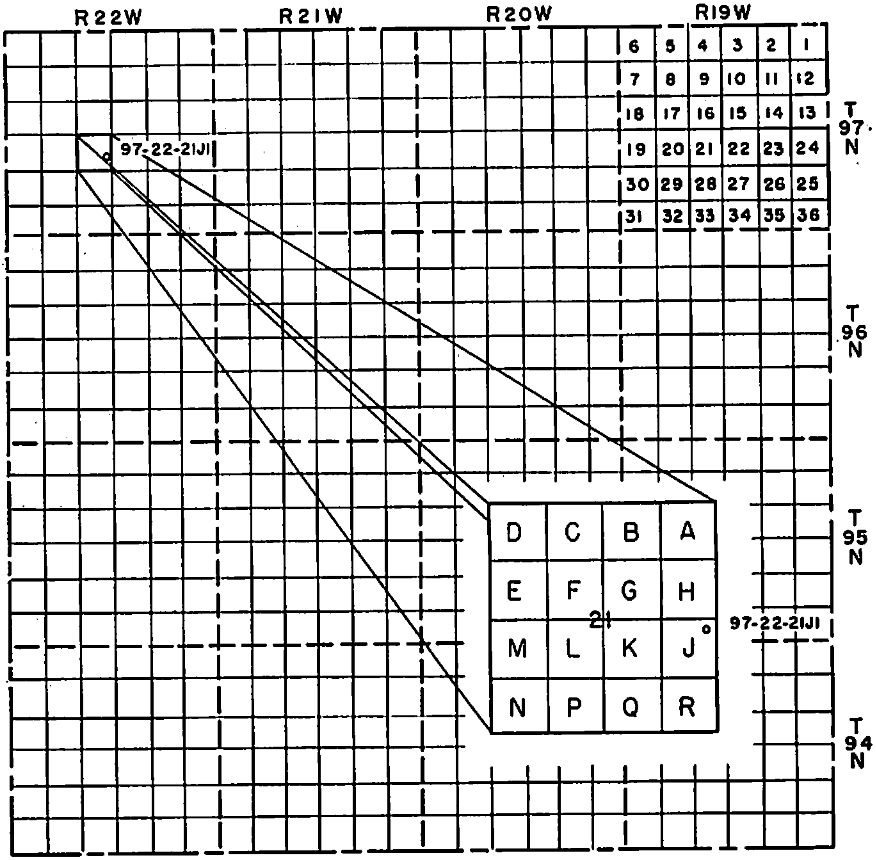


Figure 7.—Map of Cerro Gordo County showing well-numbering system.

merly superintendent of the Mason City Water Department, was of particular assistance in obtaining well records, measuring water levels, and in arranging for and making pumping tests on wells in the area. Well drillers and contractors Art Butts, C. W. Butts, C. W. Cox, W. E. Curtis, J. Gaffney, Hoeg and Ames, Layne-Western Company, McCutcheon Well Company, Bert Sharff, Thorpe Well Company, and C. W. Varner provided especially useful well records and logs.

GEOLOGY

The occurrence, quantity, quality, and reliability of groundwater supplies in Cerro Gordo County are directly related to the geology. Accordingly, the geologic features of the county are reviewed briefly as fundamental considerations of hydrologic discussions to follow.

The basic framework consists of an igneous or metamorphic Precambrian basement complex overlain, in ascending order, by consolidated sedimentary rocks of Precambrian, Cambrian, Ordovician, Devonian, Mississippian, and Cretaceous age and unconsolidated sand, gravel, and clay of Quaternary age (table 1). Rocks of Cretaceous age occur as small, thin outliers overlying Devonian rocks and, because of their size and hydrologic insignificance here, are not shown on the geologic map or discussed further. Rocks of Devonian age make up the top of the bedrock throughout most of Cerro Gordo County, the exception being the southwestern corner where rocks of Mississippian age underlie those of Quaternary age.

Structurally Cerro Gordo County is in the northern part of the Iowan Basin. Sedimentary units of Cambrian through Devonian age dip southward at rates ranging from about 9 to 14 feet per mile. Rocks of Devonian and Mississippian age were deeply eroded before and during deposition of the overlying glacial and alluvial deposits. The result is a highly irregular bedrock surface which was buried and masked over most of the county by glacial, alluvial, and eolian material.

The following discussion of geologic units will describe only rocks encountered in wells or exposed at the surface in Cerro Gordo County. Stratigraphic nomenclature used in this report is that used by the Iowa Geological Survey and does not conform in every detail with nomenclature used by the U. S. Geological Survey. The units will be described in ascending order from oldest to youngest.

Precambrian

The deepest and oldest rocks encountered in wells in the county are designated the Precambrian basement complex which consists of metamorphic or igneous crystalline rocks at a depth of 1,468 to 1,698 feet, indicating a Precambrian surface of high relief. Wells do not penetrate deeply into these rocks because the general nature of crystalline rocks precludes the possibility of their

TABLE 1.—SUMMARY OF GEOLOGIC UNITS, PHYSICAL CHARACTER, AND WATER AVAILABILITY

System	Series	Unit*	Thickness (feet)	Physical Character	Water Availability
Quaternary	Holocene	Undifferentiated	0–10	Soils and thin localized silt and sand along some streams and in marshes.	Generally not a source of ground water.
	Pleistocene	Wisconsin, Kansan, and Nebraskan glacial drift and related interglacial deposits.	0–125	Predominantly till, and poorly sorted to well-sorted gravel, sand, silt, and clay.	Well-sorted deposits of sand and gravel will yield small-to-moderate quantities of water throughout the county. Water generally is of good quality except for iron content which may cause objectionable staining.
Mississippian	Kinderhook	Hampton Formation	0–20	Brown finely crystalline dolomite and gray to white chert.	May yield small supplies of water in southwestern corner of county. Water probably hard and of good quality except for iron content which may cause objectionable staining.
Devonian	Upper	Aplington Formation	0–40	Buff finely crystalline dolomite and white to light gray chert.	
		Sheffield Formation	0–60	Soft blue-gray shale locally containing concretions of pyrite.	Generally not water bearing, is an aquiclude in southwestern part of the county.
		Lime Creek Formation	0–130	Gray shale, thin argillaceous limestones or dolomites, and massive buff-to-gray dolomite and limestone.	Limestone and dolomites yield 120 to 200 gpm of hard water from erratically located openings along fractures. Water generally is of good quality except for iron content which may cause objectionable staining.
		Shell Rock Formation	0–85	Buff, gray, or brown medium to coarsely crystalline dolomite and light gray finely crystalline to lithographic limestone.	
	Middle	Cedar Valley Limestone	205 ±	Silty or argillaceous, brown to gray fine-grained dolomite and lithographic limestone.	
Ordovician	Cincinnatian	Maquoketa Formation	100 ±	Cream to brown cherty argillaceous dolomite.	Shale units generally are not water-bearing. Small quantities of hard water may be available from the Galena and other limestone or dolomite zones. In general, these four units are a major aquiclude between the St. Peter and the Cedar Valley.
	Mohawkian	Galena Formation	220	White to light gray limestone and tan coarsely crystalline dolomite.	
		Decorah Formation	35	Soft, calcareous, green shale and gray limestone lenses.	
		Platteville Formation	45	Green fissle shale, brown argillaceous dolomite, and blue-gray shale containing limestone lenses.	
	Chazyan	St. Peter Sandstone	70	Fine-to-medium grained, poorly cemented quartz sandstone containing some coarse-grained sand locally.	Will yield 30 to 200 gpm of good quality water throughout the county. The sandstone is subject to caving and causes sand problems in many wells.

	Beekmantown	Prairie du Chien Formation		320	Argillaceous, coarse, crystalline dolomite, and dolomitic sandstone.	Upper part probably yields little if any water. Lower part probably is in hydraulic connection with underlying Jordan Sandstone and is part of the Jordan aquifer.
Cambrian	St. Croixan	Jordan Sandstone		70	Poorly cemented, medium- to coarse- grained well-sorted quartz sandstone.	The Jordan aquifer which consists of the Jordan Sandstone and adjacent parts of the Prairie du Chien and St. Lawrence Formations yields 1200 gpm of good quality water at Mason City. Similar yields probably would be available throughout at least the northwestern half of the county and probably throughout the entire county.
		St. Lawrence Formation		100	Buff to brown, fine-grained dolomite containing minor amounts of silt and argillaceous material.	Upper part probably is in hydraulic connection with overlying Jordan Sandstone and is part of the Jordan aquifer. Lower part probably will yield little if any water.
		Franconia Sandstone		115	Sandstone, shale, siltstone, and dolomite.	Will yield small-to-moderate quantities of water. The water is soft but more mineralized than water from overlying units.
		Dresbach Group	Galesville Sandstone	55-75	Light-gray to buff, well-sorted, dolomite cemented sandstone.	
			Eau Claire Sandstone			
			Mt. Simon Sandstone			
?		Undifferentiated red beds.		0-160	Pink-to-red shale and pink stained dolomite.	Not water bearing in Cerro Gordo County.
Precambrian		Crystalline rocks		?	Diabase, basalt, and gabbro.	

---

*Stratigraphic nomenclature used in this report is that used by the Iowa Geological Survey and does not conform in every detail with nomenclature used by the U. S. Geological Survey.

containing substantial quantities of water, and they are considered to be the base of the ground-water reservoir in most of the State. Three wells in Mason City have penetrated the basement complex. According to Yoho (1967, p. 16) the basement complex at Mason City is diabase, basalt, and some gabbro.

The basement complex may be overlain by siltstone, shale, or dolomite of Precambrian or Cambrian age or by sandstone of Cambrian age, see logs of city wells 8 and 12 (96-20-3L2 and 16J2, table 10). Deposits of Precambrian or Cambrian age in city well 8 consist of about 160 feet of dolomite and silty shale. The dolomite is stained pink and the shale is pink to red and contains traces of dolomite, sand, and igneous or metamorphic rocks. Pink shale containing igneous or metamorphic rock fragments is generally considered to indicate Precambrian age (Winchell, 1899, p. 567); but according to Stauffer and Thiel (1941, p. 15), it also occurs in the overlying Dresbach Group of Cambrian age. The age of the pink-stained dolomite and pink shale is therefore in doubt and it is classified as Precambrian or Cambrian for the purposes of this report.

Cambrian

Units of Cambrian age in Cerro Gordo County are the Dresbach Group, the Franconia Sandstone, the St. Lawrence Formation, and the Jordan Sandstone. The Dresbach has been subdivided into the Mt. Simon Sandstone, Eau Claire Sandstone, and the Galesville Sandstone.

In Cerro Gordo County the Dresbach Group consists of well-sorted, fine- to medium-grained sandstones that are light gray to buff in color. The sandstones are poorly cemented by minor amounts of dolomite. The thickness of the Dresbach in the county has been determined only at Mason City where it ranges from 55 feet in city well 12 (96-20-16J2) to 75 feet in city well 8 (96-20-3L2). The Dresbach crops out in northeastern Iowa, southwestern Wisconsin, and southern Minnesota; and the top occurs at a depth of about 1,500 feet at Mason City.

The Franconia Sandstone consists of about 115 feet of sandstone, shale, siltstone, and dolomite. The basal part of the Franconia consists of sandstone which is only slightly coarser and less sorted than the underlying Dresbach, making that contact difficult to determine in the subsurface. Logs of wells 96-20-3L2 and 16J2 (table 10) show typical Franconia sections and the similarity between the lower part of the Franconia and the upper part of the Dresbach. The Franconia crops out in northeastern Iowa, southern Minnesota, and southwestern Wisconsin; and the top occurs at a depth of about 1,350 feet at Mason City.

The St. Lawrence Formation overlies the Franconia Sandstone and as known from samples obtained from wells 96-20-3L2 and 16J2 in Mason City (table 10) consists of about 100 feet of buff colored medium fine-grained dolomite that commonly contains minor amounts of silt and argillaceous material. Glauconite is abundant throughout the formation and traces of waxy green shale occur in the basal part. The St. Lawrence crops out in northeastern Iowa, southern Minnesota, and southwestern Wisconsin; and the top of the formation occurs at a depth of about 1,250 feet at Mason City.

The Jordan Sandstone which is the upper part of the Cambrian System in Cerro Gordo County consists of about 70 feet of friable to dolomite cemented medium- to coarse-grained, very well sorted quartz sandstone. The quartz grains are well rounded and have frosted surfaces. In general, the upper part of the formation is coarser grained than the lower part. The Jordan crops out along the lower Minnesota River in south-central Minnesota and along the Mississippi River in southeastern Minnesota, southwestern Wisconsin, and northeastern Iowa. In the Mason City area the top of the Jordan occurs at a depth of about 1,150 feet.

Ordovician

Units of Ordovician age in Cerro Gordo County are the Prairie du Chien Formation, St. Peter Sandstone, Platteville Formation, Decorah Formation, Galena Formation, and the Maquoketa Formation. All except the St. Peter have been subdivided into members; however, because some of the members are difficult to recognize in the subsurface they will not be used in this report.

The Prairie du Chien Formation consists of about 320 feet of sandy, cherty dolomite and sandstone. The lower part of the formation is light gray to buff, medium to coarsely crystalline dolomite that includes minor accounts of sand and chert. The middle part of the formation is chiefly dolomitic sandstone containing some oolitic chert locally. The upper part consists of light gray to buff or brown, dense, granular, sandy dolomite. The Prairie du Chien crops out in a large area in southeastern Minnesota and in smaller areas in northeastern Iowa, southwestern Wisconsin, and northern Illinois. In the Mason City area the top of the Prairie du Chien Formation occurs at a depth of about 800 feet.

The St. Peter Sandstone consists of about 70 feet of fine- to medium-grained poorly cemented quartz sandstone containing some coarse-grained sand locally. Individual beds are well sorted; the quartz grains are rounded and have frosted surfaces. The formation is about 70 feet thick in Cerro Gordo County and is remarkably uniform in thickness and lithology throughout northern Iowa. The formation is chiefly quartz except for fragments of chert or dolomite which may occur in the basal part. The St. Peter crops out in southern Minnesota, southwestern Wisconsin, northeastern Iowa, and in northern Illinois. In Cerro Gordo County the St. Peter occurs only in the subsurface, and at Mason City the top of the formation is at a depth of about 750 feet.

The Platteville Formation consists of about 45 feet of shale, dolomite, and limestone. The lower part of the formation is dark- to olive-green fissle shale. The green shale is overlain by brownish to buff argillaceous dolomite containing phosphatic concretions, which is in turn overlain by gray fine-grained limestone having green shale partings. The upper part of the unit is blue-gray, mostly noncalcareous, shale containing limestone lenses.

The Decorah Formation comprises about 35 feet of soft, calcareous, green shale containing gray, fossiliferous limestone lenses.

The Platteville and Decorah crop out in Winneshiek, Allamakee, and Clayton Counties, Iowa, and occur in the subsurface in Cerro Gordo County. The depth to the top of the Decorah at Mason City is about 660 feet.

The Galena Formation consists of about 220 feet of white to light-gray limestone, tan, coarsely crystalline dolomite, and tan, finely crystalline limestone containing embedded dolomite rhombs. In Iowa the Galena crops out in the northeastern part of the State and along the Mississippi River in the east-central part of the State. In Cerro Gordo County the Galena occurs only in the subsurface, and the top of the formation is at a depth of about 460 feet at Mason City.

The Maquoketa Formation is the uppermost unit of Ordovician age in Cerro Gordo County. The Maquoketa overlies the Galena Formation and, because Silurian and Lower Devonian age beds are absent, underlies the Cedar Valley Limestone of Middle Devonian age. In eastern Iowa the Maquoketa is chiefly shale, however, in Cerro Gordo County the upper part of the unit is missing and the lower part consists chiefly of cherty argillaceous cream-to-brown dolomite. The Maquoketa is about 100 feet thick at Mason City but, because the top is an erosional contact, the thickness may vary considerably within the county. The

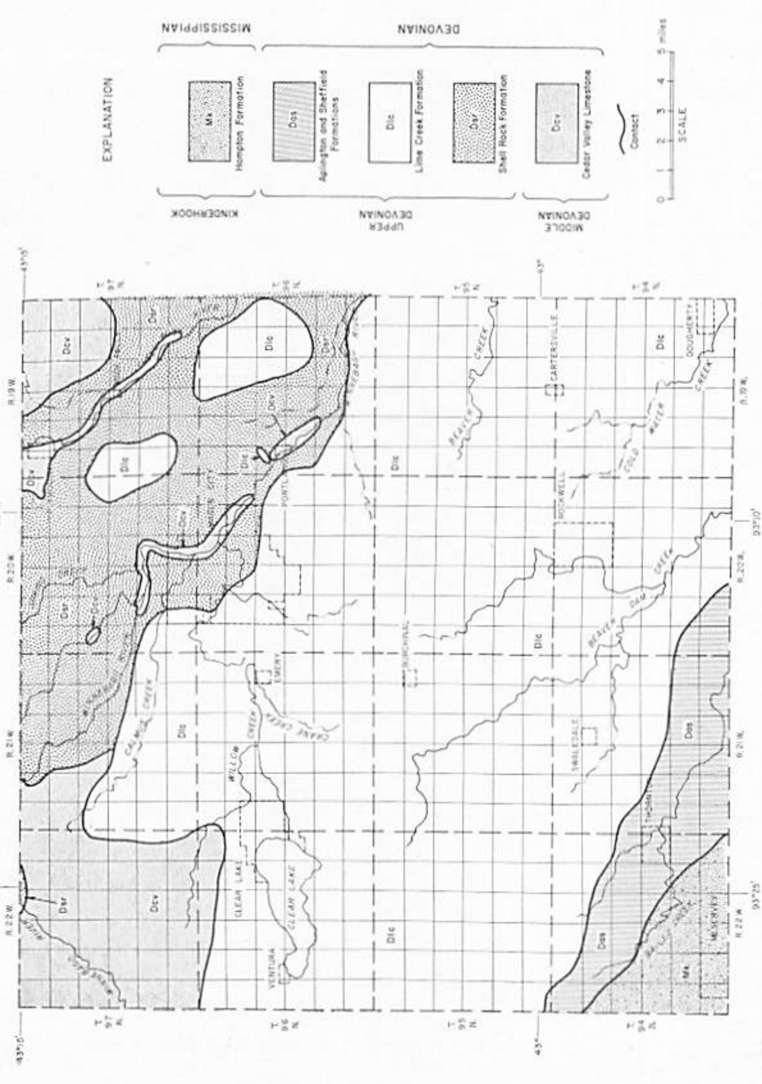


Figure 8.—Bedrock geologic map of Cerro Gordo County showing distribution of formations below the glacial drift.

Maquoketa crops out in east-central and northeastern Iowa, and the top of the formation is at a depth of about 340 feet at Mason City.

Devonian

Units of Devonian age in Cerro Gordo County are the Cedar Valley Limestone, and the Shell Rock, Lime Creek, Sheffield, and Aplington Formations. All except the lower part of the Cedar Valley crop out in the county (fig. 8), although the outcrops are small in number and size because of the almost continuous cover of glacial and alluvial deposits.

The Cedar Valley Limestone consists predominantly of brown to gray fine-grained dolomite that is characteristically slightly silty or argillaceous. Lithographic limestones occur at several horizons, and chert and quartz sand occur in some of the dolomites. The Cedar Valley is 265 feet thick at Mason City in well 96-20-10N1 and 250 feet thick in well 96-21-13M1 (table 10). The Cedar Valley Limestone crops out in limited areas along major streams in northeastern Cerro Gordo County (fig. 8). Major outcrop areas occur in adjacent counties to the northwest, north, east, and southeast.

The Shell Rock Formation comprises buff, gray, and brown, medium to coarsely crystalline dolomite and light gray lithographic to finely crystalline limestone. Some beds are argillaceous or silty and may be interbedded with thin shales. The Shell Rock is a local unit and occurs only in northeastern Cerro Gordo County and in adjacent parts of Worth, Mitchell, and Floyd Counties. The formation is estimated to attain a maximum thickness of about 85 feet in Cerro Gordo County.

The Lime Creek Formation overlies the Shell Rock Formation or the Cedar Valley Limestone where the Shell Rock is absent. The lower part of the Lime Creek is bluish- to medium-gray shale that weathers yellow to buff. Thin silty dolomite layers occur within the lower shale and become more numerous and thicker toward the middle of the formation. The middle part of the Lime Creek is yellow, marly, calcareous shale containing thin argillaceous limestones or dolomites and large concretions of calcium carbonate. The upper part is massively bedded, buff-to-gray dolomite and limestone containing minor intercalated shale layers. The Lime Creek Formation crops out in a wide band trending southeast across the middle of Cerro Gordo County (fig. 8) and has an estimated maximum thickness of 130 feet.

The Sheffield Formation crops out in a narrow band across the southwestern corner of Cerro Gordo County (fig. 8). The Sheffield consists of about 60 feet of soft, blue-gray shale locally containing concentrations of pyrite.

The Aplington Formation, the uppermost unit of Devonian age in Cerro Gordo County, overlies the Sheffield Formation. The Aplington crops out in a narrow band across the southwestern corner of the county (fig. 8) and consists of as much as 40 feet of buff, medium to finely crystalline dolomite and some white to light-gray chert.

Mississippian

Rocks of Mississippian age occur only in the extreme southwestern corner of Cerro Gordo County (fig. 8). These rocks are classified as part of the Maynes Creek Member of the Hampton Formation and consist of brown, finely crystalline dolomite containing some gray to white chert. The Maynes Creek underlies about 100 feet of glacial drift in the southwestern corner of Cerro Gordo County and is not known to be exposed in the county. About 20 feet of Maynes Creek was penetrated at Meservey in well 94-22-32M1; however, the maximum thickness and the area of occurrence are not precisely known.

Quaternary

Rocks of Quaternary age in Cerro Gordo County consist of a surficial covering of Pleistocene and Holocene clay, silt, sand, and gravel. Three major glacial advances, the Nebraskan, Kansan, and Wisconsin, covered all or part of the county during the Pleistocene Epoch and left behind glacial drift consisting of till and related outwash deposits. Between and after the glacial periods the previously deposited drift was subject to erosion or was covered by loess deposits.

Nebraskan and Kansan drift and related interglacial deposits occur throughout the county and range from zero to about 100 feet in thickness. In general, the drift is thickest in the western part of the county. Drift of Cary age occurs only in the western part of the county (fig. 9) where it overlies the Nebraskan and Kansan and ranges from zero to about 25 feet in thickness.

Deposits of Holocene age, aside from surficial soils, are thin and scattered. Peat and sediments carried by rain wash have accumulated in numerous undrained depressions on the Cary drift, but little or no alluvium has accumulated along streams in the county.

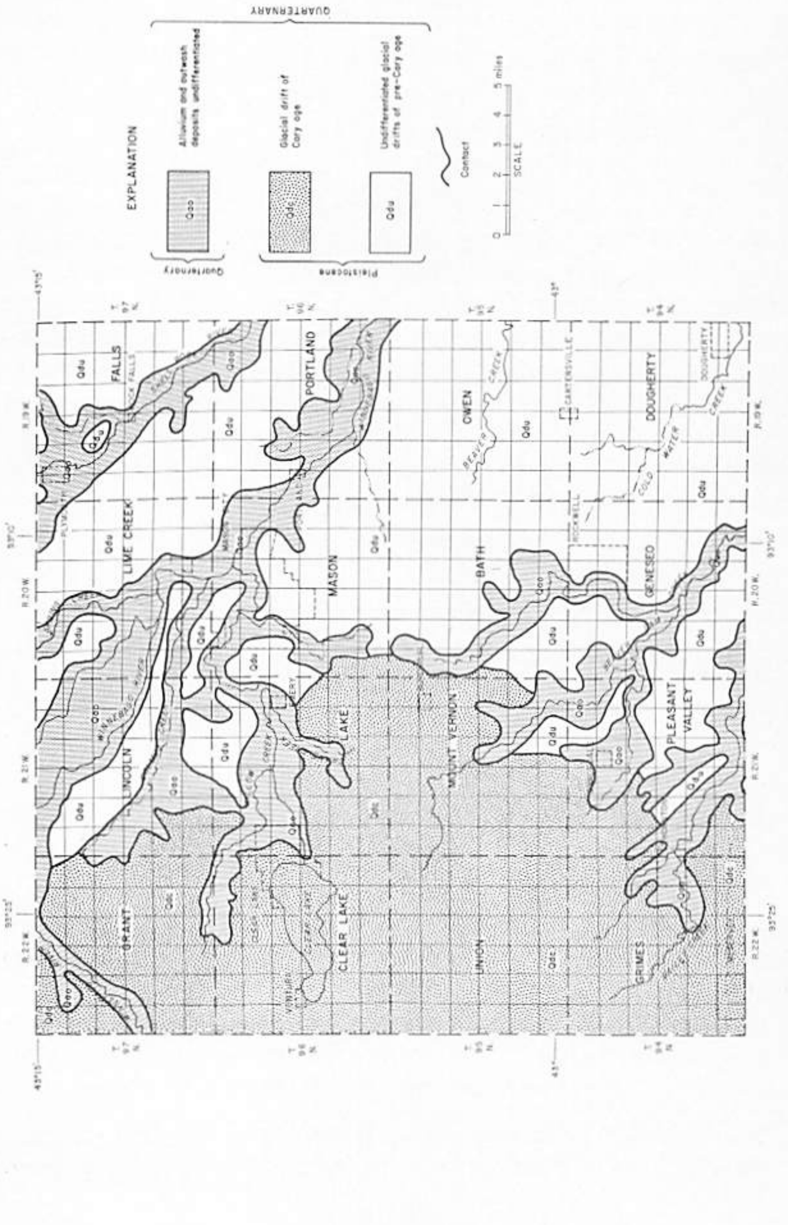


Figure 9.—Glacial geologic map of Cerro Gordo County, Iowa.

AVAILABILITY AND QUALITY OF WATER FROM AQUIFERS

The availability of ground water in Cerro Gordo County is controlled by the stratigraphic position, extent, thickness, boundary conditions, and water-bearing and transmitting properties of the aquifers and aquicludes in the ground-water reservoir, whose base is the Precambrian basement complex. The aquifers, in ascending order, are the deep Cambrian sandstones, Jordan aquifer, St. Peter Sandstone, Devonian and Mississippian limestones and dolomites, and the glacial drift. The principal aquiclude, consisting of the Platteville, Decorah, Galena, and Maquoketa Formations, occurs between the St. Peter Sandstone and Devonian limestones. Although these units are classified as an aquiclude, they do contain minor quantities of water and may yield some water; however, when compared to adjacent aquifers, the yield is of little importance. Several minor aquicludes also occur within water-bearing units and will be discussed as part of those units.

The chemical suitability of water from the various aquifers depends on the type and amount of dissolved minerals the water holds in solution and its intended use. Many mineral substances dissolved in water are objectionable if they occur in large amounts, and some are objectionable or even toxic in small amounts. The principal chemical properties that determine the acceptability of ground water for most uses in Cerro Gordo County are iron, sulfate, fluoride, manganese, nitrate, total dissolved solids, and total hardness. The U. S. Public Health Service has set up recommended limits (U. S. Public Health Service, 1962). The recommended limits and the significance of each of the constituents are shown on table 2. The availability and quality of water and its intended use are primary factors to be considered when determining the suitability of a potential water supply. Chemical analyses of water from Cerro Gordo County are given in table 9.

Deep Cambrian Sandstones

Geologically this water-bearing unit consists of the Dresbach Group and the overlying Franconia Sandstone. These geologic units have been combined because the Dresbach and the lower part of the Franconia both consist predominantly of sandstone and probably are hydrologically connected.

TABLE 2.—SIGNIFICANCE OF MINERAL CONSTITUENTS AND PHYSICAL PROPERTIES OF WATER[1]

Constituent or Property	Maximum Recommended Concentration	Significance
Iron (Fe)............	0.3 mg/l*..........	Objectionable as it causes red and brown staining of clothing and porcelain. High concentrations affect the color and taste of beverages. Iron may be added to water from well casings, pumps, and pipes. The concentration also is affected by micro-organisms. Special sampling and analytical techniques are needed for an accurate study.
Manganese (Mn)......	0.05 mg/l.........	Objectionable for the same reasons as iron. When both iron and manganese are present, it is recommended that the total concentration not exceed 0.3 mg/l. Micro-organisms also affect the concentration. Special techniques are needed for an accurate study.
Calcium (Ca) and Magnesium (Mg).....		Principal causes for hardness and scale-forming properties of water. They reduce the lathering ability of soap.
Sodium (Na) and Potassium (K)........		Impart a salty or brackish taste when combined with chloride. Sodium salts cause foaming in boilers.
Sulfate (SO_4).........	250 mg/l...........	Commonly has a laxative effect when the concentration is 600 to 1,000 mg/l, particularly when combined with magnesium or sodium. The effect is much less when combined with calcium. This laxative effect is commonly noted by newcomers, but they become acclimated to the water in a short time. The effect is noticeable in almost all persons when concentrations exceed 750 mg/l. Sulfate combined with calcium forms a hard scale in boilers and water heaters.
Chloride (Cl)..........	250 mg/l...........	Large amounts combined with sodium impart a salty taste.
Fluoride (F)..........	2.2 mg/l..........	In northern Iowa, concentrations of 0.8 to 1.5 mg/l are considered to play a part in the reduction of tooth decay. However, concentrations over 2.2 mg/l will cause the mottling of the enamel of children's teeth.
Nitrate (NO_3)........	44 mg/l............	Waters with high nitrate content should not be used for infant feeding as it may cause methemoglobinemia or cyanosis. High concentrations suggest organic pollution from sewage, decayed organic matter, nitrate in the soil, or chemical fertilizer. High nitrates in the natural waters of Iowa are limited to isolated occurrences, usually from shallow dug wells on farms. Since the high concentrations are characteristic of individual wells and not of any one aquifer, nitrate will not be discussed in this report.
Dissolved Solids......	500 mg/l...........	This refers to all of the material in water that is in solution. It affects the chemical and physical properties of water for many uses. Amounts over 2,000 mg/l will have a laxative effect on most persons. Amounts up to 1,000 mg/l are generally considered acceptable for drinking purposes if no other water is available.
Hardness (as $CaCO_3$)..		This affects the lathering ability of soap. It is generally produced by calcium and magnesium. Hardness is expressed in milligrams per liter equivalent to $CaCO_3$ as if all the hardness were caused by this compound. Water becomes objectionable for domestic use when the hardness is above 100 mg/l; however, it can be treated readily by softening.
Temperature.........		Affects the desirability and economy of water use, especially for industrial cooling and air conditioning. Most users want a water with a low and constant temperature.
Suspended Sediment...		Causes water to have a cloudy or muddy appearance. It must be settled or filtered out before the water is used. It is the material that "silts-up" reservoirs, and it is the major cause of the reduction of reservoir life.

---

[1] See U. S. Public Health Service (1962) and Hem (1959) for further discussion of chemical and physical properties of water.

* (milligrams per liter) mg/l's are approximately equal to ppm (parts per million) in concentrations of less than 7,000 ppm (Hem, 1959, p. 30).

The deep Cambrian sandstones have been penetrated by only three wells in Cerro Gordo County: 96-20-3L2, 96-20-10N2, and 96-20-16J2, all at Mason City. Two of these wells were uncased through overlying units and little specific information about the deep Cambrian sandstones could be obtained from them. The third well, 96-20-3L2 (city well No. 8), was originally drilled to the top of the overlying St. Lawrence Formation at a depth of 1,219 feet. This well was deepened in 1946 to a total depth of 1,765 feet penetrating the St. Lawrence, Franconia, Dresbach, and about 67 feet of Precambrian crystalline rocks. For test purposes all units above the Dresbach Group were cased off and the well was pumped at a rate of about 60 gpm for 7¼ hours, causing a drawdown of 83 feet. That test and information collected during drilling and casing the well indicate that the deep Cambrian sandstones probably will not yield large quantities of water in the Mason City area.

Chemical analyses of water samples collected from the deep Cambrian sandstones during drilling and testing of city well No. 8 indicates that the water is soft but more mineralized than water from overlying units (table 9, well 96-20-3L2). The concentrations of sodium, sulfate, and chloride in particular are higher, and are 304, 262, and 55 mg/l (milligrams per liter) respectively in a sample collected in July 1946. The fluoride content, 3.6 mg/l, is objectionably high (table 2) but could be reduced by mixing with water low in fluoride from other sources.

The upper part of the Franconia Sandstone, containing siltstones and shales, serves as a minor aquiclude separating water in the deep Cambrian sandstones from water in the overlying Jordan aquifer. Because water from the deep Cambrian sandstones is more mineralized than that from overlying units and only relatively small quantities are available, well 96-20-3L2 was plugged below a depth of 1,225 feet to improve the quality of water produced from the well. Well 96-20-10N2 was abandoned in 1957; therefore, only one well, 96-20-16J2 (city well No. 12), is known to produce water from the deep Cambrian sandstones in Cerro Gordo County.

Jordan Aquifer

The Jordan aquifer is a hydrogeologic unit that includes the upper part of the St. Lawrence Formation, the Jordan Sandstone, and the lower part of the Prairie du Chien Formation. The Jordan Sandstone is the principal water-bearing unit; however, water occurring in openings along fractures and solution channels in the St. Lawrence and the Prairie du Chien probably is in hydrologic connection with water in the Jordan. For this reason, and because all three units generally are left uncased, they have been designated as the Jordan aquifer in Iowa.

The Jordan aquifer underlies all of Cerro Gordo County, but at this time (1969) has been utilized only in the Mason City area (fig. 10) where it supplies large quantities of water for municipal and industrial use. Wells producing from the Jordan aquifer range from 1,200 to 1,538 feet in depth and produce as much as

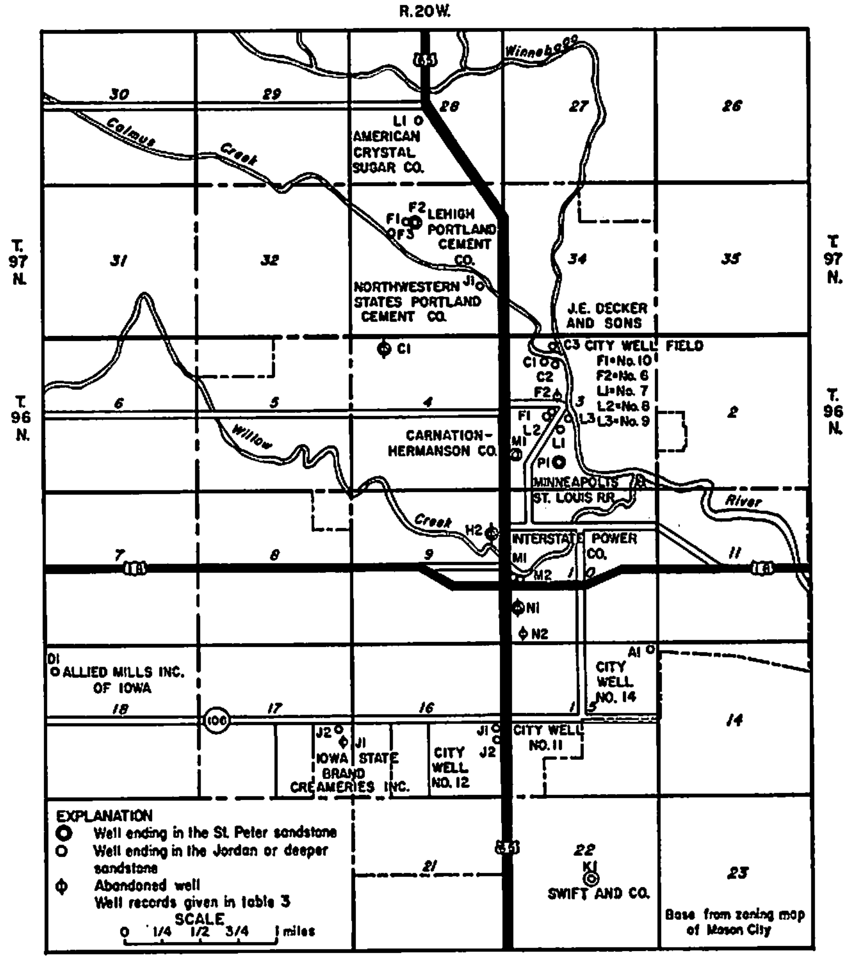


Figure 10.—Map showing wells penetrating the St. Peter Sandstone or Jordan aquifer at Mason City.

1,200 gpm (tables 3 and 4). The approximate depth to the base of the Jordan aquifer throughout Cerro Gordo County is shown in figure 11. These depths have been calculated from an average land-surface altitude of 1,150 feet and should be adjusted to local altitude where necessary.

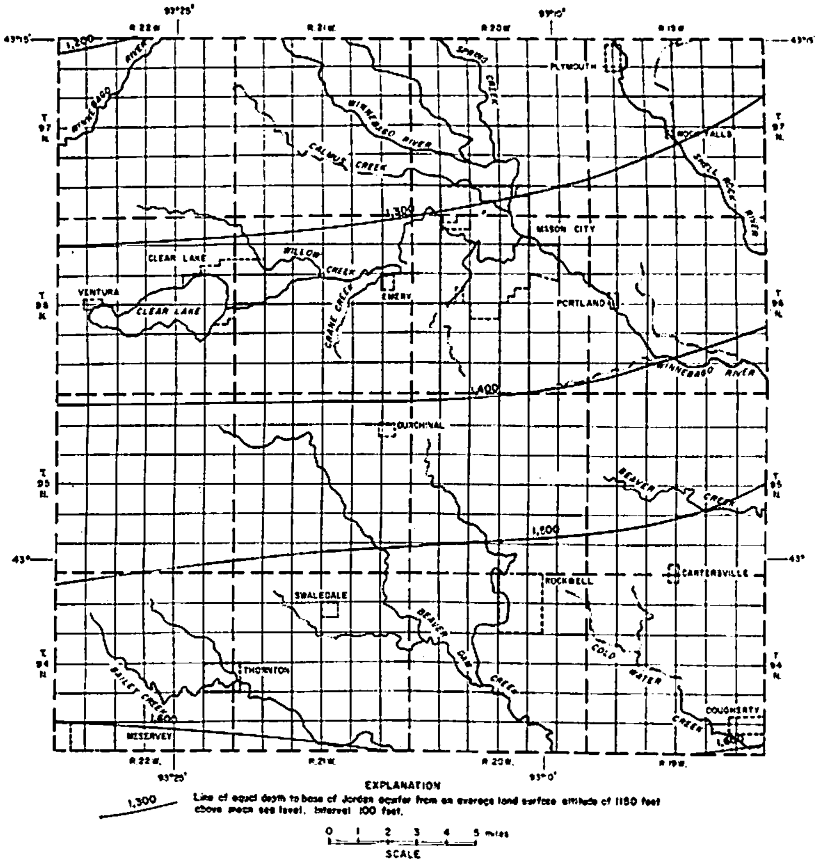


Figure 11.—Map showing approximate depth to the base of the Jordan aquifer in Cerro Gordo County.

Most of the wells producing from the Jordan aquifer at Mason City are also open to overlying or underlying aquifers and produce some water from them. However, the largest part of the water comes from the Jordan aquifer because production is reported to increase considerably when it is penetrated. Because the Jordan is not the only aquifer open to the wells, hydrologic properties determined from pumping tests are not completely reliable, but those determined from two pumping tests were considered to be reasonable.

TABLE 3.—RECORDS OF WELLS THAT PENETRATE THE ST. PETER SANDSTONE OR JORDAN AQUIFER AT MASON CITY.

Number	Owner or Name	Year Drilled	Depth (feet)	Casing Record
97-20-28L1......	American Crystal Sugar Co.........	1924	1,347	20-inch at top; 12-inch 653 to 815 ft.
97-20-33F1......	Lehigh Portland Cement Co........	1924	1,260	20-inch 0 to 14.8 ft.; 12-inch 603.6 to 755 ft.
97-20-33F2......	Lehigh Portland Cement Co........	1911	796[1]	12-inch 0 to 12 ft.; 6-inch 620 to 725 ft.
97-20-33F3......	Lehigh Portland Cement Co........	1957	1,215	20-inch 0 to 65 ft.; 16-inch 630 to 824 ft.
97-20-33J1......	Northwestern States Portland Cement Co....................	1924	1,281.5	12-inch 663.5 to 750 ft.
96-20-3C1.......	J. E. Decker and Sons, No. 2.......	1918	1,200	No record.
96-20-3C2..	J. E. Decker and Sons, No. 3.......	1933	1,260	28-inch 0 to 12 ft.; 20-inch 0-50.8 ft.; 12-inch 607.2 to 726.5 ft.
96-20-3C3.......	J. E. Decker and Sons, No. 4.......	1957	1,210	20-inch 0 to 102 ft.; 16-inch 633 to 742 ft.; 12-inch 795 to 1,042 ft.
96-20-3F1.......	Mason City, No. 10..............	1932	1,243	20-inch 0 to 99.7 ft.; 12-inch 634.6 to 743 ft.
96-20-3F2.......	Mason City, No. 6...............	Prior to 1910	1,218[2]	8-inch 635 to 735 ft.
96-20-3L1.......	Mason City, No. 7...............	Prior to 1910	1,230[3]	20-inch 0 to 94.8 ft.; 12-inch 614 to 757 ft.
96-20-3L2.......	Mason City, No. 8...............	1912	1,225[4]	20-inch 0 to 99 ft.; 10-inch 349 to 710 ft.
96-20-3L3.......	Mason City, No. 9...............	1913	1,220[5]	20-inch 0 to 55 ft.; 12-inch 632 to 804 ft.
96-20-3M1......	Hermanson Bros. Creamery.........	1930	840	6.5-inch 0 to 759 ft.
96-20-3P1.......	Minneapolis and St. Louis R.R......	1920	805	12-inch 0 to 30 ft.; 10-inch 614 to 730 ft.
96-20-4C1.......	Chicago and Northwestern R.R.....	1900	862	10-inch 0 to 54 ft.; 6-inch 644 to 765 ft.
96-20-9H2......	Ideal American Laundry..........	....	810	12-inch 0 to 20 ft.
96-20-10M1.....	Interstate Power Co., No. 1	1915	1,200[6]	20-inch 0 to 100 ft.; 12-inch 625 to 700 ft.; 10⅝-inch 700 to 960 ft.
96-20-10M2.....	Interstate Power Co., No. 2........	1933	1,201.5	18-inch 0 to 17 ft.; 16-inch 17 to 70 ft.; 12-inch 596 to 700 ft.; 150 ft. of 9-inch at unknown depth.
96-20-10N1.....	Swift and Co....................	....	815[7]	12-inch 0 to 36 ft.; 10-inch 28 to 68 ft.
	Chicago, Milwaukee, St. Paul and Pacific R.R., No. 1.............	1879	1,473[8]	No record.
96-20-10N2....,	Chicago, Milwaukee, St. Paul and Pacific R.R., No. 3.............	1913	1,278.5[9]	16-inch 0 to 41 ft.; 12-inch 221.5 to 259.5 ft.; 10-inch 630 to 820 ft.
96-20-15A1......	Mason City, No. 14..............	1957	1,297	20-inch 0 to 150 ft.; 18-inch 650 to 770 ft.; 16-inch 742 to 849 ft.
96-20-16J1......	Mason City, No. 11..............	1939	1,306	20-inch 0 to 142.7 ft.; 14-inch 713.2 to 777.2 ft.; 16-inch 777.2 to 814.3 ft.; 10-inch liner from 715 to 930 ft.
96-20-16J2......	Mason City, No. 12..............	1948	1,538.5	30-inch 0 to 10 ft.; 20-inch 0 to 145 ft.; 18-inch 793 to 815 ft.; 14-inch 732 to 879.5 ft. Drilled to Precambrian rocks at 1,585 ft.; plugged back to 1,538.5 ft. in April 1948.
96-20-17J1......	State Brand Creameries, Inc., No. 1..	1933	1,336	10-inch 0 to 95.5 ft.; 7¼-inch 780 to 860 ft.; 6-inch 860 to 1,080 ft.[10]
96-20-17J2......	State Brand Creameries, Inc., No. 2..	1956	1,369	20-inch from +2 to 102 ft.; 16-inch 742 to 856 ft.; both casings grouted.
96-20-18D1.....	Allied Mills, Inc., of Iowa..........	1953	1,425	16-inch 0 to 92 ft.; 12-inch 679.5 to 800 ft.; 10-inch 1,016 to 1,036 ft.
96-20-22K1.....	Swift and Co....................	1953	977	12-inch 0 to 130 ft.; 10-inch 764 to 891 ft.

---

[1] Deepened from 405 to 796 ft. in 1940.

[2] Reportedly deepened from 616 to 1,218 ft. in 1920. Filled in and abandoned in 1932, after standing idle since 1922.

[3] Deepened from 875 to 1,219 ft. in 1920. Reconditioned and deepened to 1,230 ft. in 1934.

[4] Originally drilled to 1,219 ft. in 1912; reconditioned and recased in 1932. Deepened to 1,765 ft. in 1946, with resultant loss in head and production. Plugged back to 1,225 ft. in August 1946.

[5] Reportedly drilled to 1,200 ft. in 1913; reconditioned and recased in 1934, and again in March 1959, when depth was determined to be 1,220 ft.

[6] Capped and abandoned.

[7] Deepened from 462 to 815 ft. in 1946.

[8] Data from Norton and others (1912, p. 767); abandoned about 1896.
[9] Not used since 1953; capped and abandoned in 1957.
[10] In 1947, 6-inch liner set from 860 to 1,080 ft. to prevent loose sands of the St. Peter from entering well.

TABLE 4.—SUMMARY OF PUMP TESTS ON WELLS PENETRATING THE JORDAN AQUIFER AT MASON CITY

Well Number	Date of Test	Discharge (gallons per minute)	Length of Test (minutes)	Drawdown at End of Test (feet)	Specific Capacity (gallons per minute per foot of drawdown)
96-20-16J1	11-23-39	1,203	1,440	75.0	16.0
96-20-3F1	7- 8-36	600[1]		32[1]	19
Do	10-10-37	930	215	41.1	22.6
96-20-3L1	10-17-37	780	180	34.9	22.3
96-20-3L3	10-25-37		190	38.75	
96-20-10M2	10-23-37	1,040	515	37.4	27.8
96-20-15A1	3-11-57	1,100	1,519	52.3	21
96-20-17J1	9-16-37	180	47	8.5	21.2
96-20-17J2	12- -56	1,250		52.0	24.6
97-20-28L1	9-17-37		88	47.9	

[1] Reported by well owner.

TABLE 5.—ALTITUDES IN FEET ABOVE SEA LEVEL OF NON-PUMPING WATER LEVELS IN WELLS PENETRATING THE JORDAN AQUIFER AT MASON CITY

Well / Date	97-20-28L1	97-20-33F1	97-20-33J1	96-20-3C1	96-20-3F1	96-20-3L1	96-20-3L2	96-20-3L3	96-20-10M1	96-20-10M2	96-20-10N2	96-20-15A1	96-20-16J1	96-20-17J1
1912							1,015							
1913								1,007			1,004			
1914				994				994						
1915														
1918				998										
1919								979						
1924	1,085	1,098	994	968										
1925								969						
1927							974				1,004			
1932				951	939		942							
1933									959					
1934						947					959			
1936		963*		918	909*		916	898*						
1937	949		926	944		928*	913	926		944	940*			
1938	961	955	952	924										
1939				901									957	
1940				897									966*	
1941				893			905						970*	
1942	958		930	881			916*						960*	
1943	956		931	878			910*			938			969	
1944	975*						914*							
1945	959						911*							
1946	947			861		913*	927*	929						
1947	950				904*	919*		905					963	
1948	948				908*	911*		900*					950*	
1949	936*				892*	887		888*					955	
1950	940				890*	902		890*					950	
1951	940*				880	893*	859	895*					947*	
1952	932				896*	890*	865*	886*					949*	
1953	938*				883*	878*	851*	864					938*	
1954	933*				881*	893	852	850					935*	
1955	925*				891			891						
1956	916				886			906						912
1957	910*				863*	876*	852*	858*					914*	
1958	903*				871	870*	864*	865*					899*	
1959	895*				856*	858*	848*						885*	
1960	894*				844	848						904*	887*	
1961	893*				823*	845*	839*	800*				890*	895*	
1962	895*				830*	840*	832	803*				899*	897*	
1963	895*				824	837*						890*	879*	
1964	897*				841*	851*		816*				895*	886*	
1965	894				801	867		827				895*	869*	
1966	897*				818	859*	852*	829*				889*	893*	
1967	899*											894*	885*	
1968	875	875										874*	873	861
1969	892*							789				870	873	867

*Average of two or more measurements.

The time-drawdown relations for a test on well 96-20-10M2 (Interstate Power Co. well No. 2) are shown on figures 12 and 13. The semi-log time-drawdown plot (fig. 13), which is a

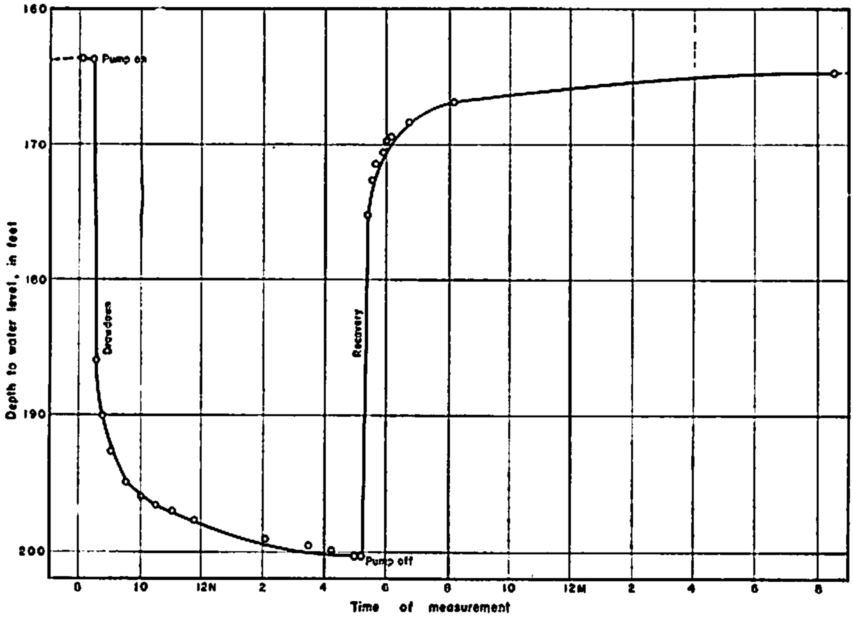


Figure 12.—Graph showing water level in well 96-20-10M2 during a pumping test on October 23 and 24, 1937.

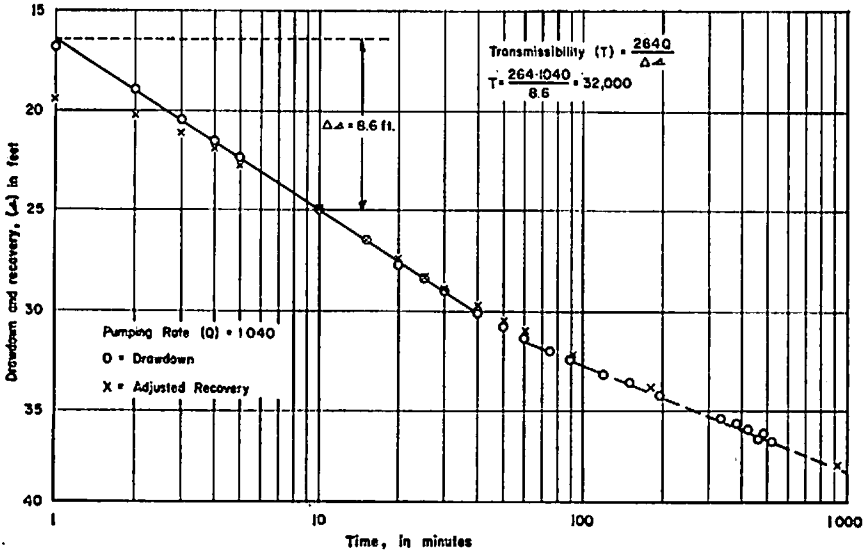


Figure 13.—Semi-log time-drawdown graph for well 96-20-10M2.

straight line for ideal conditions, shows a distinct change in slope after about 1 hour of pumping. The difference in slope of the line in the latter part of the test indicates that a nearby well was shut down, that the cone of drawdown had reached a more permeable area of the aquifer or a recharge boundary, or some other anomalous condition. The transmissibility in the immediate vicinity of well 96-20-10M2, as determined from figure 13 by the straight-line method (Cooper and Jacob, 1946) using a discharge value of 1,040 gpm, was 32,000 gallons per day per foot. After 1 hour of pumping the aquifer had an apparent transmissibility of 50,000 gallons per day per foot.

The time-drawdown relations for an observation well during pumping of well 96-20-15A1 are shown on figure 14. The trans-

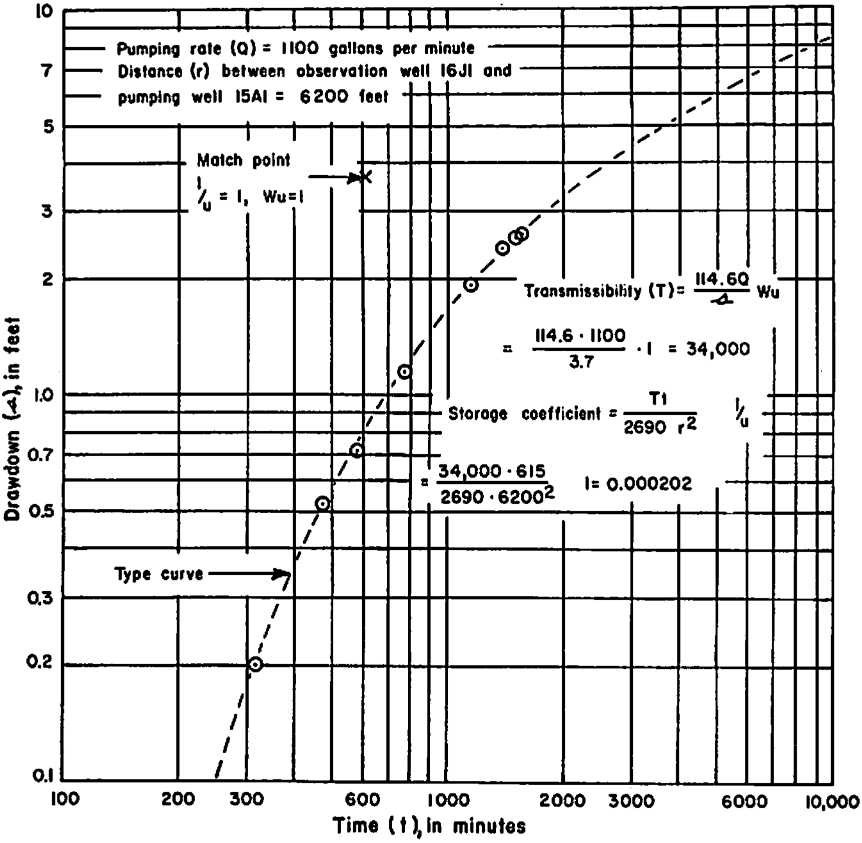


Figure 14.—Log-log time-drawdown graph for well 96-20-16J1 during pumping of well 96-20-15A1.

missibility and storage coefficient of the aquifer in the vicinity of wells 96-20-15A1 and 16J1, as determined from figure 14 by a modification of the Theis non-equilibrium method (Ferris and others, 1962, p. 92), were 34,000 gallons per day per foot and 2.02×10^{-4} respectively.

Water levels in wells penetrating the Jordan aquifer are given in table 5. The most authentic data as to the original water level in the aquifer are given by Norton (1928, p. 256-258). According to that information the water level was at an altitude of about 1,015 feet in 1912 and began to decline rapidly when pumping started. Reported water levels in wells 97-20-28L1 and 33F1 in 1924 are unusually high and probably are in error or are representative of overlying aquifers.

Water-level declines to 1942 owing to pumping from the Jordan aquifer were about 100 feet at the pumping center near the J. E. Decker and Sons wells and city wells Nos. 7 to 10, about 60 feet in the northern part of the city at the American Crystal Sugar plant, and about 45 feet in the southern part of the city at city well No. 11. By 1969 declines due to pumping were about 200 feet at the pumping center, about 125 feet at American Crystal Sugar, and about 140 feet at city well No. 11. Hydrographs of water levels in the American Crystal Sugar Company well, 97-20-28L1, and city well No. 11, 96-20-16J1 (fig. 15), show that since 1959 water levels in the Jordan have not declined significantly but have fluctuated 10 to 30 feet annually. Water-level fluctuations of 10 to 30 feet in the Jordan are due to pumping as shown in figure 16.

Pumping from the Jordan aquifer from 1912 to 1942 was concentrated in the northern part of Mason City resulting in a slightly elongated cone of drawdown with its center in the area of maximum pumping (fig. 17). Between 1942 and 1969 additional pumping in the southern part of Mason City has caused the overall cone of drawdown to deepen and expand toward the south; although the deepest part has remained in the area of maximum pumping (fig. 17).

The estimated average rate of withdrawal in million gallons per day from the Jordan aquifer on the basis of historical records and estimates by well owners is less than 1 in 1912, 1.2 in 1915, 2.6 in 1920, 3.3 in 1925, 4.8 in 1930, 5.0 in 1935, and 5.6 in 1940. After 1940 withdrawal information is available for the two largest users, Decker Packing Company and the city of Mason City (fig. 24). Withdrawals by other industries in the

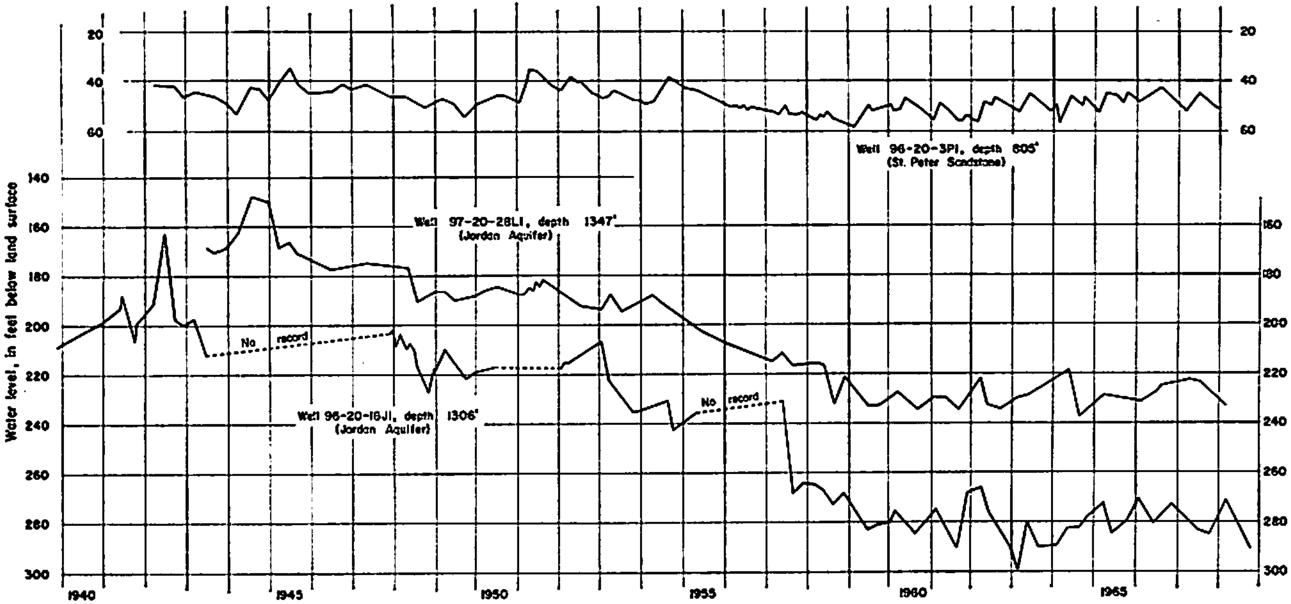


Figure 15.—Hydrographs showing fluctuations and the general decline of water levels caused by variations in withdrawals from the Jordan aquifer.

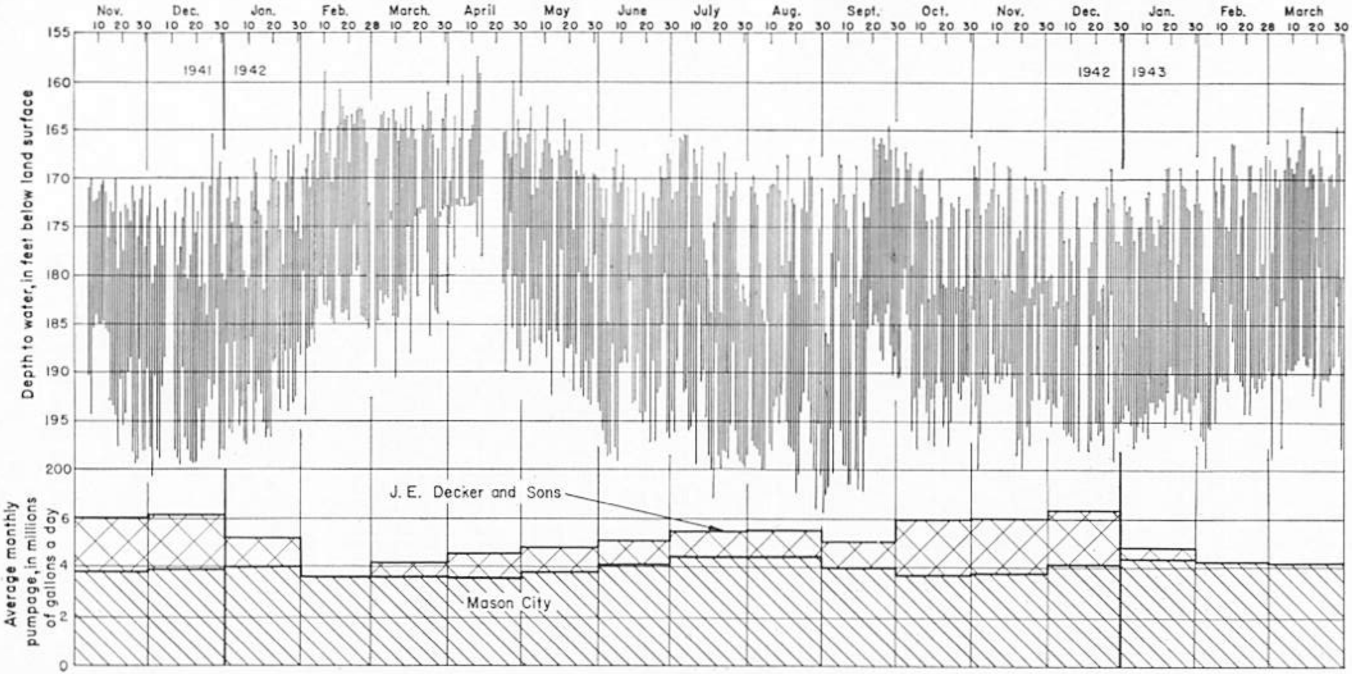


Figure 16.—Graph showing daily high and low water level in well 96-20-3L2 and withdrawals from nearby municpial and industrial wells.

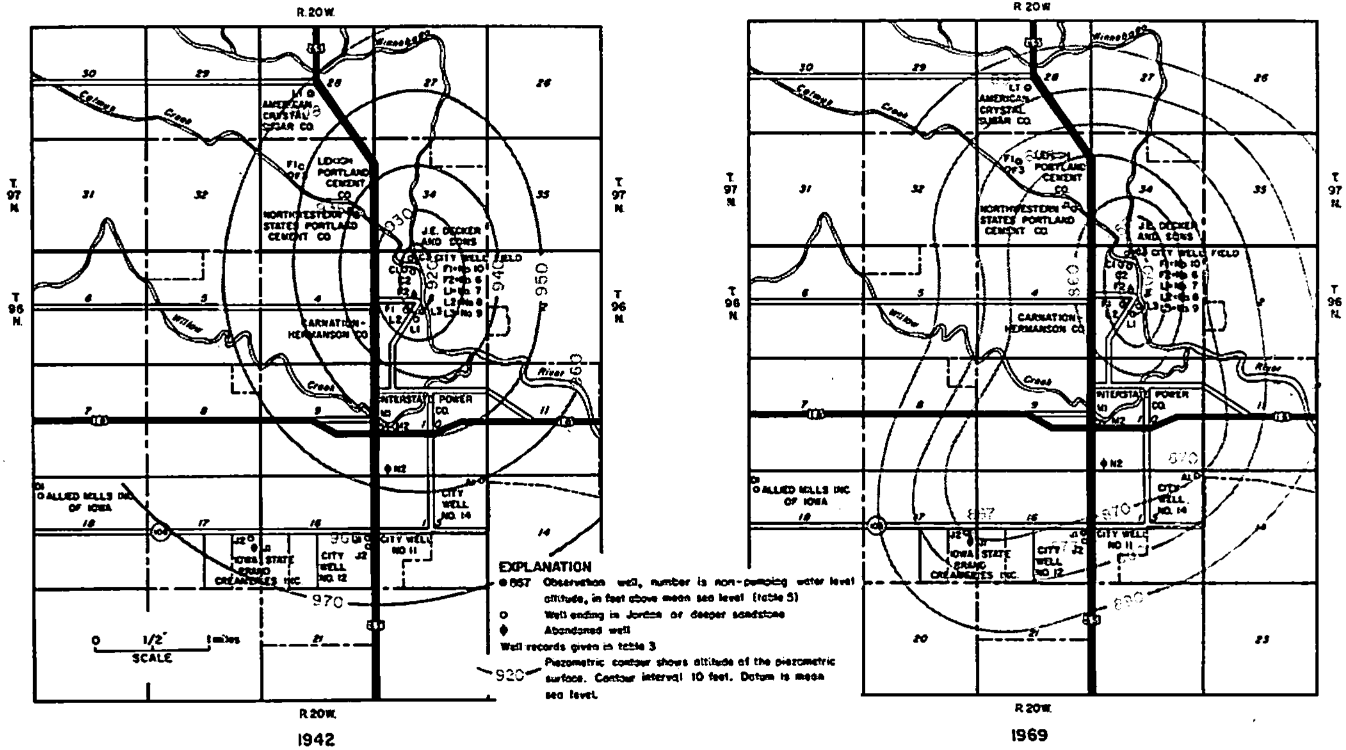


Figure 17.—Generalized piezometric surface of Jordan aquifer at Mason City in 1942 and 1969.

area are estimated to gradually increase from 1.5 mgd in 1940 to 2.5 in 1968. Since 1959 pumping from the Jordan aquifer has been relatively constant (8 to 9 mgd) and water levels have not declined significantly (fig. 15). Evidently the cone of drawdown is approaching stability at that pumping rate. However, increased withdrawals will cause additional drawdowns to occur throughout the area.

Transmissibility and storage values of 35,000 and 2.0×10^{-4} respectively, which are in agreement with those obtained from a pumping test on city well No. 14, were used to calculate drawdowns as a result of estimated total pumping in the area (table 6). The calculated water levels are in near agreement with 1969 measured water levels shown on figure 17, indicating that these values will serve to predict future drawdowns due to increased pumping in the area.

If future development of the Jordan aquifer is to be to the best economical advantage, careful consideration should be given to the location, capacity, and pumping schedules of proposed wells and nearby existing wells so that local overdevelopment

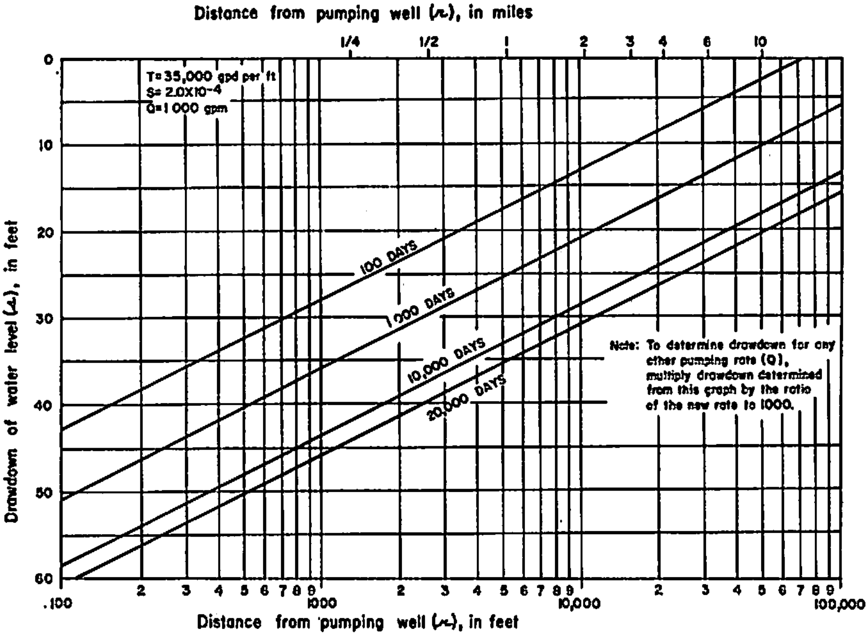


Figure 18.—Graph showing drawdown in water level around a well pumping from the Jordan aquifer.

or excessive interference do not occur. The hydrologic properties calculated for the Jordan may be used to determine optimum spacing by estimating the drawdowns that will occur at specific distances from wells pumped at a given rate for a definite period of time. The drawdowns can be estimated readily from the distance-drawdown graph presented in figure 18. Drawdowns determined for increased withdrawals from the Jordan aquifer will be superimposed on the 1969 drawdown cone.

TABLE 6.—CALCULATED WATER-LEVEL DRAWDOWNS IN JORDAN WELLS, 1912-1969

Pumping Location	Average Pumping Rate in g.p.m.	Time of Pumping in Days	Drawdown, in Feet				
			At City Well No. 11	At State Brand Creameries No. 1	At City Wells No. 7-10	At American Crystal Sugar Co.	At City Well No. 14
City wells, No. 7-10	2,420	20,800	70	69	148	74	74
City well, No. 14	500	3,000	14	12	13	10	25
City well, No. 12	500	9,000	27	16	13	11	16
State Brand Creameries, No. 2	400	5,000	12	21	10	8	10
Northwestern and Lehigh Portland Cement Co's	830	16,400	22	22	28	29	22
Total drawdown 1912-1969			145	140	212	132	147
Estimated water-level elevation 1912			1,013	1,012	1,015	1,017	1,014
Calculated water-level elevation 1969			868	872	803	885	867
Difference from measured water-level elevation 1969 (fig. 14)			−5	+5	+3	−7	−3

For example, a new well in the center of section 2, T. 96 N., R. 20 W., pumping at an average rate of 700 gpm for 3 years, would cause about 15 feet of additional drawdown at city well No. 14 and lower the water level to an elevation of about 855 feet. Increased drawdowns at other wells in the city can be determined similarly from figure 18. As suggested by figure 18, the widest spacing is advantageous because of reduced well interference and consequently higher pumping levels in the wells. New developments should be avoided in the vicinity of the city well fields and Decker Packing Company because of the cones already established in these areas.

As indicated on figure 19 and in table 9, water from the Jordan aquifer contains a moderate quantity of dissolved solids and has a hardness of about 340 mg/l (milligrams per liter). The hardness is mostly of the carbonate type and may be removed rather easily. The dissolved solids content ranges from about 400 to 500 mg/l and is not objectionable for most uses. The iron con-

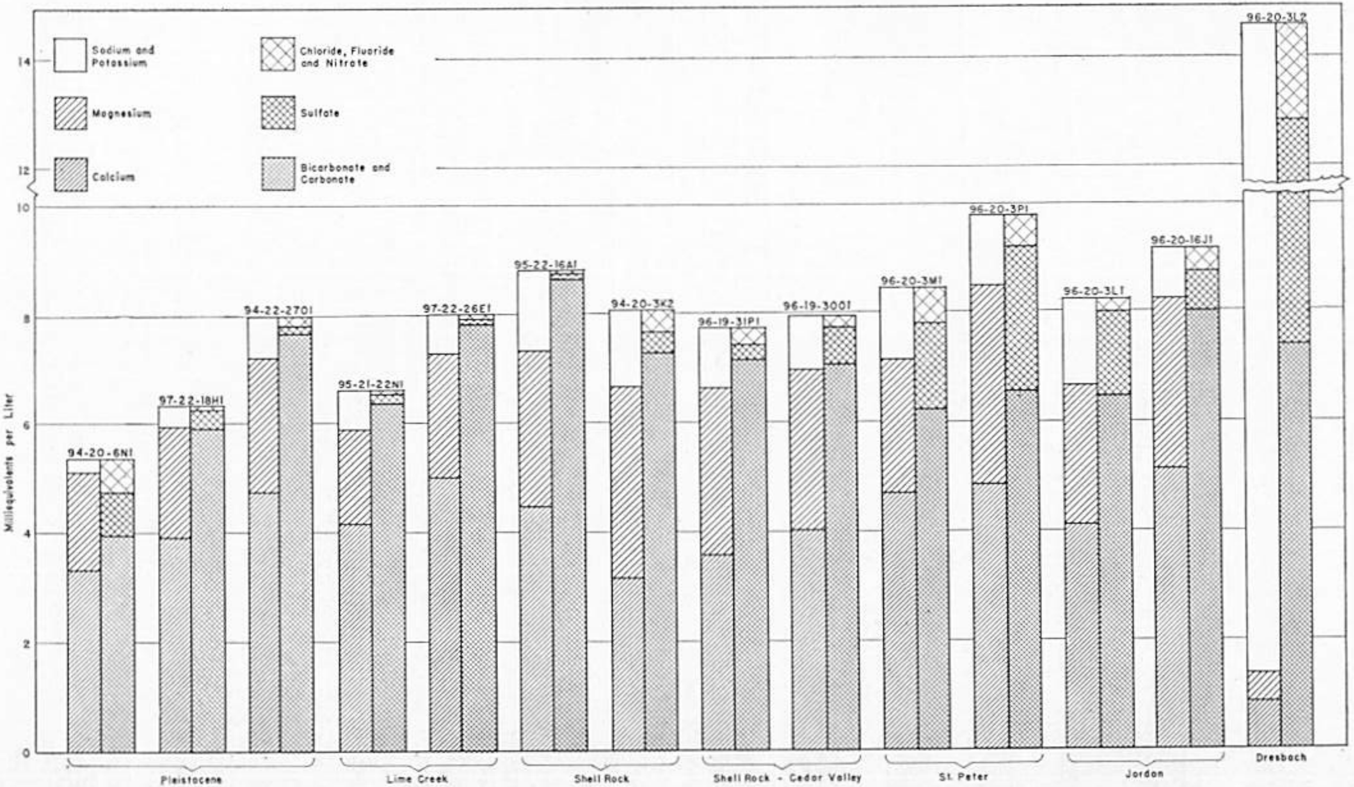


Figure 19.—Graphic representation of chemical analyses of water from principal water-bearing formations in Cerro Gordo County.

tent ranges from 0.1 to 0.9 mg/l and may cause discoloration locally, although it has not been a major problem. The sulfate content averages about 70 mg/l and although higher than in water from shallower aquifers it is not objectionable for most uses. The fluoride content ranges from a trace to 1.6 mg/l and is not a problem in present developments.

St. Peter Sandstone

The St. Peter Sandstone is separated from underlying aquifers by the upper part of the Prairie du Chien Formation which is of low permeability and from overlying aquifers by the Platteville, Decorah, Galena, and Maquoketa Formations which are relatively impermeable. Most wells penetrating the St. Peter are also open to underlying or overlying aquifers, and consequently the amount and reliability of ground-water information for the unit is limited. Wells ending in or just below the St. Peter range from about 800 to 850 feet in depth at Mason City and only one, 96-20-3M1, is cased through overlying aquifers.

The St. Peter Sandstone underlies all of Cerro Gordo County, but significant amounts of water are withdrawn from it only in the Mason City area. The first recorded wells tapping the St. Peter at Mason City were drilled in 1900. From 1900 to 1927 numerous wells were completed in the St. Peter. After 1927 a number of those wells were deepened to the underlying Jordan aquifer or were abandoned because of inadequate yield or caving problems.

The original static water level in two wells penetrating the St. Peter was at an altitude of about 1,105 feet in 1900. Because the wells were open to overlying limestones and dolomites in addition to the St. Peter, the water levels may be slightly high due to a higher head in the overlying units. A considerable decline in water level in the same two wells had occurred by 1908 and might be attributed to caving since the same declines were not noted in other newer wells. By 1937 water levels in wells tapping the St. Peter had dropped about 156 feet to an altitude of 949 feet as measured in well 96-20-3M1. From 1937 to 1942 water levels in wells tapping the St. Peter rose to an altitude of about 1,074 feet as measured in well 96-20-3P1. Since 1942 water levels have been relatively high with only minor fluctuations (fig. 15).

Yields from the St. Peter are highly variable as indicated in the following table.

Well Number	Yield (g.p.m.)	Drawdown (feet)	Hours Pumped	Specific Capacity (g.p.m./ft. dd)
96-20-3M1	37.5	33	¾	1.1
96-20-3P1	170	31	....	5.5
96-20-4C1	82	....	10	....
	110	....	1	....
96-20-10N1	100	19	....	5.2
	165	50	....	3.3
	220	68	....	3.2
96-20-22K1	265	139	....	1.9

Well 96-20-3M1 provides the most reliable information because others are open to overlying aquifers also, and the yields are higher than if they were open only to the St. Peter. Based on specific capacity data from well 96-20-3M1 (Theis and others, 1963), the transmissibility of the St. Peter is estimated to be about 2,000 gallons per day per foot. Assuming the storage coefficient is the same as the Jordan aquifer, 2.0×10^{-4}, the drawdowns around a pumping well after 100 days of continuous discharge were calculated and are shown in table 7.

TABLE 7.—COMPUTED DRAWDOWN, IN FEET, AROUND A WELL PUMPING FROM THE ST. PETER SANDSTONE CONTINUOUSLY FOR 100 DAYS

Discharge (gallons per minute)	Distance From Pumped Well (in miles)			
	⅛	¼	½	1
50	18	14	10	6.7
100	37	29	21	14
200	74	58	42	27
300	111	87	63	41

As indicated in table 7 the cone of drawdown around a well producing from the St. Peter is deep, relatively small, and wells spaced one-half to one mile apart will have little interference unless the pumping rate is relatively large. Many wells producing from the underlying Jordan aquifer also produce some water from the St. Peter if it is not cased. Because of the difference in head between the Jordan and St. Peter, as shown in figure 15, water moves from the St. Peter to the Jordan when the well is not being pumped. The contribution from the St. Peter when pumping these multi-aquifer wells is not known but probably is within the range shown on table 7. Consequently, the loss of water to deeper aquifers should be taken into consideration when planning new developments from the St. Peter.

The chemical quality of water from wells penetrating the St. Peter is good but variable due to the mixing of water from overlying units. Generally the water contains 400 to 500 mg/l dissolved solids and the hardness is about 375 mg/l. The sulfate content is about 100 mg/l which is not objectionable but is notable as being higher than all units except the deep Cambrian sandstones. The fluoride content is low and the iron content from most wells is not objectionable.

Devonian and Mississippian

Limestones and dolomites in the Cedar Valley Limestone and in the Shell Rock, Lime Creek, Aplington, and Hampton Formations are water bearing in Cerro Gordo County. Water occurs in openings along joints, fractures, and solution channels in the rock. The quantity available from a well depends on the number and size of water-bearing openings penetrated. The Sheffield Formation, which overlies the Lime Creek Formation, and shale within the Lime Creek are aquicludes and retard the movement of water to and from underlying units.

Although the quantities of water available from the Devonian and Mississippian are not particularly large, these units are the shallowest dependable source of supply in many parts of Cerro Gordo County. The quantities of water available from the Cedar Valley, Shell Rock, or the upper part of the Lime Creek range from about 10 to as much as 200 gpm. The Aplington and Hampton Formations are relatively thin and probably will yield only sufficient water for domestic or stock use (about 10 gpm). Because the water occurs in erratically developed openings in the limestone and dolomites, the determination of the availability of a water supply is largely a matter of test drilling and test pumping. For maximum yield a well should be drilled to the base of the Cedar Valley Limestone to assure that all available openings are penetrated.

Areas where the Devonian and Mississippian rocks are exposed or directly underlie the glacial drift are shown on figure 8. Each of the units shown, except the Shell Rock Formation, also occurs under younger rock units southwest from their outcrop. The Shell Rock occurs only in the northeast part of the county and extends only a short distance southwest under the overlying Lime Creek Formation.

The thickness of the Devonian and Mississipian ranges from about 250 feet in the northwestern part of the county where only the Cedar Valley is present to about 500 feet in the southwestern part of the county where younger units are also present. The depth to the top of the Devonian or Mississippian depends on the thickness of overlying glacial drift which may be from 0 to about 125 feet. In areas where shale is the uppermost bed underlying the glacial drift, the shale must also be penetrated before water-bearing openings are likely to be found. The depth of wells producing from the Devonian or Mississippian may therefore range from less than 50 feet to about 600 feet.

Many domestic and stock wells are completed in weathered limestone or dolomite just beneath the glacial drift and probably produce chiefly from openings which are in hydrologic connection with sand and gravel in the basal part of the glacial drift. For that reason the chemical quality of water from the Devonian and Mississippian is variable depending on each individual situation. The water generally is hard and high in iron content which causes undesirable staining. Locally the fluoride content exceeds 1.5 mg/l and in some localities the water may have an undesirable odor due to hydrogen sulfide gas. The hardness ranges from about 150 to 430 mg/l but generally is about 350 mg/l (table 9).

Glacial Outwash

The glacial drift in Cerro Gordo County consists of till and related outwash deposits of three major glacial advances—the Nebraskan, Kansan, and Wisconsin. The till deposits generally are poorly sorted, relatively impermeable, and do not yield significant quantities of water to wells. Thin, well sorted alluvial sand and gravel beds occur between the glacial till and bedrock or between individual till layers in some areas. These beds generally are relatively permeable and yield water to some wells. Because these buried alluvial deposits are relatively thin and the recharge is slow, yields are small, although sufficient for domestic and stock use in some areas.

Outwash deposits in Cerro Gordo County supply moderate-to-large quantities of water to a considerable number of wells. The approximate areal extent of the outwash deposits is shown on figure 9. The outwash deposits are truncated by glacial drift of Wisconsin (Cary) age in the western part of Cerro Gordo County, and may underlie or interfinger with that drift in some areas.

The outwash deposits are composed of permeable sand and gravel and contain water under water-table conditions in most areas and under artesian conditions in some where a surficial clay is present. The outwash receives recharge from precipitation during the season when the ground is not frozen. Water levels in wells tapping the outwash fluctuate in response to variations in precipitation (fig. 22).

The altitudes of water levels in wells tapping outwash and buried alluvial aquifers are shown on figure 20. Contours on figure 20 are based on 1941 water-level data; however, figure 22 shows that the water levels have fluctuated less than 10 feet from 1940 to 1968. Consequently, there probably has been little change in the overall shape of the water table. In general, the

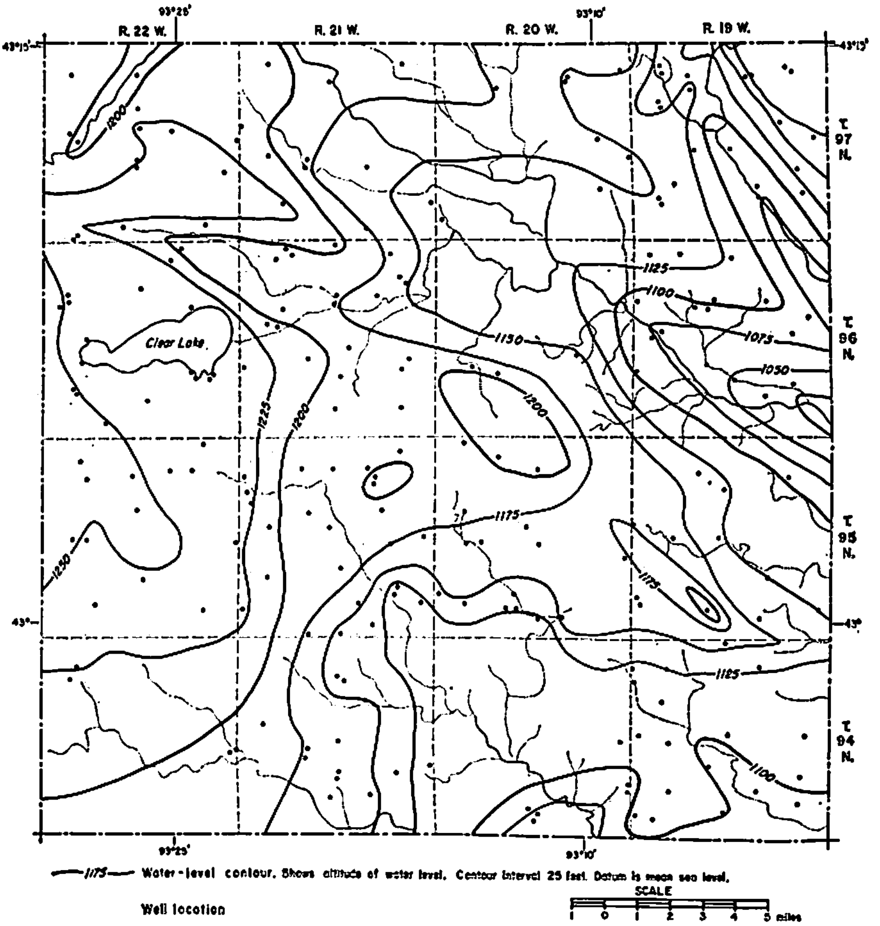


Figure 20.—Map showing generalized altitude of water levels in wells tapping drift aquifers in 1941.

water table follows the topographic surface in the county indicating ground-water movement from upland areas to lowland areas and discharge into local streams.

In the eastern part of Cerro Gordo County the outwash is relatively thin and probably would yield only small quantities of water to wells. The outwash deposits are thickest and most extensive just east of the Cary drift area (fig. 9). Consequently, outwash deposits in that area would be the most favorable for developing ground-water supplies.

A relatively large area located adjacent to Willow Creek between Clear Lake and the junction of Willow Creek and Winnebago River in Lake and Mason Townships is underlain by very permeable saturated outwash gravel (fig. 21). A similar accumulation of water-bearing gravel is adjacent to and north of Winnebago River in northern Lincoln and western Lime Creek Townships. In these areas and in other small areas moderate to relatively large quantities of water may be obtained from shallow outwash deposits.

The water level in Clear Lake and in nearby shallow wells shows similar fluctuations indicating that the lake and the surficial aquifer are in hydraulic connection (fig. 22). Clear Lake is in part sustained by ground-water inflow from the north, west, and south (fig. 20). However, during prolonged periods of below normal precipitation the inflow diminishes and the lake level subsequently declines (fig. 22).

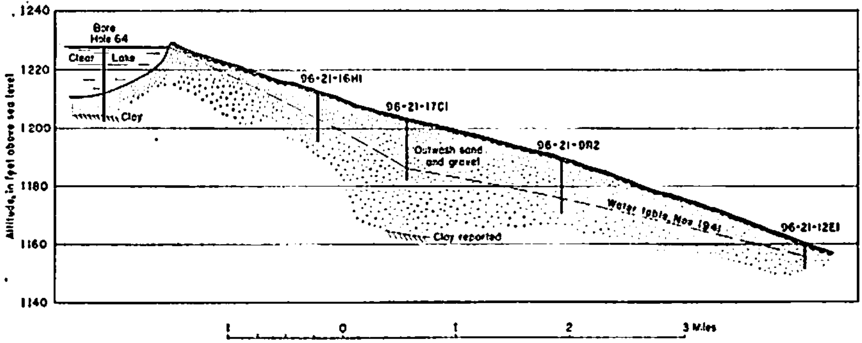


Figure 21.—Section eastward from Clear Lake showing slope of water table, 1941.

Water-level data indicate that Clear Lake is recharging the surficial aquifer east of the lake (figs. 20 and 21). Withdraw-

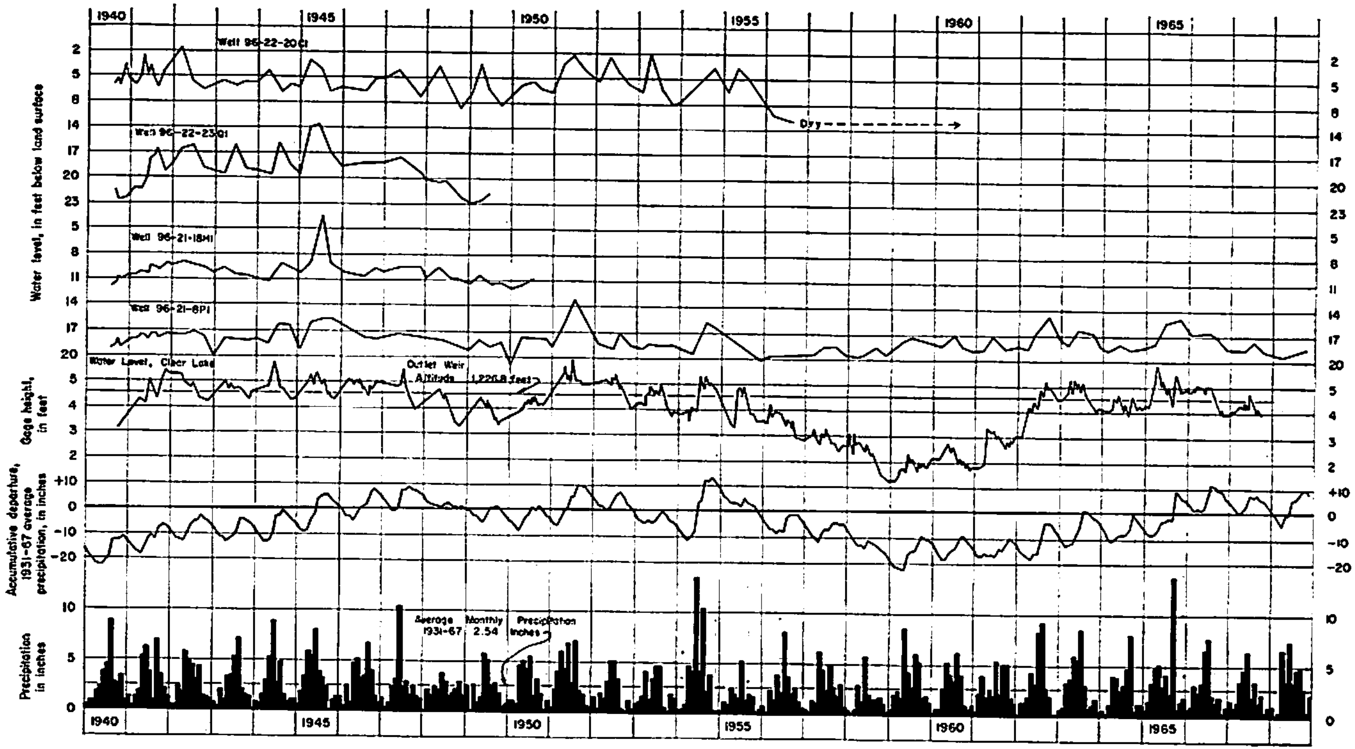


Figure 22.—Graph showing precipitation at Mason City and water-level fluctuations in Clear Lake and nearby shallow wells.

als from the aquifer in that area may induce additional recharge from the lake and consequently water levels could remain relatively high even if substantial quantities of water are pumped from the aquifer. Sizable withdrawals from the surficial aquifer north, west, or south of the lake would initially cause much larger declines in water level; however, the rate of decline would decrease sharply if water levels fall below lake level and recharge is induced from the lake.

Present withdrawals from outwash sand and gravel are chiefly for domestic and stock purposes and the quantities are relatively small. Large quantities of water probably could be developed in many areas; however, the quantities available are not presently known. If large quantities of water are withdrawn from the outwash deposits in the future, well spacing and pumping rates should be based on hydraulic characteristics of the aquifer, which as yet have not been determined.

The quality of water from the glacial drift differs from place to place depending on the rapidity of recharge and the composition and texture of the rock material. Commonly the total hardness is about 300 mg/l and the concentrations of sodium, sulfate, chloride, and fluoride are relatively low. Most of the water contains undesirable amounts of iron which cause staining. In general, water from the larger deposits of outwash in the county is slightly softer and less mineralized than water from the smaller deposits or from sand or gravel within or underlying the till.

WATER UTILIZATION

Surface water has been utilized as a major source of supply at Clear Lake and Mason City. Clear Lake water is used for public supply in the city of Clear Lake and water from Willow Creek has been used for industrial cooling in Mason City. The

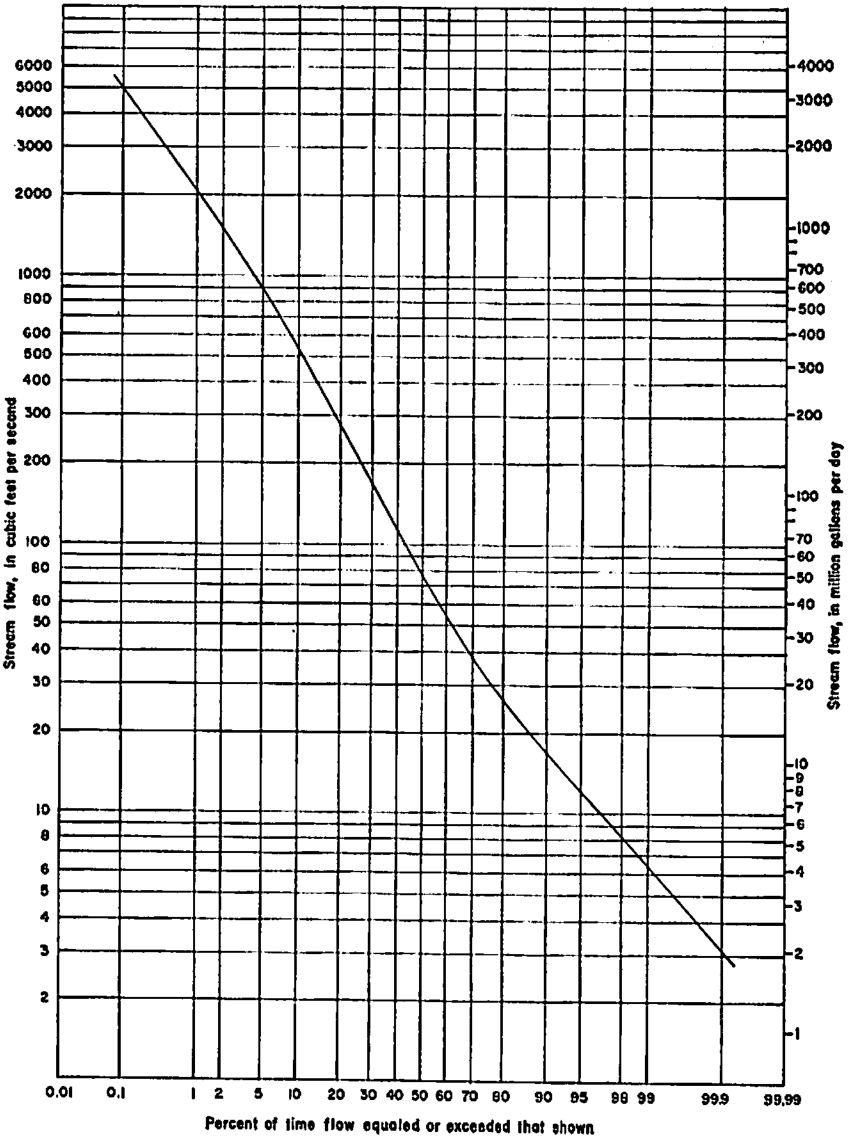


Figure 23.—Duration curve for Winnebago River at Mason City, Iowa.

flow of Winnebago and Shell Rock Rivers would also be sufficient for moderate water-supply developments if storage facilities were built to augment flow in the summer and during periods of drought. The percentage of time that the flow of Winnebago River has equalled or exceeded given rates of flow for the period between 1932 and 1965 appears on figure 23, which shows that flow was equal to or exceeded 5 million gallons per day about 98 percent of the time. Thus, development of storage facilities would be necessary for Winnebago River to furnish a dependable supply of water for Mason City. Without storage facilities even moderately large withdrawals of water at Mason City could create a pollution problem downstream during periods of low flow.

Ground water is a major source of supply throughout Cerro Gordo County. The majority of wells in the county are used for domestic and stock supplies, but the largest withdrawals of water are for municipal and industrial supplies. Although irrigation is not a major water use, some water is used on lawns, gardens, and golf courses. Wells visited during the investigations are shown on plate 1 and figure 10, and pertinent data on construction, pumping equipment, and water use are available in the U. S. and State Geological Survey files.

Domestic and stock supplies are obtained from ground-water sources throughout the county. Adequate farm supplies (± 10 gpm) are obtained at relatively shallow depths, usually less than 200 feet, and the wells generally are 5 inches or less in diameter. Most domestic and stock wells in the area covered by and adjacent to the Cary glacial drift, and especially around Clear Lake, obtain water from shallow outwash gravel. Elsewhere in the county most of the domestic and stock wells are drilled into limestone or dolomite of Devonian or Mississippian age or obtain water from sand and gravel immediately above the bedrock. Although generally not a reliable source of water, some shallow driven wells and large diameter bored wells are completed in sand and gravel within the glacial till. A few springs have been improved for use as stock supplies throughout the county and flowing artesian wells are used for domestic and stock supplies in the southwestern part of the county.

Most domestic and stock wells are pumped intermittently and the discharge rates are commonly only a few gallons per minute. The approximate number of domestic and stock wells in the county is estimated to be 3,000 to 3,500 on the basis of the well inventory and a State Highway map showing rural dwellings. This includes an estimated 500 to 800 wells used primarily for domestic purposes in towns and villages that lack municipal supplies.

Six of 12 municipalities in Cerro Gordo County have public water-supply systems. One municipality, Clear Lake, uses a surface-water source; the others use ground-water sources. The city of Clear Lake water system, serving a population of 6,301 people according to a 1965 census, obtains water from Clear Lake. A water plant with a capacity of one million gallons per day built in 1949 chemically treats and filters the lake water before it is distributed.

Four municipalities, Meservey, Plymouth, Rockwell, and Thornton, obtain water from wells tapping limestone and dolomites of Devonian age at depths of 175 to 500 feet. The four municipalities have a total population of about 2,000 people and, assuming an average per capita use of 65 gpd, use about 47 million gallons per year.

Mason City, the largest municipality in the county, presently obtains its water supply from deep wells. Mason City originally obtained its water supply from springs and streams within the city, but filtration and treatment became a problem and in 1892 four wells 651 feet deep were drilled. A few years later two more wells 616 feet deep were drilled. These six wells, known as Mason City wells 1 to 6, were reported to have obtained water "at a depth of about 600 feet in porous limestone, said to be 40 inches thick, lying above the Decorah Shale" (Norton and others, 1912, p. 761).

Two of the six wells were deepened to the St. Peter Sandstone at about 800 feet in 1911 and 12, and to the Jordan Sandstone in 1926 and 27. One of these two wells is still in use although it has been renamed number 7; the other five were subsequently abandoned and destroyed. Six more wells producing from the Jordan were added to the system from 1912 to 1956 as needed; details of construction, date and depths are shown in table 3. Location of the seven wells presently in use are shown on figure 10.

All wells presently in use penetrate the Jordan aquifer. It is believed that the Jordan aquifer is the major source of water; however, overlying units of Ordovician and Devonian age are also open to some of the wells and presumably yield some water.

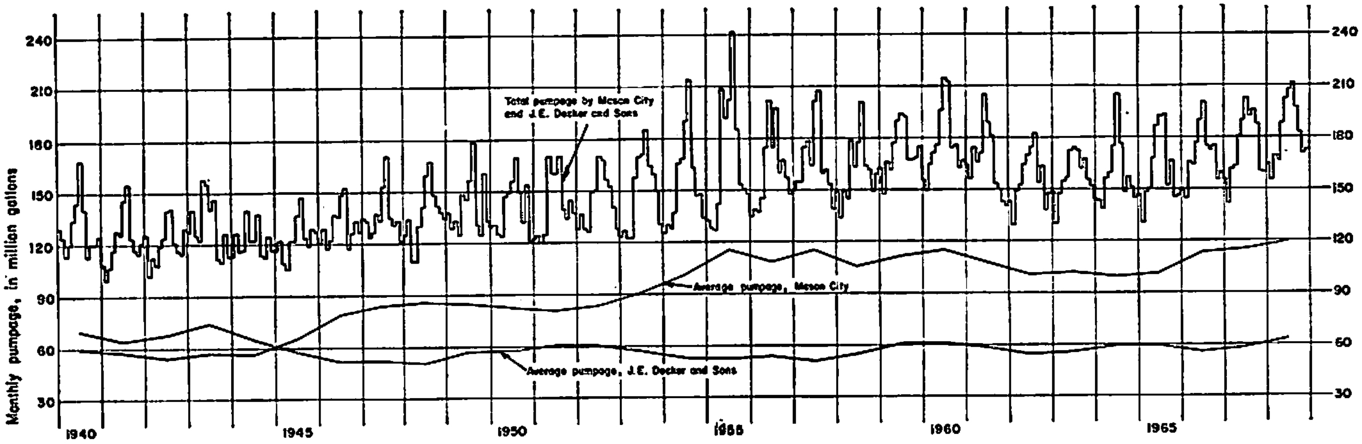


Figure 24.—Monthly pumpage by Mason City and J. E. Decker & Sons.

The quantity of water produced from each aquifer is not known, although the records of average pumpage and total pumpage by the city and the largest industrial user from 1940 to 68 are shown on figure 24.

A relatively large quantity of ground water is also used by self-supplied industries in the vicinity of Mason City. With few exceptions the industrial users have not maintained records of the quantity of water pumped and estimates of withdrawals have therefore been made on the basis of reported pumping rates and estimated average operating time. Table 8 shows pumpage estimates for most of the major self-supplied industries in 1941 and 1968. The largest self-supplied industrial user, Decker Packing Company, has maintained pumping records since 1940; those records are shown on figure 24.

TABLE 8.—SOURCE AND ESTIMATED QUANTITY OF WATER, IN MILLION GALLONS, PUMPED BY MAJOR SELF-SUPPLIED INDUSTRIES IN CERRO GORDO COUNTY IN 1941 AND 1968

Name	From Well Ending above St. Peter Sandstone		From Wells Ending in St. Peter Sandstone		From Wells Ending in Jordan Aquifer or Deeper Sandstones		Total	
	1941	1968	1941	1968	1941	1968	1941	1968
J. E. Decker and Sons	0	0	0	0	770	768	770	708
Lehigh Portland Cement Co.	0	10	9	10	202	400	301	420
Northwestern States Portland Cement Co.	0	0	0	0	0	118	0	118
American Crystal Sugar Co.	9	9	0	0	75	179	83	188
Chicago, Milwaukee, St. Paul and Pacific	2	0	0	0	73	0	75	0
Interstate Power Co.	0	0	0	0	24	5	24	5
Minneapolis and St. Louis R.R.	0	0	22	0	0	0	22	0
Ideal American Laundry	0	0	20	0	0	0	20	0
Swift and Co.	18	0	0	4	0	0	18	4
Hutchinson Ice Cream Co.	15	13	0	0	0	0	15	13
Hermanson Bros. Creamery (Carnation)	0	0	13	0	0	0	13	0
Very Best Dairy and Creamery	13	0	0	0	0	0	13	0
State Brand Creamery Inc.	0	0	0	0	9	280	9	280
Higley Cold Storage Co.	8	0	0	0	0	0	8	0
Mason City Brick and Tile Co.	4	8	0	0	0	0	4	8
Radio Station KGLO	1	0	0	0	0	0	1	0
Allied Mills	0	0	0	0	0	4	0	4
Pepsi-Cola Co.	0	4	0	0	0	0	0	4
Chicago and Northwestern R.R.	3	0	0	0	0	0	3	0
Dougherty Creamery	8	0	0	0	0	0	8	0
Rockwell Creamery	4	0	0	0	0	0	4	0
Swaledale Creamery	1	0	0	0	0	0	1	0
Thornton Co-op Creamery	3	0	0	0	0	0	3	0
Great Lakes Pipeline Co.	2	0	0	0	0	0	2	0
Plymouth Creamery	6	0	0	0	0	0	6	0
Total	97	44	64	14	1,243	1,754	1,404	1,812

SUMMARY AND CONCLUSIONS

Rock material exposed at the surface of Cerro Gordo County consists chiefly of glacial drift. Devonian and Mississippian limestones and shales occur immediately below the drift and are exposed locally in the central and eastern parts of the county. Ground water occurs in the glacial drift and in the underlying bedrock formations of Mississippian, Devonian, Ordovician, and Cambrian age.

The shallow ground-water reservoir, chiefly in the glacial drift, is recharged by precipitation that occurs within the county and by percolation from streams, Clear Lake, and numerous undrained depressions. The deeper bedrock aquifers are in part recharged by vertical seepage from the overlying shallow aquifers and in part by underflow. Ground water is discharged from Cerro Gordo County by evaporation and transpiration in areas where the water table is near the land surface, by movement into adjacent counties or into adjacent aquifers, by seepage into streams and lakes, and by pumpage from wells.

Throughout the county adequate supplies of reasonably good quality water are obtained for domestic and stock purposes at relatively shallow depths, generally less than 200 feet. Industrial and municipal wells in the Mason City area obtain water from Devonian limestones and dolomites at a depth of about 400 feet, from the St. Peter Sandstone at about 820 feet, and from the Jordan aquifer at about 1,250 feet. Because the beds dip toward the south, the depths increase with distance south of Mason City and decrease with distance north of Mason City.

At Mason City the Devonian limestones and dolomites generally yield from 120 to 200 gpm, the St. Peter Sandstone will yield 30 to 200 gpm, the Jordan aquifer will yield as much as 1,200 gpm, and the deep Cambrian sandstones were determined to yield about 60 gpm in one well. The depth to water in wells at Mason City varies considerably and depends on the aquifers open to the well, pumpage in the area, and the topographic position. Commonly the non-pumping water level in the Devonian is 20 to 60 feet below the surface, in the St. Peter is about 165 feet below the surface, and in the Jordan aquifer is about 220 to 300 feet below the surface.

The average total daily withdrawal of water for industrial and municipal use from wells penetrating the Jordan aquifer increased from less than 1 mgd in 1912 to about 9 mgd in 1968.

Total pumpage during that period, estimated to be about 110 billion gallons, caused declines in water levels of about 200 feet at the pumping center and about 125 to 140 feet 2 miles from the center. Additional wells should be widely spaced in relation to existing wells and pumping controlled to avoid interference and local overdevelopment.

Ground water in Cerro Gordo County generally is of suitable quality for domestic, industrial, or municipal use. Water from the glacial drift and from the underlying Mississippian or Devonian generally has a hardness of 300 to 350 mg/l, dissolved solids of 325 to 400 mg/l, and commonly contains undesirable quantities of iron. Water from the St. Peter Sandstone is slightly harder and contains more sulfate and total dissolved solids. Water from the Jordan aquifer is similar to that from the Devonian except for slightly less iron and slightly more fluoride, sulfate, hardness, and dissolved solids. The deepest aquifer, the deep Cambrian sandstones, contains water that is notably soft (35 to 67 mg/l) but contains more sulfate, fluoride, chloride, and dissolved solids than water from other aquifers. Water from all aquifers is suitable for most ordinary uses; although softening and other treatment may be needed for specialized purposes.

All in all, Cerro Gordo County has an abundance of ground water of usable quality. Supplies should be available indefinitely if withdrawals are held within certain limits and are properly distributed in space and time. However, ground-water development, particularly the development of water from deeper aquifers, is concentrated in the vicinity of Mason City causing local declines in water levels. The cone of drawdown in the Jordan aquifer at Mason City is approaching stability with pumpage averaging about 9 mgd. A significant increase in withdrawals would cause additional water-level declines to occur. Hence, future installations should be carefully planned and located and pumping rates controlled to avoid local overdevelopment and excessively deep pumping levels.

REFERENCES

Belanski, C. H., 1927-28, The Shellrock stage of the Devonian of Iowa: Am. Midland Naturalist, v. 10, p. 317-370; v. 11, p. 165-170.

———, 1931, The stratigraphy of the Hackberry stage: Wagner Free Inst. Sci. Bull., v. 2, p. 1-7.

Calvin, Samuel, 1883, On the fauna found at Lime Creek, Iowa, and its relation to other geological faunas: Am. Jour. Sci., ser. 3, v. 25, p. 432-436.

———, 1897, Geology of Cerro Gordo County: Iowa Geol. Survey Ann. Rpt., v. 7, p. 117-195, figs. 11-24, 2 maps.

Collinson, Charles, 1967, Devonian of the north-central region, United States, *in* International Symposium on the Devonian System: Alberta Soc. of Petroleum Geologists, v. 1, p. 933-971.

Cooper, G. A., and others, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America Bull., v. 53, no. 12, pt. 1, p. 1729-1793, 1 pl., 1 fig.

Cooper, H. H., and Jacob, C. E., 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: Am. Geophys. Union Trans., v. 27, p. 526-534, figs. 1-5.

Fenneman, N. M., 1938, Physiography of eastern United States: New York and London, McGraw-Hill Book Co., 714 p.

Fenton, C. L., 1919, The Hackberry stage of the upper Devonian of Iowa: Am. Jour. Sci., ser. 4, v. 48, p. 355-376, figs. 1-5.

———, 1920, The Hackberry stage of the upper Devonian: Am. Midland Naturalist, v. 6, p. 179-200, fig. 1, pl. 1.

Fenton, C. L., and Fenton, M. A., 1924, The stratigraphy and fauna of the Hackberry stage of the upper Devonian: Michigan Univ., Mus. Geology, Contr., v. 1, p. 1-260, figs. 1-9, pls. 1-45.

Ferris, J. G., and others, 1962, Theory of aquifer tests: U.S. Geol. Survey Water-Supply Paper 1536-E, p. 69-174.

Gwynne, C. S., 1943, Ceramic shales and clays of Iowa: Iowa Geol. Survey Ann. Rpt., v. 38, p. 263-377, figs. 1-14, pl. 1.

Hall, James, and Whitfield, R. P., 1873, Descriptions of new species of fossils from Devonian rocks of Iowa: N.Y. State Cabinet Ann. Rpt. 23, p. 223-239.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473.

Iowa State Planning Board, 1938, Mineral analysis of the underground waters of Iowa: Iowa State Planning Board, 123 p.

Iowa State Department of Health, 1964, Iowa public water-supply data: State of Iowa, 78 p.

Kay, G. F., and Apfel, E. T., 1929, The pre-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey Ann. Rpt., v. 34, p. 1-304, figs. 1-63, pls. 1-3.

Kay, G. F., and Graham, J. B., 1943, The Illinoian and post-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey Ann. Rpt., v. 38, p. 1-262, figs. 1-89.

Kay, G. F., and Miller, P. T., 1941, The Pleistocene gravels of Iowa: Iowa Geol. Survey Ann. Rpt., v. 37, p. 1-231, figs. 1-61.

Keyes, C. R., 1893, Geological formations of Iowa: Iowa Geol. Survey, v. 1, p. 11-144, figs. 1-15, pls. 1-9.

Larimer, O. J., 1957, Drainage areas of Iowa streams: Iowa Highway Research Board Bull. 7, p. 77-80, fig. 17.

Lees, J. H., 1935, Additional deep wells: Iowa Geol. Survey Ann. Rpt., v. 36, p. 365-419.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U.S. Geol. Survey Water-Supply Paper 489, p. 1-321, figs. 1, 110, pls. 1-31.

Norton, W. H., 1897, Artesian wells of Iowa: Iowa Geol. Survey Ann. Rpt., v. 6, p. 113-428, figs. 29-44, pls. 5-24.

———, 1928, Deep wells of Iowa: Iowa Geol. Survey Ann. Rpt., v. 33, p. 10-374, pl. 1.

———, and others, 1912, Underground water resources of Iowa: Iowa Geol. Survey Ann. Rpt., v. 21, p. 29-1214, figs. 1-7, pls. 1-18.

Ruhe, R. V., Dietz, W. P., Fenton, T. E., and Hall, G. F., 1968, Iowan drift problem, northeastern Iowa: Iowa Geol. Survey Rpts. of Inv. 7, 40 p.

Stainbrook, M. A., 1935, Stratigraphy of the Devonian of the upper Mississippi Valley: Kans. Geol. Soc. 9th Ann. Field Conf., p. 248-260.

———, 1941, Biotic analysis of Owen's Cedar Valley Limestone: Pan.-Am. Geologist, v. 75, p. 321-327.

———, 1944, The Devonian system in Iowa: Ill. Geol. Survey Bull. 68, p. 182-188.

———, 1950, Brachiopoda and stratigraphy of the Aplington Formation of northern Iowa: Jour. Paleontology, v. 24, p. 365-385, pls. 53-54.

Stauffer, C. R., and Thiel, G. S., 1941, The Paleozoic and related rocks of southeastern Minnesota: Minn. Geol. Survey Bull. 29, p. 1-261, figs. 1-62, pl. 1.

Tester, A. C., 1936, Water use and conservation in Iowa, v. 1, Iowa-Cedar River Basin, pt. 4, Underground Water Resources: Iowa State Planning Board, p. 53-71.

Theis, C. V., and others, 1963, Estimating the transmissibility of aquifers from specific capacity of wells: U.S. Geol. Survey Water-Supply Paper 1536-I, p. 331-341.

Upham, Warren, 1881, Report of progress in exploration of the glacial drift and its terminal moraines: Minn. Geol. Survey 9th Ann. Rpt., p. 281-356.

U.S. Public Health Service, 1962, Drinking water standards 1962: U.S. Public Health Service Pub. 956, 61 p.

Webster, C. L., 1889, A general preliminary description of the Devonian rocks of Iowa: Am. Naturalist, v. 23, p. 229-243.

White, C. A., 1870, Report on the Geological Survey of the State of Iowa: v. 2, p. 1-443, 5 pls., fig. 1-100.

Winchell, Alexander, 1899, Minnesota Geol. Survey, Final Report, v. 4, p. 1-24, 212-312, 358-398, 502-580.

Yoho, W. H., 1967, Preliminary report on basement complex rocks of Iowa: Iowa Geol. Survey Rpts. of Inv. 3, 19 p.

TABLE 9.—ANALYSES OF TYPICAL SURFACE AND

Dissolved Constituents Given in Milligrams Per

One milligram per liter is equivalent to one gram of substance per thousand liters of water, or approximately 8.33 pounds per million gallons of water. A milli-equivalent is a unit chemical equivalent weight of solute per liter of solution. Concentration in milli-equivalents is calculated by dividing the concentration in milligrams per liter by the chemical combining weight of the substance or ion. In concentrations of less than 7,000, milligrams per liter and parts per million are approximately equal.

Well Number	Date of Collection	Geologic Source	Depth (feet)	Temperature	Iron (Fe)	Manganese (Mn)
97-22-16H1	11-30-49	Pleistocene glacial drift	34	50 *10*	0.1	0.04
97-22-18H1	11-30-49	do	73	49 *9*	2.4	.28
97-22-26E1	11-30-49	Lime Creek	149	......	.6	0
97-20-33F1	10-29-37	Jordan	1,260	52 *11*	.4	Tr.
97-19-6R1	1-23-50	Shell Rock-Cedar Valley	208	50 *10*	.2	0
97-19-30R1	1-23-50	Pleistocene sand	16	......	.1	.06
97-19-30R3	1-23-50	Shell Rock	60	49 *9*	13.6	.03
96-22-22K1	10-16-39	Cedar Valley	302	49 *9*	.5	Tr.
96-21-5M1	12- 1-49	Pleistocene drift	103	......	3.4	.2
96-21-11K1, 11K2	12- 1-49	Shell Rock-Cedar Valley	330	......	.2	0
96-21-13M1	3-10-44	Shell Rock-Cedar Valley, Maquoketa	430	50 *10*	.60	0
96-20-3C1	3-18-37	Jordan	1,250	52 *11*	.2	Tr.
96-20-3F1	1-24-50	do	1,243	52 *11*	.4	0
96-20-3L1	1-24-50	do	1,230	52 *11*	.1	0
96-20-3L2	1-25-50	do	1,220	52 *11*	.5	0
96-20-3L2	6- 5-46	Dresbach[3]	1,525	52 *11*	.8	0
96-20-3L2	7-16-46	do	1,765	55 *13*	.5	0
96-20-3L3	1-25-50	Jordan	1,230	52 *11*	.1	0
96-20-3M1	9-17-38	St. Peter	840	53 *12*	2.0	0
96-20-3M1[5]	1-24-50	do	840	......	.65	.02
96-20-3P1	3-10-43	do	605	49 *9*	.1	0
96-20-7J1	1-24-50	Shell Rock-Cedar Valley	412	......	5	.02
96-20-9H1	1-24-50	do	464	50 *10*	.15	0
96-20-9H2	7-10-42	St. Peter	810	54 *12*	.1	0
96-20-10M2	10-23-37	Jordan	1,201	50 *10*	.3	0
96-20-10M3	1-25-50	Shell Rock-Cedar Valley	408	51 *11*	.1	0
96-20-10N1	1-24-50	St. Peter	815	50 *10*	.2	0
96-20-16J1	2-24-39	do	894[6]	......	.1	Tr.

GROUND WATERS IN CERRO GORDO COUNTY

Liter and in Milli-Equivalents (in italics)

Geologic Source: Principal water-bearing formation is given; water commonly is derived, also, from other formations in the uncased portion of the well.

Temperature: upper number in °F.; lower number (in italic) in °C.
pH: determination commonly made several days after collection of sample and so may not be identical with determinations made at the well.

Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	pH	Hardness (as $CaCO_3$) Total	Carbonate	Non-Carbonate	Electrical Conductivity (micromhos, at 25° C.)
99 *4.94*	40 *3.29*	12 *.52*	408 *6.69*	50 *1.04*	9.0 *.25*	0.2 *.01*	42 *.68*	520	7.5	412	335	77	1,120
79 *3.94*	25 *2.06*	9.1 *.40*	359 *5.88*	17 *.35*	2.0 *.06*	.2 *.01*	0 *0*	351	7.6	300	294	6	820
98 *4.89*	27 *2.22*	16 *.70*	488 *8.00*	4.1 *.09*	2 *.06*	.3 *.02*	0 *0*	414	7.4	356	356	0	720
85 *4.24*	29 *2.39*	35 *1.52*	400 *6.56*	51 *1.06*	8.0 *.23*	Tr. *0*	0 *0*	410	7.0	332	328	4	....
83 *4.09*	29 *2.39*	14 *.61*	393 *6.44*	20 *.42*	3 *.08*	.1 *.01*	0 *0*	351	7.3	327	322	5	632²
165 *8.23*	51 *4.19*	36 *1.57*	332 *5.44*	200 *4.16*	80 *2.26*	0 *0*	137 *2.21*	871	7.1	622	272	350	1,320
39 *1.95*	10.9 *.90*	12 *.52*	188 *3.08*	7.2 *.15*	2 *.06*	.4 *.02*	7.1 *.12*	152	7.4	168	154	0	298
68 *3.39*	24 *1.97*	29 *1.26*	393 *6.44*	8.2 *.17*	8.0 *.23*	1.3 *.07*	0 *0*	315	7.5	269	269	0	....
84 *4.19*	27 *2.22*	15 *.65*	429 *7.03*	11 *.23*	2.0 *.06*	.2 *.01*	0 *0*	394	7.4	325	325	0	641
80 *3.99*	40 *3.29*	23 *1.00*	461 *7.56*	5.6 *.12*	6.0 *.17*	1.6 *.08*	0 *0*	392	7.5	364	364	0	686
83 *4.14*	44 *3.62*	21 *.91*	486 *7.97*	4.1 *.09*	6.0 *.17*	1.3 *.07*	.2 *0*	374	7.5	388	388	0	....
84 *4.19*	28 *2.30*	37 *1.61*	386 *6.33*	57 *1.19*	20 *.56*	0 *0*	.9 *.01*	472	6.0	325	317	8	....
83 *4.14*	35 *2.88*	37 *1.61*	400 *6.56*	74 *1.54*	8 *.23*	.5 *.03*	0 *0*	438	7.4	351	328	23	770
84 *4.19*	31 *2.55*	36 *1.57*	395 *6.47*	73 *1.52*	7 *.20*	.5 *.03*	0 *0*	438	7.6	337	324	13	731
63 *3.14*	28 *2.30*	81 *3.52*	390 *6.39*	105 *2.19*	16 *.45*	1.0 *.05*	2.2 *.04*	516	7.7	273	273	0	851
13 *.65*	.6 *.05*	311 *13.52*	433³ *7.10*	265 *5.52*	53 *1.50*	3.4 *.18*	0 *0*	885	8.2	35	35	0	1,320
17 *.85*	5.9 *.49*	304 *13.22*	452⁴ *7.41*	262 *5.46*	55 *1.55*	3.6 *.19*	0 *0*	877	8.2	67	67	0	1,310
81 *4.04*	32 *2.63*	34 *1.48*	398 *6.52*	61 *1.27*	7 *.20*	.4 *.02*	0 *0*	416	7.2	334	326	8	709
84 *4.19*	30 *2.47*	35 *1.52*	408 *6.69*	41 *.85*	8.0 *.23*	Tr. *0*	0 *0*	398	7.0	333	333	0	....
93 *4.64*	29 *2.39*	31 *1.35*	386 *6.33*	77 *1.60*	21 *.59*	.3 *.02*	3.5 *.06*	450	7.2	352	316	36	755
97 *4.84*	44 *3.62*	30 *1.30*	405 *6.64*	126 *2.62*	21 *.59*	.0 *0*	Tr. *0*	660	7.0	423	332	91	....
81 *4.04*	38 *3.13*	29 *1.26*	456 *7.47*	17 *.35*	8 *.23*	1.2 *.06*	0 *0*	400	7.3	359	359	0	700
86 *4.29*	41 *3.37*	27 *1.17*	461 *7.56*	21 *.44*	11 *.31*	1.0 *.05*	0 *0*	408	7.2	384	378	6	733
146 *7.29*	4.2 *.35*	64 *2.78*	371 *6.08*	172 *3.58*	46 *1.30*	.0 *0*	.4 *.01*	709	7.7	382	304	78	....
87 *4.34*	34 *2.80*	30 *1.30*	420 *6.88*	76 *1.58*	15 *.42*	1.0 *.05*	.9 *.01*	408	6.9	357	344	13	....
85 *4.24*	43 *3.54*	26 *1.17*	420 *6.88*	69 *1.44*	21 *.59*	1 *.05*	.4 *.01*	520	7.3	389	344	45	783
153 *7.63*	59 *4.85*	45 *1.96*	403 *6.61*	291 *6.05*	64 *1.81*	.5 *.03*	0 *0*	882	7.2	625	330	295	1,230
79 *3.94*	40 *3.29*	35 *1.52*	386 *6.33*	103 *2.14*	16 *.45*	1.2 *.06*	3.5 *.06*	471	7.6	362	317	45	....

TABLE 9.—ANALYSES OF TYPICAL SURFACE AND

Well Number	Date of Collection	Geologic Source	Depth (feet)	Temperature	Iron (Fe)	Manganese (Mn)
96-20-16J1	4-13-39	Jordan	1,306	51 *11*	0.5	Tr.
96-20-16J2	11-20-47	do	1,377[2]	50 *10*	.11	0
96-20-16J2	9- 7-50	Jordan and Dresbach	1,677[6]	54 *12*	.1	0
96-20-17J1	9-16-37	Jordan	1,330	49 *9*	.9	Tr.
96-19-30D1	1-23-50	Shell Rock-Cedar Valley	246	......	.6	0
96-19-31P1	1-23-50	do	335	......	22	0
95-22-2Q1	12- 1-49	Pleistocene drift	70	51 *11*	6.0	.17
95-22-14R1	12- 1-49	Pleistocene gravel	86	49 *9*	1.0	0
95-22-16A1	12- 1-49	Shell Rock	202	50 *10*	4.5	0
95-21-22N1	12- 1-49	Lime Creek	100	50 *10*	1.3	0
95-21-32D1	12- 1-49	do	127	50 *11*	1.5	0
95-20-22D1	1-23-50	do	60	48 *9*	10.4	.03
95-19-4A1	1-23-50	Shell Rock-Cedar Valley	304	48 *9*	[1]	0
94-22-24J2	1- 9-41	Shell Rock	290	......	.6	0
94-22-27D1	1-25-50	Pleistocene gravel	21	50 *11*	2.4	.17
94-22-32N1	12- 1-49	Hamption(?)	129	50 *11*	1.9	0
94-21-10F1	12- 1-49	Shell Rock	128	......	.15	0
94-21-10R1	1-25-50	Lime Creek	47	......	[1]	.08
94-20-3G1	10-10-39	Shell Rock-Cedar Valley	462	......	.3	Tr.
94-20-3K2	6-30-34	Shell Rock	167	......	1.7	0
94-20-3P1	12- 1-49	Lime Creek Shell Rock-Cedar Valley	431	......	0	0
94-20-6N1	1-25-50	Pleistocene gravel	33	48 *9*	1.6	0
Clear Lake	6-30-34	Untreated water	....	......	1.8	0
Do	12- 1-49	do	....	......	.1	0
Do	12- 1-49	Treated water	....	......	0	0
Do	7- 6-50	Untreated water	....	......	.1	0
Do	9- 6-50	do	....	......	[1]	0

---

[1] Less than 0.1 milligrams per liter.
[2] Other water-bearing formations cased off.
[3] Includes equivalent of 12 milligrams per liter carbonate (CO_3).
[4] Includes equivalent of 22 milligrams per liter carbonate (CO_3).
[5] New well generally similar to old well.
[6] Sample collected by bailer during drilling.

GROUND WATERS IN CERRO GORDO COUNTY (Continued)

Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	pH	Hardness (as Ca CO_3)			Electrical Conductivity (micromhos, at 25° C.)
										Total	Carbonate	Non-Carbonate	
86 *4.29*	35 *2.88*	39 *1.70*	459 *7.52*	59 *1.23*	11 *.31*	1.0 *.05*	0 *0*	445	7.3	359	359	0	....
86 *4.29*	42 *3.45*	30 *1.30*	483 *7.92*	16 *.33*	9.3 *.26*	1.6 *.08*	1.2 *.02*	424	7.7	388	388	0	643
84 *4.19*	34 *2.80*	31 *1.35*	429 *7.03*	47 *.98*	7.0 *.20*	1.2 *.06*	0 *0*	430	7.6	350	350	0	717
79 *3.94*	40 *3.29*	22 *.96*	439 *7.19*	26 *.54*	11 *.31*	1.5 *.08*	0 *0*	417	6.9	362	360	2	....
81 *4.04*	36 *2.96*	23 *1.00*	429 *7.03*	31 *.65*	6 *.17*	.9 *.04*	0 *0*	379	7.3	351	351	0	688
71 *3.54*	37 *3.04*	25 *1.09*	442 *7.24*	11 *.23*	9 *.25*	1.4 *.07*	0 *0*	414	7.2	330	330	0	679
79 *3.94*	32 *2.63*	22 *.96*	429 *7.03*	8.6 *.18*	2.0 *.06*	.5 *.03*	0 *0*	353	7.6	329	329	0	638
66 *3.29*	29 *2.39*	23 *1.00*	417 *6.84*	2.7 *.06*	2 *.06*	.4 *.02*	0 *0*	348	7.5	284	284	0	621
89 *4.44*	34 *2.80*	34 *1.48*	532 *8.72*	4.1 *.09*	2 *.06*	.4 *.02*	0 *0*	449	7.4	362	362	0	782
84 *4.19*	21 *1.73*	16 *.70*	386 *6.33*	5.6 *.12*	1.0 *.03*	.3 *.02*	.9 *.01*	304	7.0	296	296	0	570
78 *3.89*	33 *2.71*	36 *1.57*	471 *7.72*	9.1 *.19*	2.0 *.06*	.6 *.03*	11 *.18*	416	7.6	331	331	0	698
74 *3.69*	30 *2.47*	28 *1.22*	449 *7.36*	6.4 *.13*	2 *.06*	.3 *.02*	0 *0*	388	7.2	308	308	0	665
67 *3.34*	36 *2.96*	15 *.65*	371 *6.08*	22 *.46*	7 *.20*	1.2 *.06*	7.1 *.12*	299	7.5	316	304	12	505
80 *3.99*	32 *2.63*	39 *1.70*	459 *7.52*	21 *.44*	9.0 *.25*	1.5 *.08*	0 *0*	393	7.2	332	332	0	....
95 *4.74*	30 *2.47*	18 *.78*	404 *7.01*	8 *.16*	1 *.03*	.4 *.02*	8.0 *.14*	413	7.3	361	361	0	670
91 *4.54*	32 *2.63*	29 *1.26*	481 *7.89*	8.0 *.16*	1.5 *.04*	.3 *.02*	.9 *.01*	434	7.5	359	359	0	1,030
106 *5.29*	40 *3.29*	18 *.78*	356 *5.84*	78 *1.62*	23 *.65*	.1 *.01*	55 *.89*	541	7.6	429	292	137	814
81 *4.04*	26 *2.14*	7.8 *.34*	342 *5.61*	12 *.25*	10 *.28*	.4 *.02*	11 *.18*	338	7.5	309	280	29	578
79 *3.94*	38 *3.13*	22 *.96*	461 *7.56*	9.4 *.20*	14 *.40*	2.0 *.11*	0 *0*	399	7.1	356	356	0	....
63 *3.14*	42 *3.45*	32 *1.39*	451 *7.39*	18 *.38*	12 *.34*	1.5 *.08*	.9 *.01*	384	7.2	330	330	0	....
80 *3.99*	38 *3.13*	27 *1.17*	434 *7.11*	27 *.56*	10.0 *.28*	2.0 *.11*	1.3 *.02*	419	7.5	356	356	0	1,020
67 *3.34*	22 *1.81*	5.8 *.25*	239 *3.92*	37 *.77*	5.0 *.14*	0 *0*	32 *.52*	304	7.5	258	196	62	490
18 *.90*	27 *2.22*	13 *.56*	142 *2.33*	20 *.42*	7.0 *.20*	1.0 *.05*	Tr. *0*	241	8.6	156	148	8	....
27 *1.35*	22 *1.81*	9.7 *.42*	171[9] *2.80*	19 *.40*	6.0 *.17*	.3 *.02*	0 *0*	220	8.0	158	140	18	328
32 *1.60*	21 *1.73*	14 *.61*	168[9] *2.75*	31 *.65*	10 *.28*	.25 *.01*	0 *0*	223	8.1	166	138	28	358
28 *1.40*	20 *1.65*	10.4 *.45*	171[10] *2.80*	15 *.31*	6.5 *.18*	.4 *.02*	0 *0*	220	8.5	152	140	12	303
24 *1.20*	20 *1.65*	12 *.52*	161[11] *2.64*	14 *.29*	6.5 *.18*	.4 *.02*	0 *0*	206	8.2	142	132	10	292

---

[7] Well penetrated to base of St. Lawrence Formation.

[8] Well penetrated to base of Dresbach Group.

[9] Includes equivalent of 4.8 milligrams per liter carbonate (CO_3).

[10] Includes equivalent of 9.6 milligrams per liter carbonate (CO_3).

[11] Includes equivalent of 3.6 milligrams per liter carbonate (CO_3).

TABLE 10.—LOGS OF SELECTED WELLS

The locations of these wells are shown on plate 1 or figure 10. Similar records of other wells in the county are available in the files of the Iowa Geological Survey at Iowa City.

94-22-32M1. Sample log of Meservey city well drilled in 1957 by Thorpe Well Company. Samples studied by R. C. Northup and D. L. Koch.

	Thickness (feet)	Depth (feet)
Quaternary System		
Pleistocene Series		
Loess, grayish-yellow, calcareous	5	5
No sample	5	10
Till, gray	25	35
No sample	5	40
Till, yellow	60	100
Mississippian System		
Kinderhook Series		
Hampton Formation		
Dolomite, cherty	10	110
Dolomite	10	120
Dolomite and limestone	10	130
Devonian System		
Upper Devonian Series		
Aplington Formation		
Dolomite, light gray	5	135
Dolomite, buff, cherty	15	150
Sheffield Formation		
Dolomite, tan to brown, calcareous	30	180
Dolomite, gray; and gray shale	5	185
No sample	5	190
Dolomite, light gray	10	200
Dolomite, light gray to brown	5	205
Lime Creek Formation		
Dolomite, brown, calcareous	10	215
Limestone, buff; and dark brown dolomite	10	225
Dolomite, dark brown	10	235
Dolomite, light gray	5	240
Shale, light gray	25	265
Dolomite, brown	10	275
Dolomite, gray; and gray shale	5	280
Dolomite, gray to brown	20	300
Dolomite, gray; and light gray shale	15	315
Shale, light gray; and some dolomite	20	335
Cedar Valley Limestone		
Limestone, light gray to tan	20	355
Dolomite, buff to brown	60	415
Dolomite, buff to brown; and buff limestone	5	420
Dolomite, buff to brown	153	573

96-20-3L2. Sample log of city well No. 8 at Mason City in the NW¼NW¼ NE¼SW¼ sec. 3, T. 96 N., R. 20 W. Deepened 1,219 to 1,765 feet by Thorpe Well Company in 1946. Surface altitude, 1,098.3. Samples studied by S. E. Harris.

	Thickness (feet)	Depth (feet)
Cambrian System		
Jordan Sandstone		
No samples	6	1,225
St. Lawrence Formation		
Dolomite (35 percent), yellowish-gray, fine; sandstone (65 percent), white, fine to medium, subangular to rounded, with pyrite	5	1,230
Dolomite (75 percent), as above; sandstone (25 percent), as above, glauconite	15	1,245
Dolomite (80 percent), as above, but sandy and glauconitic; sandstone (20 percent), fine	15	1,260
Dolomite, light brown with gray spots, fine to medium, sandy	10	1,270
Dolomite, light to medium brown, fine to medium, porous, with glauconite	15	1,285
Dolomite, light brown, fine, slightly silty, with much glauconite	25	1,310
Dolomite, brownish-yellow, fine, silty, with glauconite	5	1,315
Dolomite, light yellowish-gray, fine, slabby, scattered glauconite	10	1,325
Franconia Sandstone		
Dolomite (40 percent), as above; siltstone (60 percent), drab, dolomitic, very glauconitic	10	1,335
Dolomite (20 percent), as above; siltstone (80 percent), yellowish-drab, dolomitic, micaceous and glauconitic	40	1,375
Siltstone (20 percent), as above; shale (80 percent), light gray, fissile, trace pink, with dark mica	15	1,390
Shale, as above, with 0 to 10 percent gray silty dolomite, very glauconitic and micaceous	35	1,425
Dolomite (20 to 50 percent), light yellow to pinkish, fine to medium, very glauconitic and micaceous	16	1,441
Sandstone, yellowish-gray, medium to coarse, subround to angular, dolomitic, with glauconite and black fossil fragments (Ironton member)	19	1,460
Dresbach Group		
Sandstone, very light gray, well sorted, fine to medium, subangular to round	32	1,492
Sandstone, fine to medium, angular to subangular, dolomitic, with quartz and glauconite	43	1,535
Dolomite (50 percent), grayish-brown, fine to medium, dense; siltstone, tan, with glauconite	10	1,545
Precambrian or Cambrian Systems		
Dolomite, buff to grayish-brown, fine to medium, pinkish coating on fragments	25	1,570

	Thickness (feet)	Depth (feet)
Dolomite (30 percent), as above; shale (70 percent), silty, dolomitic, sandy, with trace igneous minerals and fossil fragments	5	1,575
Dolomite (10 percent), as above; shale (90 percent), pinkish-brown, silty, with trace igneous or metamorphic minerals	65	1,640
Shale, brick red, silty, slightly dolomitic	20	1,660
Siltstone, red, argillaceous	15	1,675
Shale, red, silty with phosphatic fragments	15	1,690
Siltstone, red, argillaceous, with angular quartz sand	8	1,698
Precambrian System		
Igneous or metamorphic rock, dark greenish-gray, with hornblende, chlorite, feldspar; may be schist or phyllite	67	1,765

96-20-10N1. Sample log of Swift and Company well at Mason City in the SW¼NW¼SW¼SW¼ sec. 10, T. 96 N., R. 20 W. Drilled to 460 feet by Sharff in 1938; deepened to 815 feet by Hoeg and Ames in 1926. Surface altitude, 1,105 feet. Samples studied by M. C. Parker.

	Thickness (feet)	Depth (feet)
Quaternary System		
Pleistocene Series		
No samples	35	35
Devonian System		
Shell Rock Formation		
Dolomite, light to medium gray-brown, crystalline, pyrite, calcite crystals	5	40
Dolomite, medium gray, mottled, coarsely crystalline, pyrite, calcite rhombs	5	45
Limestone, pale drab to medium gray, lithographic to very fine crystalline, pyrite, calcite rhombs	10	55
Limestone, as above except slightly dolomitic, brachiopods	10	65
Limestone, gray and brown, fine to medium crystalline, dolomitic	5	70
Limestone (40 percent), beige, finely crystalline; shale (60 percent), green, laminated, calcareous, crinoid columnals	5	75
Cedar Valley Limestone		
Limestone (70 percent), beige to gray, finely crystalline; dolomite (20 percent), dark gray to brown, crystalline to dense; shale (10 percent), as above, with calcite rhombs	5	80
Limestone (78 percent), as above; dolomite (22 percent), as above; pyrite, calcite rhombs	5	85
Limestone (50 percent), as above; dolomite (50 percent), as above; pyrite, calcite rhombs	5	90
Dolomite (75 percent), light brown, fine to medium crystalline; shale (25 percent), green, laminated, dolomitic; pyrite	5	95
Dolomite, as above, with pyrite and calcite rhombs	5	100
Dolomite, light tan to gray, medium to coarsely crystalline, pyrite, calcite rhombs	5	105
Dolomite (80 percent), as above; shale (20 percent), dark green, laminated, unctuous dolomitic	5	110
Dolomite, brown and gray, medium to coarsely crystalline	5	115
Dolomite (80 percent), as above; shale (20 percent), gray and brown, laminated; pyrite, calcite rhombs	10	125

	Thickness (feet)	Depth (feet)
Dolomite (70 percent), brown, medium crystalline to subsaccharoidal; limestone (20 percent), cream, very fine; pyrite, calcite rhombs; shale (10 percent), as above	5	130
Dolomite (90 percent), brown, medium crystalline, calcareous; shale (10 percent), as above	5	135
Dolomite (60 percent), beige to gray, crystalline, calcareous; shale (40 percent), brown laminated, sandy	5	140
Dolomite (80 percent), as above; shale (20 percent), as above; calcite rhombs	5	145
Dolomite (70 percent), as above; shale (30 percent), as above; calcite rhombs	5	150
Dolomite (80 percent), gray and beige, finely granular, calcareous; dolomite (20 percent), brown, crystalline	5	155
Dolomite, brown and dark gray, finely granular to crystalline	5	160
Dolomite, brown and dark gray, finely granular to subsaccharoidal	5	165
Dolomite, as above, calcite rhombs	5	170
Dolomite, drab to gray, coarsely crystalline, dense, granular	10	180
Dolomite, brown and gray, crystalline, dense	5	185
Dolomite (90 percent), as above; shale (10 percent), gray-green, dolomitic	10	195
Dolomite, tan and gray, finely granular to lithographic	5	200
Dolomite (70 percent), tan, lithographic; limestone (30 percent), gray, argillaceous, finely granular	5	205
Dolomite (70 percent), tan to brown, crystalline; limestone (30 percent), gray, finely granular; calcite rhombs	5	210
Dolomite, drab-brown, crystalline, dense, pyrite, calcite rhombs	5	215
Dolomite (90 percent), as above; shale (10 percent), green, laminar, unctuous	5	220
Dolomite, tan to brown, granular to subsaccharoidal, calcite rhombs	10	230
Dolomite (70 percent), light brown, crystalline; shale (30 percent), light gray, very fine, soft, dolomitic	5	235
Dolomite (70 percent), as above; limestone (30 percent), gray, finely granular	5	240
Dolomite, tan and brown, crystalline, calcareous	5	245
Dolomite, gray, very finely granular; dolomite, light medium brown, finely crystalline; calcite rhombs	5	250

	Thickness (feet)	Depth (feet)
Dolomite, medium gray, finely granular, silty, slightly calcareous	5	255
Dolomite (70 percent), as above; shale (30 percent), gray, lumpy, dolomitic	5	260
Dolomite, light medium gray, finely crystalline, embedded sand	5	265
Dolomite, as above, pyrite, calcite rhombs	5	270
Dolomite (60 percent), as above; dolomite (40 percent), tan to light brown, medium crystalline	10	280
Dolomite, light medium gray, finely granular, embedded sand	5	285
Dolomite, medium gray, fine, argillaceous	25	310
Dolomite, as above; dolomite, light drab to gray and brown, dense, medium crystalline	22	332
Limestone, light to drab gray, fine to medium crystalline, silty, calcite rhombs	8	340
Ordovician System		
Cincinnatian Series		
Maquoketa Formation		
Dolomite (70 percent), light drab, finely to coarsely crystalline; limestone (30 percent), tan, mottled, crystalline	5	345
Dolomite, as above	5	350
Dolomite, drab to light gray, coarsely crystalline, dense	5	355
Dolomite, as above, crinoid columnal	5	360
Dolomite, light gray, coarsely crystalline, porous	5	365
Dolomite, light to dark gray and brown, coarsely crystalline, porous	5	370
Dolomite (70 percent), as above; chert (30 percent), dull white and gray, opaque, conchoidal; calcite rhombs	5	375
Dolomite (30 percent), light to medium gray, medium to coarsely crystalline, dense; chert (70 percent), as above	7	382
Dolomite (20 percent), as above; chert (80 percent), dull white and gray, granular to conchoidal, black specks	5	387
Dolomite (30 percent), as above; chert (70 percent), as above; pyrite	4	391
Dolomite (20 percent), as above; chert (80 percent), light gray, opaque, black specks	4	395
Dolomite (20 percent), medium gray, crystalline; chert (80 percent), as above and granular	5	400

	Thickness (feet)	Depth (feet)
Dolomite (25 percent), tan, coarsely crystalline; chert (75 percent), as above	5	405
Dolomite (40 percent), light gray, crystalline; chert (60 percent), light gray, dull, conchoidal, pyrite	10	415
Dolomite (50 percent), light to drab gray, crystalline, dense; chert (50 percent), as above; pyrite, calcite rhombs	5	420
Dolomite (70 percent), as above; chert (30 percent), as above	5	425
Dolomite (85 percent), light medium gray and brown, medium crystalline, granular, pyrite; chert (15 percent), as above; crinoid columnals	5	430
Dolomite (95 percent), as above; chert (5 percent), as above; pyrite	4	434
Dolomite (90 percent), light medium gray-brown, medium to coarsely crystalline; chert (10 percent), as above	4	438
Dolomite, as above	4	442
Dolomite, beige to gray, medium to coarsely crystalline, pyrite, calcite rhombs	8	450
No sample	10	460
Mohawkian Series		
Galena Formation		
Limestone, light beige-gray, finely crystalline, embedded dolomite crystals, pyrite	10	470
Limestone, beige, finely to coarsely crystalline, pyrite, cinnamon specks	10	480
Limestone, cream beige, coarsely crystalline, dolomitic, pyrite; trace chert	10	490
Dolomite, light beige, coarsely crystalline, porous	10	500
Limestone (85 percent), cream-beige, coarsely crystalline, dolomitic; chert (15 percent), dull white and gray, opaque, conchoidal	10	510
Dolomite, light tan, coarsely crystalline calcareous, pyrite	10	520
Dolomite, beige-gray, medium crystalline, argillaceous	10	530
Dolomite, cream and beige, fine to medium crystalline, argillaceous	10	540
Dolomite, as above, porous; chert, trace, white, opaque, conchoidal	10	550
Dolomite (95 percent), light gray, mottled black, medium crystalline, porous; chert (5 percent), white with black spots, opaque, conchoidal	10	560

	Thickness (feet)	Depth (feet)
Dolomite (95 percent), beige-tan, medium crystalline, porous; chert (5 percent), as above	10	570
Dolomite (55 percent), light drab, medium crystalline; limestone (30 percent), pale to light gray, mottled black; chert (15 percent), dull, gray, opaque, conchoidal to rough	10	580
Limestone (70 percent), light gray, soft, embedded dolomite rhombs; dolomite (25 percent), as above; chert (5 percent), as above; crinoid columnals, pyrite	10	590
Limestone, light gray to cream, mottled black (fossil fragments?), dolomite rhombs, pyrite	10	600
Limestone, light drab, fine to medium crystalline, dolomite, pyrite, calcite rhombs	10	610
Limestone, pale to light gray, mottled black, fine to medium crystalline, dolomitic, pyrite, calcite rhombs, fossil fragments	10	620
Limestone, light to dark gray, mottled black, dolomitic, fossil fragments	10	630
Limestone, light to dark gray-brown, embedded dolomite rhombs, pyrite, calcite rhombs	10	640
Limestone, cream to beige, embedded dolomite rhombs, soft, pyrite, calcite rhombs, fossil fragments	10	650
Limestone, as above; limestone, light gray, mottled black, medium crystalline, pyrite, calcite rhombs, fossil fragments	10	660
No sample	5	665
Decorah Formation		
Shale (70 percent), light gray-green, soft, waxy, fissile, calcareous; limestone (30 percent), tan, crystalline; bryozoans	5	670
Shale (80 percent), as above; limestone (20 percent), as above, abundant bryozoans and crinoid columnals, pyrite	10	680
Shale (90 percent), as above; limestone (10 percent), as above; crinoid columnals, bryozoans, brachiopod fragments, pyrite	10	690
Shale, dark green, lumpy, waxy, brittle, pyrite, fossils as above	10	700
Platteville Formation		
Shale, dark green, laminated, waxy, non-calcareous, bryozoa; limestone, as above, trace	10	710
Shale (90 percent), as above and brown; limestone (10 percent), light gray and tan, finely crystalline; pyrite, bryozoans	10	720

	Thickness (feet)	Depth (feet)
Limestone (70 percent), light medium gray-brown, mottled, finely crystalline, dense, pyrite, calcite rhombs; shale (30 percent), as above	10	730
Shale (75 percent), dark green, laminar, slightly calcareous; limestone (25 percent), light brown, coarse, embedded sand, finely crystalline; abundant siderite and phosphatic pebbles	13	743
Chazyan Series		
St. Peter Sandstone		
Sandstone (85 percent), coarse to medium, frosted, finely pitted; shale (15 percent), as above	7	750
Sandstone, coarse and medium (60 percent), fine (40 percent), frosted, pyrite	10	760
Sandstone, as above, coarse and medium (40 percent), fine (60 percent), pyrite	10	770
Sandstone, as above, coarse and medium (30 percent), fine and very fine (70 percent)	10	780
Sandstone, as above, coarse and medium (40 percent), fine and very fine (60 percent)	10	790
Sandstone, as above, coarse and medium (20 percent), fine and very fine (80 percent)	10	800
Sandstone, as above, coarse and medium (10 percent), fine and very fine (90 percent)	10	810
Sandstone, as above, coarse and medium (30 percent), fine and very fine (70 percent)	5	815

96-20-16J2. Sample log of city well No. 12 at Mason City in the NW¼ SE¼ sec. 16, T. 96 N., R. 20 W. Drilled by Layne-Western Company, Inc., in 1947. Surface altitude, 1,163.9 feet. Samples studied by R. W. Screven.

	Thickness (feet)	Depth (feet)
Record essentially similar to that of well 96-20-10N1	885	885
Ordovician System		
Prairie du Chien Formation		
Dolomite, sublithographic to medium, grayish-white to brown, very slightly sandy	10	895
Dolomite, as above, but light brown to gray	10	905
Dolomite, as above, but cream to light gray	20	925
Dolomite (40 percent), as above; sandstone (60 percent), fine to medium	5	930
Dolomite, cream to buff, fine, very sandy	15	945
Dolomite, buff, fine to medium, sandy	15	960
Dolomite (60 percent), as above; sandstone (40 percent), fine, with few dolomite oolites	15	975
Dolomite, cream, fine to medium, sandy; chert (10 percent), white, tripolitic	5	980
Dolomite, as above, but grading downward to dolomitic sandstone	20	1,000
Dolomite (20 percent), cream, oolitic; sandstone (80 percent), fine to medium, dolomitic	15	1,015
Sandstone (60 percent), as above; chert (40 percent), white tripolitic, with quartz crystals	10	1,025
Sandstone, as above, but very dolomitic; chert, trace, as above	5	1,030
Dolomite, buff to cream, medium, slightly sandy	15	1,045
Dolomite, grayish-white to buff, medium, sandy	10	1,055
Dolomite (80 percent), as above; limestone (20 percent), white chalky, with quartz crystals	5	1,060
Dolomite, very siliceous, with quartz fragments and crystals	5	1,065
Dolomite, grayish-white, fine to medium, chert (10 percent), light gray, granular; quartz, as above	15	1,080
Dolomite, as above; chert (10 percent), white to quartzose, one sample	35	1,115
Dolomite, cream, fine to medium; trace chert as above; trace sand, fine to coarse, rounded	15	1,130
No samples	25	1,155
Dolomite, as above, with traces sand and quartzose chert	48	1,203

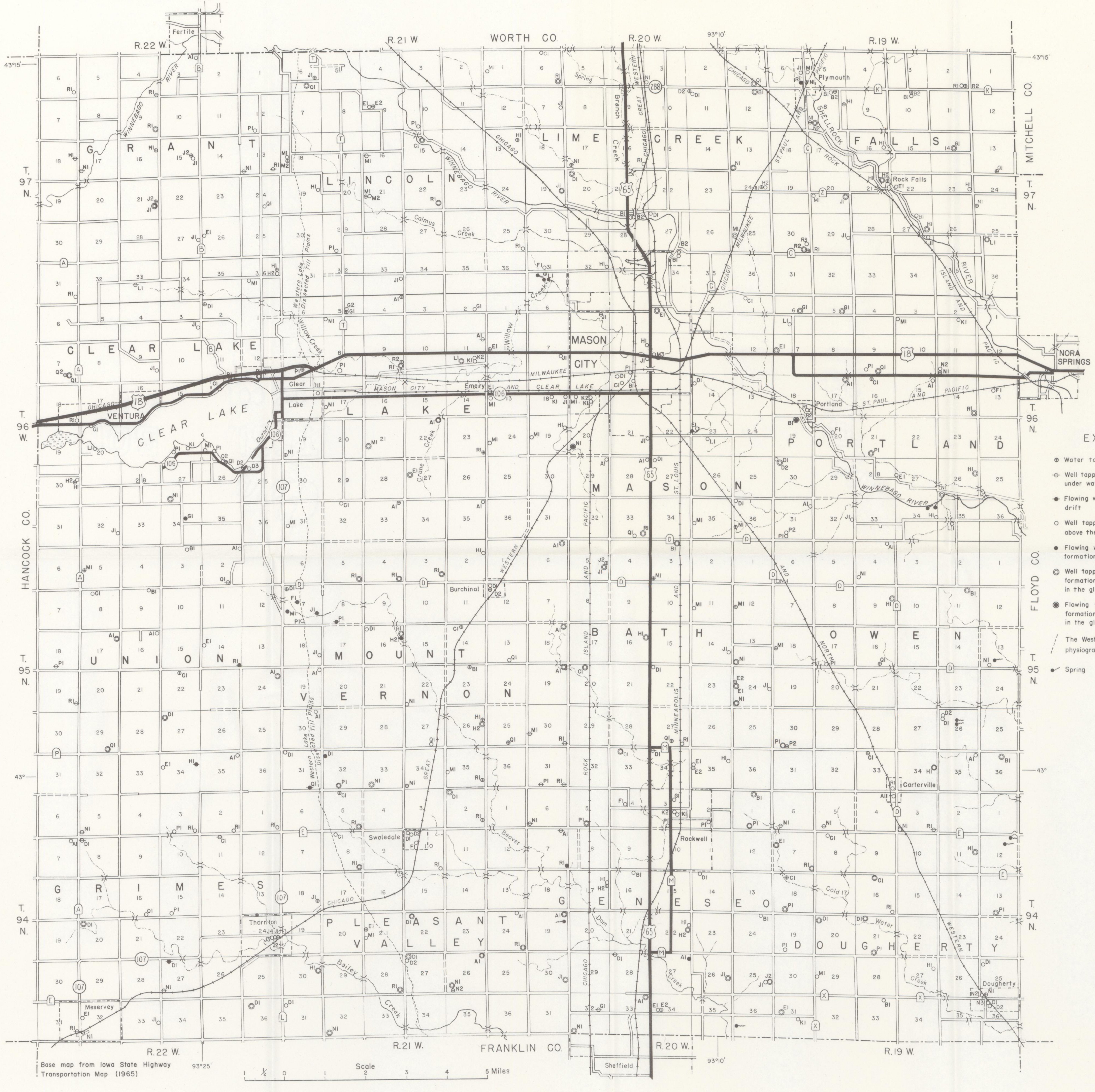
	Thickness (feet)	Depth (feet)
Dolomite (70 percent), as above; limestone (30 percent), white, chalky, soft	7	1,210
Dolomite (60 percent), as above; sandstone (40 percent), fine to medium	5	1,215
Cambrian System		
Jordan Sandstone		
Sandstone, medium to coarse, subrounded to rounded, frosted grains	60	1,275
St. Lawrence Formation		
Dolomite (40 percent), gray, mottled, silty, with glauconite; sandstone (60 percent), fine to medium, with pyrite	10	1,285
Dolomite, buff to brownish-gray, fine to medium, with pyrite	10	1,295
Dolomite, as above, with black mottling	15	1,310
Dolomite (60 percent), light brown to gray, fine to medium, slightly silty, very glauconitic; limestone (40 percent), buff, fine to lithographic, with pyrite	25	1,335
Limestone, white to light brown, lithographic to medium, silty, very glauconitic, dolomitic	15	1,350
Dolomite, light brown to gray, fine to medium, silty, very glauconitic	10	1,360
Dolomite (80 percent), as above; shale (20 percent), green, clayey, with black fossil fragments	5	1,365
Dolomite, as above	12	1,377
Franconia Sandstone		
Dolomite (20 percent), as above; sandstone (80 percent), clear to frosted angular to subrounded	8	1,385
Dolomite (50 to 80 percent), gray, mottled, silty, glauconitic; sandstone (20 to 50 percent), clear to frosted, subrounded to rounded	20	1,405
Dolomite (40 to 70 percent), cream to light gray, fine, glauconitic; sandstone (10 to 30 percent), as above; shale (10 to 30 percent), greenish-gray, soft, with mica and pyrite	20	1,425
Dolomite and sandstone (30 percent), as above; shale (70 percent), as above and slightly calcareous	40	1,465
Limestone grading to dolomite (50 percent), white to brown, fine to medium, glauconitic; trace subrounded frosted sand; shale (50 percent) as above	15	1,480
Dolomite (80 percent), buff to mottled brown, medium to coarse; sandstone (20 percent), medium to fine dolomitic, glauconitic	10	1,490

	Thickness (feet)	Depth (feet)
Dolomite (20 percent), as above; sandstone (80 percent), clear and frosted, angular to rounded, mostly medium to coarse	10	1,500
Sandstone, as above	10	1,510
Dresbach Group		
Sandstone, clear and frosted mostly fine to medium, subangular to subround	50	1,560
Sandstone, gray, dolomitic, with quartz fragments	8	1,568
Precambrian System		
Igneous or metamorphic red, green, and dark minerals	17	1,585

96-21-13M1. Sample log of Mason City Hemp Mill well near Emery in the NW¼NW¼SW¼ sec. 13, T. 96 N., R. 21 W. Drilled by Bert Sharff in 1943. Surface altitude, 1,170 feet. Samples studied by Harris and Jeffords.

	Thickness (feet)	Depth (feet)
Quaternary System		
Pleistocene Series		
Till, light gray, slightly oxidized, unleached	5	5
Till, buff to yellow, oxidized, unleached	5	10
Till, buff, as above, but more pebbly	7	17
Gumbotil, light gray, compact	3	20
Devonian System		
Lime Creek Formation		
Dolomite, yellowish-brown, calcareous, finely crystalline, oxidized	10	30
Dolomite, light medium gray, finely to medium crystalline to granular	10	40
Shale, light gray, clayey, soft, calcareous	10	50
Shale (90 percent), as above; dolomite (10 percent), gray, argillaceous, fine	10	60
Shale (75 percent), as above; dolomite (25 percent), as above	20	80
Shell Rock Formation		
Dolomite, light gray, dense, with pyrite	10	90
Dolomite, dark brown, fine to medium crystalline, hard, with pyrite	10	100
Dolomite (90 percent), buff, fine to medium crystalline; limestone (10 percent), very light gray, dense; with calcite rhombs	10	110
Dolomite, light and medium gray, fine to sublithographic, silty	10	120
Limestone, light brown, fine; with abundant calcite rhombs, crinoid columnals, and pyrite	20	140
Dolomite, brown, finely crystalline; with trace of soft, green, non-calcareous shale	20	160
Cedar Valley Limestone		
Dolomite (55 percent), as above; and light tan, finely crystalline	10	170
Dolomite (60 percent), tan as above; limestone 40 percent), very light brown, finely crystalline	10	180
Dolomite, light gray, calcareous, argillaceous, fine to medium	20	200

	Thickness (feet)	Depth (feet)
Dolomite, buff, fine, porous; and sublithographic, tan, stylolitic	10	210
Dolomite (80 percent), as above; shale (20 percent), gray, hard, blocky, calcareous	10	220
Dolomite (90 percent), gray to buff, fine to dense; shale (10 percent), as above, with medium, subrounded, frosted embedded sand grains	10	230
Dolomite, as above, but silty and calcareous	10	240
Dolomite, dark brown, fine, porous, calcite rhombs; with trace of silty shale and frosted fine sand	30	270
Dolomite, as above, grading to sublithographic	50	320
Limestone, tan, sublithographic	10	330
Dolomite (80 percent), gray, finely crystalline, silty; chalcedony (20 percent), pale gray, tripolitic to fresh, grading to vitreous quartz	20	350
Dolomite, light medium gray, finely crystalline, argillaceous, pyrite	10	360
Dolomite, as above, with trace very light gray speckled and white chert	10	370
Dolomite, as above, but without chert	30	400
Dolomite, as above, with trace chert	10	410
Ordovician System		
Maquoketa Formation		
Dolomite, light gray, dense, soft, very argillaceous	10	420
Limestone, pale yellow to gray, finely to medium crystalline, slightly argillaceous	10	430



EXPLANATION

- ⊕ Water table well
- Well tapping water in the glacial drift either under water table or artesian conditions
- ● Flowing wells tapping water in the glacial drift
- ○ Well tapping water in the bedrock formations above the Maquoketa Formation
- ● Flowing well tapping water in the bedrock formation above the Maquoketa Formation
- ◎ Well tapping water either in the bedrock formations above the Maquoketa Formation or in the glacial drift, or both
- ◉ Flowing well tapping water in the bedrock formations above the Maquoketa Formation or in the glacial drift
- The Western Lake and Dissected Till Plains physiographic boundary
- Spring

MAP OF CERRO GORDO COUNTY, IOWA, SHOWING PHYSIOGRAPHIC DIVISIONS AND LOCATION OF WELLS ENDING ABOVE THE MAQUOKETA FORMATION