COOPERATIVE GROUND-WATER REPORT I
Urbana, Illinois 1959

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William C. Ackermann, Chief

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Preliminary Report on GROUND-WATER RESOURCES OF THE CHICAGO REGION, ILLINOIS

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Printed by Authority of the State of Illinois

FOREWORD

This report initiates a joint series of publications designed to present results of ground-water resource investigations carried on cooperatively by the State Water Survey and the State Geological Survey. It is indeed fitting that the first in this series deals with the ground-water resources of the Chicago region in Illinois. Within this part of Illinois there occurs not only the greatest concentration of people and of industries, but also the largest withdrawals of ground water in relation to area.

It should be pointed out that this report presents preliminary findings based largely on data collected independently by the two Surveys over a period of several decades. The urgent need for continuing integrated research on ground-water resources of this region is clearly apparent, and, within the limitations of their financial resources, the Geological and Water Surveys are planning to carry forward a series of such joint studies.

It also is anticipated that cooperative studies already started or in the planning stage for other parts of the state will result in reports in this new series, with the ultimate objective of a satisfactorily thorough knowledge of the ground-water resources of all parts of Illinois.

WILLIAM C. ACKERMANN .
Chief, Illinois State Water Survey

JOHN C. FRYE
Chief, Illinois State Geological Survey

CONTENTS

ILLUSTRATIONS

FIGURE PAGE

TABLES

TABLE PAGE

PRELIMINARY REPORT ON

GROUND-WATER RESOURCES OF THE CHICAGO REGION, ILLINOIS

MAX SUTER, ROBERT E. BERGSTROM, H. F. SMITH,
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ABSTRACT

The purpose of this study was to make an evaluation of the ground-water resources of the Chicago region on the basis of available data. Such an evaluation is particularly urgent at this time due to the progressively increasing demands for water supplies and the continuing decline of water levels in some aquifers.

Ground-water resources in the Chicago region of Illinois are developed from four water-yielding units: 1) glacial drift aquifers; 2) shallow dolomite aquifers; 3) Cambrian-Ordovician Aquifer; and 4) the Mt. Simon Aquifer.

The Cambrian-Ordovician Aquifer has been the most highly developed source of large ground-water supplies. Its estimated yield in 1958 of more than 43 million gallons a day (mgd) approaches the amount that can be withdrawn without dewatering the Ironton-Galesville Sandstone, the lowermost and most productive formation in the aquifer. Artesian pressure in the Cambrian-Ordovician Aquifer at Chicago has declined as much as 660 feet since 1864 as a result of pumpage.

The glacial drift and shallow dolomite aquifers yielded more than half of the 127.9 mgd of ground water pumped in the region in 1957. This withdrawal resulted in no general decline in nonpumping water levels, indicating that the potential yield is considerably larger than present withdrawal. Future ground-water supplies should be taken from the shallow aquifers wherever possible.

SUMMARY

The Chicago region as defined in this report consists of Cook, DuPage, Kane, Kendall, Lake, McHenry, and a portion of Will and Grundy Counties of northeastern Illinois. The region is the most densely populated and heavily industrialized area in Illinois. Compared to the state as a whole, the region contains only 7.5 percent of the land area but has 61.3 percent of the population. It has been one of the most favorable ground-water areas in the state. However, the tremendous industrial and municipal growth in the region has brought about local problems of water supply.

Some 110 municipalities not served by water from Lake Michigan obtain supplies from wells. Many industries, including a large number of plants within the area served by Lake Michigan water, have private wells and use ground water for processing and cooling.

Ground-water resources in the region are developed from four aquifer systems: 1) sand and gravel deposits of the glacial drift; 2) shallow dolomite formations, mainly of Silurian age; 3) Cambrian-Ordovician Aquifer, of which the Ironton-Galesville and Glenwood-St. Peter Sandstones are the most productive formations; and 4) the Mt. Simon Aquifer, consisting of the sandstone of the Mt. Simon and lower Eau Claire Formations of Cambrian age.

Unconsolidated deposits, mainly glacial drift, ranging in thickness from a foot or less to more than 400 feet, overlie the. bedrock in the Chicago region. Water-yielding sand and gravel deposits locally occur in the drift, particularly in valleys cut in the bedrock.

Silurian age dolomite, which is widely used as a source of ground water, is the uppermost bedrock formation in most of the region. The bedrock formations dip slightly-south of east at a rate of about 10 feet per mile. They are warped into minor folds and at some places are faulted. There is no indication that the folds or faults act as barriers to the regional movement of ground water. .

The glacial drift and shallow dolomite aquifers are connected hydrologically and are separated from the Cambrian-Ordovician Aquifer in most of the region by the Maquoketa Formation, mainly shale, of Ordovician age. The relatively impermeable parts of the Eau Claire Formation separate the Cambrian-Ordovician from the Mt. Simon Aquifer.

Pumpage in the region in 1957 was 127.9 million gallons per day (mgd) of which 72.4 mgd were from deep wells penetrating the Cambrian-Ordovician Aquifer and, locally, the Mt. Simon Aquifer, 41.2 mgd were from wells finished in the shallow dolomite, and 14.2 mgd were from wells finished in the glacial drift. It was estimated that about 27 percent of the water pumped from deep wells comes from the shallow dolomite or glacial drift aquifers, thus making the present yield of the shallow aquifers about 60 percent of the total pumpage in the region.

The Cambrian-Ordovician Aquifer has been the most highly developed aquifer for large ground-water supplies in the Chicago region and is considered in most detail in this report. Artesian pressure in the aquifer at Chicago has declined as much as 660 feet since 1864 to a low of 50 feet above sea level, an average rate of decline of about seven feet per year. There are now six pro-

nounced cones of depression in the region. Little decline has occurred west of the border of the Maquoketa Formation, and the presence there of a hydrologic connection between the Cambrian-Ordovician Aquifer and the shallow aquifers is indicated. A large part of the recharge to the Cambrian-Ordovician Aquifer is from this area. This is further substantiated by the low temperature and low sulfate content of water from the Cambrian-Ordovician Aquifer in the area. This part of the Chicago region is the most favorable for further development of deep wells.

Data from 63 pumping tests were analyzed to determine the hydraulic properties of the Cambrian-Ordovician Aquifer. The average coefficient of transmissibility was determined to be 17,400 gallons per day per foot. Coefficients of transmissibility decrease to the southeast. A coefficient of storage of 0.0006 applies for periods of pumping involving several years or more.

In making estimates of future water levels in the Cambrian-Ordovician Aquifer, a recharge boundary 47 miles west of Chicago and two barrier boundaries, one 37 miles east, and one 60 miles south of Chicago, were assumed. It was estimated that the practical sustained yield of the aquifer is about the present rate of withdrawal.

Based on the assumption that total pumpage from deep wells will increase to about 92 mgd in 1980, water levels will decline at Chicago to an elevation of about 250 feet below sea level, which will be sufficient to dewater much of the upper part of the Cambrian-Ordovician Aquifer. Predictions of future water levels are based in part on extrapolations of past ground-water use in the region. Future conditions may vary from the general findings of the report in local areas where the distribution and rates of pumping are not as assumed.

The Mt. Simon Aquifer contains water that is under greater artesian pressure but is more highly mineralized than water in the Cambrian-Ordovician Aquifer. Proper plugging of abandoned deep wells to prevent upward movement of the water from the Mt. Simon Aquifer is necessary to protect the highly developed Cambrian-Ordovician Aquifer.

Hydrographs indicate no general or permanent decline in water levels in wells finished in the shallow aquifers. The fact that there has been no water-level decline even in the areas of heaviest pumpage indicates that the potential yield of the shallow aquifers probably is considerably larger than the present withdrawal of more than 75 mgd. Therefore the shallow aquifers are the most likely sources to investigate for additional ground-water supplies. Additional study is necessary to delineate favorable areas for further ground-water development and to determine the potential yield of the shallow aquifers.

The temperature of water from the shallow aquifers averages 51.6° F. The hardness of the water ranges from less than 100 parts per million (ppm) to more thau 1000 ppm.

The temperature of water from the Cambrian-Ordovician Aouifer ranges from about 53° F. in the western part of the region to about 62° F. in the eastern part.

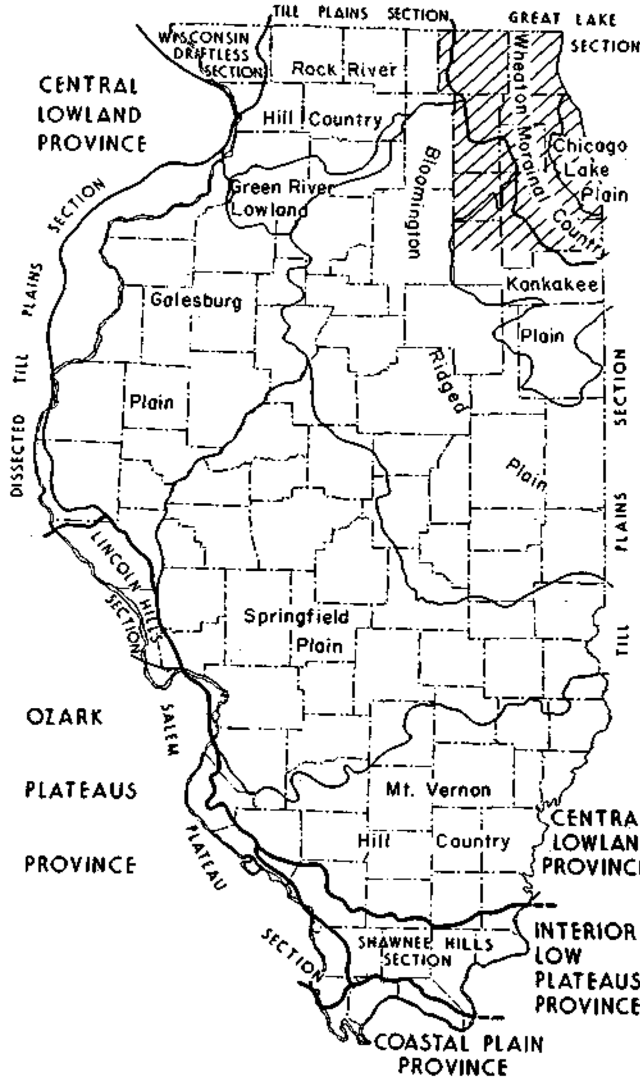


Fig. 1. Location of the Chicago region and physiographic divisions of Illinois.

The hardness increases from about 290 ppm in the central part of the region to about 800 ppm in the eastern part.

Water from the Mt. Simon Aquifer appears to increase in temperature by about one degree per 100 feet of additional depth below an elevation of 1300 feet below sea level where the temperature is 66° F. The primary characteristic of the quality of water from the Mt. Simon Aquifer is the rapid increase in chloride concentration with depth. Deeper than an elevation of about 1300 feet below sea level, water from the Mt. Simon Aquifer is too highly mineralized for most purposes.

Further geologic and hydrologic studies are recommended, relating to quantitative evaluations of the shallow aquifers, detailed stratigraphy of the deeper formations, effects of dewatering parts of the Cambrian-Ordovician Aquifer, effects of Lake Michigan on possible recharge, and the relations between the Chicago and Milwaukee pumpage cones.

INTRODUCTION

The Chicago region has been one of the most favorable ground-water areas in Illinois. It is underlain at depths of 500 feet and more by sandstone aquifers that have been prolific sources of water for nearly 100 years. In early days of ground-water development in the region, roughly before 1895, wells drilled to the aquifers were especially desirable because the sandstones yielded water of excellent quality with enough artesian pressure to cause water to flow at the surface without pumping. At lesser depths the Chicago region is underlain by glacial deposits and creviced dolomite that locally are excellent sources of ground water.

The diversity of water sources has promoted industrial expansion of the region and also facilitated urban growth. Large users of water obtain supplies from deep rock wells when water is not available from Lake Michigan and other surface sources. Small users of water, such as suburban residences or farms, obtain adequate water at reasonable cost from shallow wells finished in the glacial deposits or underlying creviced dolomite.

However, the tremendous industrial and municipal growth in the Chicago region has brought about local problems of water supply. Exploitation of the deep rock aquifers has lowered water levels in some areas to the point where pumping costs are restricting further development at present water rates. The expansion of suburban residential areas with individual sewerage systems and wells has in some areas adversely affected shallow ground-water sources.

PURPOSE AND SCOPE

This report is based on all data on file at the Illinois State Water Survey and the Illinois State Geological Survey and on other published reports. It presents the hydrologic and geologic factors along with history, present conditions, and effects of possible future development on the ground-water resources of the Chicago region. Special emphasis is placed on the most heavily developed deep sandstone aquifers. Basic geologic, hydrologic, and chemical data applicable to local problems and to regional and long-range interpretations are presented to help formulate future policy on water resource planning and development in northeastern Illinois.

The investigation was begun in 1942 with a program to collect data in the Chicago region. Data on water levels, pumpage, mineral quality of water, and well tests were collected by the State Water Survey. Well logs, drilling samples, geophysical logs and other geologic information were collected by the State Geological Survey.

Although the report summarizes present-day knowledge of ground-water conditions in the Chicago region, it must be considered a preliminary report in the sense that it is part of a continuing study of the Chicago region ground-water resources, and its conclusions and interpretations will be modified and expanded as more data are obtained.

All elevations given in this report refer to mean sea level (m.s.L), 1929 general adjustment, Coast and Geodetic Survey.

PREVIOUS REPORTS

The geology and water resources of the region have received considerable study and many reports have been published. The major reports are listed in the Selected References at the end of the report.

ACKNOWLEDGMENTS

Many persons and organizations have assisted in the collection of data and preparation of the report for this investigation. Much of the basic data was collected by Jacob S. Randall, J. G. Geils, John B. Millis, Robert T. Sasman, and W. J. Wood, of the Water Survey and Lowell A. Reed and Arthur J. Zeizel of the Geological Survey.

W. H. Voskuil prepared the section on economy. George E. Ekblaw prepared the map of glacial geology and a portion of the map of bedrock topography. John W. Hawley helped prepare the maps showing the thickness of the unconsolidated deposits and the Silurian rocks. All three are staff members of the Geological Survey. Stanley A. Changnon, Jr., of the Water Survey prepared the material on climate. Helpful suggestions and criticisms were given, particularly by G. B. Maxey but also by many individuals from both Surveys, during the course of the investigation.

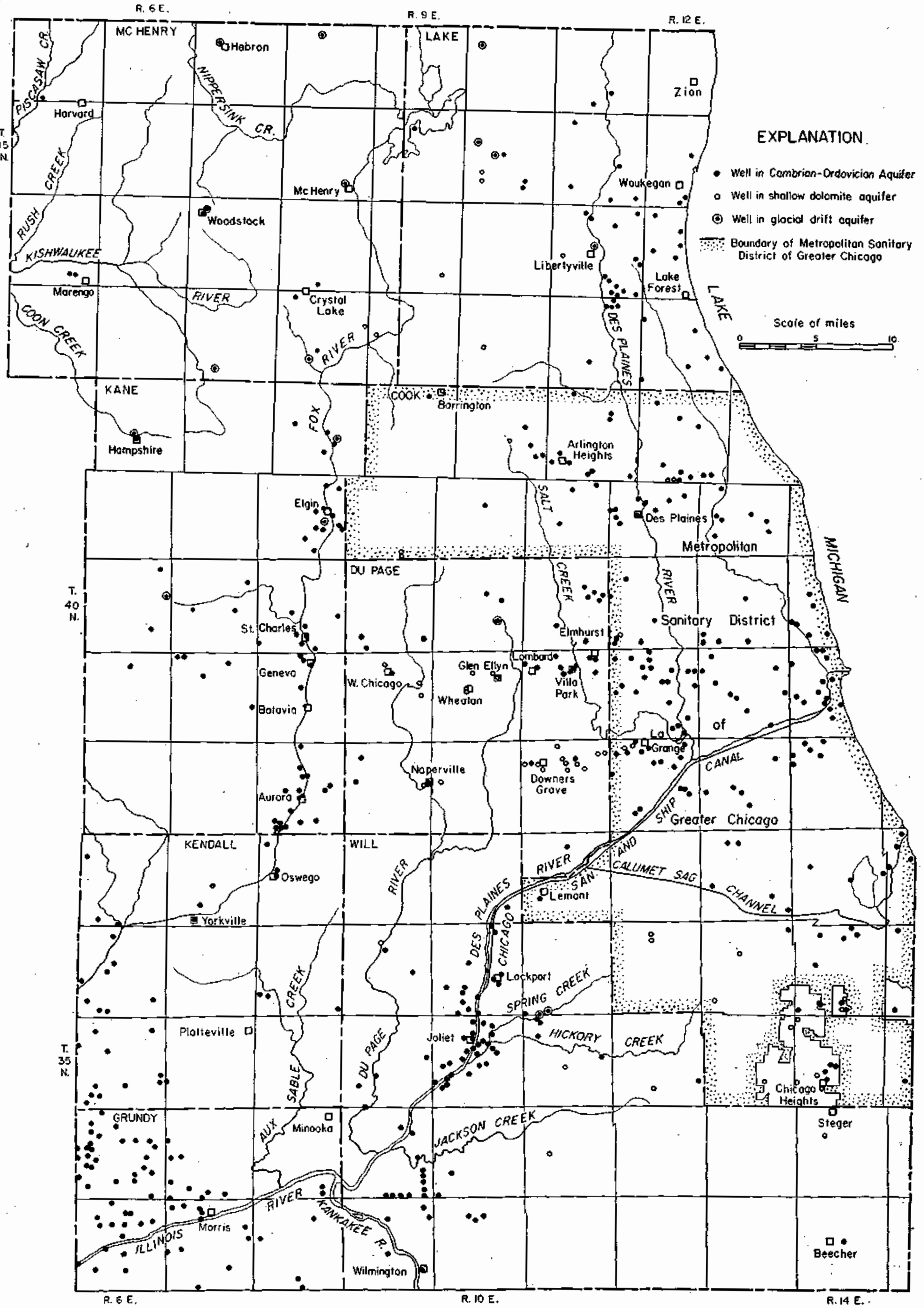
The Wisconsin Geological Survey and the Ground-Water Branch of the United States Geological Survey at Madison generously gave the authors access to logs' and hydrographs of wells in southeastern Wisconsin.

This report would have been impossible without the generous cooperation of municipal officials, industries, engineers, and water-well contractors who provided information on wells, water levels, and pumpage.

LOCATION AND GENERAL FEATURES

The Chicago region of Illinois described in this report includes Cook, DuPage, Kane, Kendall, Lake, and McHenry Counties, and the parts of Grundy and Will Counties north of the north boundary of T. 32 N. (figs. 1 and 2). Quadrangle topographic maps of this area have been prepared under a cooperative arrangement between the United States Geological Survey and the Illinois State Geological Survey. Figure 3 is an index map showing the location of the quadrangles.

The region is the most densely populated and heavily industrialized section of Illinois. The area and population are given in table 1. The region under consideration contains only 7.5 percent of the land area of the state of Illinois but has 61.3 percent of the population.



EXPLANATION
Well in Cambrian-Ordovician Aquifer
Well in shallow dolomite aquifer
Well in glacial drift aquifer
Boundary of Metropolitan Sanitary District of Greater Chicago
Scale of miles
0 5 10
R. 6 E.
R. 9 E.
R. 12 E.
R. 10 E.
R. 14 E.
T. 45 N.
T. 40 N.
T. 35 N.
MC HENRY
LAKE
KANE
COOK
DU PAGE
KENDALL
WILL
GRUNDY
Hebron
Harvard
Zion
Woodstock
Mc Henry
Waukegan
Libertyville
Lake Forest
Marengo
Crystal Lake
Barrington
Hampshire
Arlington Heights
Elgin
Des Plaines
St. Charles
Geneva
Batavia
W. Chicago
Glen Ellyn
Wheaton
Lombard
Villa Park
Elmhurst
La Grange
Naperville
Downers Grove
Aurora
Oswego
Yorkville
Lemont
Lockport
Plattville
Joliet
Minooka
Morris
Wilmington
Chicago Heights
Steger
Beecher
Metropolitan Sanitary District of Greater Chicago
LAKE MICHIGAN
PISCASAW CR.
NIPPERSINK CR.
RUSH CREEK
KISHWAUKEE RIVER
COON CREEK
FOX RIVER
DES PLAINES RIVER
SALT CREEK
SANITARY AND SHIP CANAL
CALUMET SAG CHANNEL
CHICAGO
SPRING CREEK
HICKORY CREEK
AUX SABLE CREEK
DU PAGE RIVER
JACKSON CREEK
ILLINOIS RIVER
KANKAKEE R.

TABLE 1. AREA AND POPULATION OF THE CHICAGO REGION BY COUNTY

County	Area in square miles	1950* Population	1950* Population per square mile	1957† Population	1957† Population per square mile
Cook	954	4,508,792	4,726	5,028,800	5,270
DuPage	331	154,599	467	249,100	750
Part of Grundy	210	11,520	55	16,300	78
Kane	516	150,388	291	179,300	348
Kendall	320	12,115	38	14,200	44
Lake	457	179,097	392	251,300	550
McHenry	611	50,656	83	69,400	113
Part of Will	770	131,097	170	171,400	213
Totals for Region	4,169	5,198,264	1,247	5,979,800	1,432
State of Illinois	55,947	8,712,176	156	9,754,000	174

* U. S. Bureau of the Census.
† Illinois Department of Public Health estimates.

According to the 1954 Census of Manufactures, the eight counties under study had 13,279 manufacturing establishments producing goods valued, after deduction of labor and supply costs, at $7,010,865,000 that year. The state as a whole had 17,628 manufacturing establishments with a net production value of $9,668,752,000. Thus the Chicago region has 75.2 percent of the state's manufacturing establishments and produced 72.5 percent of the value added by manufacturing.

The vast economic importance of the area is a result of many factors (Fryxell, 1927, p. 1-10) : 1) it is near the center of one of the richest agricultural belts in the world; 2) favorable terrain and location have made Chicago a major railway and highway center; 3) the Great Lakes afford a water transportation system that links Chicago with the other great ports of the world; 4) the Chicago Drainage Canal and the Calumet-Sag Channel connect Chicago with the Illinois and Mississippi River systems; 5) adequate resources and moderate climate are favorable for supporting a large population.

All cities that border Lake Michigan in the Chicago region, except Lake Bluff, Zion, and Winthrop Harbor, obtain water supplies from the lake. The City of Chicago, which serves about 60 municipalities and pumps more than a billion gallons a day from the lake, is the largest user of water.

Some 110 municipalities not served by water from Lake Michigan obtain supplies from wells. Suburban and rural water supplies beyond the municipal distribution system are obtained from ground water. Many industries, including a large number of plants within the area served by Lake Michigan water, have private wells and use ground water for processing and cooling. Some industrial water is obtained from surface sources other than Lake Michigan.

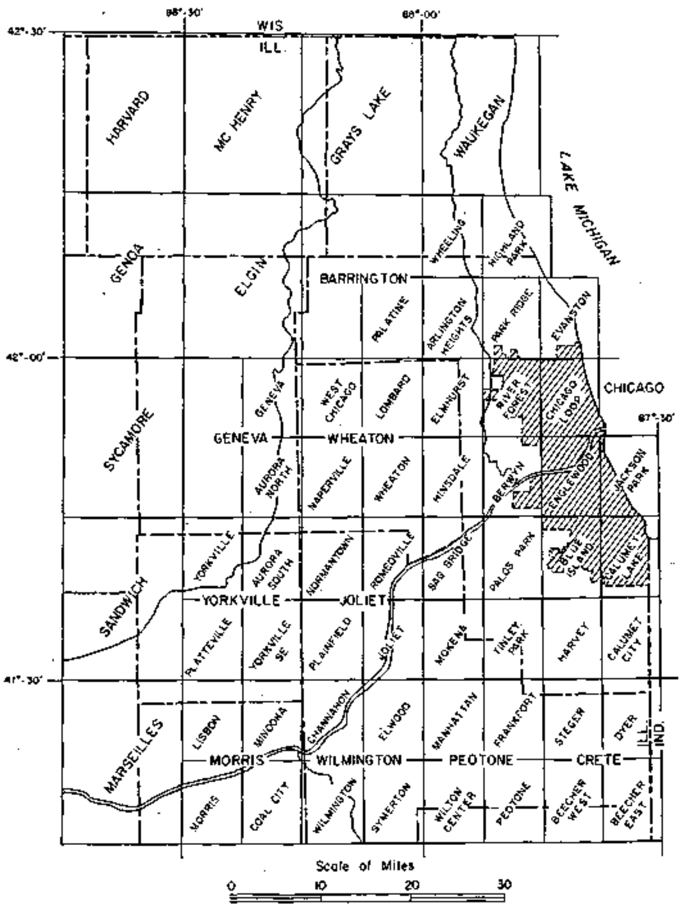


Fig. 3. Quadrangle topographic maps of the Chicago region.

Fig. 2. Chicago region with location of selected wells. Shown are most wells in Cambrian-Ordovician Aquifer for which geologic or hydrologic records are on file at the State Surveys. Only a few wells in shallow dolomite and glacial drift aquifers, representative of the several thousand for which records are on file, are shown. See Appendix B for summaries of well data.

GEOGRAPHY

TOPOGRAPHY

The Chicago region lies near the center of the physiographic Central Lowland Province, a glaciated lowland that stretches from the Appalachian Plateau on the east to the Great Plains of Kansas, Nebraska,. and the Dakotas on the west. It includes five physiographic subdivisions (fig. 1) : 1) the Chicago lake plain, 2) the Wheaton morainal country, 3) the Kankakee plain, 4) the Bloomington ridged plain, and 5) the Rock River hill country.

The Chicago lake plain, extending from Indiana as far north as Winnetka and as far west as LaGrange, is a low, flat surface sloping gently toward the lake, interrupted by a few low ridges and knolls and by two large valleys along the Des Plaines River and Sag Channel (figs. 2, 4). Low, discontinuous ridges (fig. 5, in pocket) on the lake plain mark the position of three former levels of Glacial Lake Chicago, the ancestor of Lake Michigan. The highest and earliest beach ridge, the Glenwood stage shore line, has an elevation of about 635 feet or 55 feet above present lake level (fig. 6, in pocket). About 20 feet lower (615-foot elevation) is the Calumet stage shore line, and about 15 feet still lower (600-foot elevation) is the Toleston stage shore line. Present lake level is about 580 feet.

Bordering the lake plain to the north, west, and south is the Wheaton morainal country, characterized by hilly topography, broad parallel morainic ridges, lakes, and swamps (figs. 5 and 6). This is the most extensive physiographic subdivision in the region, and includes most of Lake, McHenry, DuPage, and Will Counties. It also contains the highest land, for extensive tracts in Kane and McHenry Counties are more than 900 feet above sea level. The highest point in the region, four miles northeast of Harvard, is 1192 feet.

The Kankakee plain, including western Will, southeastern Kendal], and Grundy Counties, is a level to gently undulatory plain that occupies the position of a basin between higher morainic country to the west and east. Low ridges, terraces, bars, and dunes locally rise above the general level.

The Bloomington ridged plain lies west of the Kankakee plain. Only the northeastern part of it, in southwestern Kane and northwestern Kendall Counties, is within the region covered by this report. It is characterized by broad, morainic ridges with intervening wide stretches of relatively flat or gently rolling plains. Lakes and swamps are less common than in the Wheaton morainal country.

The Rock River hill country extends into the area of this report only in western McHenry County and the northwest corner of Kane County. It is characterized by rolling hills, thin glacial drift, and narrow valleys.

Fryxell (1927, p. 1-10), Bretz (1955, p. 27-41), and Leighton, Ekblaw, and Horberg (1948, p. 21-26) present descriptions of the physiography of the region.

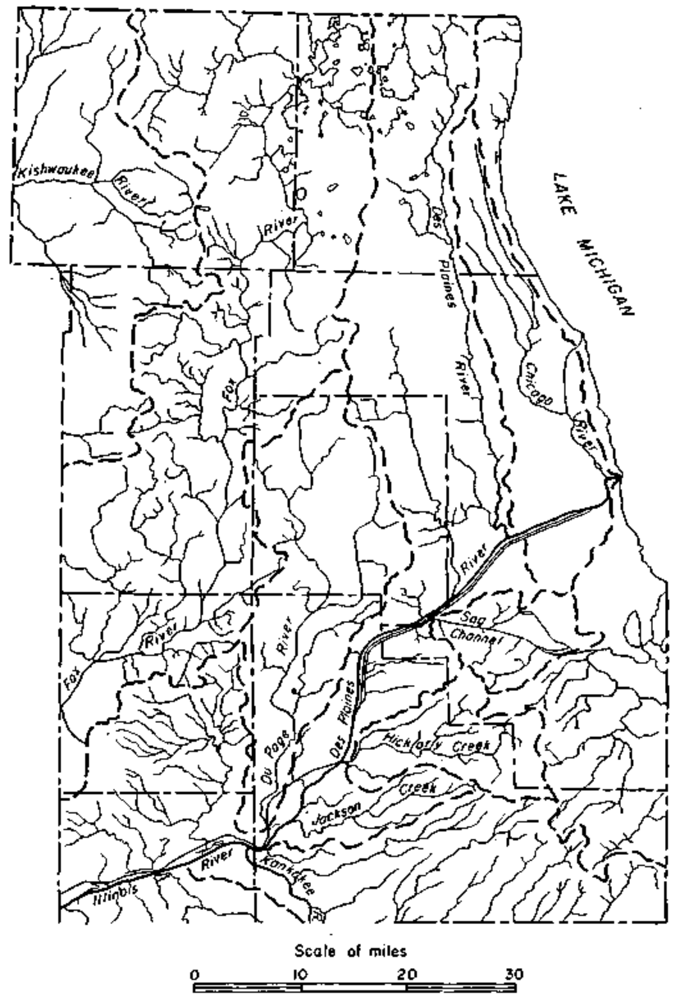


Fig. 4. Drainage and watersheds of the Chicago region.

DRAINAGE

The drainage map of the Chicago region (fig. 4), showing all streamways however slightly incised, has many blank areas, indicating poor drainage. Much of the morainal country is without integrated drainageways and still has the constructional slopes that were fashioned by the glaciers. Swamps and lakes are common. Most of the lake plain is without natural drainageways.

The drainage divide between the Great Lakes and the Mississippi River systems crosses the region only a few miles from the lake (fig. 4). About 68 square miles along Lake Michigan north of downtown Chicago and some 294 square miles around and south of Calumet Lake drain into Lake Michigan. The remainder of the region drains into the Mississippi River system, 465 square miles through the Kishwaukee-Rock Rivers, and 3,342 square miles through the Illinois by way of the Des Plaines, DuPage, Fox, and Kankakee Rivers.

TABLE 2. HIGHEST AND LOWEST MONTHLY PRECIPITATION DURING 1938-1957

Months	Highest			Lowest		
	Precipitation	Station	Year	Precipitation	Station	Year
January	5.38	Park Forest	1949	0.11	Antioch	1956
February	4.84	Park Forest	1950	0.10	Antioch	1947
March	7.23	Wheaton	1948	0.33	Newark	1956
April	9.72	Channahon Island	1950	0.49	McHenry	1942
May	9.18	Peotone	1943	0.49	Arlington Heights	1950
June	10.65	Wheaton	1939	0.70	Chicago University	1956
July	10.73	Peotone	1957	0.02	Morris	1940
August	9.65	Waukegan	1945	0.46	Newark	1953
September	10.62	Waukegan	1945	0.15	McHenry	1940
October	14.86	Aurora	1954	T	Waukegan	1952
November	5.57	Aurora	1942	0.34	Aurora	1949
December	7.11	Joliet	1949	T	Wheaton	1943

CLIMATE

Precipitation, evaporation, and temperature are the most commonly measured climatic factors that are directly related to the availability, storage, movement, and withdrawal of ground water. Precipitation adds water to the land and evaporation takes it away. Temperature influences evaporation and infiltration and also affects the rate and distribution of ground-water withdrawal.

The climate of the Chicago region is classified as continental with warm summers and cold winters. Precipitation, evaporation, and temperature vary with the latitude. Aside from local influences, such as Lake Michigan and the large urban area of Chicago, the average annual precipitation for the period 1938-1957 ranged from about 32 inches in the north to about 36 inches in the southeast (fig. 7) and the average annual temperature ranged from about 48° F. to 51° P. (fig. 8).

Precipitation varies through a wide range in intensity, geographic distribution, and frequency of storms. During the period 1938-1957, June was the wettest month with 4.15 inches of rain and February was the driest, with 1.7 inches. Highest and lowest precipitation for each month for the 20-year period, regardless of location, are shown in Table 2. The table illustrates the wide variation in amount of precipitation that may be expected for a given month over a number of years. The greatest range shown in the table is for October when a trace of precipitation was recorded at Waukegan in 1952 whereas 14.86 inches of precipitation were recorded at Aurora in 1954.

On the average, 120 days per year have measurable precipitation. The average annual snowfall is 31 inches, and normally nine days each winter have snowfall of more than one inch.

The Chicago region has a wide seasonal range of temperatures. January, the coldest month, had a mean temperature of 25.1 degrees, ranging from 22.7 degrees at Antioch to 27.2 degrees at Joliet. July, the warmest month, had a mean temperature of 74.1 degrees, ranging from 75.5 degrees at Joliet to 72.4 degrees at Antioch.

During the period of frequent and persistent daily temperatures below freezing little or no' recharge to the ground-water reservoir occurs because much of the time the ground is frozen and relatively impermeable. During the 1938-57 period the region averaged 90 days per year with mean daily temperatures below freezing.

The length of the growing season also influences recharge because plants intercept most of the water soaking into the soil zone during this period. The growing season for the Chicago region ranges from 150 to 180 days with most of the region in the 160- to 170-day range. The average dates of beginning and end of the growing season (the period between killing frosts) occur in late April or early May and in October, respectively.

Temperatures during the summer months directly influence ground-water pumpage because ground water

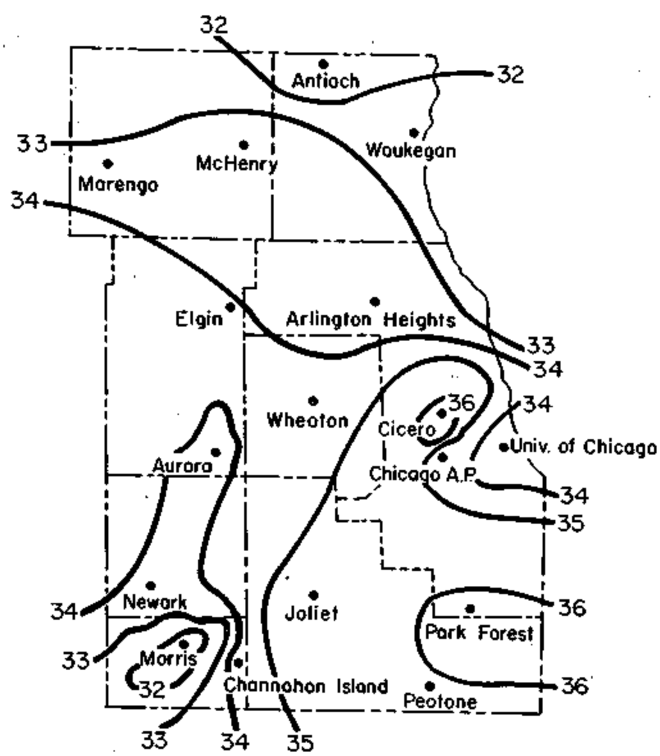


Fig. 7. Average annual precipitation in the Chicago region.

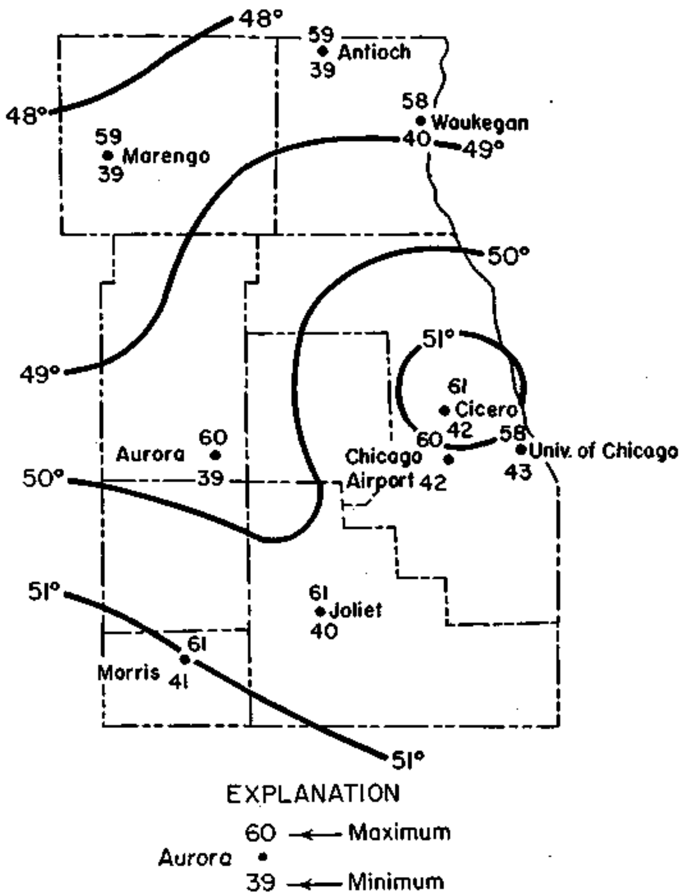


Fig. 8. Mean annual temperature in the Chicago region.

is widely used for air conditioning and other cooling purposes in the Chicago region. To estimate the magnitude of cooling requirements, a classification of cooling degree days is used and computed on a daily basis by subtracting 75 degrees from the mean daily temperature. For the months during which cooling degree days normally occur, the average and extreme values for Chicago are shown in figure 9. On an annual basis, Chicago averages 139 cooling degree days per year. The annual average in the eight county area ranges from 80 in northeastern Lake County to approximately 150 per year in southwestern Grundy County.

In general, recharge from precipitation to the ground-water reservoir is greatest in the spring, that is, after the ground thaws and before vigorous plant growth begins. This has been substantiated by observations of water-levels in the Chicago region and also in adjacent areas. It has been estimated that about 10 to 12 percent of the annual precipitation reaches the ground-water reservoirs in Illinois, and it is reasonable to believe that recharge in the Chicago region is within this order of magnitude. More study is needed to determine accurately the amount of recharge in the region.

POPULATION

The pattern of population controls ground-water use. In the Chicago region the large urban area is the main factor. The extension of urban areas affects ground-water conditions in the following ways: 1) newly built-up areas obtain water supplies from many individual wells whose combined effect increases pumpage over a widespread area; 2) such areas later develop communal water supplies that increase local concentrations of pumpage; 3) urbanization may affect ground-water recharge and is known to alter the run-off relationships of the natural terrain.

The first settlements in the Chicago area were at the mouth of the Chicago River where Fort Dearborn was built in 1803. Cook County was established in 1831 and the other seven counties of the area within the following 10 years.

The growth of the population in the region is shown in figures 10 and 11, which also show the predominance of the population of Chicago compared with that of the rest of the state. The region under consideration has had one-half the state's population since 1914, and Cook County has had more than one-half the state's population since 1927. Population is given in table 1, p. 11.

The growth of urban areas in Illinois has accompanied the growth in population, especially in the last 30 years. Much of the urban growth has taken place in suburbs of the larger cities.

ECONOMY

The economy of northeastern Illinois is based on manufacturing, agriculture, and mining, named in the

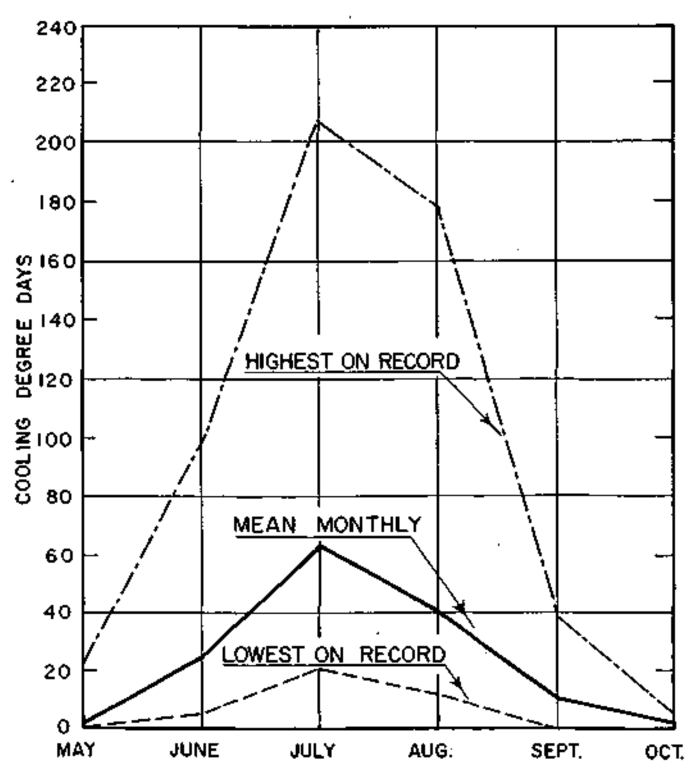


Fig. 9. Cooling degree days at Chicago.

order of. value of output. In addition, Chicago is the focal point for vast rail and truck systems and for petroleum and natural gas pipelines that transport raw materials into the Chicago industrial district and also distribute the products manufactured from these raw materials.

Of the 20 manufacturing groups in the Chicago area classified by the Census of Manufactures for 1954, the iron and steel industry is the largest and is also the largest industrial user of ground water.

Pood processing, including the meat, dairy products, canned and frozen goods, grain mill products, and bakery products industries, ranks second to the metal working industries in northeastern Illinois in terms of number employed and wages paid and these industries are the second largest industrial users of ground water.

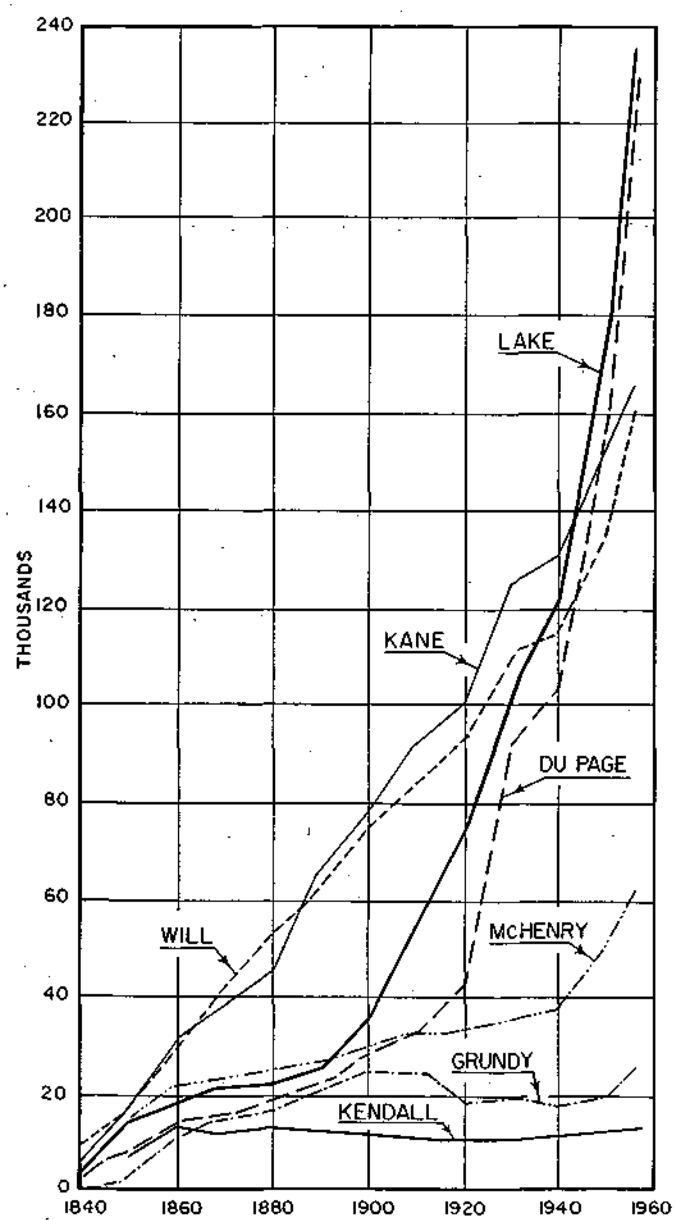


Fig. 10. Growth of population by county (except Cook). Data from U. S. Census; 1956 estimate from Illinois Department of Public Health.

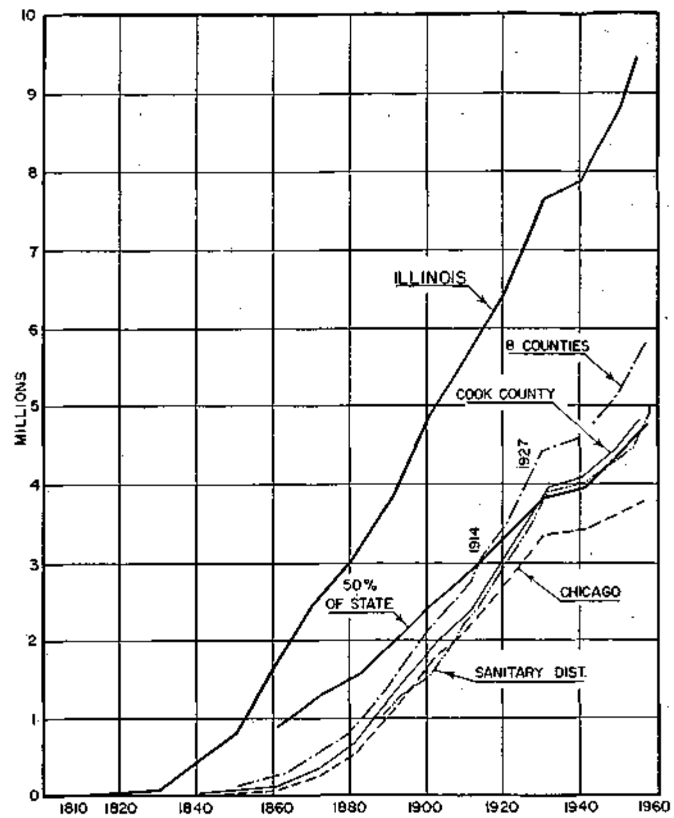


Fig. 11. Growth of population of region compared with that of Illinois. Data from U. S. Census; 1956 estimate from Illinois Department of Public Health.

Chicago is the second largest printing and publishing center in the nation. Commercial printing is the largest branch of the industry, followed by newspaper publishing and lithographing.

The manufacture of apparel, chemicals, petroleum products, furniture, and pulp and paper follow in order of value of output.

Electric utility power plants in the Chicago area, including plants at Waukegan, Aurora, Joliet, and Lockport, have a capacity of 3,000,000 kilowatts and an annual electric power output of approximately 15 billion kilowatt hours. Electric power plants use large amounts of surface water but only minor amounts of ground water.

Agriculture also is of considerable importance in northeastern Illinois. The eight counties in the region have 2,027,000 acres, or 71 percent of the area, in farms, compared with 86.5 percent for the state as a whole. In the dominantly agricultural counties of Grundy, Kane, Kendall, McHenry, and Will, the land in farms is 87.3 percent of the total land area. Farm water supplies are generally drawn from ground-water sources, including water for domestic use, watering stock, and some for irrigation.

The principal mineral products of the area are sand, gravel, stone, and clay, with small quantities of coal. The value of quarry products in the area in 1956 was $36 million, about half the total value for the state. About 70 percent of the quarry products come from Cook County and the remainder from the other seven counties in the area. Ground water is heavily used in the washing processes in sand and gravel production, and pits and quarries influence the local hydrology.

SOURCE, MOVEMENT, AND OCCURRENCE OF GROUND WATER

The general principles underlying the source, movement, and occurrence of ground water have been described by Meinzer (1923, 1942, p. 385-487) and others. They are summarized here to explain technical terms used in this report.

Ground water is derived from precipitation that falls mainly as rainfall and seeps into the ground. The water infiltrates through loose particles of the soil and percolates downward. Below a certain depth all openings in the earth materials are filled with water. *Ground water* is defined as water in the zone of saturation. The process of addition of water to the ground-water reservoir is called *recharge.*

Openings in which ground-water is stored in the zone of saturation range in size from tiny pores between particles of clay and silt to large crevices in dolomite and limestone. The *porosity* of an earth material refers to its pore space and is expressed quantitatively as the percentage of its total volume.

Earth materials that have interconnected openings large enough to store and transmit water readily into a well or spring are called *aquifers.* The capacity of an earth material to transmit water under pressure is called its *permeability.*

The upper limit of the saturated zone is called the *water table.* The water immediately below the water table is unconfined and can rise or lower freely, as water is added or withdrawn. In wells that penetrate the saturated zone under these conditions the water level indicates the elevation of the water table; such wells are called *water-table wells.*

Under natural conditions, the water table roughly parallels the surface topography, rising under the uplands and intersecting the ground surface along perennial streams, lakes, and swamps into which groundwater is discharged by gravity flow from adjacent areas where the water table is higher. The position and shape of the water table may be modified by the kind of rocks present or by other factors affecting permeability. The position of the water table and the discharge of groundwater to streams fluctuate from season to season and year to year.

If a permeable water-bearing formation, or aquifer, is confined between nonpermeable beds and water is supplied to it from a higher elevation, the water is confined under hydraulic pressure. When such an aquifer is penetrated by a well, water will rise above the aquifer in the well to a height equal to the hydraulic head of the aquifier. Ground water that is confined under pressure iu this manner is said to be under *artesian conditions.* Wells penetrating such aquifers are called *artesian wells.* If the hydraulic head is above land surface at the well, the well will flow.

To supply a producing well, ground water must move through the aquifers toward the well. Under water-table conditions, pumping lowers the water table in the vicinity of the well and induces the flow of ground water toward the well from adjacent areas. Under artesian conditions, pumping causes, in the vicinity of the well, a reduction of hydrostatic pressure that induces the flow of ground water toward the well. The aquifer under artesian conditions is not dewatered but remains full because the discharged water is derived by the compaction of the aquifer and associated beds, by the expansion of the confined water, and by flow from the recharge area. The compaction of the aquifer and associated beds and expansion of confined water constitute the storage factor of an artesian aquifer.

The depression of the water table, or the reduction of artesian pressure, that results from pumping is in the form of an inverted cone with the well at the center, and is called the *cone of depression.*

The measurement of the elevation of the water level or artesian pressure surface is made by determining the water levels in wells. Two types of water levels are recognized: nonpumping levels and pumping levels.

The *nonpumping level* is the level at which the water stands in a well not influenced by pumping in the immediate vicinity of the well. The level may change over long periods of time, and also it may be affected by regional pumpage and changes in barometric pressure. It is of great importance in evaluating the water resources of a region.

The *pumping level* is the level to which the water surface lowers in wells during pumping. This level depends on rate and duration of pumping, permeability and thickness of the aquifer, and well characteristics.

The difference between the nonpumping level and the pumping level in a well is called *drawdown.* The drawdown is a temporary lowering of the water level due to pumpage in the well. When the pump is stopped the water level rises. This rise in the water level is called *recovery.* The yield of a well in gallons per minute per foot of drawdown is the *specific capacity.*

A continued lowering of the nonpumping level of a region is called a water level *decline.* Decline of water level is usually caused by excessive pumpage, diversion of recharge, or drought.

TABLE 3. WELLS TO PRECAMBRIAN ROCKS NEAR THE CHICAGO REGION

Name of well	Sec.-T.-R. county	Top of Precambrian Depth	Top of Precambrian Sea level elevation	Thickness penetrated	Type of rock
1. Ivan A. Seele No. 1	24-44N-2E Winnebago	2656	−1786	44	Red granite
2. Northern Ill. Oil and Gas Co.*	28-43N-3E Boone	2925	−2105	73	Gray granite
3. Paul Schulte Wyman No. 1*	35-41N-5E DeKalb	3845	−2935	639	Red granite
4. Vickery No. 1 Mathesius	32-35N-1E LaSalle	3532	−2854	24	Granite
5. A. C. Otto No. 1 Swenson	1-35N-5E LaSalle	3700	−3043	24	Granite
6. Larvinger No. 1 Miller	1-36N-4E LaSalle	3469	−2788	190	Granite
7. Ft. Atkinson No. 3 (Wis.)†	9-5N-14E Jefferson	1060	−278		Granite
8. Edgewood Farm Pewaukee (Wis.)†	9-7N-19E Waukesha	1190	−330		Granite

* Grogan, 1950, p. 98.
† Thwaites, 1940, p. 238-239.

GEOLOGY

Unconsolidated deposits of glacial and Recent age, which overlie the layered bedrock in most of the region (figs. 5-6, in pocket) range from a foot or less to more than 400 feet thick (fig. .12). They are mainly of Wisconsin age, the last major episode of glaciation in the Midwest, as shown in the classification of Pleistocene deposits. Illinoian and possibly older glacial deposits are preserved beneath the Wisconsin drift at some places.

CLASSIFICATION OF PLEISTOCENE DEPOSITS

Recent stage
Wisconsin (glacial) stage
- Mankato substage
- Cary
- Tazewell
- Towan
- Farmndale

Sangamon (interglaeial)
Illinoian (glacial)
Yarmouth (interglacial)
Kansan (glacial)
Aftonian (interglaeial)
Nebraskan (glacial)

The glacial deposits rest on an eroded bedrock surface of considerable relief (fig. 13), a surface that was carved primarily by streams before the Pleistocene glaciers advanced across the region (fig. 14). The configuration of the bedrock surface strongly influenced the deposition of glacial materials.

Beneath the glacial deposits the bedrock formations, consisting mainly of beds of dolomite (a limestone-like rock), shale, and sandstone, dip slightly south of east about 10 feet per mile (fig. 15). In some places the rocks are broken and displaced along faults. They are also warped into synclines and anticlines.

The bedrock formations range in age from Precambrian to Pennsylvanian, but rocks below the Silurian in the eastern three-quarters of the region are known only from wells (figs. 16 and 17). Silurian age dolomite, which commonly yields ground water from crevices, underlies the drift in most of the region. The oldest rocks encountered directly below the drift are dolomites and sandstones of the Prairie du Chien Series (lower Ordovician) south of the Sandwich fault zone in western Kendall County. The youngest are Pennsylvanian rocks in Grundy and Will Counties.

BEDROCK STRATIGRAPHY

The stratigraphy, description and water-yielding characteristics of the rocks in the region are summarized in figure 17. Figure 18 gives the stratigraphic nomenclature used in this report, compared with that of previous reports relating to the Chicago region. Some formations have been grouped or boundaries modified to form what are considered geohydrologic units.

Precambrian Rocks

Rocks of Precambrian age form the basement below the layered sedimentary rocks. No wells are known to have been drilled to the Precambrian rocks in the region of the report, although several have been drilled in adjoining parts of Illinois and Wisconsin. These are listed in Table 3.

The Precambrian rock encountered in most wells in Illinois has been granite or related crystalline rocks. In Wisconsin, wells reaching the Precambrian have encountered granitic rocks or metamorphosed sediments, particularly quartzite. Much of the quartzite appears to stand as "ranges" or "monadnocks" above the general Precambrian level (Thwaites, 1957).

From data on Precambrian depths and Mt. Simon (Cambrian) thicknesses in adjoining Boone, DeKalb, LaSalle, and Kankakee Counties, it appears that the Precambrian surface in the Chicago region slopes eastward and ranges from about 2000 to more than 4000 feet below sea level. Depth to the Precambrian ranges from 3000 to 5000 feet.

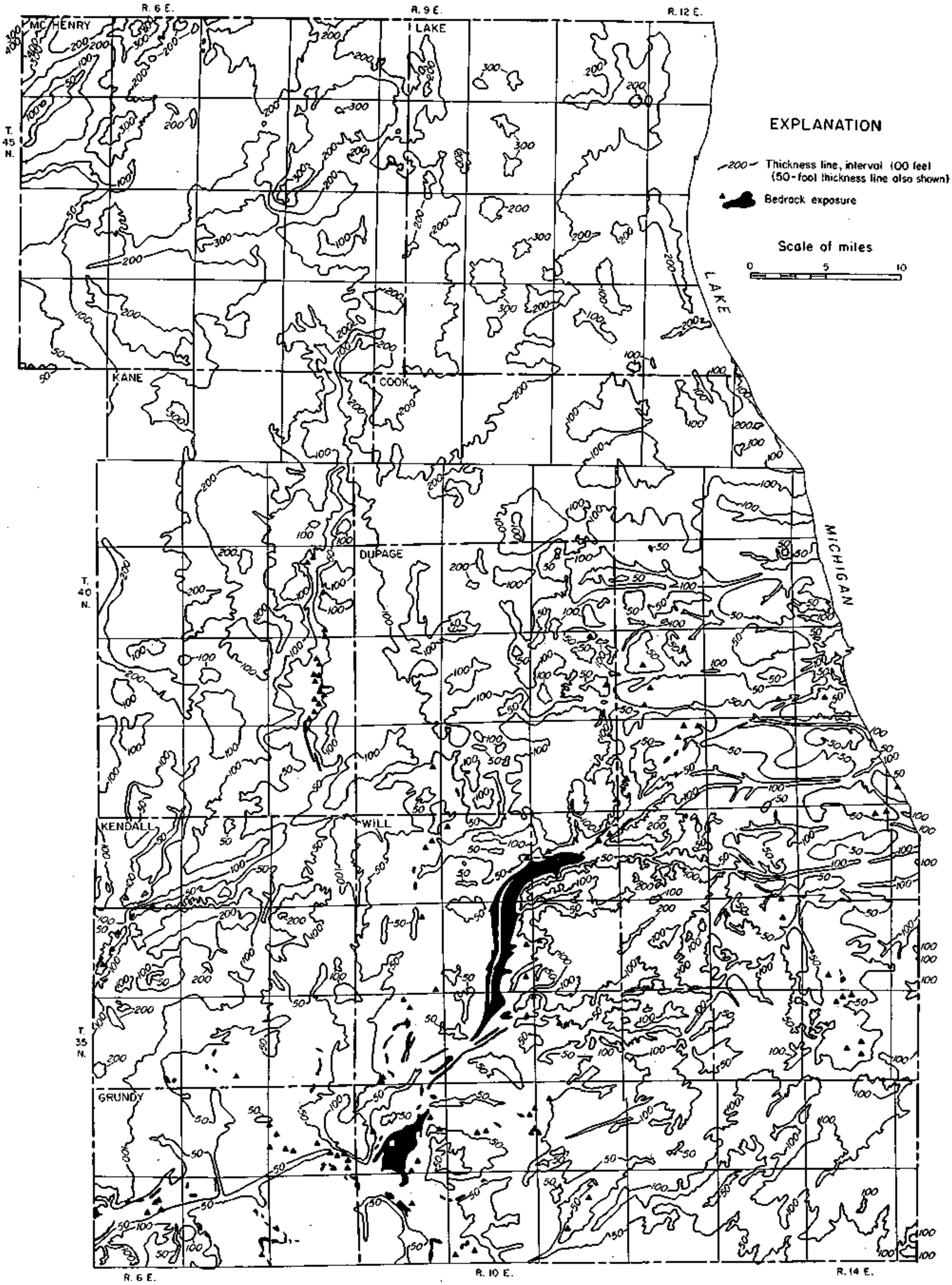


Fig. 12. Thickness of the unconsolidated deposits overlying the bedrock in the Chicago region.

The Precambrian rocks are not sources of ground water but form an impermeable basement complex below the sedimentary rocks.

Cambrian Rocks

The Cambrian rocks (fig. 15) in the area of this report unconformably overlie the Precambrian rocks and are known only from deep wells, none of which penetrate the complete section. These rocks range in thickness from approximatly 2000 feet near the Wisconsin border to more than 3000 feet in Will and Grundy Counties. The lower two-thirds of the Cambrian rocks are generally fine- to coarse-grained sandstones and are overlain by interbedded sandstone, dolomite, and shales, and an upper dolomite.

The Cambrian rocks are divided in this report into five units on the basis of geohydrologic characteristics. The units in ascending order are: 1) Mt. Simon Sandstone and lower sandstone of the Eau Claire Formation; 2) middle and upper members of the Eau Claire Formation; 3) Ironton-Galesville Sandstone; 4) Franconia Formation; and 5) Trempealeau Dolomite.

The Mt. Simon Sandstone and lower incoherent sandstone of the E'au Claire Formation are hydrologically connected and in this report are considered as one unit, called the Mt. Simon Aquifer. The Mt. Simon Sandstone includes the sandstone called Fond du Lac on the state geologic map (1945).

The Mt. Simon Sandstone is fine- to coarse-grained, pink, yellow, and white, incoherent to friable sandstone. In some places it is arkosic and contains red to green shale beds near the base. Granules up to 6 mm in diameter are common in the upper part of the sandstone, and red, micaceous, hematitic shale beds occur at some places in the northern counties. The lower sandstone unit of the Eau Claire Formation may contain a "sooty" zone resulting from incrustations of black pyrite on sand grains.

Wells in nearby counties (table 3) indicate that the sandstones of the Mt. Simon and Eau Claire Formations near Wisconsin are approximately 1500 feet thick and thicken southward to approximately 2000 feet. The top of the sandstones (fig. 19) dips from the northwest to the southeast at a rate of 10 feet to the mile. Because of a paucity of information, the structure of the Mt. Simon is not well known. Figure 19 is doubtless a simplification of the true structural picture.

The Eau Claire Formation overlies the Mt. Simon Sandstone throughout the region and consists of shale, sandstone, and dolomite that grade laterally from one to another within short distances. The middle and upper parts of the Eau Claire Formation are dolomitic, micaceous, fine- to medium-grained, compact sandstone with variable amounts of green to gray, sandy shale and siltstone, and sandy, brown dolomite. Cemented sandstone predominates in the middle unit. Glauconite is common throughout the formation.

The Eau Claire Formation is known only from wells that generally are grouped around the major cities, with the result that regional control for a structure map is uneven. The formation dips from the northwest to the southeast at a rate of about 11 feet to the mile (fig. 20A). The thickness of the middle and upper Eau Claire units is variable. They range in total thickness from less than '300 feet to over 400 feet (fig. 20B).

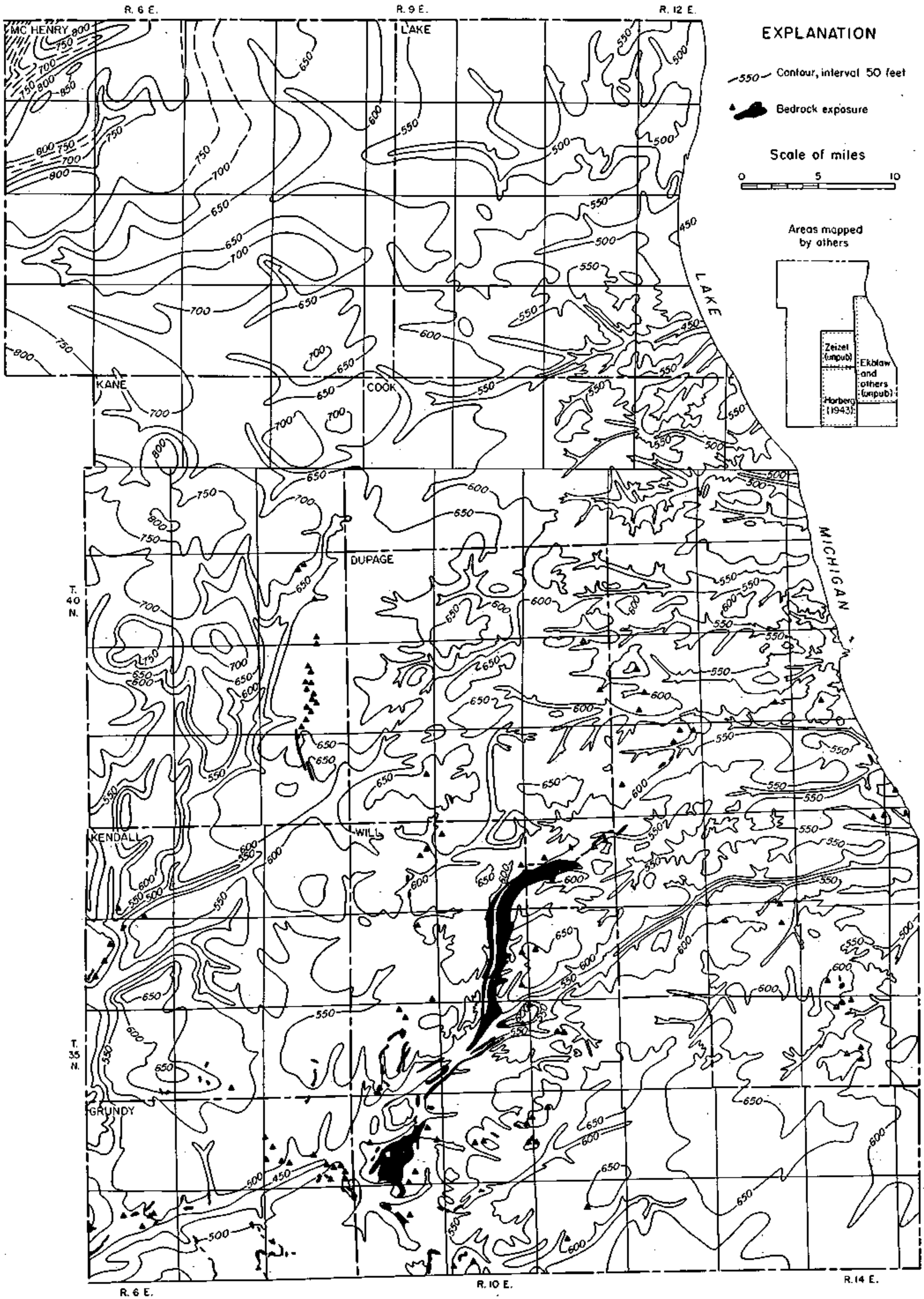
The Ironton-Galesville Sandstone is the major bedrock aquifer in northeastern Illinois. It conformably overlies the Eau Claire Formation and grades upward into the Franconia Formation throughout northern Illinois. The unit is composed of white to light gray, fine- to coarse-grained sandstone, some of which is dolomitic. The dolomite may cement the sandstone or occur as interbedded sandy, pinkish buff lenses. The Ironton-Galesville Sandstone is nonglaueonitic except at the top and its compactness varies with the amount of dolomite present as cementing material. The following sample study log illustrates the typical lithology. The well number is based on geographic location and the system is described in the appendix.

Well No. COK 38N12E-18.8g
Suburban Cook County Tuberculosis Sanitarium District, Well No. 3,
Illinois Geological Survey Sample Set No. 31261.

	Thickness (feet)	*Depth (feet)*
Cambrian System		
Ironton-Galesville Sandstone		
Sandstone, silty, light gray, fine to coarse grains, incoherent; dolomite, sandy, light buff to pinkish buff, very fine, crystalline	31	1400
Sandstone, silty, light buff, coarse to fine grains, incoherent	10	1410
Sandstone, silty, light gray, fine to coarse grains, incoherent; dolomite, sandy, light brown to a pinkish buff, very fine, crystalline	10	1420
Sandstone, silty, light gray, fine to coarse grains, incoherent	40	1460
Sandstone, slightly silty, light gray, medium to fine grains, few coarse grains, incoherent	50	1510
Sandstone, white, fine grains, incoherent to friable	25	1535
Total thickness	166	

All information on the Ironton-Galesville Sandstone in the Chicago region is based on well records. The sandstone dips to the southeast at a rate of about 10 feet to the mile, is generally 175 to 200 feet thick (fig. 21) but thins rapidly to the northeast.

The Franconia Formation is composed of varying amounts of sandstone, shale, and dolomite and is in many ways similar to the Eau Claire Formation. The different rocks grade rapidly from one to another laterally and are commonly interbedded. The sandstone is variegated, dolomitic, fine-grained, compact, micaceous, silty, and grades to buff, pink, greenish gray, finely crystalline, sandy dolomite. The shales are sandy, gray, green, red, micaceous, and weak (caves and slakes



R. 6 E.
R. 9 E.
R. 12 E.
EXPLANATION
550 Contour, interval 50 feet
Bedrock exposure
Scale of miles
0 5 10
Areas mapped by others
Zeizel (unpub)
Horberg (1943)
Ekblaw and others (unpub)
MC HENRY
LAKE
KANE
COOK
DUPAGE
KENDALL
WILL
GRUNDY
T. 45 N.
T. 40 N.
T. 35 N.
LAKE MICHIGAN
R. 6 E.
R. 10 E.
R. 14 E.

easily). Throughout the Franconia Formation are large amounts of coarse glauconite that commonly give a greenish tint to the sandstones and shales.

The Franconia Formation underlies the entire region but is known only from wells. It is approximately 100 feet thick and dips from northwest to southeast, as do the underlying formations.

The Trempealeau Dolomite is the uppermost formation of Cambrian age. It grades upward from the underlying Franconia Formation and is commonly slightly sandy and glauconitie at the base. The Trempealeau is buff to gray, very finely crystalline, dense dolomite with minor amounts of geodic quartz and is slightly sandy at the top.

The unconformity that separates the Cambrian and Ordovician rocks occurs at the top of the Trempealeau, causing variation in its thickness. In the northern half of the region the Trempealeau is overlain by the Glenwood-St. Peter Sandstone. The Trempealeau Dolomite has an average thickness of 150 to 200 feet in the region of this report.

Ordovician Rocks

Rocks of Ordovician age in northeastern Illinois are divided in this report into the following geohydrologic units, in ascending order: 1) Prairie du Chien Series, 2) Glenwood-St. Peter Sandstone, 3) Galena-Platteville Dolomite, and 4) Maquoketa Formation (fig. 15). These rocks are predominately carbonate with a middle sand unit (Glenwood-St. Peter) and an upper shale and dolomite unit (Maquoketa). The Ordovician rocks underlie the drift along the western margin of the area (fig. 16) and dip to the southeast. They range in thickness from approximately 500 feet in western McHenry County to more than 1050 feet in southwestern Will County.

The Prairie du Chien Series, consisting of three formations (Oneota Dolomite, New Richmond Sandstone, and Shakopee Dolomite), are considered here as one geohydrologic unit. The series is composed almost entirely of finely to coarsely crystalline, cherty (oolitic), white to light gray to pink dolomite with lenses of sandstone.

The Prairie du Chien rocks are approximately 300 feet thick in southern Will County and thin northward to a feather edge in Cook, DuPage, and Kendall Counties. North of these counties the rocks have been removed, except for isolated outliers, by pre-St. Peter erosion. Prairie du Chien rocks underlie the drift in western Kendall County southwest of the Sandwich Fault zone (fig. 16).

The Glenwood-St. Peter Sandstone underlies all the area reviewed by this report except extreme western Kendall County (fig. 22). It is white to light gray and buff, fine- to coarse-grained, friable sandstone with varying amounts of silt. Near the top, the sandstone is fine-grained with dispersed coarse grains, dolomitic, with occasional lenses of sandy, green shale and buff to greenish gray, argillaceous dolomite. Most of the Glenwood-St. Peter is a fine- to medium-grained, incoherent to friable sandstone. The sandstone was deposited on a very uneven surface and its thickness varies greatly (figs. 15 and 22B). Where the sandstone is exceptionally thick the lower section may consist of fine- to coarse-grained, pink to reddish brown sandstone with varying amounts of shale, chert, and dolomite fragments. The shale is commonly red or green, sandy, and weak.

Fig. 13. Bedrock topography.

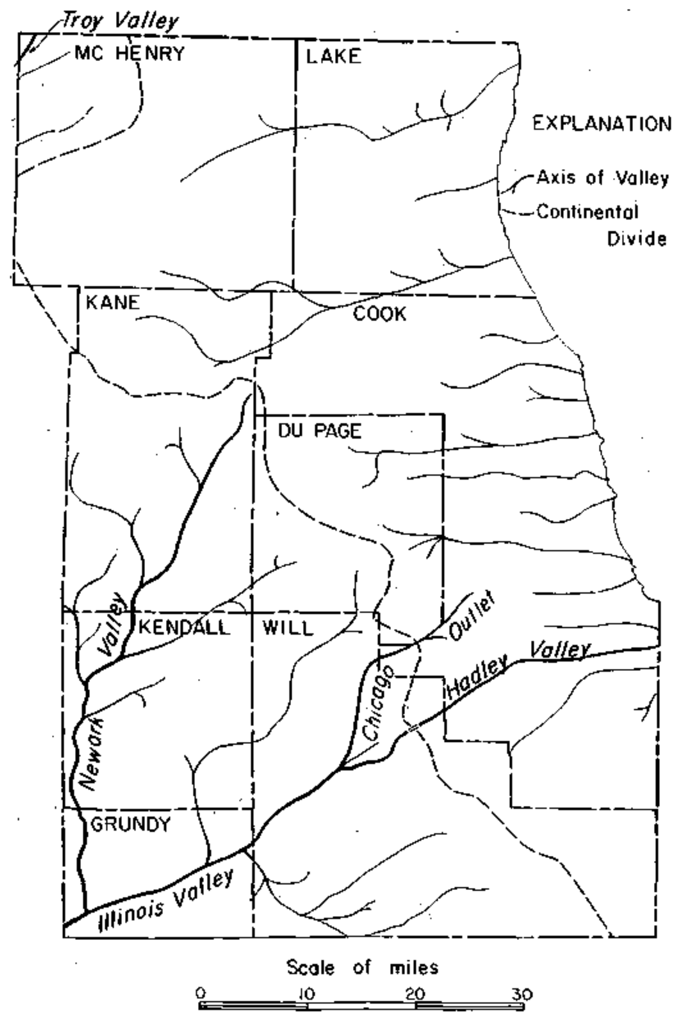


Fig. 14. Bedrock valleys.

The pattern of variation in the thickness of the sandstone (fig. 22B) suggests deposition in previously eroded channels and on adjacent uplands. In some channel areas the Glenwood-St. Peter Sandstone is as much as 650 feet thick. Outside the channel areas, it averages from 150 feet to 250 feet in thickness. The Glenwood-St. Peter Sandstone underlies the drift in only a small part of the area covered by this report and dips generally from the northwest to the southeast at a rate of approximately 10 feet to the mile (figs. 15 and 22A).

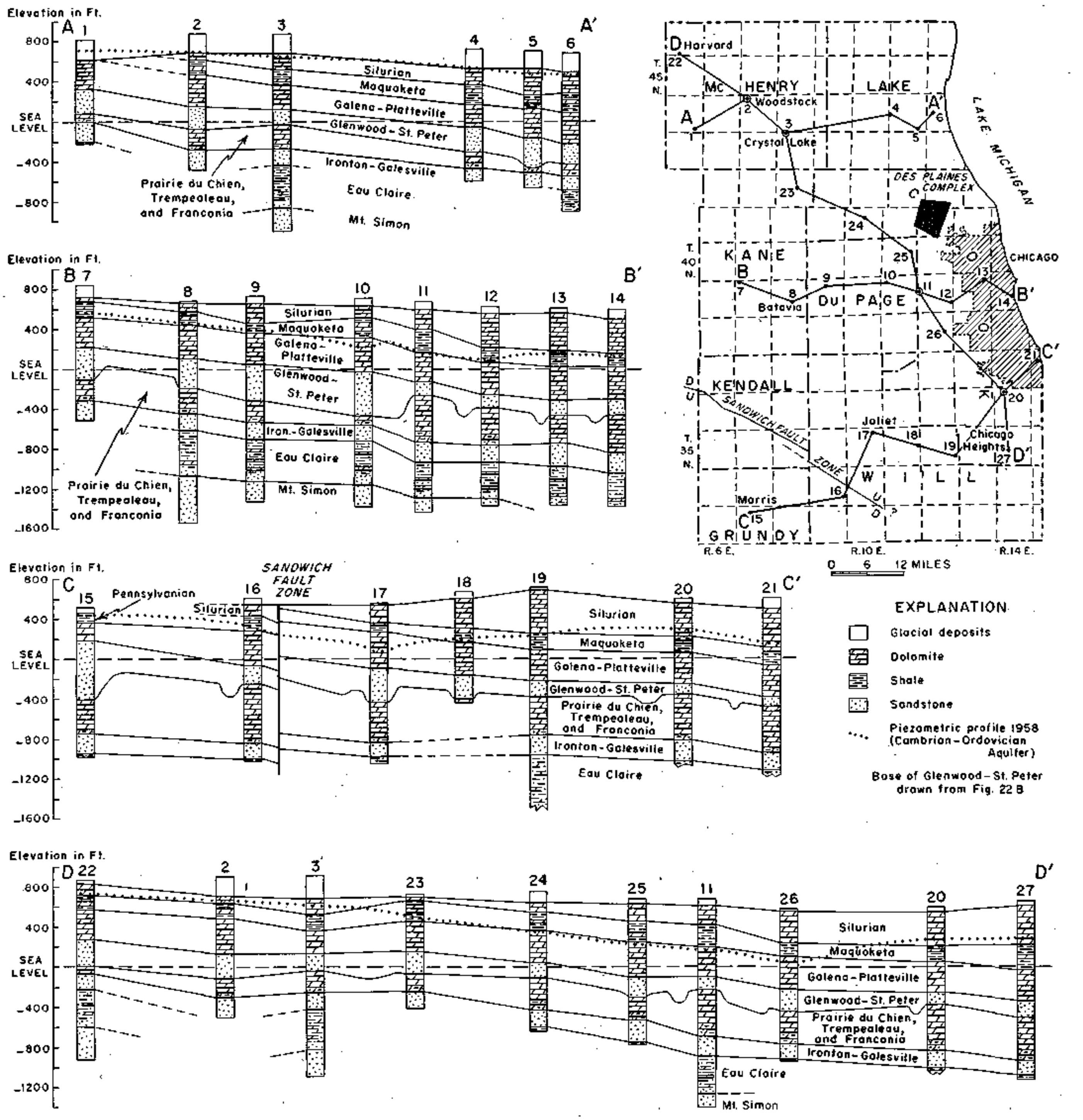


Fig. 15. Cross sections of the structure and stratigraphy of the bedrock and piezometric profiles of the Cambrian-Ordovician Aquifer in the Chicago region.

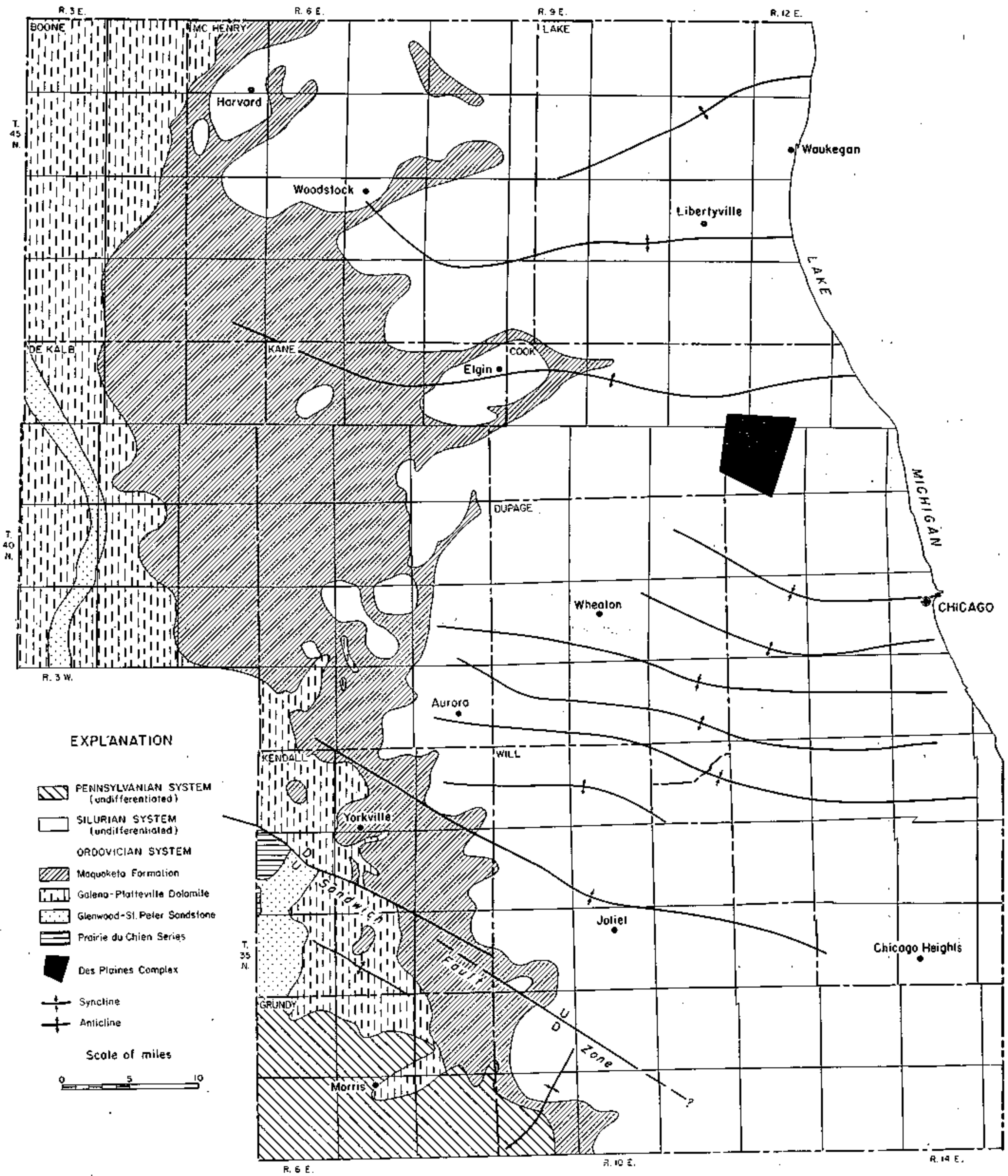


Fig. 16. Areal geology of the bedrock surface and major structures in the Chicago region.

SYSTEM	SERIES	GROUP OR FORMATION	HYDROLOGIC UNITS	LOG	THICKNESS (FT.)	DESCRIPTION
Quaternary	Pleistocene		Glacial drift aquifers		0-350+	Unconsolidated glacial deposits - pebbly clay (till), silt, and gravel. Alluvial silts and sands along streams.
Pennsylvanian		Carbondale Tradewater			0-175	Shale; sandstones, fine-grained; limestones; coal; clay.
Mississippian	Kinderhook				0-365	Shale, green and brown, dolomitic; dolomite, silty.
Devonian					0-25	Shale, calcareous; limestone beds, thin.
Silurian	Niagaran	Port Byron Racine Waukesha Joliet	Silurian (Shallow dolomite aquifer)		0-465	Dolomite, silty at base, locally cherty.
	Alexandrian	Kankakee Edgewood				
Ordovician	Cincinnatian	Maquoketa	Maquoketa (Shallow dolomite aquifer)		0-250	Shale, gray or brown; locally dolomite and/or limestone, argillaceous.
	Mohawkian	Galena	Galena-Platteville (Shallow dolomite aquifer / Cambrian-Ordovician Aquifer)		220-350+	Dolomite and/or limestone, cherty.
		Decorah				Dolomite, shale partings, speckled.
		Platteville				Dolomite and/or limestone, cherty, sandy at base.
		Glenwood	Glenwood-St. Peter (Cambrian-Ordovician Aquifer)		100-650	Sandstone, fine- and coarse-grained; little dolomite; shale at top.
	Chazyan	St. Peter				Sandstone, fine- to medium-grained; locally cherty red shale at base.
	Prairie du Chien	Shakopee	Prairie du Chien (Cambrian-Ordovician Aquifer)		0-340	Dolomite, sandy, cherty (oolitic); sandstone.
		New Richmond				Sandstone, interbedded with dolomite.
		Oneota				Dolomite, white to pink, coarse-grained, cherty (oolitic), sandy at base.
Cambrian	St. Croixian	Trempealeau	Trempealeau (Cambrian-Ordovician Aquifer)		0-225	Dolomite, white, fine-grained, geodic quartz, sandy at base.
		Franconia	Franconia (Cambrian-Ordovician Aquifer)		45-175	Dolomite, sandstone, and shale, glauconitic, green to red, micaceous.
		Ironton Galesville	Ironton-Galesville (Cambrian-Ordovician Aquifer)		105-270	Sandstone, fine- to medium-grained, well sorted, upper part dolomitic.
		Eau Claire	Eau Claire (upper and middle beds)		235-450	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic.
		Mt. Simon	Sandstones Eau Claire (lower) & Mt. Simon (Mt. Simon)		2000±	Sandstone, coarse-grained, white, red in lower half; lenses of shale and siltstone, red, micaceous.
Precambrian						

Fig. 17. Stratigraphy and water-yielding properties of the

DRILLING AND CASING CONDITIONS	WATER-YIELDING PROPERTIES	CHEMICAL QUALITY OF WATER	WATER TEMPERATURE °F
Boulders, heaving sand locally; sand and gravel wells usually require screens and development; casing required in wells into bedrock.	Sand and gravel, permeable. Some wells yield more than 1000 gpm. Specific capacities from 2.1 to 66 gpm/ft, av. 12 gpm/ft. Coefficient of trans. from 3400 to 100,000 gpd/ft, av. 25,000 gpd/ft.	McHenry County, hardness from 100 to 450 ppm., av. 275. Other counties, see Silurian below and text.	46° min. 52° av. 54° max.
Shale requires casing.	Jointed beds yield small supplies locally.		
	Limited areal extent; not used as aquifer.		
Upper part usually weathered and broken; extent of crevicing varies widely.	Not consistent; some wells yield more than 1000 gpm. Crevices and solution channels more abundant near surface. Specific capacities from 0.1 to 550 gpm/ft. Highest av. specific capacities (54.4 gpm/ft) in Du Page Co. wells, lowest (5 gpm/ft) in Lake Co. Coefficient of trans. averages 100,000 gpd/ft in Du Page Co., 9000 gpd/ft in Lake Co.	Variable. Hardness, <100 to >1000 ppm. Iron >0.3 ppm in 80% of analyses.	54°
Shale requires casing.	Shales, generally not water yielding, act as barriers between shallow and deep aquifers. Crevices in dolomite yield small amounts of water.		
Crevicing common only where formations underlie drift. Top of Galena usually selected for hole reduction and seating of casing.	Where formation lies below shales, development and yields of crevices are small; where not capped by shales, dolomites are fairly permeable.	Hardness < 100 ppm. H_2S often present.	54° to 55°
Lower cherty shales cave and are usually cased. Friable sand may slough.	Small to moderate quantities of water. Trans. probably about 15% of that of Cam.-Ord. Aquif.	Water similar in quality or slightly harder than that in Ironton-Galesville Sandstone.	53° to 56° 56° to 58° (Lake Co.)
Crevices encountered locally in the dolomite, especially in Trempealeau. Casing not required.	Crevices in dolomite and sandstone generally yield small amounts of water. Trempealeau locally well creviced and partly responsible for exceptionally high yields of several deep wells.		
Amount of cementation variable. Lower part more friable. Sometimes sloughs.	Most productive unit of Cam.-Ord. Aquif; trans. probably about 80% its total. Coefficients of trans. and storage of the Cam.-Ord. Aquif. av. 17,400 gpd/ft and 0.00035.	Hardness 200 to 250 ppm in northwest part of area, increasing toward east and south. Iron usually <0.4 ppm.	56° - 58° to 62° - 64°
Casing not usually necessary. Locally weak shales may require casing.	Shales, generally not water yielding, act as barrier between Ironton-Galesville and Mt. Simon.	Water soft in upper 100'; hardness increases downward (4000 ppm at elev. -2100'); chlorides 400 ppm at elev. -1600', increase at rate of 400 ppm each additional 25' depth.	66° at elev. -1300', increasing 1° with each additional 100' depth. Influenced by water from upper formations.
Casing not required.	Moderate amounts of water; permeability intermediate between that of Glenwood-St. Peter and Ironton-Galesville.		
crystalline rocks			

rocks and character of the ground water in the Chicago region.

SYSTEM	THIS REPORT	FOLEY, WALTON, & DRESCHER (1953)	WILLMAN & PAYNE (1942)	THWAITES (1927)	FISHER (1925)	ANDERSON (1919)
Quat.	Pleistocene Series	Recent Pleistocene	Pleistocene		Pleistocene	Pleistocene
Penn.	Pennsylvanian		Pennsylvanian	Pennsylvanian		Pennsylvanian
Miss.	Kinderhook Series	Carboniferous (Mississippian)				
Dev.	Devonian	Milwaukee Thiensville		Devonian		
Silurian	Niagaran Series	Waubakee	Niagaran	Niagaran	Niagaran	Niagaran
Silurian	Alex. Series: Kankakee, Edgewood	Niagara	Alexandrian	Alexandrian	Alexandrian	Alexandrian
Ordovician	Maquoketa	Maquoketa	Maquoketa	Maquoketa	Richmond	Maquoketa
Ordovician	Galena Decorah Platteville	Galena Platteville	Galena Decorah Platteville Glenwood	Galena Decorah Platteville	Galena Platteville	Galena Platteville
Ordovician	Glenwood – St. Peter	St. Peter	St. Peter	St. Peter	St. Peter	St. Peter
Ordovician	Prairie du Chien Series: Shakopee, New Richmond, Oneota		Prairie du Chien Series: Shakopee, New Richmond, Oneota	Prairie du Chien Group: Shakopee, "New Richmond", Oneota	Prairie du Chien Series: Shakopee, New Richmond, Oneota	Prairie du Chien Group: Shakopee, New Richmond, Oneota
Cambrian	Trempealeau		Jordan	Jordan	Croixian Series "Potsdam Sandstone"	
Cambrian			Trempealeau	Trempealeau		
Cambrian	Franconia		Franconia	Mazomanie Franconia		
Cambrian	Ironton – Galesville		Galesville	Dresbach		Jordan
Cambrian	Eau Claire	Eau Claire	Eau Claire	Eau Claire		St. Lawrence
Cambrian	Mt. Simon	Mt. Simon	Mt. Simon	Mt. Simon		Dresbach

Fig. 18. Stratigraphic nomenclature used in this and previous reports relating to the Chicago region.

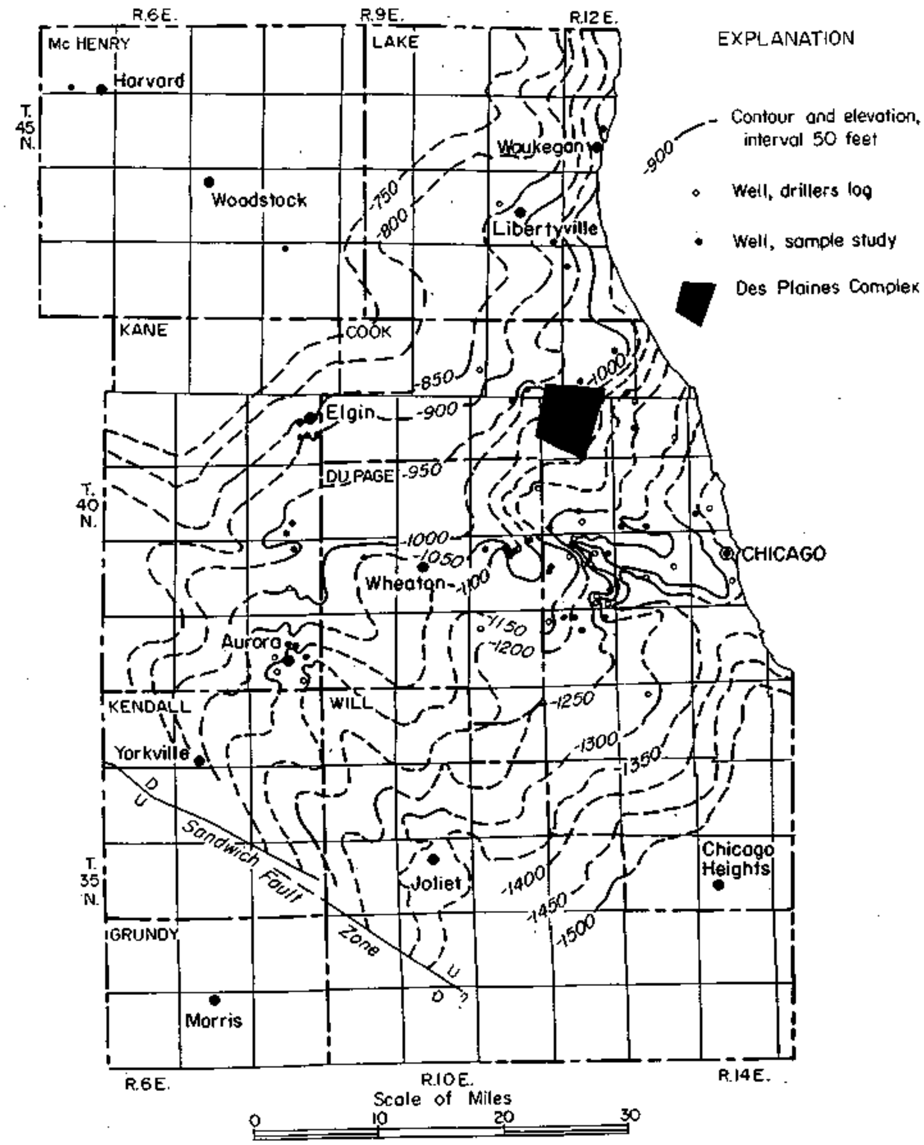


Fig. 19. Elevation of the top of the Mt. Simon Aquifer.

The extreme variability in thickness and lithologic character of the Glenwood-St. Peter are exemplified by the following logs of the Automatic Electric Company Wells No. 1 and No. 2, which are 770 feet apart:

Well No. COK 40N12E-31.4d
Automatic Electric Company Well No. 1,
Illinois Geological Survey Sample Set No. 27117

	Thickness (feet)	*Depth (feet)*
Ordovician System		
Glenwood-St. Peter Sandstone		
Sandstone, partly dolomitic, white, fine to medium, few coarse grains	10	800
Sandstone, silty, white, very fine to coarse grains, incoherent	100	900
Sandstone, slightly silty, white, fine to coarse grains, incoherent	60	960
Sandstone, silty, white, very fine to coarse grains	10	970
Total thickness	180	

Well No. COK 40N12E-31.4c
Automatic Electric Company Well No. 2,
Illinois Geological Survey Sample Set No. 27118

	Thickness (feet)	*Depth (feet)*
Ordovician System		
Glenwood-St. Peter Sandstone		
Sandstone, dolomitic, gray, fine and coarse grains	7	790
Sandstone, white, fine to coarse grains	5	795
Sandstone, partly silty, white, very fine to coarse grains, incoherent	40	835
Sandstone, silty, white, very fine to fine grains, few medium grains, incoherent	5	840
Sandstone, silty to slightly silty, white, very fine to coarse grains, incoherent	45	885
Sandstone, partly silty, white, very fine to coarse grains, some siliceous cementing at base	135	1020
Sandstone, white, very fine to coarse grains, incoherent	55	1075
Sandstone, silty at top, pink to light red, very fine to coarse grains, incoherent	115	1190
Sandstone, silty, very fine to coarse grains, shale, red, green, purple, weak	10	1200
Total thickness	417	

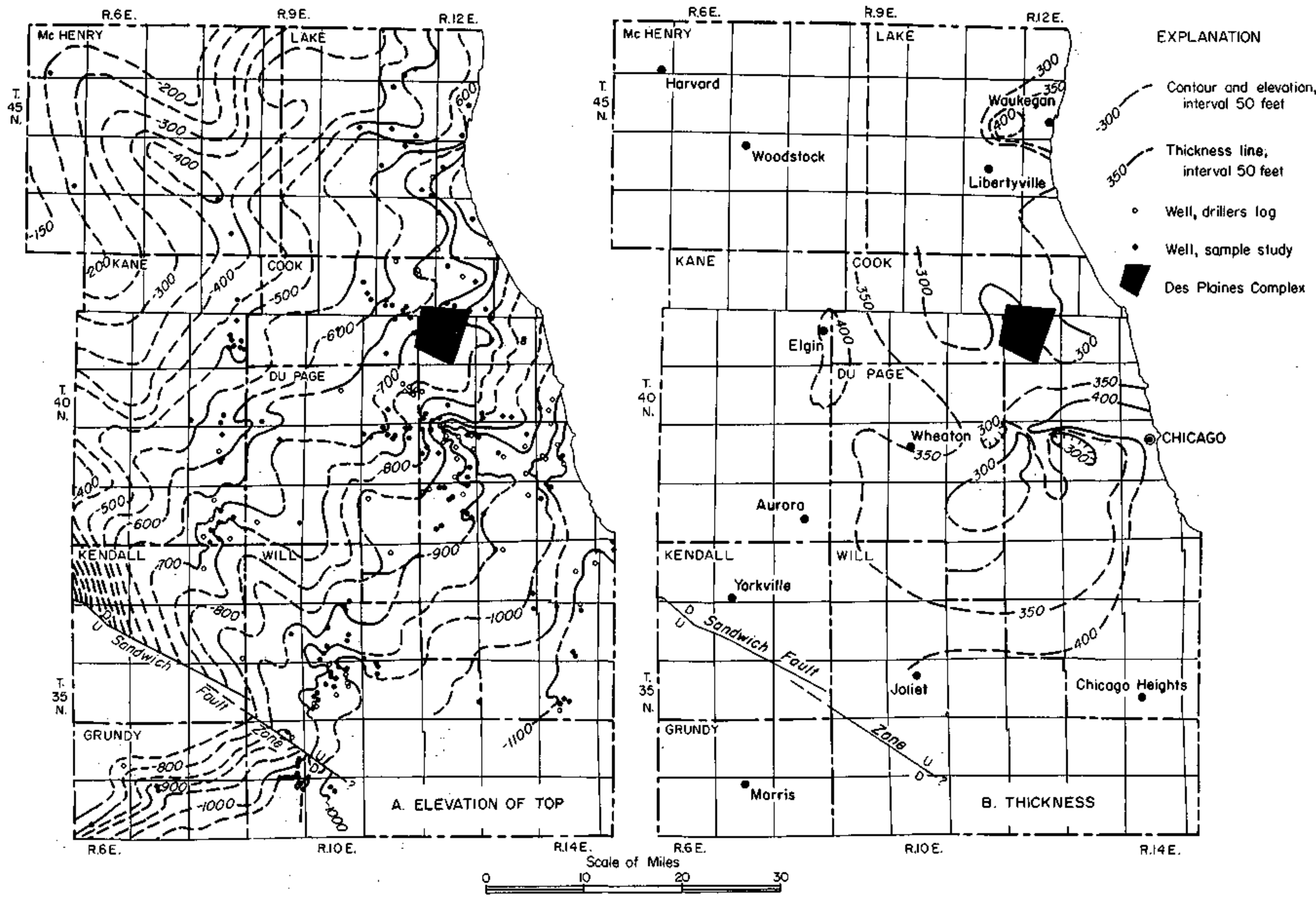


Fig. 20. Elevation of the top (A) and thickness of the upper and middle units (B) of the Eau Claire Formation.

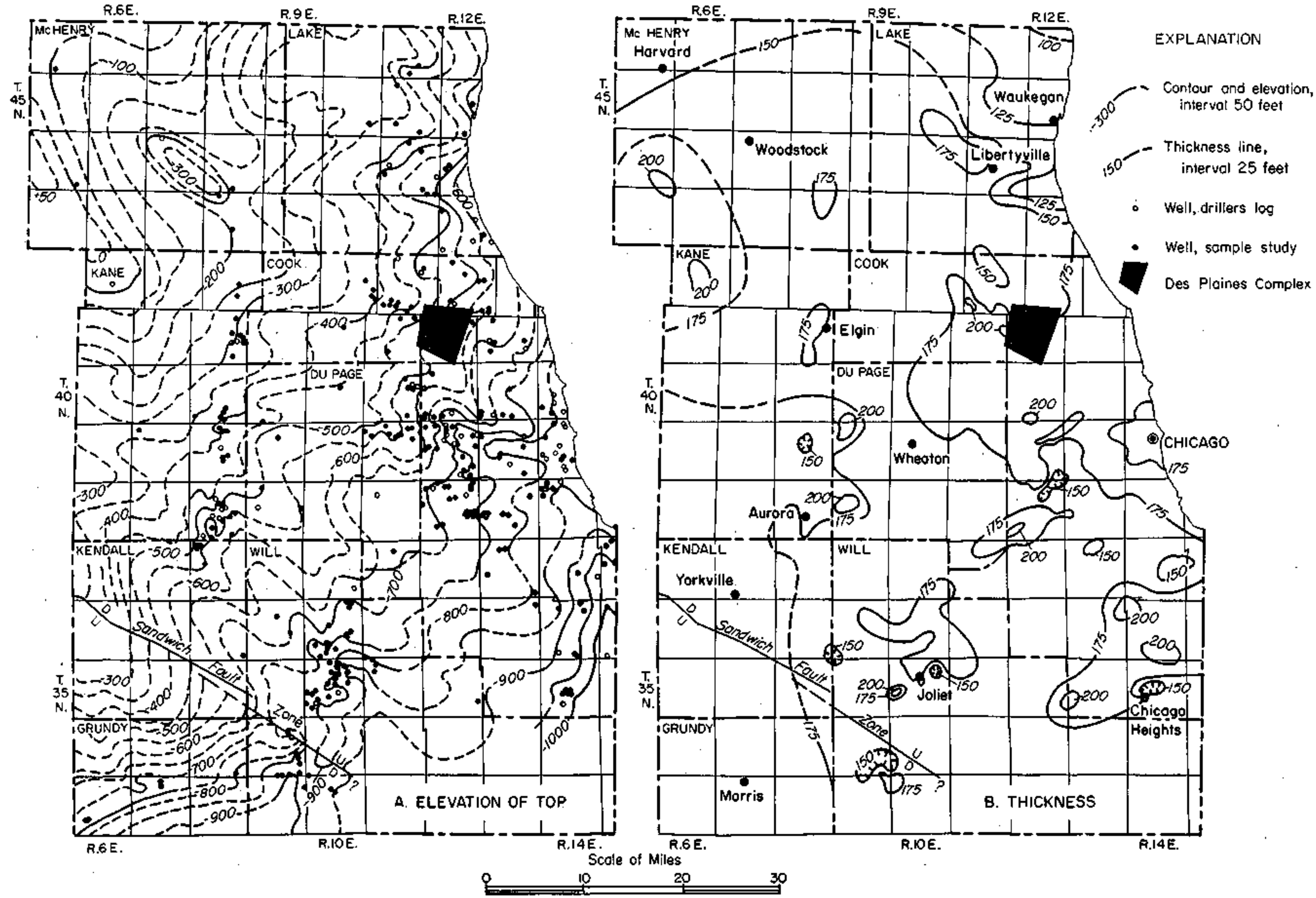


Fig. 21. Elevation of the top (A) and thickness (B) of the Ironton-Galesville Sandstone.

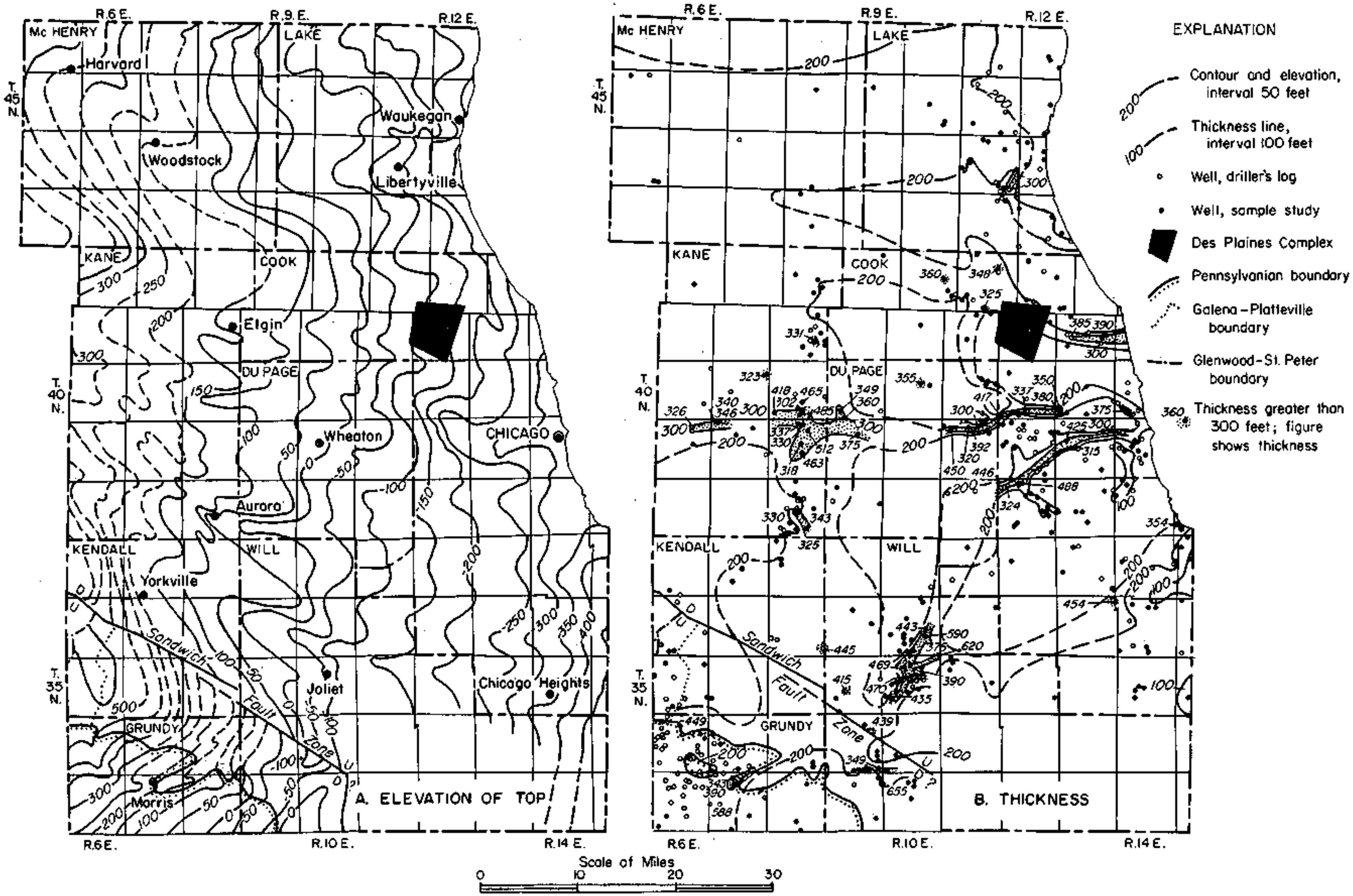


Fig. 22. Elevation of the top (A) and thickness (B) of the Glenwood-St. Peter Sandstone.

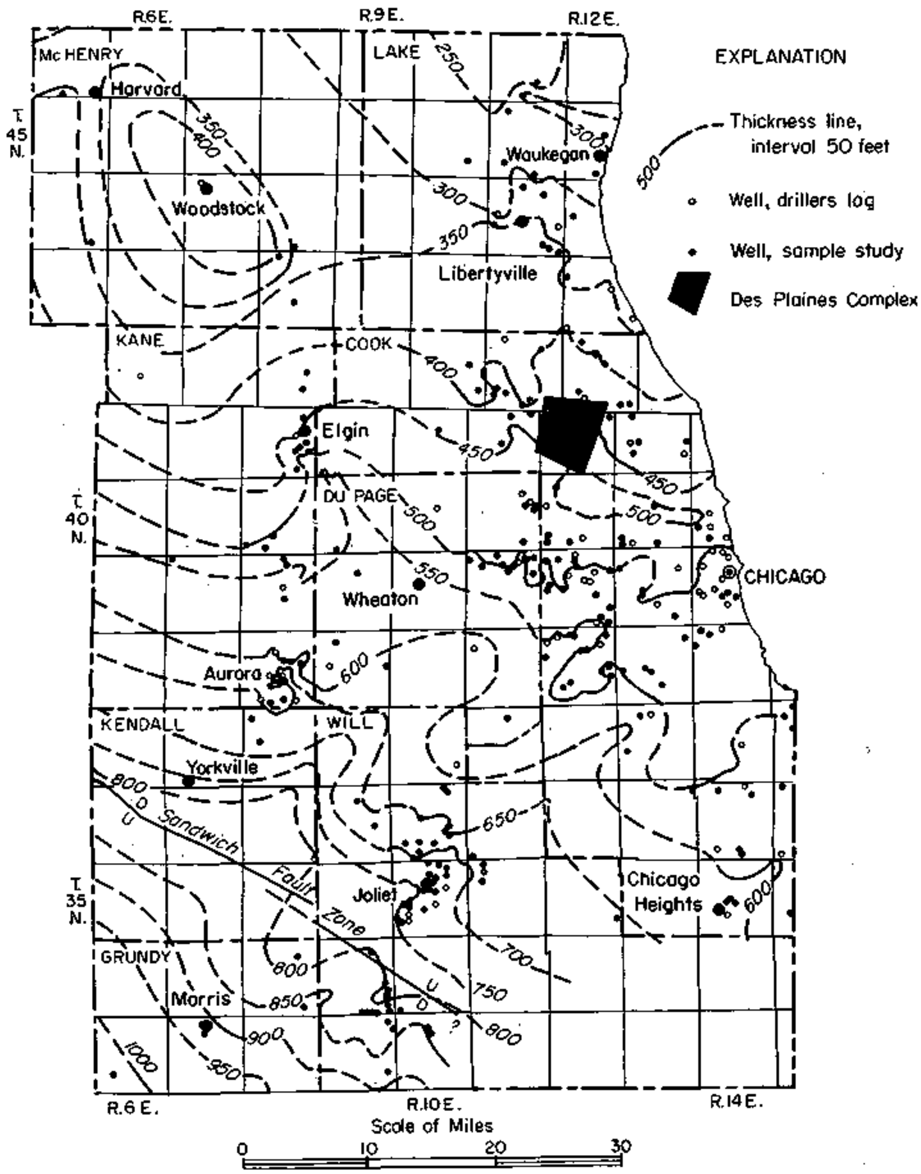


Fig. 23. Thickness of the rocks between the top of the Glenwood-St. Peter Sandstone and the top of the Ironton-Galesville Sandstone.

Considerable thinning of beds between the Glenwood-St. Peter and Ironton-Galesville Sandstones occurs between Grundy and Lake Counties (fig. 23). Much of the northward thinning was produced by pre-St. Peter uplift and subsequent erosion. Following the erosion the St. Peter Sandstone was deposited on beds that range from Shakopee to Franconia in age.

The Galena-Platteville Dolomite consists of three formations that are considered one geohydrologic unit. The lowest formation is the Platteville Dolomite, which is commonly argillaceous, cherty in the upper half, buff to gray, very fine- to fine-grained, and commonly mottled. Near the base it is sandy. The Decorah Formation lies above the Platteville and consists of fine- to medium-grained, speckled (red and black) dolomite with thin gray to red shale partings. The overlying Galena Dolomite is cherty in the lower half, fine- to medium-grained, buff to brown, and includes scattered thin shale beds. In Grundy, Kendall, DuPage, southeastern Kane, and western Will Counties the Galena-Platteville is interbedded dolomitic limestone and calcareous dolomite that grade into one another.

The Galena-Platteville Dolomite is uniform in thickness, ranging from approximately 300 to 350 feet (fig. 24B). It dips generally to the east at a rate of about 10 feet to the mile (fig. 24A). Galena-Platteville rocks underlie the drift in northwestern McHenry, southwestern Kane, western Kendall, and northwestern Grundy Counties (fig. 16) and are known from wells in the rest of the region.

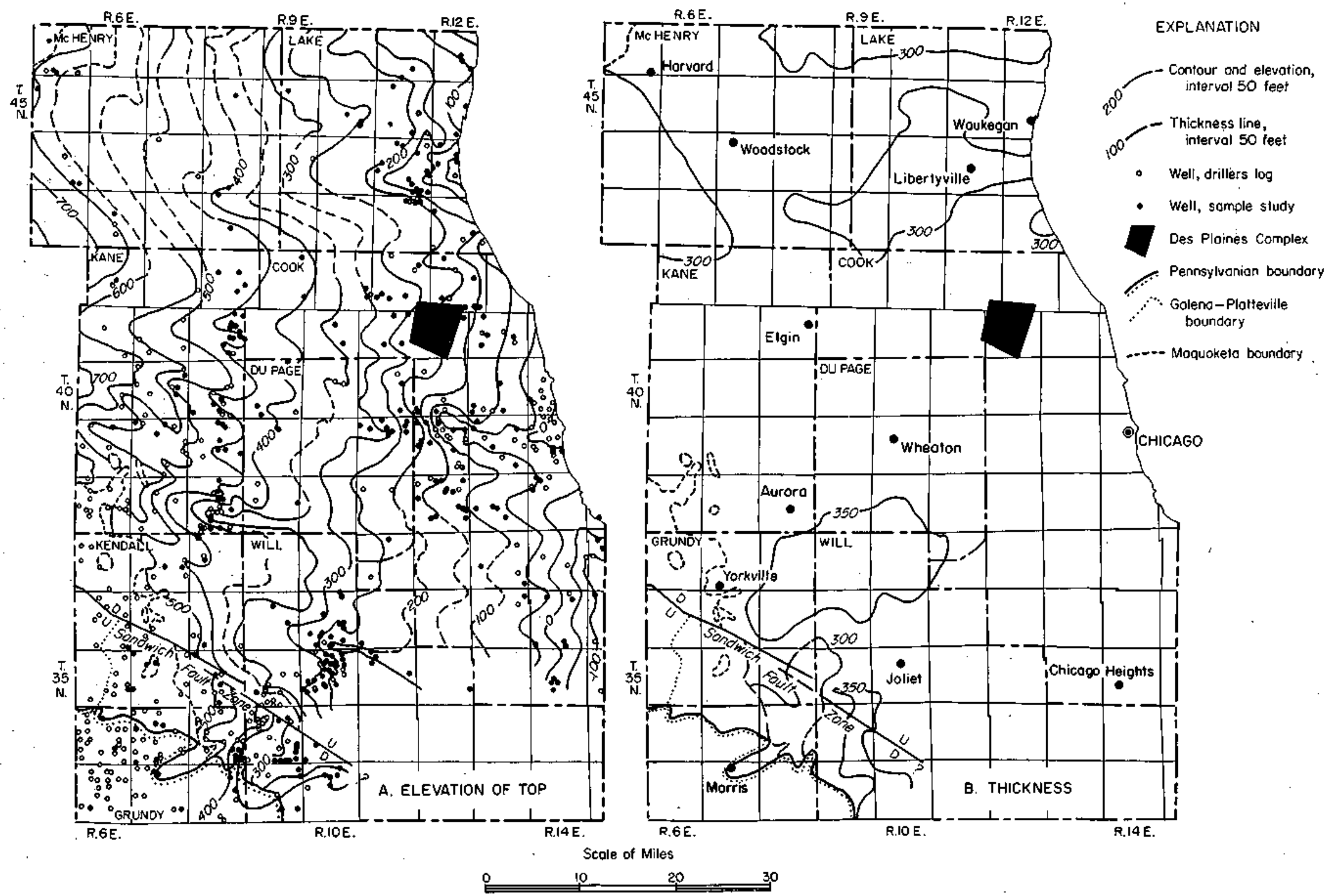


Fig. 24. Elevation of the top (A) and thickness (B) of the Galena-Platteville Dolomite.

The Maquoketa Formation can be divided into three units (fig. 25) : 1) lower shale, 2) middle dolomite and/or limestone and shale, and 3) upper dolomitic shale. There is commonly difficulty in separating the middle and upper units that may grade into each other.

The lower unit is normally a brittle, dark brown, occasionally gray or grayish brown, dolomitic shale grading' locally to dark brown, argillaceous dolomite. This unit is thicker in Cook and Will Counties where it exceeds 100 feet (fig. 25C). It thins to the north and west to less than 50 feet. Local variations in the thickness of the lower unit may be a result of its grading into the middle unit.

The middle unit is dominantly brown to gray, fine- to coarse-grained, fossiliferous, argillaceous, speckled dolomite and limestone. It is commonly interbedded with a fossiliferous brownish gray to gray, dolomitic shale. This unit is thicker to the west where it is more than 100 feet locally, and thins to the east (fig. 25B).

The upper unit of the Maquoketa Formation is a greenish gray, weak, silty, dolomitic shale that grades into very argillaceous, greenish gray to gray dolomite. This dolomite is distinguishable with difficulty from the dolomite of the middle unit or from the overlying dolomite of Silurian age. It ranges in thickness from less than 50 feet in the west to more than 100 feet in parts of Cook and Will Counties (fig. 25A). The three divisions of the Maquoketa Formation are shown in the following log:

Well No. COK 35N14E-21.3h
Calumet Steel Division, Borg Warner Corporation,
Well No. 4, Illinois Geological Survey
Sample Set No. 21216

	Thickness (feet)	*Depth (feet)*
Ordovician System		
Maquoketa Formation		
Shale, dolomitic, greenish gray, weak; interbedded dolomite, pale yellowish brown to green, fine, silty	80	525
Dolomite, silty, green, light to dark gray, fine to coarse, mottled; few shale streaks in lower half, sandy, olive, weak . .	40	565
Shale, slightly dolomitic, grayish brown to brown, weak to brittle; interbedded thin dolomite, olive, finely crystalline	114	679
Total thickness	234	

The Maquoketa Formation underlies the drift along most of the western margin of the region and is overlain by the dolomite of Silurian age to the east. It attains a thickness of as much as 250 feet and thins to the west (fig. 26B). The formation dips to the east at a rate of about 10 feet to the mile (fig. 26A).

Silurian Rocks

Rocks of Silurian age form the bedrock surface throughout the eastern three-quarters of the region (fig. 16). They are mainly dolomites (popularly called limestones) and are silty at the base. The Silurian rocks are divided into the Alexandrian Series below and the Niagaran Series above (fig. 17). The Alexandrian Series consists of two formations: Edgewood below and Kankakee above.

The Edgewood Formation is an argillaceous to finely sandy, light gray to gray brown, finely crystalline dolomite. At some places it is quite similar to the dolomite of the Maquoketa Formation. The Kankakee Formation is a light gray to buff, cherty, finely crystalline dolomite.

The Niagaran Series is white to light gray, finely to medium crystalline, compact dolomite with varying amounts of silt. White to light gray chert generally occurs in the upper part. At the base the dolomite is commonly green, pink, or red and is slightly silty.

The Silurian rocks are buried beneath glacial deposits except in small areas. They have been deeply eroded during pre-Pleistocene and Pleistocene time, producing variations in thickness (fig. 27). They range from a feather edge to more than 450 feet thick, thickening to the southeast.

Devonian and Mississippian Rocks

Rocks of Devonian and Mississippian age occur locally on top of Silurian rocks in Will and Cook Counties. They are covered by glacial drift and known only from well records.

Rocks of possible Devonian age (fig. 17) are reported in a few drillers' logs. The rocks are generally blue to dark colored, "limy" shale.

The Mississippian rocks (fig. 17) are known only from the area of the Des Plaines Complex (fig. 16), where they are dolomitic, gray to brown, weak shales interbedded with silty, slightly cherty, brown to gray, finely crystalline dolomite. They are reported from only a few wells and range in thickness up to 375 feet.

Pennsylvanian Rocks

Rocks of Pennsylvanian age (fig. 17) are the youngest bedrock strata in the region. They are exposed or underlie the glacial drift only in Grundy and southwestern Will Counties (fig. 16) and overlie unconformably the older rocks of the region.

The Pennsylvanian rocks are composed of gray to black, partly calcareous, pyritic, weak to brittle shale; argillaceous, brownish gray, calcareous, pyritic sandstone; gray, argillaceous limestone; and coal. They range in thickness from less than a foot to more than 190 feet in the area of study.

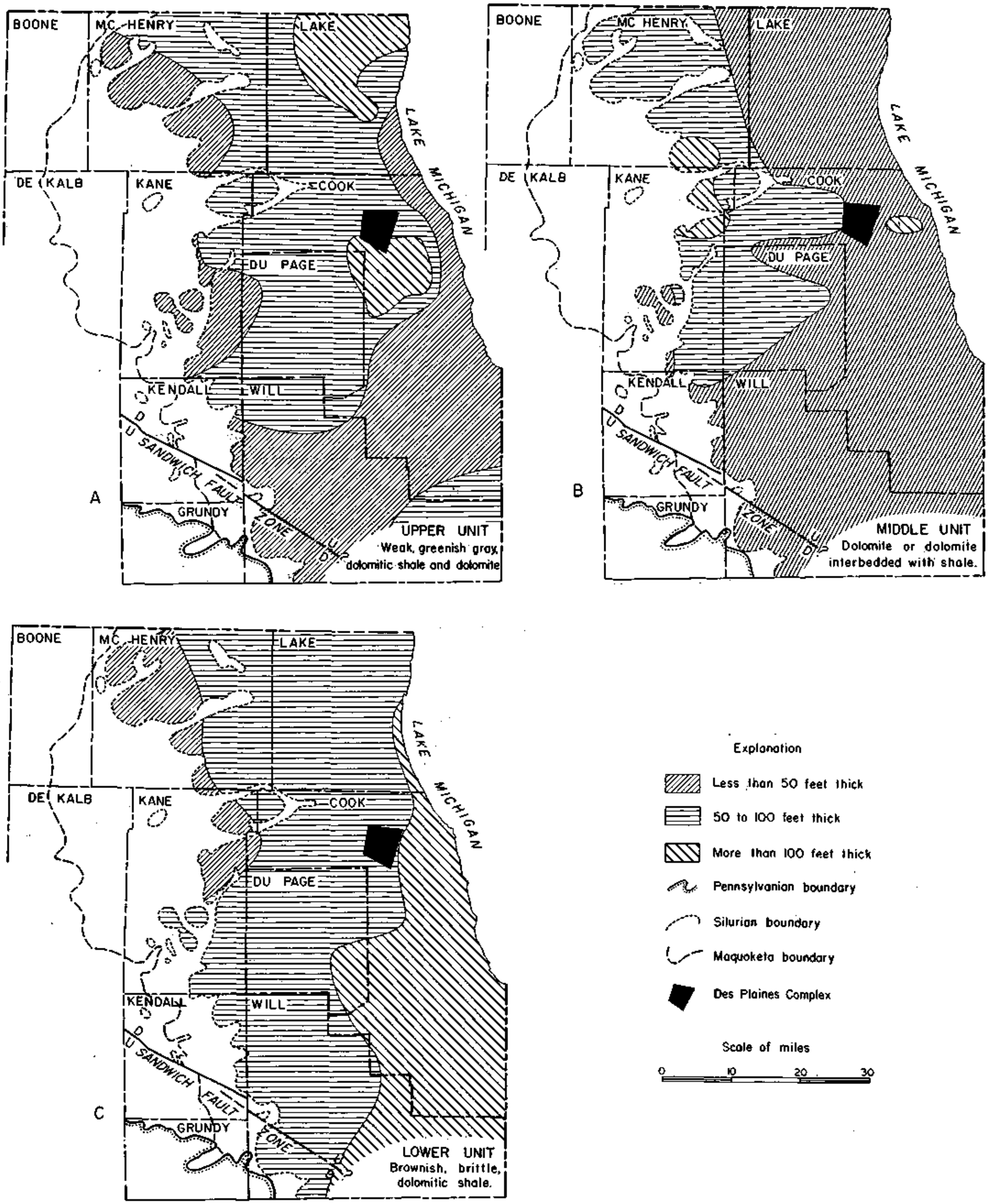


Fig. 25. Lithologic character and thickness of the upper (A), middle (B), and lower (C) units of the Maquoketa Formation.

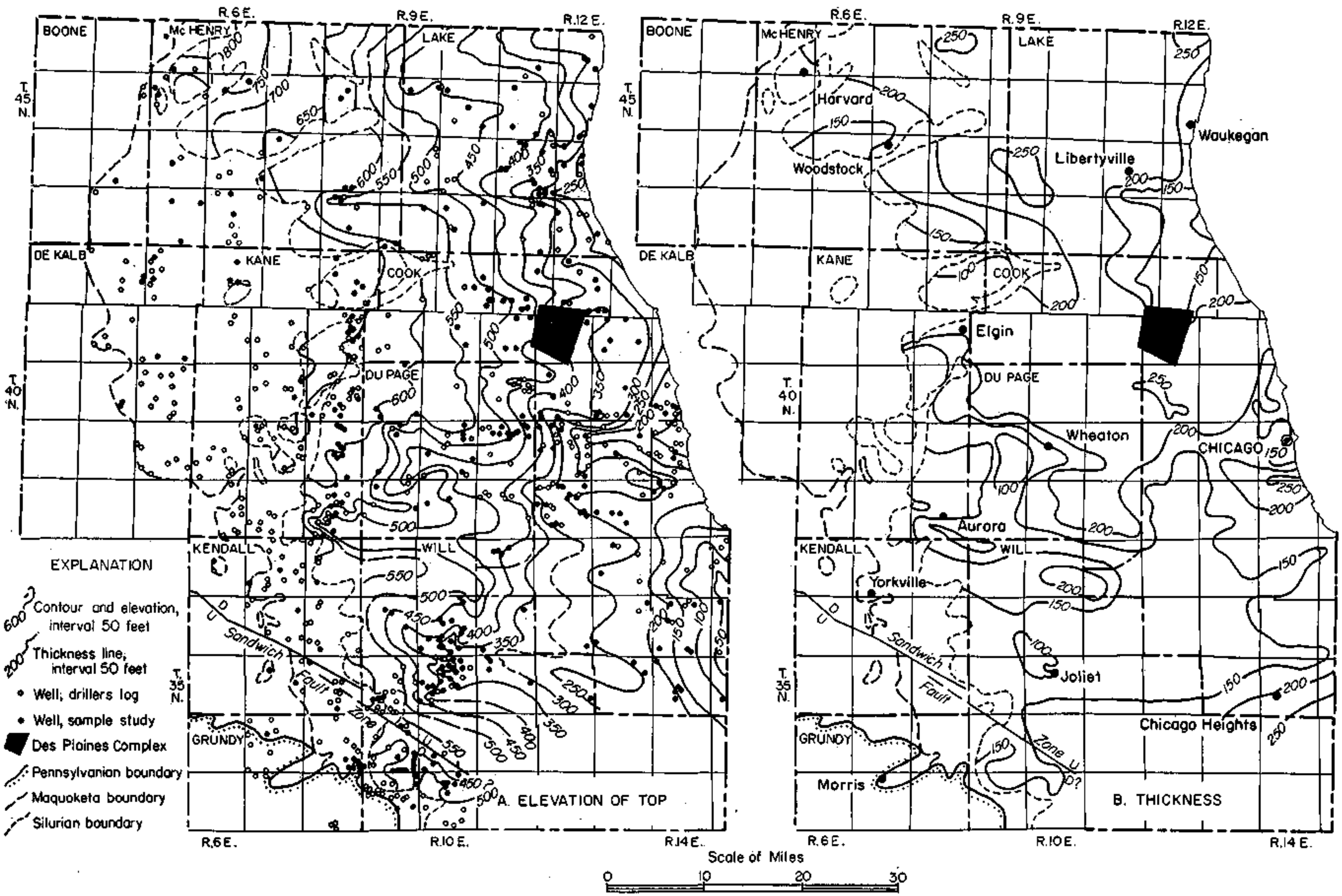


Fig. 26. Elevation of the top (A) and thickness (B) of the Maquoketa Formation. Thickness is not shown where the Maquoketa crops out or directly underlies the glacial drift.

BEDROCK STRUCTURE

Structure Contour Maps

Structure contours are lines connecting points of equal elevation of a given rock formation. Depth to the formation can be estimated for any location by subtracting the elevation on the structure contour map from the surface elevation at that point. Structure contour maps (figs. 19, 20A, 21A, 22A, 24A, and 26A) show elevations of the tops of the following units: Mt. Simon Aquifer, Eau Claire, Ironton-Galesville, Glenwood-St. Peter, Galena-Platteville, and Maquoketa. Because of the uneven spacing of well control points for the Ironton-Galesville and lower formations, many elevations for the structure maps in figures 19, 20A, and 21A were estimated. Estimates were made of Ironton-Galesville elevations by subtracting from elevations of the Glenwood-St. Peter Sandstone the thickness of the interval from the top of the Glenwood-St. Peter to the top of the Ironton-Galesville (fig. 23). Estimates made in a similar manner were used in constructing the Eau Claire and the Mt. Simon Aquifer structure contour maps.

Regional Structure

Northeastern Illinois is on a structural high called the Kankakee Arch between two major structural basins, the Michigan Basin to the northeast and the Illinois Basin to the south. In the Chicago region the beds have a gentle regional dip to the east and south of about 10 feet to the mile (fig. 15).

Folds

A series of folds trending east-west and pitching eastward with the regional dip are well defined locally by all stratigraphic horizons and appear to be at least post-Silurian in age. The axes of these folds are shown in figure 16.

Faults

The Sandwich Fault zone (figs. 15 and 16) extends eastward from Sandwich, DeKalb County, and into Will County. Faulting is complex. There are at least two major faults with possible minor faults paralleling or at angles to the general trend. In Kendall County a fault in this zone strikes northwest-southeast with the south side upthrown. The throw is more than 50 feet in western Kendall County, but it decreases to the southeast. Farther east in Will County a fault in the same zone strikes northwest-southeast with the north side upthrown and has a throw of more than 125 feet which decreases to the west. The eastern extent of the fault zone is not known due to lack of information in southeastern Will County:

Faulting in the Des Plaines area, Cook County, is complex and has no apparent relationship to regional structure. The 25-square-mile area is bounded and cut by a series of faults. Within the complex, rocks as old as Prairie du Chien occur just below the drift and rocks as young as Mississippian have been preserved. Because of the complexity and lack of data, the Des Plaines Complex is not considered in detail in this report.

HISTORY OF BEDROCK

The bedded sedimentary rocks beneath the glacial drift record the advance and retreat of shallow seas across northeastern Illinois. Sandstones and shales were formed from sands and muds washed into the sea, whereas most dolomites and limestones were formed by deposition of carbonates in clear, shallow seas away from the influx of clastic sediments. Slow general subsidence of the whole area permitted the accumulation of more than 3000 feet of sedimentary rocks, though from time to time episodes of uplift and erosion produced breaks in the sedimentary record. One of the more prominent episodes of uplift occurred after the deposition of the Prairie du Chien rocks, when erosion beveled rocks ranging in age from Prairie du Chien to Franconia and cut deep channels that were later filled by St. Peter Sandstone.

Final emergence from beneath the sea occurred during Pennsylvanian time when the region lay close to sea level and was successively the site of shallow marine basins and terrestrial coal swamps.

Local deformations of the sedimentary rocks probably occurred during the latter part of the Paleozoic Era. The widespread absence of Paleozoic rocks younger than Silurian in northeastern Illinois makes precise dating of such structures as the Sandwich Fault zone, Des Plaines Complex, and local anticlines and synclines highly speculative.

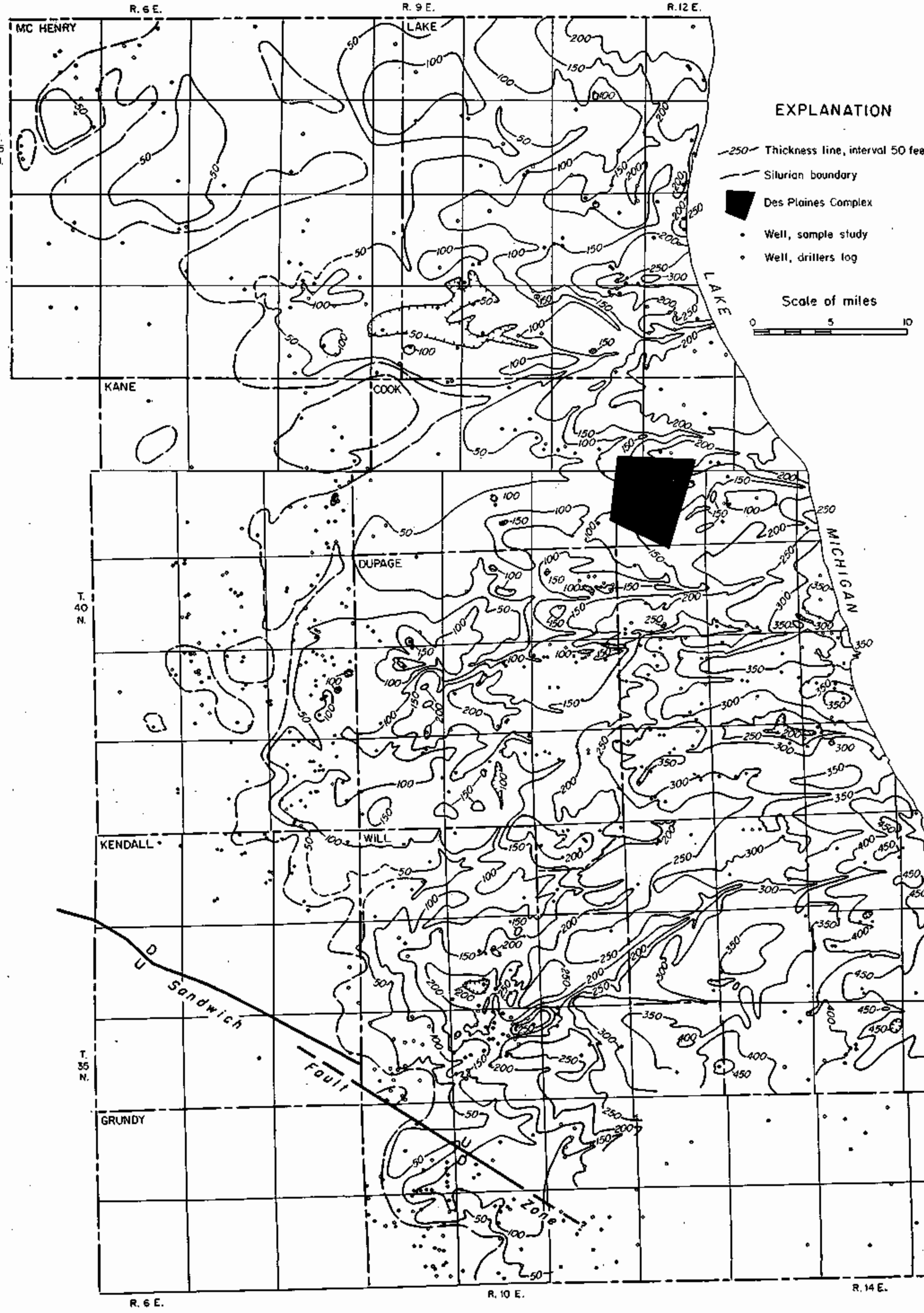
BEDROCK TOPOGRAPHY

The contouring of the bedrock topography (fig. 13) and the thickness of the unconsolidated deposits (fig. 12) is made possible by the hundreds of well records that are available for the region. Most features of the bedrock topography shown in figure 13 have been previously delineated, named, and discussed by Horberg (1950) in his study of the bedrock topography of the state. Bretz (1955, p. 51-57) also described the bedrock topography of the Chicago region.

The depth to bedrock at any location can be estimated by subtracting the bedrock surface elevation (fig. 13) from the land surface elevation at that point.

The surface of the bedrock topography slopes with the bedding, descending gradually toward the east. This is shown by the cross sections of the glacial drift and bedrock (figs. 6 and 15) and the various bedrock structure maps. Along the western townships the highest bedrock surfaces rise from slightly more than 650 feet elevation in Kendall County to more than 850 feet in McHenry County, whereas much of the bedrock surface in the eastern half of the region is well below the level of present Lake Michigan (580 feet).

Fig. 27. Thickness of the Silurian rocks.


R. 6 E.
R. 9 E.
R. 12 E.
MC HENRY
LAKE
KANE
COOK
DUPAGE
KENDALL
WILL
GRUNDY
T. 45 N.
T. 40 N.
T. 35 N.
EXPLANATION
250 Thickness line, interval 50 feet
Silurian boundary
Des Plaines Complex
Well, sample study
Well, drillers log
Scale of miles
0 5 10
LAKE MICHIGAN
Sandwich Fault Zone
D
U
R. 6 E.
R. 10 E.
R. 14 E.

The bedrock surface is scored by a number of stream valleys and their tributaries whose bottom slopes are either directed eastward toward present Lake Michigan, southwestward toward the Illinois-Mississippi drainage system, or southward toward the Mahomet-Mississippi drainage system. Figure 14 shows the axes of the main valleys and the major drainage divide prior to glaciation of the region. The divide, passing from southeastern Will County to northwestern McHenry County, is well west of the present divide developed on the glaciated surface (fig. 4).

Most of the bedrock valleys that slope eastward toward Lake Michigan head near the crest of the Silurian highlands. They are commonly cut less than 100 feet below the adjoining bedrock uplands and pass below the present shore of Lake Michigan at elevations of about 450 feet above sea level.

The valleys west of the divide belong to the Illinois-Newark network or to the Troy-Rock network. Troy Valley, which passes through the northwest township of the region, is cut more than 250 feet below the adjacent upland and is overlain by the thickest glacial deposits in the region (fig. 12). A tributary of the Troy Valley underlies the next township south.

Most of the bedrock valleys of Kendall and southern Kane Counties belong to the Newark system. The main valley heads in the Silurian escarpment in northeastern Kane County and crosses the Maquoketa, Galena-Platteville, Glenwood-St. Peter, and Pennsylvanian rocks. The valley has an average width of a mile and is 100 to 150 feet deep. Before glaciation the Newark drainage continued southward through Grund.y and Livingston Counties toward Mahomet Valley, but it was diverted westward, perhaps by Kansan or Nebraskan glaciers. The valleys in western and southern Will, southeastern Kendal], and northeastern Grundy Counties had a similar history.

Two glacial spillways, the Glacial Lake Chicago Outlet and the buried Hadley Valley, breach the bedrock divide in northeastern Will County. Hadley Valley is cut 100 feet or more below the nearby Chicago Outlet (BB, fig. 6, in pocket). The bedrock surface map (fig. 13) suggests that prior to glaciation of the region an eastward flowing stream occupied Hadley Valley east of the divide. A westward flowing tributary of Newark Valley may have headed in the divide west of Hadley Valley. Prior to Illinoian time, glacial meltwaters cut a deep trench through the drainage divide. The Chicago Outlet was cut after Hadley Valley was buried.

UNCONSOLIDATED DEPOSITS

The unconsolidated material above the bedrock consists of glacial drift and Recent deposits. The drift is differentiated into that deposited directly from the ice (till) and that modified by the associated melt-water into glaeiofluvial (glacial river) and glaciolacustrine (glacial lake) deposits. Recent deposits include those made by wind, running water, standing water, waves, and organisms under present-day conditions.

Glacial Drift

Till is ice-laid debris, a mixture of fragments of all sizes with rarely any stratification. It occurs in the form of marginal morainic ridges and intervening undulatory plains. The marginal moraines record times when the ice front temporarily maintained a fixed position and the intervening plains record times when the ice front melted back.

In composition the tills of the region range from dense clayey silt with few pebbles to gravelly sand containing abundant stratified material. The till of the Valparaiso, Tinley, and Lake Border moraines in Lake, Cook, DuPage, and Will Counties (fig. 5, in pocket) has high clay content and scarcity of pebbles and coarser fragments (Krumbein, 1933, p. 385; Bretz, 1955, p. 43). Clayey till also occurs in Will, Grundy, and Kendall Counties in the Manhattan, Rockdale, Minooka, and Marseilles moraines. The West Chicago moraine of the Valparaiso system, from West Chicago and Elgin northwestward into McHenry County, is composed of sandy, gravelly, bouldery till associated with water-laid deposits.

The older moraines west of the Minooka and West Chicago in McHenry and Kane Counties (fig. 5) are highly variable. Some of them are principally clayey till; others are less clayey and are associated with much sand and gravel, and they form rough, irregular topography. Where the Lemont Till east of Joliet is seen below the Valparaiso drift—as along Sag Channel and the Des Plaines Valley—it is silty rather than clayey, and contains abundant stratified material.

Glaciofluvial deposits were laid down by meltwater that was discharged along the front of the ice and through crevasses and channels extending back into the ice. The meltwater contained rock debris ranging from fine clay and rock flour to gravel, and, in response to changing volume and velocity of flow; sorted the particles as it deposited them downstream. Sand and gravel generally were deposited close to the ice front or along channelways that carried a large volume of meltwater. The finer particles were carried farther, often not settling out until they reached the quiet water of a pond or lake.

The types and character of glaciofluvial deposits are summarized in table 4.

Surficial glaeiofluvial deposits are most common in McHenry, Kane, Kendall, Grundy, and Will Counties. They consist mainly of very coarse gravel and sand in the form of outwash plains, valley trains, and kames in McHenry and Kane Counties and sandy valley trains along the Fox River in Kendall County, along the Illinois River in Grundy County and along the Des Plaines and Kankakee Rivers in Will County (fig. 5).

TABLE 4. CHARACTERISTICS OF GLACIOFLUVIAL DEPOSITS

Name	Form	Composition and structure
Esker	Winding ridge	Sand and gravel, poorly sorted; irregular, arcuate bedding
Kame	Hill or knoll	Coarse sand and gravel, poorly sorted; irregular bedding
Kame terrace	Knolly ridges or benches along valley sides	Sand and gravel, poorly sorted; bedding distorted along inner wall
Outwash plain	Smooth or pitted plain bordering end moraine	Sand and gravel, well sorted; horizontal or cross-bedded
Valley train	Terraced valley flat heading in morainal area	Sand and gravel, well sorted; horizontal or cross-bedded

Glaciolacustrine deposits consist of well sorted sand and gravel accumulated along beaches by wave action, inclined sand and gravel beds laid down in deltas, and fine sediment that settled in quiet waters off shore. They are characteristically found on the Chicago lake plain, though not restricted to it in the area of the report. The most extensive and conspicuous deposits of the lake plain are the beach ridges and spits (fig. 5). The prominence of some of the beach ridges was increased during glacial times by the deposition of wind-blown sand in the form of dunes.

Recent Deposits

Much of the deposition of sediments taking place today in the region involves the reworking or redistribution of glacial deposits. Silts, sands, and gravels are shifted about by scour and fill in floodplains. Coarse to fine sediments are deposited as alluvial fans where tributary streams of relatively high gradients enter the floodplain of a larger stream. Silts are carried by slope wash to lower ground and eventually into ponds, lakes, swamps, and streams. Along Lake Michigan waves and shore currents are forming beach deposits. The wind has formed dunes along the lake in Recent time, particularly east of the Chicago region in Indiana.

Organic matter is an additional component of Recent deposition. Peat, marl, and driftwood are common in present-day floodplains. Many swamps in the poorly drained morainal areas and on the lake plain fill with water-loving vegetation and other sediments, forming peat and muck.

Thickness

The map of the thickness of the unconsolidated deposits (fig. 12) shows that the drift is thinner (commonly less than 50 feet thick) in the low area between the Marseilles and Valparaiso moraines (fig. 5) in Grundy, southeastern Kendall, and southwestern Will Counties, and thicker (commonly more than 200 feet thick) in the morainal areas of McHenry, Lake, and Kane Counties.

The lines that show thickness of the drift more or less parallel bedrock surface contours in areas of thin drift, but in areas of thick drift they may correspond with either bedrock or surface features. The alignment of thickness lines in the relatively flat Chicago lake plain reflects mainly bedrock valleys and intervening divides at right angles to Lake Michigan. Some of the thickness lines in DuPage, Kendall, Kane, and McHenry Counties outline the higher moraines. More often the thickness lines have irregular patterns because the topographies of the surface and bedrock do not conform and have considerable relief.

History

Between the time the rocks of Pennsylvanian age were formed and the glaciers advanced from centers of snow accumulation in Canada, hundreds of feet of rock were eroded. Prior to the advance of glaciers, the topography of the bedrock was similar to that shown in figure 13. The master stream in the region probably occupied a valley approximately along the axis of Lake Michigan and had as tributaries streams that headed in western McHenry and DuPage Counties.

Pre-Illinoian Pleistocene history is not well recorded in the Chicago region. It is summarized by Bretz (1955, p. 99-132).

The. Illinoian ice covered the region and deposited drift that has been identified in wells in McHenry and Kane Counties (Horberg, 1953, p. 26). The Lemont drift, which is exposed east of Joliet and which nearly fills Hadley Valley, may be Illinoian in age (Horberg and Potter, 1955, p. 18). Glacial scour doubtless had created a lake basin in the pre-existing valley along the Lake Michigan axis, and as the Illinoian ice retreated a glacial lake was formed which discharged westward across the area of the Lemont drift.

The Tazewell glacier of Wisconsin age advanced across the region and south and west beyond it to as far as Mattoon and Peoria, and across the Mississippi River near Fulton, Illinois. The Bloomington, Marengo, Elburn, Gilberts, Farm Ridge; and Marseilles moraines were built during successive partial retreats and readvances of the Tazewell glacier.

A great volume of meltwater was discharged by the ice retreating from the Marseilles moraine in the upper part of the Fox River Valley north of Elgin, resulting in the deposition of thick, coarse outwash and the breaching of the Bloomington morainal dam at Peoria.

Following the withdrawal of the ice at the end of Tazewell time, the Fox River and its tributaries cut deep valleys. A new valley was cut across the bedrock divide north of buried Hadley Valley.

The Cary glacier advanced out of the Lake Michigan basin with change in alignment of the ice front to build the Minooka, Manhattan, and Valparaiso moraines. North of Elgin, the Valparaiso ice incorporated abundant coarse material in overriding coarse Marseilles outwash.

Enormous quantities of meltwater were discharged down the Kankakee and Illinois Valleys during the Valparaiso glaciation. The meltwater came from glacial lobes in northeastern Illinois, south-central Michigan, and northern Indiana. Outwash was deposited along the Fox River Valley. In the Kankakee Valley the water constituted a flood with currents that transported large slabs of limestone and built bars of rubble. The volume of water was so great that it could not all escape down the Illinois Valley and therefore rose to form a series of lakes between the younger Tazewell moraines (figs. 5 and 6B-B). In the lakes, channels were eroded and gravels were deposited by strong currents, silt and sand settled in backwaters, and higher, submerged areas were smoothed by cutting and filling.

After the ice retreated from the position of the Valparaiso moraines, it readvanced and built the slender Tinley moraine as a continuous ridge parallel to the lake basin. With the melting back of the ice from the Tinley moraine, Glacial Lake Chicago formed between the ice front and the moraine. Water that was ponded behind the moraine found an outlet along the already existing Sag and Des Plaines Valleys.

The three beach levels—Glenwood, Calumet, and Toleston (fig. 6B-B')—correspond to stillstands of the lake. During the Glenwood and Calumet stages stillstands were produced by residual concentrations of boulders from the till (boulder pavements) in the outlet channel; during the Toleston stage further downcutting was checked when the outlet floor had been cut to bedrock. Deepenings of the outlet occurred during times of increased discharge, when outlets to the east were blocked and drainage from glacial lakes in Ontario, southeastern Michigan, and western Ohio was added to that from Lake Chicago.

During the Glenwood stage the ice advanced out of the Lake Michigan basin north of Winnetka to build the four moraines of the Lake Border system.

After retreat of the ice beyond the straits of Mackinac, an eastward outlet into the Atlantic Ocean was established. The lake lowered to the present level of Lake Michigan, and the present Chicago lake plain emerged.

RELATIONSHIP OF GEOLOGY TO GROUND WATER

GENERAL RELATIONS

The source, occurrence, movement, quality, and availability of ground water are controlled by the nature, distribution, and structure of the various earth materials below the land surface. Of prime importance is the occurrence of permeable formations that serve as aquifers, storing ground water, channelling the movement, and acting as avenues of recharge.

The nature of the permeable formations has hydrologic significance because it affects water quality, rate of yield, and design of wells. Relatively impermeable beds such as shales act as barriers to ground-water movement or maintain pressure differences between aquifers and sometimes require special handling during drilling or well construction. Geologic structure commonly influences the direction of ground-water movement, artesian pressures, water quality and temperature, and areas of recharge. A study of the geologic history, particularly episodes of uplift, weathering, and erosion, sometimes explains the occurrence of zones of porosity, permeability, or cementation.

CAMBRIAN-ORDOVICIAN AND MT. SIMON AQUIFERS

The Mt. Simon Aquifer, previously defined, is the lowest known hydrologic system of the area. It is separated from the overlying system by the middle and upper parts of the Eau Claire Formation.

Above the Eau Claire occurs a sequence of rocks hydrologically interconnected and referred to in this report as the Cambrian-Ordovician Aquifer. It consists in upward order of the Ironton-Galesville Sandstone, Franconia Formation, Trempealeau Dolomite, Prairie du Chien Series, Glenwood-St. Peter Sandstone, and Galena-Platteville Dolomite. This interconnected hydrological system is, in most of the area, separated from the overlying aquifers by the Maquoketa Formation. In general, the principal water-yielding units are the sandstones of the Ironton-Galesville and Glenwood-St. Peter.

Many of the deep bedrock wells in this region are not limited to a single aquifer but are open to the Mt. Simon Aquifer as well as the Cambrian-Ordovician Aquifer, and even to the Silurian age dolomite above the Maquoketa Formation.

The various units, as they are encountered in drilling wells, are described below.

Galena-Platteville Dolomite

The Galena-Platteville Dolomite yields small quantities of water from joints, fissures, and solution cavities. Yields are greater in the western part of the region where the dolomite directly underlies the drift and is weathered. Finely disseminated pyrite in the rock is responsible for dark, sulfurous water in many wells. Occasionally oil shows are encountered. Because the dolomite is firm, homogeneous rock of uniform thickness (fig. 24B) it is easily recognized during drilling and is a favorable unit in which to seat casing.

Glenwood-St. Peter Sandstone

The variability of the Glenwood-St. Peter Sandstone in texture, cementation, and thickness creates anomalies in water-yielding capacity and problems in drilling and well construction. The upper part generally is not productive because of the shaly or dolomitic character of the sandstone. The basal part, composed of shale and conglomerate, sometimes called by drillers the "St. Peter caving zone," also is unproductive. Thus ground-water production from the Glenwood-St. Peter generally is restricted to 60 to 80 feet of sandstone that occurs 35 to 200 feet below the top of the formation.

The occurrence of unusual thicknesses of Glenwood-St. Peter in channel areas (fig. 22B) may result in greater yields where the sand is clean. Often, however, the thickening in the channel areas is a result of thickening of the lower shale or rubble zone, which does not readily yield water. Water in the lower part of the Glenwood-St. Peter in the channel areas may be slightly more highly mineralized because it circulates poorly in the less permeable part of the sandstone.

The Glenwood-St. Peter presents some difficulties in drilling and well construction because the friable sands tend to slough off and the lower shale and rubble zone tends to cave. It is common practice to set a liner through the lower part of the formation.

Prairie du Chien Series

The Shakopee and Oneota Dolomites are not well creviced and yield little ground water. The New Richmond Sandstone no doubt furnishes some ground water in deep rock wells, but its variation in dolomite content and thickness makes it unpredictable as a ground-water source.

Trempealeau Dolomite

The presence of water-yielding crevices in the upper part of the Trempealeau Dolomite in some wells is reported by drilling contractors and is indicated in a few caliper logs of deep wells. Crevicing may be related' to the unconformity between the Trempealeau and Prairie du Chien Series or, in the northern half of the region, between the Trempealeau and Glenwood-St. Peter Sandstone. Filling of the fissure systems has occurred locally. Where unusually high specific capacities of deep rock wells are obtained it is likely that cavities in the Trempealeau provide substantial quantities of water.

Franconia Formation

Although the shales and dolomites of the Franconia do not readily yield water, the sandy portion of the formation is permeable and probably contributes some water in deep rock wells where it is not cased off by liners.

Ironton-Galesville Sandstone

The Ironton-Galesville Sandstone is the most consistently permeable and productive aquifer in northeastern Illinois. Although the lower 20 to 85 feet of the sandstone is commonly the least cemented and most permeable part of the interval, clean friable zones also are encountered in its upper dolomitic part in some wells. Because the most favorable water-producing zone occurs in the lower part of the unit, it is advisable to penetrate the full thickness of the Ironton-Galesville if maximum well yield is desired. In fact, drilling to a short distance below the base of the Ironton-Galesville is advisable so that caving in the well will not shut off the lower productive section.

The poor cementation of the sandstone is responsible for some of the caving and sand-pumping problems in deep wells. Study of cuttings and caliper logging can sometimes lead to identification of cemented and weak zones and thereby guide shooting and rehabilitation of wells.

Eau Claire Formation

The middle and upper parts of the Eau Claire Formation in the Chicago region are primarily shale, dolomitic sandstone, and dolomite and are, therefore, not a productive part of the deep aquifers. However, the unit is of hydrologic importance in that it is a barrier between the Ironton-Galesville Sandstone and Mt. Simon Aquifer which contain water of different quality and head. The shales of the Eau Claire Formation protect the Ironton-Galesville from the intrusion of highly mineralized water from the Mt. Simon Aquifer. The effectiveness of this barrier under various pressures needs further study.

Mt. Simon Aquifer

The coarse, clean portions of the Mt. Simon Aquifer are capable of yielding moderate quantities of water. However, the erratic distribution of the clean beds, the occurrence of micaceous shales and siltstones, and the presence of warmer, more highly mineralized water make the Mt. Simon a less consistently favorable aquifer than the Ironton-Galesville. Wells that withdraw water from the Mt. Simon Aquifer at an elevation of 1300 feet or more below sea level commonly yield water too salty for ordinary use.

MAQUOKETA FORMATION

The Maquoketa Formation is at least a partial barrier between the shallow ground water of the drift and Silurian age dolomite above and the deeper ground water of the Cambrian-Ordovician Aquifer. The lower dense shale unit of the Maquoketa Formation is the most persistent and doubtless the most impermeable unit (fig. 25C). The effectiveness of the Maquoketa as a barrier is indicated by the reduction in crevicing and water-yielding capacity of the Galena-Platteville Dolomite where the Maquoketa overlies it (fig. 16). This is also suggested by studies by Foley and Smith (1954, p. 228) of recharge of the deep sandstone aquifer.

Dolomite beds in the middle unit of the formation yield small quantities of ground water. These beds are best developed in Kane County.

The Maquoketa is subject to swelling and caving and is customarily cased in deep rock wells.

SHALLOW DOLOMITE AQUIFERS

Ground water in the shallow dolomite occurs in joints, fissures, and solution cavities,. so yields at any given location generally are unpredictable. The reservoir -capacity of the rock as a rule is controlled more by solution openings below the weathered bedrock surface than by stratigraphic position. The development of. solution openings has been controlled by fracture and bedding planes near the surface and by regional dips.

About 75 percent of the dolomite wells in a selected 17-township area in southern Cook and Will Counties are completed within the upper 75 feet of the rock (fig. 41).

Because the openings occur mainly in the upper part of the rock it is likely that there is good connection with the overlying glacial drift.

In the circulation of ground water in other limestone terrains, concentration of flow and greater velocities near the points of discharge along drainage lines result in the enlargement of channels. If in the northeast region of Illinois the bedrock valleys were lines of discharge during the development of solution openings, they should be bordered by areas of high permeability and consequently high productivity. Available production figures are inadequate to test this hypothesis.

There is, however, an additional reason why higher yields may be anticipated in the areas underlying and adjoining bedrock valleys. As openings in the dolomite are connected with porous zones in the drift, it follows that where creviced dolomite is overlain by water-bearing sand and gravel deposits there will be more immediate recharge of the dolomite aquifer than in areas where glacial till rests on the bedrock.

Production records and drillers reports indicate that in some generally definable areas in the region crevicing is extensive and high yields can be obtained, and in other areas the dolomite is generally dense and "tight." DuPage County and eastward to the Des Plaines River south of LaGrange is one such favorable area, whereas a 2- to 8-mile belt along Lake Michigan is generally unfavorable.

Among the factors that may be responsible for differences in ground water productivity of the dolomite in various areas in northeastern Illinois are:

1. Differences in development of solution zones with respect to bedrock topography.
2. Differences in depth of ground water circulation and therefore depth of solution. For example, shallow impermeable shales in a given limestone area may limit solutional downcutting and promote extensive enlargement channels in the soluble rock above.
3. Differences in permeability of the overlying drift.
4. Differences in solubility of the various dolomite units.

GLACIAL, DRIFT AQUIFERS

Ground water in the drift is obtained mainly from sands and gravels that occur as surficial deposits or, more commonly, as deposits underlying or interbedded with glacial till. Because of their irregularity of occurrence, glacial drift aquifers are more difficult to locate than bedrock aquifers. The difficulties are compensated for in part by lower costs of drilling and pumping, often by water that is cooler or of better quality, and at some places by greater yields.

Surficial sand and gravel deposits are fairly widespread in Kane, McHenry, and western Lake Counties. Esker and kame deposits, restricted in areal extent and standing above the surrounding countryside where they are often excavated for gravel operations, are of limited importance as sources of ground water. In contrast, deposits of outwash plains and valley trains, being more extensive and occurring in lowlands where they are likely to be below the water table, are of considerable importance.

Large supplies of ground water are often encountered in sand and gravel at the base of the drift, directly above bedrock. The chances of penetrating continuous water-bearing beds of considerable thickness are better within the bedrock valleys than in bedrock uplands because 1) the drift is thicker above bedrock valleys, increasing the probability of encountering sand and gravel, and 2) meltwaters were concentrated in valleys during glacial stages, locally resulting in the deposition of sorted deposits. The bedrock valleys that slope eastward toward Lake Michigan and up which the glaciers advanced, are generally filled with till or with fine sediments of slack water origin.

Buried sand and gravel deposits commonly occur near the outer margin of end moraines. Here the water-bearing deposits are often found at the boundary between till sheets and may be continuous over wide areas. Drift aquifers in areas between the moraines are commonly lenticular and discontinuous.

Favorable Localities

Favorable areas for sand and gravel aquifers, as interpreted from surficial geology, well records, and earth-resistivity surveys, include the following:

Surficial outwash plains and valley trains (figs. 2 and 5)

1. Lowland of Rush Creek and Piscasaw Creek Valleys west of Harvard.
2. Valleys of Kishwaukee River and North and South Branches west of Woodstock and Crystal Lake.
3. Nippersink Creek lowland west and south of Hebron.
4. Coon Creek lowland northwest of Hampshire.
5. West Chicago outwash between Naperville and Elgin and along the Fox River Valley south of Elgin.
6. Des Plaines River Valley north of River Forest.
7. DuPage River Valley south of Wheaton and Naperville.
8. Des Plaines and DuPage River Valleys in vicinity of Joliet and Plainfield.

Glacial fill in buried bedrock valleys (figs. 6 and 17)

1. Troy Valley.
2. Newark Valley.
3. Hadley Valley.

Buried sand and gravel deposits of various origins (figs. 2, 5, and 6)

1. Lemont drift of Joliet, Orland Park, Downers Grove, and Worth area.
2. Marseilles sand and gravel along the Fox River north of Elgin.

STRUCTURE

Geologic structure exercises a strong control over the circulation of ground water in the sandstone aquifers of northeastern Illinois. Water moves eastward in the same direction as the regional dip. Modifications of the regional pattern of movement are brought about by: 1) pumpage, 2) local structures, and 3) lithologic variations in the aquifers. No evidence indicates that local folds that have axes parallel to regional dip modify the general movement of ground water down-dip.

Faults act as barriers to ground-water movement where displacements are large enough to bring impermeable beds into contact with permeable beds, where gouge or shale is smeared along the zone of displacement, or where a fault brecciated zone has been recemented.

In areas of complex faulting, such as the Des Plaines area, ground-water circulation is disturbed to the extent that recharge and flushing are difficult and the area as a whole should be avoided for ground-water development.

PUMPAGE

Pumpage use data are classified in this report according to the four main categories used by the U. S. Bureau of the Census. These are: 1) public, including a) municipal, and b) institutional; 2) industrial; 3) rural non-irrigation; 4) irrigation, including a) farm, and b) golf courses and cemeteries.

Most water-supply systems furnish water for several types of use. For example, a public supply commonly includes water used for drinking and other domestic uses, manufacturing processes, and lawn sprinkling. The water supplies for industries as well as those for golf courses, and cemeteries, may also be used for drinking. In all cases, the total pumpage may be known approximately, but the final use of the water cannot always be determined.

Public water supplies furnish water that has been approved as sanitary under the supervision of health departments. Municipal systems are either publicly or privately owned for incorporated cities or villages. Institutional supplies furnish sanitary water to settlements, motels, schools, and other institutions.

Any water pumped by an industry is called an industrial supply, regardless of the use of the water.

Rural non-irrigation supplies include farm or individual residence supplies which are not under the regular supervision of a health department. These supplies may also be used for lawns and home gardens.

Irrigation water is that which is applied to the land to supplement natural soil moisture for growing plants. In the Chicago region farm irrigation is practiced primarily by commercial truck farmers. The water pumped for golf courses and cemeteries may be in part used for drinking purposes but is used chiefly for watering lawns and gardens. This use is placed in a separate category in this report because it is great enough to have marked local effects.

Pumpage is also classified according to the aquifer in which the well is finished. In the Chicago region the water is obtained from wells finished in the glacial drift, the shallow dolomite, and the Cambrian-Ordovician and Mt. Simon Aquifers. For simplicity in this report the Cambrian-Ordovician and Mt. Simon Aquifers are called deep aquifers in the tables showing pumpage. In these tables, the term "apparent source" is used because the pumped water is assigned in each well to the aquifer in which the well is finished, although many wells are open to more than one aquifer. Additional uncertainty in the classification results from the fact that in systems obtaining water from more than one source, pumpage from individual sources may not be separately recorded and their use may be irregular.

In general, glacial drift wells and dolomite wells supply residences although some municipal and industrial wells depend on these sources. The deep aquifers are used exclusively for municipal and industrial supplies.

The industrial wells generally have the most uniform pumpage over the year unless large air-conditioning installations are used or the industry is seasonal. However, if a change in operation occurs, as on strikes or vacation shut-downs, the variation in pumpage is radical and sudden.

Municipal pumpage shows a gradual change with seasons, the average winter use being about three fourths of the average summer use.

Pumpage for irrigation is fully seasonal and varies considerably from year to year, depending on weather conditions.

The reliability of pumpage data varies greatly. Municipal pumpage is nearly always metered in cities, but many smaller villages operate without meters. Only a small part of the industrial supply is metered. Pumpage data from municipalities and the larger industrial establishments are systematically recorded. The pumpage from farm wells and from the many thousands of individual residential wells is estimated on the basis of detailed surveys of a few selected sections considered typical. In some districts, the water supply from individual wells is often replaced by a municipal supply, but often the old wells are retained for certain purposes such as sprinkling. For all these reasons it is difficult to ascertain exact pumpage figures.

PUBLIC SUPPLIES

Municipal

The data on municipal pumpage from 1938 to 1955 inclusive (table 5) have been taken as published periodically by the Illinois Department of Public Health. The data for 1957 (table 5) were collected by the State Water Survey.

In general table 5 shows a steady increase in municipal pumpage. The reductions shown for the 1938-1944 period are attributed to extension of Lake Michigan supplies to communities in Cook and Lake Counties that formerly were supplied by well water. In McHenry County the apparent decline is not real because of a change in method of estimation.

Comparison of the increase in municipal pumpage during the period 1938-1957 with the increase in population 1940-1957 (figs. 10 and 11) shows that the pumpage increased 3.7 times as fast as the population on an average yearly basis. This rapid increase in municipal pumpage is due partly to an increase in industrial use and partly to the development of new municipal supplies.

The distribution by apparent source of the total municipal pumpage of 70,403,000 gallons per day (gpd) in 1957 is shown in table 6.

Table 6 shows that the municipalities supplied from deep wells are the largest water producers. The municipalities supplied from dolomite wells, although forming the largest group, pump an intermediate amount. The ones supplied from drift wells or springs pump the least water. This generalization becomes more evident if the two largest cities having part of their supplies from drift wells, Joliet and Woodstock, are subtracted. The remaining 19 municipalities pump an average of only 120,000 gpd each.

TABLE 5. MUNICIPAL GROUND-WATER PUMPAGE
In 1,000 gallons per day

County	Year				
	1938	1944	1948	1955	1957
Cook	11,456	10,280	12,659	17,166	22,570
DuPage	4,385	6,726	7,045	9,764	15,568
Grundy	400	422	889	1,065	1,313
Kane	7,263	9,833	10,546	12,727	14,357
Kendall	110	265	265	578	596
Lake	1,080	990	1,653	1,980	2,904
McHenry	2,103	2,079	2,281	3,510	3,984
Will	4,792	4,938	5,939	8,284	9,111
Total	31,589	35,533	41,277	55,074	70,403

Institutional

Reliable data on institutional pumpage are essentially unavailable. No institution was found which metered its pumpage. At a few institutions the power for pumpage is metered separately, especially in housing groups where the water is sold to the individual houses.

Table 7 shows the total pumpage of 20 institutions in the region is estimated at 8.5 million gallons per day (mgd), the largest consumers being state institutions.

TABLE 6. MUNICIPAL PUMPAGE BY APPARENT SOURCE, 1957
In 1,000 gallons per day

County	Glacial drift aquifers	Shallow dolomite aquifers	Deep aquifers
Cook	(0)*	11,955(15)*	10,615(10)*
DuPage	(0)	10,759(15)	4,809 (4)
Grundy	35 (1)	267 (2)	1,011 (4)
Kane	617 (5)	83 (2)	13,657 (8)
Kendall	450 (1)	(0)	146 (2)
Lake	551 (4)	1,349 (5)	1,004 (5)
McHenry	3,186 (6)	236 (4)	562 (1)
Will	3,621 (4)	1,136 (8)	4,354 (4)
Total	8,460(21)	25,785(51)	36,158(38)
Percent of total	12.0	36.6	51.4
Pumpage per municipality	333	552	872

* The number of municipalities is shown in parentheses.

TABLE 7. ESTIMATED INSTITUTIONAL PUMPAGE BY APPARENT SOURCE, 1957
In 1,000 gallons per day

County	Glacial drift aquifers	Shallow dolomite aquifers	Deep aquifers	Total
Cook	negligible	2,596	71	2,667
DuPage	neg.	884	neg.	884
Grundy	neg.	neg.	neg.	neg.
Kane	neg.	656	1,461	2,117
Kendall	neg.	neg.	neg.	neg.
Lake	neg.	480	neg.	480
McHenry	neg.	368	neg.	368
Will	neg.	504	1,513	2,017
Total		5,488	3,045	8,533
Percent		64.4	35.6	

INDUSTRIAL SUPPLIES

Data on industrial pumpage were obtained at 130 plants, as summarized in table 8. It is likely that some plants have been overlooked; however, they are probably the small ones and have small pumpage. A much greater source of error is found in inaccurate estimates of pumpage of the large industrial plants. Only a few plants have meters to measure the pumpage, and the metered pumpage amounts to only about 10 percent of the total industrial pumpage. The remainder of the pumpage is determined from a measured or estimated time the pump operates or is estimated by factory officials. It is assumed that the total pumpage per county is more nearly correct than individual plant pumpage, as compensation for errors occurs because the pumpage in some plants is probably overestimated and in others, underestimated.

The industrial pumpage is about one half that of the municipal pumpage. Nearly 94 percent of the industrial pumpage is obtained from the deep aquifers. Owing to this concentration the industrial pumpage from the deep aquifers is nearly as great as the municipal pumpage from them.

TABLE 8. ESTIMATED INDUSTRIAL PUMPAGE BY APPARENT SOURCE. 1957

In 1,000 gallons per day

County	Glacial drift aquifers	Shallow dolomite aquifers	Deep aquifers	Total
Cook	negligible	482	21,035	21,517
DuPage	neg.	784	673	1,457
Grundy	neg.	neg.	neg.	neg.
Kane	72	569	1,950	2,591
Kendall	neg.	neg.	neg.	neg.
Lake	neg.	neg.	269	269
McHenry	neg.	neg.	456	456
Will	neg.	258	8,684	8,942
Total	72	2,093	33,067	35,232

RURAL NON-IRRIGATION SUPPLIES

Pumpage for farms and individual residences is rarely measured. The data summarized in table 9 are estimates obtained by considering the rural population of each county as given in the 1950 report of the U.S. Bureau of the Census, the population increase for 1956 as shown by the Illinois Department of Public Health, and the probable percentage of the population which depends on individual water supplies. Based on a survey of selected rural areas within the Chicago region, it was determined that the per capita use averages 50 gallons per day. This figure, as determined by the sampling, should not be confused with higher use per capita figures commonly cited which include municipal, industrial, and commercial uses. Rural non-irrigation, in this report, refers to domestic and livestock uses.

None of this pumpage is from the deeper sandstones. Much of the pumpage from the glacial drift is from dug wells. Currently, many wells in the shallow aquifers are equipped with electric pumps. Although these installations are still in the minority, their pumpage is greater because they are more convenient than manually operated pumps.

The total rural non-irrigation pumpage amounts to 13,160,000 gpd which is about one fourth of the total pumpage from the shallow aquifers. The water comes from small, wells of low capacity that are distributed generally throughout the region. Being widely distributed, these wells make an efficient use of ground water, without the problems of interference and drawdown inherent in the industrial and municipal pumpage.

TABLE 9. ESTIMATED RURAL NON-IRRIGATION PUMPAGE BY APPARENT SOURCE, 1957

In 1,000 gallons per day

County	Glacial drift aquifers	Shallow dolomite aquifers	Total
Cook	600	650	1,250
DuPage	1,300	2,200	3,500
Grundy	200	200	400
Kane	550	1,200	1,750
Kendall	400	210	610
Lake	800	1,000	1,800
McHenry	750	300	1,050
Will	1,100	1,700	2,800
Total	5,700	7,460	13,160

IRRIGATION SUPPLIES

Farm

There are 45 known irrigation systems in the eight counties, but only 12 of these, as summarized in table 10, use ground water. Pumpage for irrigation is irregular in that it is highly seasonal and also varies greatly from year to year. The momentary use may be high but of short duration. The total pumpage is calculated on an annual basis. Ground-water pumpage for irrigation is from the glacial drift and shallow dolomite aquifers.

Golf Courses and Cemeteries

The pumpage shown in table 11 is used primarily for irrigating grass and perennial plants in golf courses and cemeteries throughout the growing season. Wells in glacial drift aquifers were not considered in this table and are believed to be of minor significance.

TABLE 10. ESTIMATED FARM IRRIGATION PUMPAGE BY APPARENT SOURCE, 1957

In 1,000 gallons per day

County	No. of systems	Glacial drift aquifers	Shallow dolomite aquifers	Total pumpage
Cook	3	0	9.0	9.0
DuPage	1	3.5	0	3.5
Lake	1	3.0	0	3.0
McHenry	1	4.0	0	4.0
Will	6	0	12.5	12.5
Total	12	10.5	21.5	32.0

TABLE 11. ESTIMATED GOLF COURSE AND CEMETERY IRRIGATION PUMPAGE BY APPARENT SOURCE, 1957

In 1,000 gallons per day

County	Shallow aquifers	Deep aquifers	Total
Cook	188	196	384
DuPage	116	negligible	116
Kane	25	neg.	25
Lake	20	neg.	20
McHenry	8	neg.	8
Will	10	neg.	10
Total	367	196	563

TOTAL PUMPAGE

The estimated total pumpage of ground water in the region for 1957 is 127.9 mgd. The distribution of pumpage by use and by apparent source is shown in tables 12 and 13 respectively. Table 12 shows that public systems took more than twice as much ground water as any other category of use and pumped 61.6 percent of the total in 1957. Table 13 shows that wells finished in the deep aquifers yielded a little more than half of the total pumpage in 1957.

Pumpage from the deep wells at six pumping centers was estimated for 1958. This estimate, with break-down into actual source, is discussed in a subsequent section.

TABLE 12. SUMMARY OF ESTIMATED TOTAL PUMPAGE BY USE, 1957
In 1,000 gallons per day

County	Public	Industrial	Rural Non-Irrig.	Irrig.	Total
Cook	25,237	21,517	1,250	393	48,397
DuPage	16,452	1,457	3,500	119	21,528
Grundy	1,313	negligible	400	neg.	1,713
Kane	16,474	2,591	1,750	25	20,840
Kendall	596	neg.	610	neg.	1,206
Lake	3,384	269	1,800	23	5,476
McHenry	4,352	456	1,050	12	5,870
Will	11,128	8,942	2,800	22	22,892
Total	78,936	35,232	13,160	594	127,922
Percent of total	61.6	27.6	10.3	.5	

TABLE 13. SUMMARY OF ESTIMATED TOTAL PUMPAGE BY APPARENT SOURCE, 1957
In 1,000 gallons per day

County	Glacial drift aquifers	Shallow dolomite aquifers	Deep aquifers	Total
Cook	600	15,880	31,917	48,397
DuPage	1,303	14,743	5,482	21,528
Grundy	235	467	1,011	1,713
Kane	1,239	2,533	17,068	20,840
Kendall	850	210	146	1,206
Lake	1,354	2,849	1,273	5,476
McHenry	3,940	912	1,018	5,870
Will	4,721	3,620	14,551	22,892
Total	14,242	41,214	72,466	127,922
Percent of total	11.1	32.0	56.7	

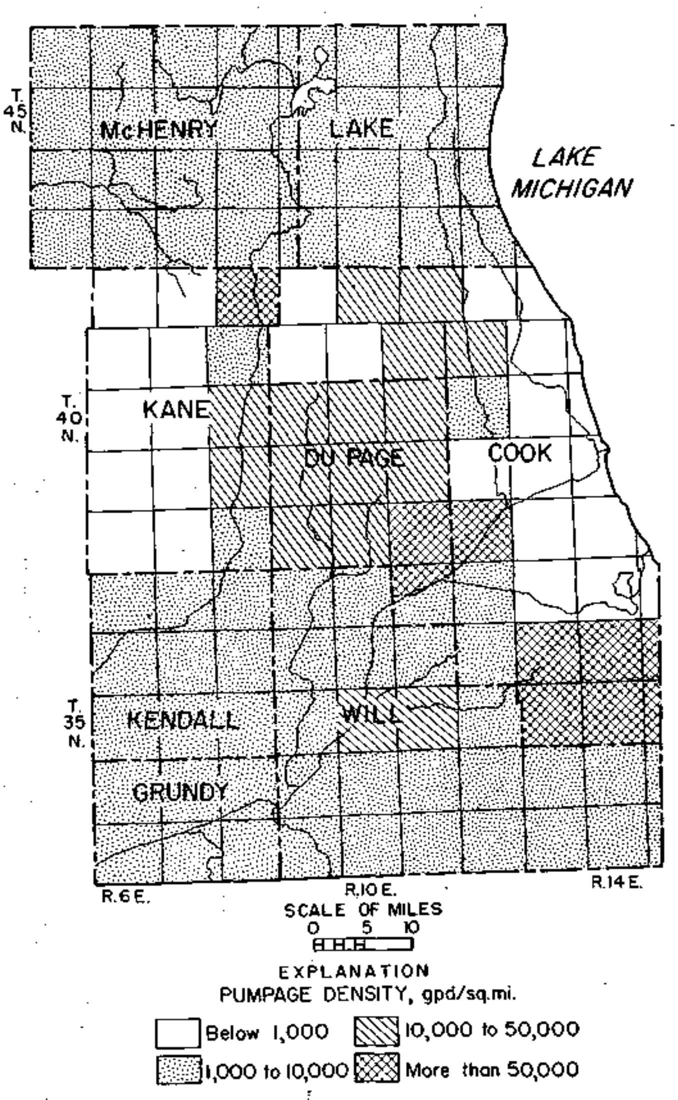


Fig. 28. Pumpage per square mile from shallow aquifers.

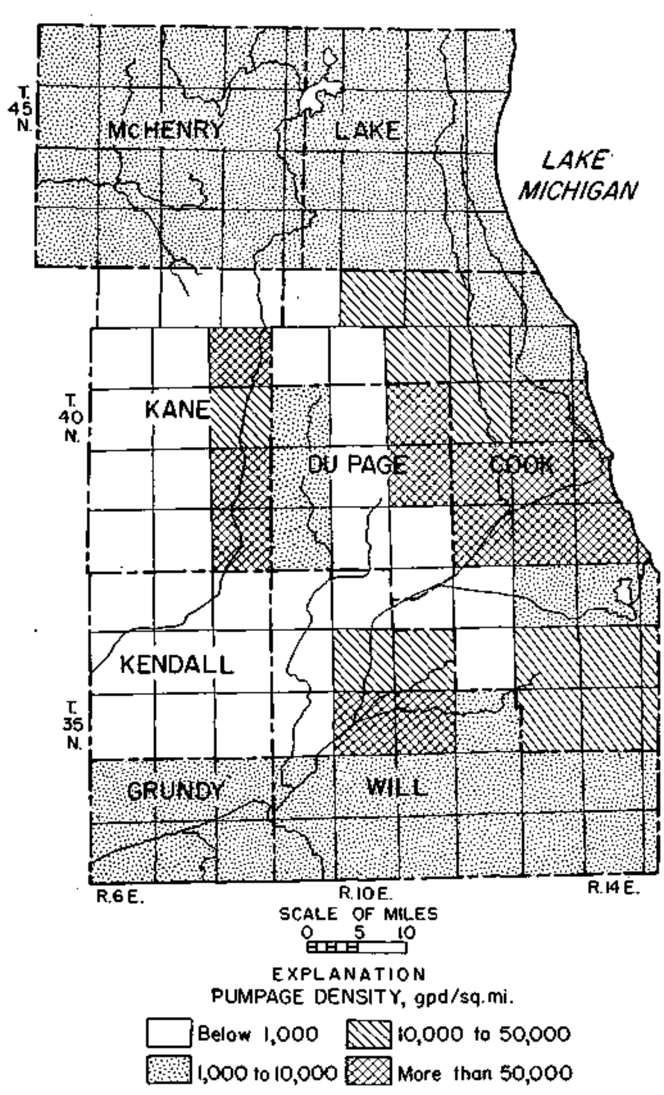


Fig. 29. Pumpage per square mile from deep aquifers.

DISTRIBUTION AND DENSITY OF PUMPAGE

Pumpage from the shallow aquifers and the deep aquifers was grouped into districts consisting of one or more townships, and the average pumpage per square mile (density of pumpage) for each district was computed. The areal extent, pumpage, and density of pumpage for each district are given in table 14. The density of pumpage for the shallow aquifers and the deep aquifers in the various districts is shown graphically in figures 28 and 29 respectively.

The districts having the highest densities of pumpage from the shallow aquifers are in the southeastern part of DuPage County and in the western part of Cook County. The density of pumpage is also high throughout the eastern part of DuPage County, the northwestern and southern parts of Cook County, at Joliet in Will County, and in the northern part of the Fox River Valley in Kane County. The pumpage per square mile is small in Lake, McHenry, Kendall, and Grundy Counties, indicating that pumpage from the shallow aquifers is fairly evenly distributed in these counties.

The highest density of pumpage from the deep aquifers occurs at Aurora in Kane County. High densities occur along the Pox River as far north as Elgin, in the central part of Cook County, in the northeast corner of DuPage County, and in the Joliet area. Pumpage from the deep aquifers is small in the southern part of Will County, in the northeastern part of Grundy County, and in Kendall, McHenry, and Lake Counties.

TABLE 14. GEOGRAPHIC DISTRIBUTION AND DENSITY OF PUMPAGE, 1957

Extent of district		Daily pumpage in gallons		Density of pumpage in gallons per square mile	
Township North	Range East	Shallow aquifers	Deep aquifers	Shallow aquifers	Deep aquifers
		Cook County			
35-36	13-14-15	8,140,000	4,685,000	50,246	28,919
36,37	12,11-12	275,000		3,161	
37	13-14-15	18,000	125,000	219	1,524
38	12	3,161,000	4,567,000	87,806	126,861
38-39	13-14	13,000	10,890,000	106	90,750
39	12	22,000	4,067,000	611	112,972
40	13-14	5,000	2,646,000	98	51,882
40	12	98,000	683,000	2,722	18,972
41	13-14	6,000	254,000	153	6,512
41	11-12	1,885,000	2,868,000	28,130	42,805
41,42	9-10,9	90,000		833	
42	12-13	8,000	147,000	156	2,882
42	10-11	2,759,000	985,000	38,319	13,681
		Du Page County			
37-38	11	5,568,000	20,000	109,177	392
39-40	11	2,506,000	5,204,000	34,805	72,278
38-40	10	5,119,000		47,398	
38-40	9	2,854,000	258,000	26,426	2,390
		Grundy County			
33-34	6-8	702,000	1,011,000	3,250	4,640
		Kane County			
38	8	131,000	7,879,000	3,639	218,861
39	8	975,000	2,436,000	27,083	67,666
40	8	393,000	1,528,000	10,917	42,444
41	8	231,000	5,224,000	6,416	145,122
42	8	1,853,000		51,472	
38-42	6-7	190,000		528	
		Kendall County			
35-37	6-8	1,060,000		3,272	
		Lake County			
43-46	9-12	4,852,000	1,018,000	8,146	3,784
		McHenry County			
43-46	5-9	3,723,000	1,730,000	7,941	1,666
		Will County			
33-34,35	11-15,12	1,773,000	350,300	5,756	1,137
33-34	9-10	949,000	1,211,000	6,590	8,410
35	10-11	3,013,000	9,833,000	41,708	136,572
36	10-11	661,000	3,156,000	9,331	43,840
35-37,37	9,9-10	1,345,000		9,340	

HYDROLOGY OF AQUIFERS

CAMBRIAN-ORDOVICIAN AND MT. SIMON AQUIFERS

The Cambrian-Ordovieian Aquifer consists in downward order of the Galena-Platteville Dolomite, Glenwood-St. Peter Sandstone, Prairie du Chien Series, Trempealeau Dolomite, Franconia Formation, and Ironton-Galesville Sandstone. It is considered in most detail in this report.

The Ironton-Galesville Sandstone is the most productive formation of the group. The Galena-Platteville Dolomite and Prairie du Chien Series generally are not well creviced and are not major contributors. The Trempealeau Dolomite is locally well creviced and is partly responsible for exceptionally high yields of several deep wells in the Chicago-Joliet-Fox Valley area. The Mt. Simon Aquifer, consisting of the sandstone of the Mt. Simon and lower Eau Claire Formations (fig. 19), yields moderate supplies in the western part of the area where the water is of acceptable quality.

The Maquoketa Formation above the Galena-Platteville Dolomite acts as a barrier between the shallow dolomite and deeper aquifers and confines the water in the deeper aquifers under artesian pressure. Any original differences in artesian pressure among the units of the Cambrian-Ordovician Aquifer have been largely equalized by the great number of wells open in all units. Available data indicate that on a regional basis, the entire sequence of strata, from the top of the Galena-Platteville to the top of the shale beds of the Eau Claire Formation, essentially behave hydraulically as one aquifer. Some differences in pressure in the various strata probably still exist in places where the permeability of intervening beds is low and there are not enough wells to have permitted equalization. However, the entire sequence of strata is treated as one aquifer in this report.

The Mt. Simon Aquifer beneath the Eau Claire Formation is fairly permeable and yields moderate amounts of water to wells. The Cambrian-Ordovician Aquifer is effectively separated from the Mt. Simon Aquifer by impermeable beds of the Eau Claire Formation. The artesian pressure in the Mt. Simon Aquifer is greater than that in the Cambrian-Ordovieian Aquifer.

In wells open to the Cambrian-Ordovieian Aquifer, Silurian age dolomite, and Mt. Simon Aquifer, ground water moves downward from the dolomite and upward from the Mt. Simon into the Cambrian-Ordovieian Aquifer.

HYDRAULIC PROPERTIES

The significant hydraulic properties of aquifers are expressed mathematically by the coefficients of transmissibility, T, and storage, S. The capacity of a formation to transmit ground water is expressed by the *coefficient of transmissibility,* which is defined as the rate of flow of water in gallons per day, through a vertical strip of the aquifer one foot wide and extending the full saturated thickness under a hydraulic gradient of 100 percent (one foot per foot) at the prevailing temperature of the water. The storage properties of an aquifer are expressed by the *coefficient of storage,* which is defined as the volume of water in cubic feet released from or taken into storage per square foot of surface area of the aquifer per foot change in the component of head normal to that surface. Under artesian conditions, water is derived from storage by the compaction of the aquifer and its associated beds and by expansion of the water itself.

Pumping Tests

The hydraulic properties of an aquifer are determined by means of pumping tests, wherein the effect of pumping a well at a known constant rate is measured in the pumped well and at observation wells penetrating the aquifer. Graphs of drawdown versus time after pumping started, and/or of drawdown versus distance from the pumped well, are used to solve equations which express the relation between the coefficient of transmissibility and storage of an aquifer and the lowering of water levels in the vicinity of a pumped well.

During the period 1922-1954, 63 pumping tests were made in northeastern Illinois to determine the hydraulic properties of the Cambrian-Ordovieian Aquifer. The data collected during the pumping tests were analyzed by means of the Thiem (see Wenzel, 1942, p. 81) and the nonequilibrium (Theis, 1935, p. 519-24) formulas. The Thiem formula is

$$T = \frac{527.7\ Q \log_{10} \frac{r_2}{r_1}}{s_1 - s_2} \qquad (1)$$

where T is the coefficient of transmissibility, in gallons per day per foot; Q is the rate of pumping, in gallons per minute (gpm); r_1 and r_2 are the distances, in feet, of two observation wells from the pumped well; and S_1 and S_2 are the respective drawdowns, in feet, in the two observation wells.

The nonequilibrium formula is

$$s = \frac{114.6\ Q}{T} \int_u^\infty \frac{e^{-u}}{u}\, du \qquad (2)$$

or, evaluating the integral,

$$s = \frac{114.6\ Q}{T} \left(-0.5772 - \log_e u + u - \frac{u^2}{2.2!} + \frac{u^3}{3.3!} - \frac{u^4}{4.4!} \ldots \text{etc.}\right)$$

where $u = \frac{1.87\ r^2 S}{Tt}$; s is the drawdown, in feet, at a distance, r, in feet, from a pumped well discharging at rate Q, in gallons per minute, for a time, t, in days; T is the coefficient of transmissibility, in gallons per day per foot; and S is the storage coefficient of the aquifer.

TABLE 15. REPRESENTATIVE COEFFICIENTS OF TRANSMISSIBILITY OF THE CAMBRIAN-ORDOVICIAN AQUIFER

County	Well owner	Depth of well (feet)	Date of test	Pumping rate (gpm)	Coefficient of transmissibility (gpd/ft)
Boone	City of Belvidere	1861	1951	615	17,500
Boone	City of Belvidere	1803	1951	540	24,200
Boone	City of Belvidere	1800	1943	852	22,500
Boone (Belvidere)	Keene Canning		1942	392	19,900
Cook	Corn Products Refining Co.	1543	1942	510	15,600
Cook	Corn Products Refining Co.	1525	1944	765	17,200
Cook	Corn Products Refining Co.	1481	1945	1020	17,200
Cook	Village of Arlington Heights	1525	1946	870	16,800
Cook	Bellwood Park Dist.	1480	1951	830	13,900
Cook	Red River Refinery	1625	1946	320	17,000
Cook	Mars Inc.	1978	1942	839	16,000
Cook	City of Chicago Heights	1794	1942	650	11,600
Cook	Village of Glenview	1251	1916	146	17,200
Cook	Baxter Lab.	1500	1946	239	15,300
Cook	Village of Mt. Prospect	1370	1951	715	18,100
Cook	Village of Riverside	2047	1944	876	17,100
Cook	Village of South Chicago Heights	2756	1941	420	10,800
Cook	Village of Willow Springs	1542	1952	1100	20,600
DeKalb	City of DeKalb	1331	1947	1000	23,200
DeKalb	City of DeKalb	1325	1930	180	18,200
DeKalb	City of DeKalb	1291	1952	1130	24,100
DeKalb	Village of Hinckley	708	1947	200	17,100
DeKalb (DeKalb)	C. M. St. P. & P. R. R.	737	1934	200	23,100
DeKalb	Village of Malta	853	1942	100	12,400
DeKalb	City of Sandwich	600	1949	730	26,900
DuPage	Village of Bensenville	1445	1954	230	17,800
DuPage	City of Elmhurst	1480	1944	625	18,000
DuPage	City of Elmhurst	1480	1944	920	14,700
DuPage	City of Elmhurst	1502	1943	950	18,300
DuPage	City of Elmhurst	1400	1948	620	18,200
DuPage	Village of Lombard	2062	1954	1200	22,000
DuPage (Villa Park)	Wander Co.	1987	1954	2390	17,600
Grundy	City of Morris	1460	1954	1470	15,900
Kane	City of Aurora	2285	1943	1120	16,400
Kane	City of Aurora	2250	1943	1476	17,700
Kane	City of Aurora	2251	1943	1300	15,700
Kane	City of Elgin	2000	1947	1124	12,600
Kane	City of Elgin	1300	1947	1146	20,100
Kane (Elgin)	Elgin National Watch	1231	1945	542	16,700
Kane	City of Geneva	1576	1946	1170	17,900
Kane	City of St. Charles	2198	1947	550	18,900
Kane	City of Batavia	1357	1953	668	20,400
Lake	Village of Lake Bluff	1804	1951	362	16,000
Lake	Onwentsia Club	1023	1949	186	15,500
LaSalle	Village of Cedar Point	1750	1922	57	13,950
LaSalle	City of Mendota	990	1949	350	15,300
LaSalle	City of Oglesby	2784	1947	350	13,500
LaSalle	City of Oglesby	2812	1949	786	19,500
LaSalle	City of Ottawa	1180	1945	1260	16,600
LaSalle (Ottawa)	Libby-Owens-Ford Glass	1168	1948	800	18,250
LaSalle (Sheridan)	Boys School 1	885	1940	170	16,100
McHenry	City of Crystal Lake	2000	1948	434	15,300
Will	Village of Elwood	1645	1941	1345	16,200
Will	Kankakee Ordnance Works	1649	1953	1253	17,400
Will	Kankakee Ordnance Works	1569	1953	1220	17,000
Will	City of Joliet	1620	1944	753	14,300
Will	City of Joliet	1544	1946	600	16,200
Will	City of Joliet	1608	1946	1290	17,100
Will	Ill. State Pen. 1	1600	1948	650	19,100
Will	Diagnostic Depot 3	1600	1948	642	19,300
Will	City of Lockport	1572	1954	700	13,000
Will	Village of Rockdale	1586	1946	293	16,500
Will	Village of Romeoville	1537	1952	1016	16,000

TABLE 16. COEFFICIENTS OF STORAGE OF THE CAMBRIAN-ORDOVICIAN AQUIFER

Location	Well owner	Date of test	Average depth of wells (feet)	Pumping rate (gpm)	Coefficient of storage
Kane County	City of Elgin	Apr., 1944	1900	750	0.00068
Joliet, Will County	Blockson Chemical Co.	Mar., 1951	1500	600	0.00037
Near Joliet, Will County	Kankakee Ordnance Works	Mar., 1943	1600	6100	0.00018
Summit, Cook County	Argo Plant, Corn Products Refining Co.	Oct., 1943	1800	700	0.00016
				Average	0.00035

A summary of the coefficients of transmissibility and storage obtained from the various pumping tests is given in tables 15 and 16. The coefficients of storage in table 16 are averages of several wells at each location.

Summary of the Results of Tests

Coefficients of transmissibility listed in table 15 range from 10,800 gpd per foot to 26,900 gpd per foot and average 17,400 gpd per foot. The coefficients of storage given in table 16 are characteristic of artesian conditions and range from 0.00016 to 0.00068 and average 0.00035. For comparison, the average coefficients of transmissibility and storage for the Cambrian-Ordovician Aquifer in the Milwaukee-Waukesha area, Wisconsin (Foley, Walton, Drescher, 1953, p. 72) are 23,800 gpd per foot and 0.00039 respectively.

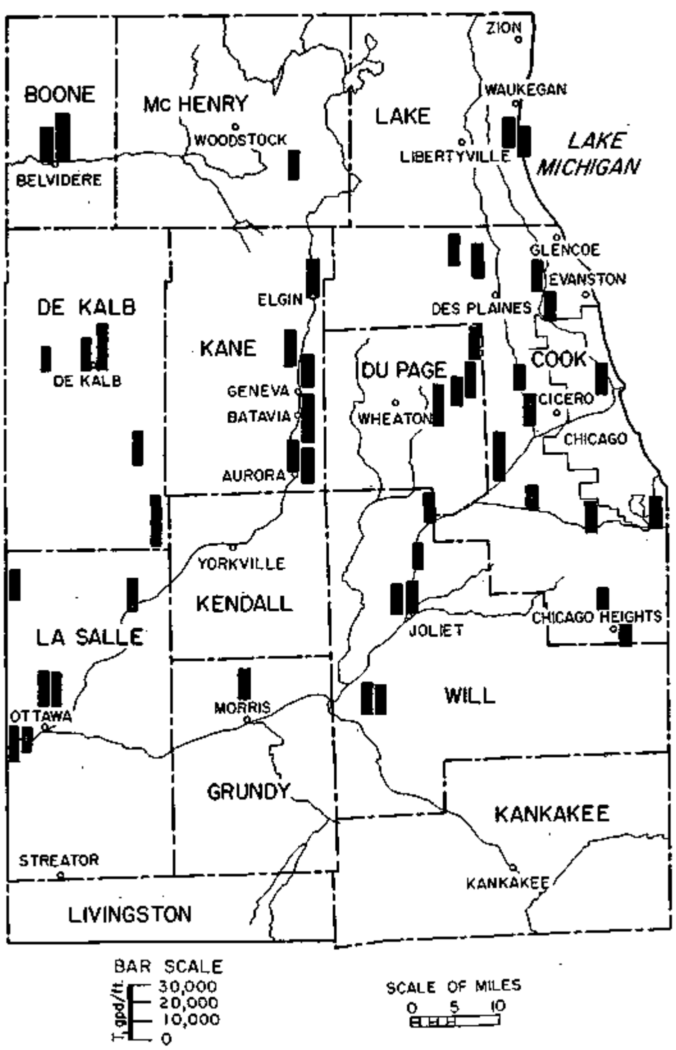


Fig. 30. Coefficients of transmissibility of Cambrian-Ordovician Aquifer.

Computed coefficients of transmissibility were used to prepare figure 30. The data indicate that the coefficient of transmissibility is fairly uniform throughout large areas in northern Illinois. The average coefficient of transmissibility of the portion of the aquifer between Chicago and the border of the Maquoketa Formation (fig. 16) is 17,000 gpd per foot. Based on a study of the data in figure 30, the coefficients of transmissibility, T, of the aquifer decrease in a southeasterly direction from an average value of 22,000 gpd per foot in Boone, DeKalb and LaSalle Counties to an average value of 15,000 gpd per foot in the southern parts of Cook and Will Counties. Deep wells in Kankakee County and near the Indiana state line have small yields indicating that the coefficients of transmissibility of the aquifer rapidly decrease south of Joliet and east of Chicago in the northwestern part of Indiana.

The coefficients of storage, S, given in table 16 were computed from the results of relatively short-term tests. The calculated coefficient of storage generally increases with time (Guyton, 1941, p. 770; Jacob, 1941, p. 786). Longer pumping tests would give larger coefficients of storage as has been demonstrated by Jacob in an analysis of data for the Kankakee Ordnance Works. Therefore, for periods of pumping involving several years or more, a coefficient of storage of 0.0006, is believed to be more realistic than the determined figure 0.00035, and is used in this report.

THEORETICAL EFFECTS OF PUMPING

The Cambrian-Ordovician Aquifer under natural conditions, prior to development of wells, was in approximate dynamic equilibrium in which discharge balanced recharge. The small amount of water that entered the aquifer in recharge areas was discharged naturally by leakage through the confining bed (Maquoketa Formation) in the parts of the aquifer under artesian conditions and by leakage into the Illinois River.

The withdrawal of water by wells disturbs the natural equilibrium. Cones of depression, with centers at the pumped wells, spread out in all directions and water is taken from storage within the aquifer as water levels are lowered in the areas under the influence, of pumping. The cones overlap and continue to grow until: (1) the lowering of water levels results in increased recharge to, or decreased natural discharge from, the aquifer or a combination of these, and (2) hydraulic gradients are established from the recharge or natural discharge area to the pumped wells sufficient to bring from the area the amounts of water pumped. The natural discharge cannot be decreased, nor the recharge increased, unless the hydraulic gradients are changed in areas of discharge and recharge. The dimensions of the cones of depression depend largely upon the hydraulic properties of the aquifer (coefficients of transmissibility and storage), the location and character of geohydrologic boundaries, and the rates of pumping.

Considerable time elapses before a cone of depression stabilizes, water is no longer taken from storage, and a new state of approximate equilibrium is established. The time required to reach approximate equilibrium may be computed by using the following equation (see Foley, Walton, Drescher, 1953, p. 86) :

$$t = \frac{R^2S}{112T\epsilon \log_{10}\left(\frac{2R}{r}\right)^2}$$

where t = time required to reach approximate equilibrium, in years; R = distance, in feet, from recharge boundary to pumped well; S = coefficient of storage; T = coefficient of transmissibility, in gallons per day per foot; r = distance, in feet, from pumped well to observation point; *t* = deviation from absolute equilibrium (arbitrarily assumed to be 0.05 in computations given below).

Computations made assuming distances of 47 miles (the average distance from Chicago [Loop] to recharge areas) from a pumped well to a source of recharge and 10 miles from a pumped well to an observation point, indicate that time in the magnitude of 180 years would elapse before the cone stabilized at the observation point.

A large part of the water withdrawn from the Cambrian-Ordovician Aquifer during the period in which the cone of depression is expanding and deepening is derived from storage by compaction of the aquifer and by expansion of the water itself.

Pumping from the Cambrian-Ordovician Aquifer has a widespread effect on water levels. Ground-water withdrawals at Chicago affect water levels in the Joliet area and in pumping centers in Kane and DuPage Counties. The development of ground water from areas in Kane, DuPage, and Will Counties also affects water levels at Chicago. The nonequilibrium formula (2) and the coefficients of transmissibility and storage, computed from the results of pumping tests, can be used to evaluate the magnitude of interference between wells and well fields and to compute the theoretical decline in artesian head at any distance from a pumped well and within any length of time after pumping is started.

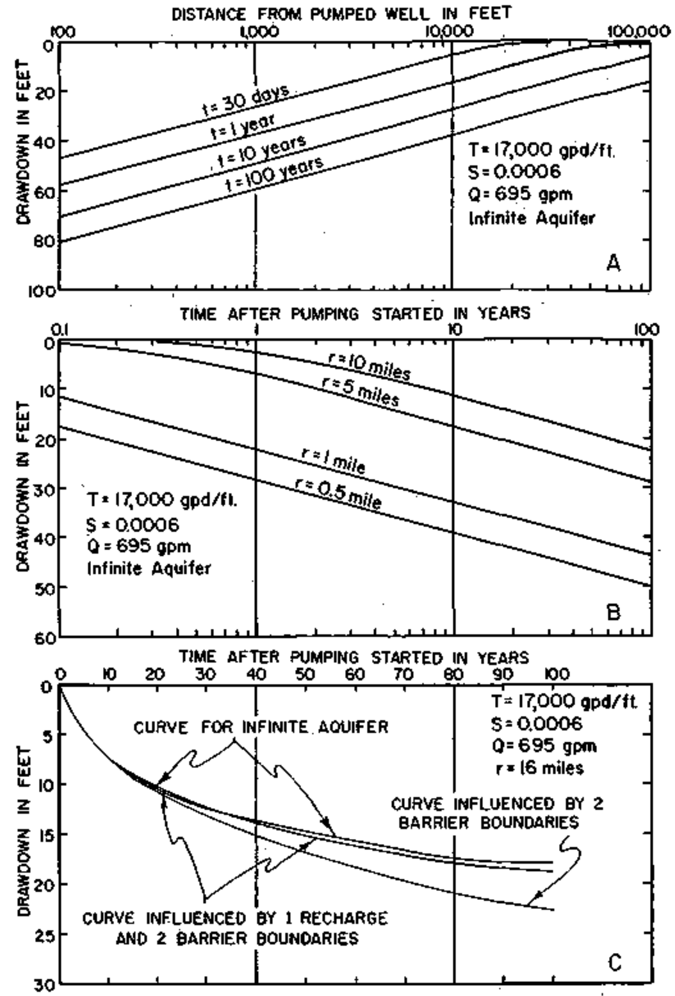


Fig. 31. Graphs of theoretical distance-drawdown (A), time-drawdown (B), and time-drawdown considering boundaries (C) for Cambrian-Ordovician Aquifer.

Figure 31A shows the amount of interference that will occur at distances of 100 feet to 19 miles from a deep well pumping continuously at 695 gpm, or 1 mgd for 30 days, 1 year, 10 years, and 100 years. The average coefficients of transmissibility and storage computed from pumping test data were used to construct the graphs. The graphs assume that all the water pumped is withdrawn from storage and that the aquifer is infinite in areal extent.

Figure 31B shows the amount of interference that will occur at any time from 37 days to 100 years 0.5 mile, 1 mile, 5 miles, and 10 miles from a well being pumped continuously at 695 gpm. Again an aquifer infinite in areal extent is assumed. The theoretical drawdown is directly proportional to the pumping rate. If the pumping rate is 347 gpm instead of 695 gpm the drawdown would be half that shown in figures 31A and 31B.

Influence of Geohydrologic Boundaries

The graphs shown in figures 31A and 31B were constructed assuming an aquifer infinite in areal extent. However, the Cambrian-Ordovician Aquifer has several boundaries. A recharge boundary exists about 47 miles west of Chicago (see subsequent section on recharge). Geologic and hydrologic data collected in northern Illinois indicate that permeabilities in the Cambrian-Ordovician Aquifer decrease south and east of Chicago and that changes in the water-bearing properties great enough to approximate the effect of barrier boundaries occur at distances of about 37 miles east and about 60 miles south of Chicago. Thus, the Cambrian-Ordovician Aquifer is enclosed by two barrier boundaries and one recharge boundary. The effect of the recharge boundary is to decrease the drawdown in a well. The effect of the barrier boundaries is to increase the drawdown in a well.

The influence of the geohydrologic boundaries, one recharge and two barrier boundaries, on the regional effects of pumping can be determined by means of the image-well theory (see Ferris, 1951, p. 247-59). The image-well theory as applied to ground-water hydrology may be stated as follows: the effect of a barrier boundary on the drawdown in a well as a result of pumping from another well is the same as though the aquifer were infinite and a like discharging well were located across the real boundary on a perpendicular thereto and at the same distance from the boundary as the real pumping well. For a recharge boundary the principle is the same except that the image well is assumed to be recharging the aquifer instead of pumping from it.

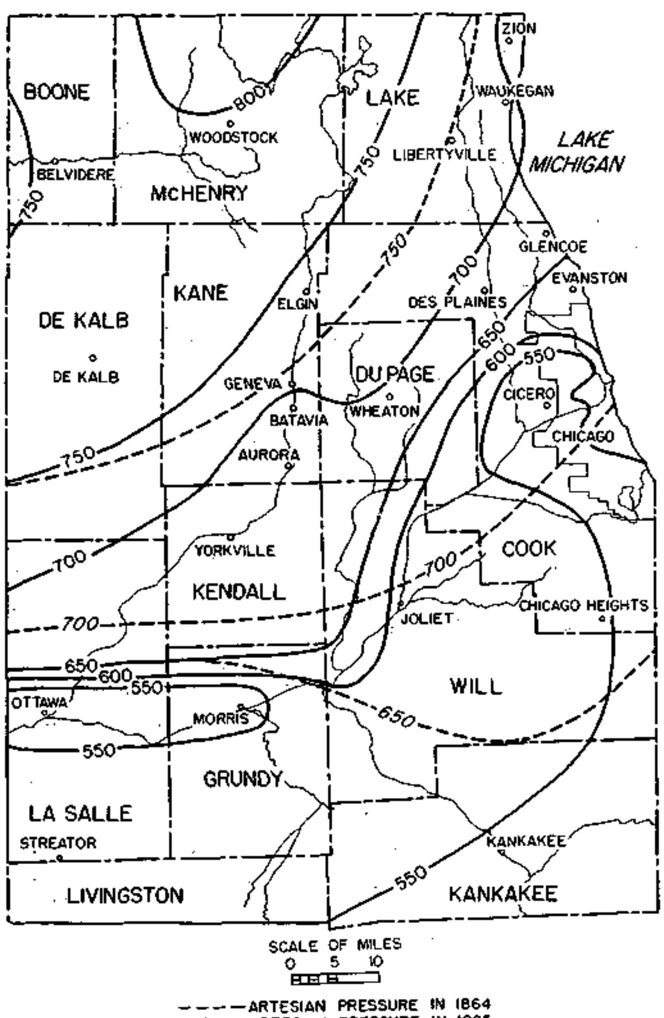


Fig. 32. Piezomefric surface of Cambrian-Ordovician Aquifer about 1864 and 1895.

The recharge boundary west of Chicago and the barrier boundary east of Chicago are for practical purposes parallel. These two boundaries are intersected at approximate right angles by a barrier boundary south of Chicago. Analysis of a multiple-boundary system with parallel boundaries by the image-well theory requires use of a multiple image-well system (Knowles, 1955, p. 88-91).

The results of geologic and hydrologic studies made in northern Illinois indicate that the effects of the geohydrologic boundaries on the response of the Cambrian-Ordovician Aquifer to development of wells can be simulated by mathematical analysis of a hypothetical hydrologic system. The system consists of a rectangular aquifer 84 miles in width enclosed by a recharge boundary 47 miles west of Chicago and by two intersecting barrier boundaries 37 and 60 miles east and south of Chicago.

Figure 31C shows the effects of the geohydrologic boundaries on the drawdown at an observation point 16 miles west of Chicago. Distances from the pumped well to the observation point of 16 miles, to the recharge boundary of 40 miles, to the barrier boundary of 58 miles south of Chicago, and to the barrier boundary of 45 miles east of Chicago were assumed in constructing the graph.

The Sandwich Fault Zone, previously discussed, runs in a northwest-southeast direction about 10 miles southwest of Joliet. There is evidence that this fault has local effects as a barrier boundary, but it does not seem to displace or modify the regional piezometric pattern. Another geologic structure, previously described, is the Des Plaines Complex which controls the hydrology locally, but does not seem to affect the surrounding piezometric pattern.

PIEZOMETRIC SURFACE OF CAMBRIAN-ORDOVICIAN AQUIFER

The *piezometric surface* is an imaginary surface to which water will rise in artesian wells. Imaginary lines of equal elevation (representing equal pressure) on the piezometric surface are called *isopiestic lines.* Ground water moves down gradient at right angles to isopiestic lines.

The exact shape of the piezometric surface of the Cambrian-Ordovician Aquifer before extensive ground-water development occurred in the Chicago-Joliet-Fox Valley area is not known. However, water-level data given by Anderson (1919) and by Weidman (1915) indicate that, under natural conditions, the piezometric surface was relatively featureless and sloped gently toward the southeast, as shown by the estimated isopiestic lines for 1864 in figure 32. As shown in this figure, a ground-

TABLE 17. WATER LEVELS IN DEEP WELLS ABOUT 1895

Elevations in Feet Above Mean Sea Level

Location	Owner	Depth of well (feet)	Surface elevation	Depth to water (ft.) above surface (+)	Date	Water-level elevation
Boone County						
Belvidere	City of Belvidere	1950	755	+ 1	1891	756
Cook County						
Chicago Stock Yards	Stock Yards Co.	1600-2200	592	0	1889	592
Chicago						
26th St. & Blue Island Ave.	McCormick Reaper Co.	1744	590	70	1901	520
1225 S. Campbell St.	Standard Brewery	2200	595	35	1892	560
1734 Fullerton Ave.	Deering Harvester Co.	1500	593	+ 2	1892	595
2530 Elston Ave.	Brand Brewing Co.	1600	591	60	1899	531
105th St. & Fort Wayne R.R.	Columbia Malting Co.	1250	587	63	1900	524
Clearing	Chicago & Western Indiana R.R. Co.	1600	617	93	1901	524
Forest Park	Village of Forest Park	1650	625	93	1901	532
Harvey	City of Harvey	1600	603	10	1895	593
Park Ridge	City of Park Ridge	1425	660	10	1895	650
Riverside	Village of Riverside	2000	617	20	1895	597
DeKalb County						
DeKalb	City of DeKalb	890	865	65	1895	800
Grundy County						
Carbon Hill	Village of Carbon Hill	1900	565	+25	1893	590
Minooka	Village of Minooka	2100	614	+46	1886	660
Morris	City of Morris	765	503	+12	1894	515
Kane County						
Aurora	City of Aurora	2250	630	+60	1899	690
Batavia	City of Batavia	1279	660	+20	1895	680
Elgin	City of Elgin	1350	742	11	1903	731
Lake County						
Lake Bluff	Village of Lake Bluff	1900	680	+45	1885	725
Zion	City of Zion	1569	648	+35	1901	683
LaSalle County						
Mendota	City of Mendota	500	752	47	1895	705
Ottawa	City of Ottawa	1450	484	+22	1894	506
Peru	City of Peru	1250	475	+85	1895	560
Will County						
Joliet	City of Joliet	1550	535	+40	1895	575
Lockport	City of Lockport	1922	568	+10	1895	578
Winnebago County						
Rockford	City of Rockford	1530	712	+33	1885	745

water ridge existed in parts of McHenry, Kane, and DeKalb Counties. Ground water moved under natural conditions toward Chicago from the ground-water ridge. In the western part of McHenry County and in the northwest, part of DeKalb County the slope of piezometric surface was to the west, and the movement of water in these areas therefore was not toward the Chicago-Joliet-Pox Valley area but was toward the Rock River Valley. Under natural conditions, the isopiestic lines bent in an upstream direction around the Illinois River in Grundy and LaSalle Counties west of the border of the Maquoketa Formation, indicating that there was leakage from the Cambrian-Ordovician Aquifer into parts of the Illinois River Valley.

Artesian Pressure in 1864 and 1895

The first deep well in Chicago was drilled in 1864 at the corner of Chicago and Western Avenues. This well was 711 feet deep and probably terminated in the lower part of the Galena-Platteville Dolomite. The well flowed with a head of 80 feet above the surface or to an elevation of 695 feet above mean sea level. It is reasonable to assume that the water in the sandstones beneath the Galena-Platteville Dolomite had a head somewhat higher than that in the first drilled well. The piezometric surface of the sandstone aquifers in the Chicago area is estimated to have had an elevation of about 710 feet in 1864 as shown in figure 32. Based largely on the water-level data given by Wiedman (1915), the elevation of the piezometric surface was between 750 and 850 feet in 1864 in McHenry, Kane, Boone, and DeKalb Counties, between 40 and 140 feet higher than at Chicago. In 1864 the 650-foot isopiestic line bent southward in Will County and some water moved toward Grundy, Livingston, and Kankakee Counties south of Chicago.

Hundreds of deep wells were drilled in Chicago and in Joliet after 1864, and the pumping of large quantities of ground water changed considerably the direction and rate of ground-water movement in northern Illinois. The artesian pressure was lowered (table 17) and cones of depression were produced. As early as about 1895 the piezometric surface was greatly modified owing to heavy withdrawals of water. The hydraulic gradients from the west were steepened and the slopes of the piezometric surface east and south of Chicago were reversed, as shown in figure 32. By 1895 water was moving from nearly all directions toward Chicago and Joliet. The 700-foot isopiestic line had migrated in a northwesterly direction about 22 miles from its estimated position in

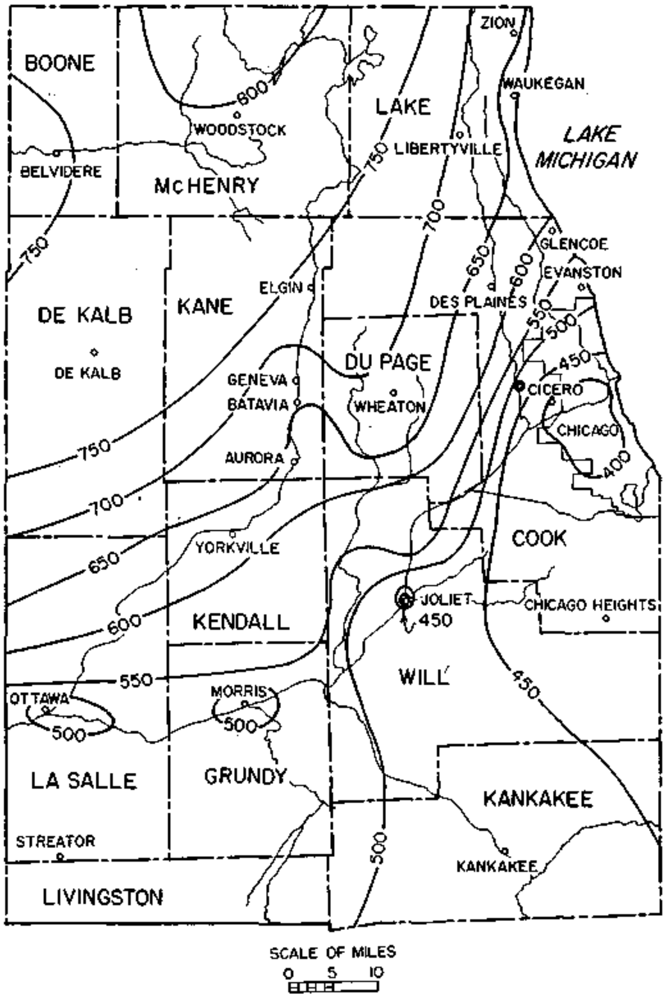


Fig. 33. Piezometric surface of Cambrian-Ordovician Aquifer about 1915.

1864. The 550-foot line had moved northwestward from northern Indiana and south of Kankakee, Illinois, to a position west of the centers of pumpage in the vicinity of Chicago, as large quantities of water were taken from storage within the aquifer.

Artesian Pressure about 1915.

Pumpage of ground water continued to increase. By 1915 the cones of depression around Chicago and Joliet had deepened since 1864 about 300 feet to elevations of about 400 feet (table 18) and isopiestic lines were distorted around pumpage centers along the Fox Valley in Kane County (fig. 33). Discharge of ground water to the Illinois River was decreased as the cone of depression moved into Kendall County. The 700-foot isopiestic line had migrated six miles from its estimated position in 1895.

Artesian Pressure in 1958

Figure 34 shows the piezometric surface of the Cambrian-Ordovician Aquifer in 1958. The levels used to prepare the map (table 19) are nonpumping water levels. Geologic cross sections and profiles of the piezometric surface of the Cambrian-Ordovician Aquifer in 1958, which were prepared for four lines across northern Illinois, are shown in figure 15. These two illustrations show clearly the cones of depression in the piezometric surface which have developed as the result of heavy pumping. It will be noted that a considerable lowering has taken place in the pressure surface since 1915. A 400-foot isopiestic line closed around Chicago in 1915, with the cone of depression centered in the Stock Yards area. During recent years the area of lowest water levels has shifted toward the west. In 1958 the deepest cone of depression in Cook County (50 feet above sea level) was in the vicinity of Summit which is southwest of Chicago.

Another pronounced cone is centered at Joliet where the artesian pressure was at an elevation of about 25 feet above sea level in 1958. Several small cones that developed within the large cones mentioned above distort the isopiestic lines, causing them to bend irregularly around many scattered pumpage centers. Depressions

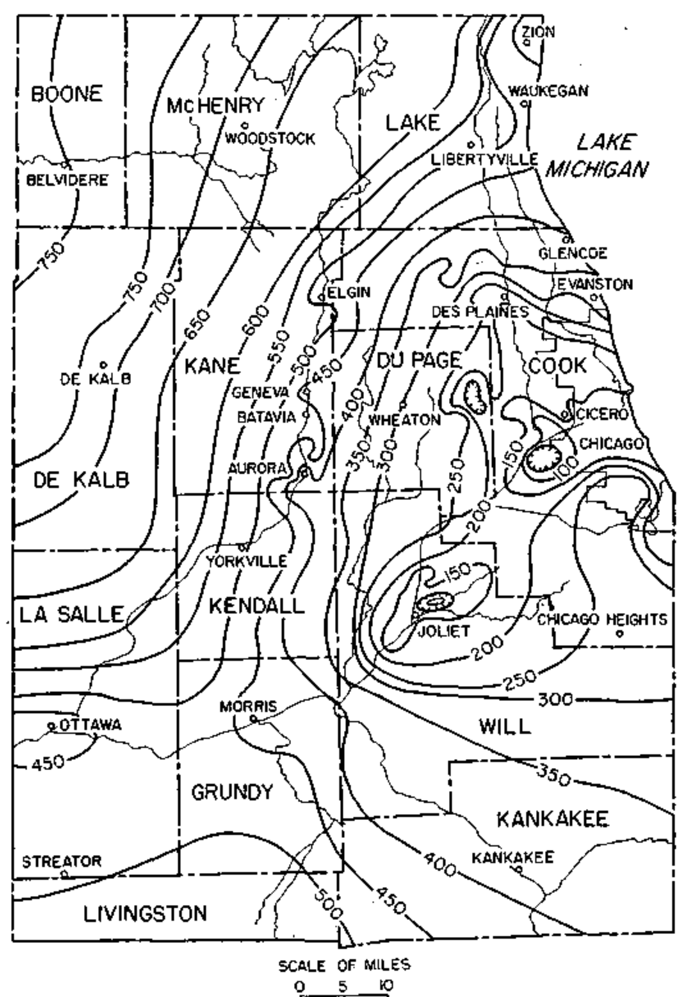


Fig. 34. Piezometric surface of Cambrian-Ordovician Aquifer in 1958.

TABLE 18. WATER LEVELS IN DEEP WELLS ABOUT 1915
Elevations in Feet Above Mean Sea Level

Location	Owner	Depth of well (feet)	Surface elevation	Depth to water (ft.) above surface (+)	Date	Water-level elevation
Boone County						
Belvidere	City of Belvidere	1950	755	8	1909	747
Cook County						
Summit	Corn Products Refining Co.	1638	592	187	1915	405
Bellwood	Village of Bellwood	1538	635	75	1913	560
Berwyn	City of Berwyn	1650	605	166	1914	439
Blue Island	City of Blue Island	1649	641	231	1914	410
Chicago Stock Yards	Chicago Stock Yards Companies	1600	592	239	1915	353
Chicago, Pitney Ct., & Archer Ave.	Light & Coke Co.	1800	588	213	1914	375
Chicago, 26th St. & Blue Island Ave.	McCormick Reaper Co.	1744	590	219	1914	371
Chicago, 79th St. & Blue Island Ave.	Grand Crossing Track Co.	1600	586	169	1914	417
Chicago, 1225 S. Campbell St.	Standard Brewery	2200	595	222	1914	373
Chicago, 1734 Fullerton Ave.	Deering Harvester Co.	1500	593	134	1914	459
Chicago, 2530 Elston Ave.	Brand Brewing Co.	1600	591	140	1914	451
Chicago, 105th St. & Ft. Wayne R. R.	Columbia Malting Co.	1250	587	155	1914	432
Clearing	Chicago & Western Indiana R.R. Co.	1600	617	212	1914	405
Forest Park	Village of Forest Park	1650	625	163	1914	462
Harvey	City of Harvey	1000	603	155	1915	448
Lyons	Village of Lyons	1595	615	137	1914	478
Maywood	Village of Maywood	1605	630	180	1913	450
Melrose	Village of Melrose	1620	630	80	1914	550
Park Ridge	City of Park Ridge	1425	660	85	1914	575
Summit	Village of Summit	1547	600	157	1914	443
DeKalb County						
DeKalb	City of DeKalb	890	865	104	1912	761
Genoa	City of Genoa	1500	825	50	1914	775
Hinckley	Village of Hinckley	708	740	4	1913	736
Sandwich	City of Sandwich	600	667	17	1914	650
Sycamore	DeKalb-Sycamore Electric Railway Co.	1002	810	17	1914	793
DuPage County						
Bensenville	C. M. & St. P. & P. R.R.	2201	680	61	1913	619
Downers Grove	Village of Downers Grove	2021	717	90	1913	627
Grundy County						
Carbon Hill	Village of Carbon Hill	1900	565	20	1915	545
Minooka	Village of Minooka	620	620	70	1915	550
Morris	City of Morris	765	503	48	1915	455
Kane County						
Aurora	City of Aurora	2185	675	48	1915	627
Aurora	Western Wheeled Scraper Co.	1410	688	78	1914	610
Batavia	City of Batavia	2000	660	6	1915	654
Elgin	City of Elgin	1350	742	14	1914	728
Geneva	City of Geneva	850	675	5	1914	670
Mooseheart	Fraternal Order of Moose	1840	709	28	1914	681
St. Charles	City of St. Charles	850	748	50	1913	698
Kankakee County						
Kankakee	Kankakee State Hospital	1812	615	126	1914	489
Lake County						
Lake Bluff	Village of Lake Bluff	1900	680	40	1914	640
Lake Forest	Ogden Armour Estate	1623	690	41	1915	649
Waukegan	C. & N. W. R.R. Co.	2200	600	+ 20	1914	620
Zion	City of Zion	1569	648	+ 5	1914	653
LaSalle County						
Cedar Point	LaSalle County Carbon Coal Co.	1749	653	90	1912	563
LaSalle	Matthiessen & Hageler Zinc Co.	1619	585	62	1913	523
Marseilles	City of Marseilles	800	500	+ 5	1915	505
Mendota	City of Mendota	500	752	73	1915	679
Oglesby	City of Oglesby	1645	642	103	1915	539
Ottawa	City of Ottawa	1450	484	+ 1	1915	485
Peru	City of Peru	1250	475	+ 10	1915	485
Streator	Various wells in City of Streator				1915	527
Utica	Private wells in Utica				1915	520
Will County						
Joliet	City of Joliet	1547	531	63	1913	468
Joliet	City of Joliet	1563	544	160	1915	384
Lockport	City of Lockport	1922	568	14	1915	554
Plainfield	Village of Plainfield	1302	612	55	1915	557

TABLE 19. WATER LEVELS IN DEEP WELLS IN 1958

Elevations In Feet Above Mean Sea Level

Location	Owner	Depth of well (feet)	Surface elevation	Depth to water (feet)	Date	Water-level elevation
Boone County						
Belvidere	City of Belvidere	1800	778	40	1957	738
Cook County						
Chicago	American Can Co.	1806	630	492	10/57	138
Broadview	Amphenol Corp.	1550	628	475	5/58	153
Arlington Heights	City of Arlington Heights	1525	686	380	5/58	306
Arlington Heights	Arlington Park Jockey Club	1825	730	373	2/58	357
North Lake	Automatic Electric Co.	1900	655	441	5/57	214
Morton Grove	Avon Products Inc.	1525	644	335	3/58	309
Morton Grove	Baxter Lab. Inc.	1700	627	348	7/58	279
Bellwood	Village of Bellwood	1951	624	460	2/58	164
Des Plaines	Benjamin Electric Co.	1340	644	430	1/58	214
River Forest	Bowman Dairy	2072	631	458	2/58	173
Chicago	Bradshaw Praeger Co.	1204	595	474	12/57	121
Buffalo Grove	Buffalo Grove Subd.	1340	686	292	11/57	394
Chicago Heights	Calumet Steel Div.	1805	640	370	1/58	270
Elk Grove	Centex Industrial Corp.	1395	682	400	4/58	282
Berwyn	Chicago Vitreous Enamel Co.	1607	608	421	6/57	187
Bensenville	J. B. Clow & Co.	1457	663	430	8/57	233
South Chicago	Columbia Malting Co.	1400	587	430	10/57	157
Summit	Corn Products Refining Co.	1481	597	545	3/58	52
Chicago	Cracker Jack Co.	1500	620	517	4/58	103
Des Plaines	City of Des Plaines	1813	653	348	1/58	305
Elk Grove	Elk Grove Subdivision	1415	717	428	10/57	289
Glenview	Eugenia Subdivision	1414	666	341	6/58	325
Evergreen Park	Evergreen Cemetery Assoc.	1656	627	360	4/57	267
Oak Park	Fair Store	1610	619	440	6/57	179
Chicago	Fleischman Malting Co.	1900	594	530	6/57	64
Willow Springs	Ford Motor Co.	1565	617	490	11/57	127
Glenview	Glenview Club	1546	643	338	7/58	305
Mt. Prospect	Hatlen Heights Subdivision	1765	680	325	1/57	355
Roselle	Hoffman Estate Subdivision	1391	750	378	4/58	372
Elk Grove	Hotpoint Co.		698	444	7/58	254
Chicago	Ideal Roller & Mfg. Co.	1147	598	464	1/58	134
Chicago	International Harvester Co.	1600	640	452	2/57	188
Chicago	International Rolling Mill Products Co.	1617	600	488	7/58	112
Chicago	Joanna Western Mills	1603	593	465	12/57	128
Chicago	Liquid Carbonic Corp.	1512	594	456	1/58	138
Wheeling	Lonetree Subdivision	1404	686	288	5/37	398
Maywood	Village of Maywood	2018	630	482	7/58	148
Dolton	Metro Glass Co.	1704	592	432	6/58	160
Blue Island	Miller Pre-Pared Potato Co.	1651	600	392	3/58	208
Chicago	Monarch Brewery	1600	593	472	12/57	121
Mt. Prospect	Village of Mt. Prospect	1354	670	449	6/58	221
Mt. Prospect	Village of Mt. Prospect	1822	673	375	6/58	298
Blue Island	Oak Hill Cemetery	1637	667	360	5/58	307
Palatine	Village of Palatine	1350	732	362	4/58	370
Riverside	Village of Riverside	2047	618	513	5/58	105
Rolling Meadows	Village of Rolling Meadows	1530	720	374	4/58	346
Skokie	G. D. Searle & Co.	1470	614	320	7/58	294
Glenview	Signode Steel Stripping Co.	1452	670	319	6/58	351
Chicago	Standard Brands, Inc.	1545	602	466	3/58	136
Chicago	Standard Brands, Inc.	1740	602	483	11/57	119
Hinsdale	Suburban Cook Co. T. B. Sanitarium	1450	687	490	6/58	197
Thornton	Village of Thornton	1724	612	344	11/57	268
Chicago Heights	Victor Chemical Co.	1800	640	350	5/57	290
Chicago	Visking Corp.	1509	619	556	4/58	63
Western Springs	Village of Western Springs	1600	678	525	4/58	153
Wheeling	Village of Wheeling	1370	645	261	6/56	384
Chicago	Bunte Candy Co.	1951	600	458	1956	142
Glenview	Glenview Countryside Subdivision	1405	677	316	4/57	361
Glenview	Kraft Foods Research Lab.	1050	628	270	1956	358
Glenview	North Shore Country Club	2017	645	266	12/56	379
Chicago	Mars Inc.	1978	653	473	1956	180
McCook	Universal Oil Co.	1564	608	490	4/58	118
DeKalb County						
DeKalb	City of DeKalb	1331	870	168	5/58	702
DeKalb	City of DeKalb	1325	860	182	5/58	678
Sandwich	City of Sandwich	600	667	25	10/58	642
Genoa	City of Genoa	730	820	67	10/58	753

TABLE 19. (Continued)

Location	Owner	Depth of well (feet)	Surface elevation	Depth to water (feet)	Date	Water-level elevation
DuPage County						
Bensenville	Village of Bensenville	1442	676	448	5/58	228
Bensenville	Village of Bensenville	1445	670	431	5/58	239
Bensenville	C. M. & St. P. & P. R.R.	1461	671	443	5/58	228
Elmhurst	City of Elmhurst	2194	680	385	3/58	295
Elmhurst	City of Elmhurst	1502	690	558	4/58	132
Elmhurst	City of Elmhurst	1476	703	572	6/58	131
Lombard	Village of Lombard	2028	696	467	4/58	229
Lombard	Village of Lombard	1793	738	452	1/58	286
Naperville	City of Naperville	1445	680	378	1/58	302
Villa Park	Village of Villa Park	2125	699	494	2/58	195
Villa Park	Wander Co.	1987	675	413	1/58	262
Villa Park	Wander Co.	2002	670	475	11/57	195
Villa Park	Wander Co.	1920	675	478	1/58	197
Grundy County						
Morris	City of Morris	1501	519	108	10/57	411
Morris	City of Morris	1501	519	57	10/57	462
Minooka	Village of Minooka	620	613	170	10/58	443
Kane County						
Aurora	Alba Mfg. Co.	1543	645	272	2/58	373
Aurora	City of Aurora	2250	646	242	10/57	404
Aurora	City of Aurora	2262	619	161	10/57	458
Aurora	City of Aurora	2280	628	281	11/57	347
Aurora	City of Aurora	2299	673	259	10/57	414
Aurora	City of Aurora	2460	665	272	4/57	393
Aurora	City of Aurora	2150	660	278	8/57	382
Aurora	Aurora Paperboard Co.	1400	696	311	1/58	385
Batavia	City of Batavia	2201	667	205	4/58	462
Batavia	City of Batavia	2200	667	177	4/58	490
Geneva	Burgess Norton Co.	1340	760	315	1/58	445
Elgin	City of Elgin	1945	741	275	6/58	466
Elgin	City of Elgin	1880	745	310	6/58	435
Elgin	City of Elgin	1255	740	335	6/58	405
Elgin	Elgin National Watch Co.	1240	734	221	1/58	513
Elgin	Elgin State Hospital	2000	748	230	6/58	518
Geneva	City of Geneva	2217	678	108	2/58	570
Geneva	City of Geneva	1578	759	284	1/58	475
Geneva	City of Geneva	2267	719	305	2/58	414
St. Charles	Ill. School for Boys	1322	790	275	12/57	515
Montgomery	Village of Montgomery	1366	633	253	11/57	380
Montgomery	Village of Montgomery	1353	640	250	1/58	390
Mercyville	Mercyville	1411	697	303	12/57	394
St. Charles	City of St. Charles	2200	764	285	4/58	479
South Elgin	City of South Elgin	1400	761	250	1/58	511
Aurora	Walker Laundry	1438	636	320	11/57	316
West Dundee	Village of West Dundee	1200	725	216	7/57	509
Carpentersville	Village of Carpentersville	1140	728	214	2/58	514
Mooseheart	Mooseheart	2200	693	234	3/58	459
North Aurora	Village of North Aurora	1272	635	214	6/57	421
Algonquin	Material Service Co.	1335	840	368	2/58	472
Elburn	Elburn Packing Co.	905	840	261	4/58	579
Batavia	Campana	930	706	168	2/58	538
Kaneville	Kaneville School Dist. 302	930	740	230	8/56	510
Kankakee County						
Reddick	Village of Reddick	1188	612	146	6/58	466
Kendall County						
Montgomery	Caterpillar Tractor Co.	1384	661	256	7/58	405
Montgomery	Caterpillar Tractor Co.	1352	661	236	7/58	425
Montgomery	Caterpillar Tractor Co.	1346	660	245	7/58	415
Oswego	Village of Oswego	1378	640	190	10/57	450
Yorkville	Village of Yorkville	590	584	82	10/58	502
Lake County						
Waukegan	Goodyear Tire & Rubber Co.	1631	680	154	6/52	526
Waukegan	Goodyear Tire & Rubber Co.	1600	680	172	3/53	508
Waukegan	Illinois Beach State Park	1002	585	150	10/57	435
Lake Bluff	Village of Lake Bluff	1825	685	211	11/56	474
Gages Lake	Wildwood Subdivision	1310	810	216	1951	594
Zion	City of Zion	1025	630	210	10/57	420
Lincolnshire	Lincolnshire Subdivision	1305	645	230	12/57	415
LaSalle County						
Ottawa	City of Ottawa	1180	488	40	6/58	448
Earlville	City of Earlville	625	700	28	10/58	672

TABLE 19. (Continued)

Location	Owner	Depth of well (feet)	Surface elevation	Depth to water (feet)	Date	Water-level elevation
Livingston County						
Cardiff	Cardiff	1785	638	121	10/58	517
Odell	Village of Odell	1941	720	129	10/56	591
McHenry County						
Crystal Lake	City of Crystal Lake	1218	917	293	3/57	624
Crystal Lake	City of Crystal Lake	1555	930	295	3/57	635
Huntley	Dean Milk Co.	1610	890	159	7/58	731
Island Lake	Village of Island Lake	1223	775	136	7/57	639
Marengo	City of Marengo	1028	817	116	4/58	701
Ogle County						
Rochelle	City of Rochelle	550	820	40	10/58	780
Will County						
Joliet	American Cyanimid Co.	1614	586	405	6/58	181
Joliet	American Institute of Laundering	1608	569	383	6/58	186
Joliet	American Oil Co.	1422	568	307	10/57	261
Joliet	Blockson Chemical Co.	1520	548	523	1/58	25
Joliet	Blockson Chemical Co.	1506	583	503	2/58	80
Joliet	Blockson Chemical Co.	1536	567	505	7/57	62
Joliet	Bohemian Brewing Co.	1484	544	391	3/58	153
Joliet	Caterpillar Tractor Co.	1510	544	360	6/57	184
Joliet	Caterpillar Tractor Co.	1543	546	360	6/57	186
Joliet	DuPage River Farm	1520	587	301	12/57	286
Joliet	Illinois State Penitentiary	1550	549	444	5/58	105
Joliet	Illinois State Penitentiary	1518	560	488	5/58	72
Stateville	Illinois State Penitentiary	1600	645	480	4/58	165
Joliet	City of Joliet	1575	535	379	3/58	156
Joliet	City of Joliet	1621	536	405	4/58	131
Joliet	City of Joliet	1535	529	401	6/58	128
Joliet	City of Joliet	1608	564	415	5/58	149
Joliet	City of Joliet	1608	558	493	6/58	65
Joliet	Hadley Valley	1660	648	450	3/57	198
Joliet	Hadley Valley	1701	674	540	10/57	134
Elwood	Joliet Arsenal (Elwood)	1645	641	284	5/58	357
Kankakee	Joliet Arsenal (Kankakee)	935	572	203	5/58	369
Joliet	Joliet Industries Inc.	1596	551	427	1/58	124
Joliet	Joliet Township High School	881	535	423	6/58	112
Joliet	Joyce 7-Up Co.	724	628	86	5/58	542
Lidice	Lidice Subdivision	1652	659	496	5/58	163
Lockport	City of Lockport	1446	589	466	1/58	123
Lockport	City of Lockport	1571	662	485	1/58	177
Lockport	City of Lockport	1572	650	508	1/58	142
Joliet	Phoenix Mfg. Co.	1595	553	441	6/58	112
Joliet	Prairie State Paper Co.	700	576	184	5/58	392
Joliet	Pratt Mfg. Co.	1505	551	458	6/58	93
Joliet	Public Service Co. of Northern Illinois	1608	518	376	7/57	142
Joliet	Public Service Co. of Northern Illinois	1507	590	375	3/57	215
Plainfield	Village of Plainfield	1481	622	316	5/58	306
Rockdale	Village of Rockdale	1586	556	424	6/58	132
Joliet	Ruberoid Co.	776	551	512	6/58	39
Joliet	Stepan Chemical Co.	1407	525	262	5/58	263
Lockport	U. S. War Dept., Lockport Locks	815	581	443	5/58	138
Joliet	Will County Sanatorium	864	622	435	6/58	187
Winnebago County						
Rockford	City of Rockford	1102	730	50	5/58	680

in the piezometric surface occur in the vicinity of Elmhurst and at Des Plaines. A significant feature shown in figure 34 is the bending of isopiestic lines around pumpage centers in the Elgin and Aurora areas along the Fox Valley in Kane County.

Changes in artesian pressure produced by pumping since the days of early settlement have been pronounced and widespread. The artesian pressure in the vicinity of Chicago has declined on the average about 600 feet. In 1864 the 700-foot isopiestic line passed through Chicago. By 1958 the 700-foot isopiestic line had migrated northwestward about 52 miles to a position in western McHenry County and eastern DeKalb County. A ground-water divide exists in eastern Boone County and in northeastern DeKalb County.

The general pattern of flow of water in the Cambrian-Ordovician Aquifer in 1958 is slow movement from all directions toward the deep cones of depression centered at Chicago and at Joliet. Some of the water flowing toward Chicago and Joliet is intercepted by cones of depression developed locally within the large cones in the Aurora, Elgin, Des Plaines, and Elmhurst areas. The lowering of head that has accompanied the withdrawals of ground water has established steep hydraulic gradients west and north of Chicago, and large quantities of water are at present being transmitted from recharge areas in northern Illinois and minor quantities from southern Wisconsin toward centers of pumping. Large amounts of water derived from storage within the Cambrian-Ordovician Aquifer move toward Chicago and Joliet from the east in Indiana, from the south in Kankakee County in Illinois, from the west in northern Illinois, and from the northeast beneath Lake Michigan. Probably there is now some recharge into the aquifer from the Illinois River Valley in areas of extensive declines in water levels in Grundy and LaSalle Counties.

RECHARGE TO CAMBRIAN-ORDOVICIAN AQUIFER

Maps and profiles of the piezometrie surface of the Cambrian-Ordovician Aquifer in figures 32, 33, 34 and 15 show high elevations in McHenry, Boone, and DeKalb Counties indicating recharge in these areas. The high elevations in McHenry and Boone Counties extend into Wisconsin. The piezometric surface reaches crests mostly in areas where the Galena-Platteville Dolomite crops out at the surface or is the uppermost bedrock formation below the glacial deposits, west of the border of the Maquoketa Formation shown in figure 16. In most parts of the Chicago-Joliet-Fox Valley area the Maquoketa Formation is relatively impervious and greatly retards the vertical movement of water to the underlying aquifers. However, in parts of McHenry, Kane, and DeKalb Counties, the Maquoketa Formation contains appreciable dolomite, is relatively thin, and locally may be completely removed by erosion. Recharge occurs through the formation in these areas. As a result areas of high elevation on the piezometric surface occur at some places east of the border of the Maquoketa Formation.

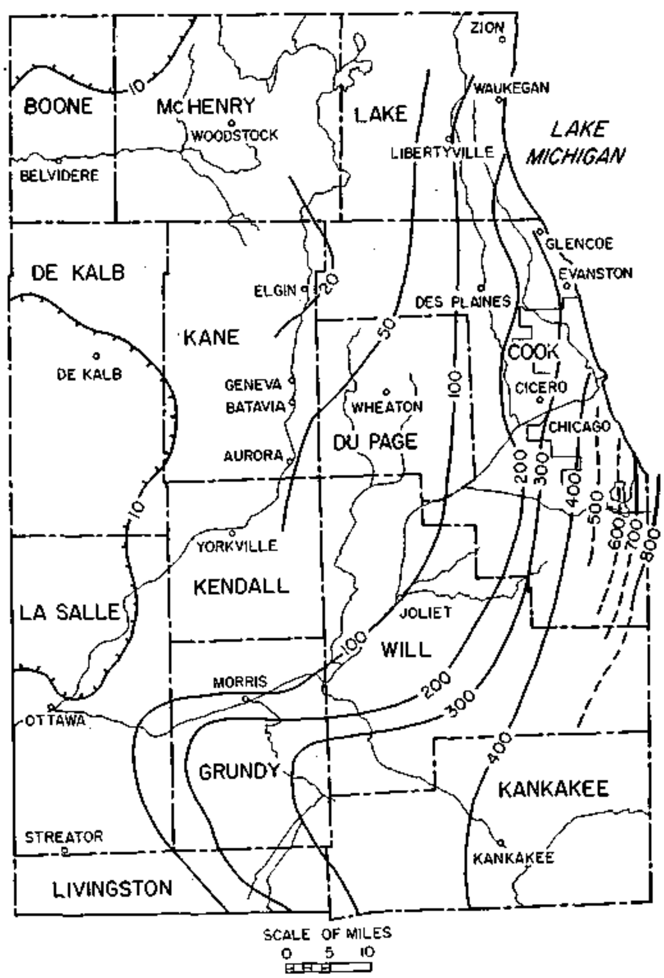


Fig. 35. Sulfate content of waters from the Cambrian-Ordovician Aquifer.

Where the Galena-Platteville Dolomite is overlain by the Maquoketa Formation there has been only small development of crevices and, although the dolomites yield some water, they are in general not very permeable. Where the Galena-Platteville Dolomite is overlain by glacial deposits more crevices are developed and the rock is fairly permeable. Thus, there is a good hydraulic connection between the Glenwood-St. Peter Sandstone and glacial deposits in areas where the Maquoketa Formation is absent or where the Maquoketa Formation overlying the Galena-Platteville is thin and dolomitic.

The Ironton-Galesville Sandstone receives water from the Glenwood-St. Peter Sandstone through crevices and other openings in the intervening dolomites. Thus, recharge to the Glenwood-St. Peter Sandstone, and eventually to the Ironton-Galesville Sandstone below, takes place generally through fractures and solution channels in the Galena-Platteville Dolomite which in turn receives water from the overlying glacial deposits. Recharge of the glacial deposits occurs from precipitation that falls locally. The indicated total area of recharge to the Cambrian-Ordovician Aquifer is about 1200 square miles.

In northern Illinois, waters from glacial sand and gravel deposits immediately overlying bedrock contain less than 10 parts per million (ppm) sulfates whereas the sulfate content of water from the Cambrian-Ordovician Aquifer is usually higher. Where waters from the Cambrian-Ordovician Aquifer contain less than 10 ppm sulfates, it is concluded that these waters have been recharged through the overlying strata (Foley and Smith, 1954, p. 229). The distribution of sulfates in water from the Cambrian-Ordovician Aquifer shown in figure 35 indicates approximately the same areas of recharge as do the piezometric-surface maps. Further confirmation of the location of the recharge area is given by the temperature of the water as explained in the subsequent section on water quality.

It is probable that a small amount of recharge occurs directly through the Maquoketa Formation under the influence of an extensive cone of depression in the Cambrian-Ordovician Aquifer.

The location of the Chicago region adjacent to the Lake Michigan basin prompts a consideration of Lake Michigan as a potential source of recharge for the deep aquifers. As shown by the succession of piezometrie maps it is clear that the original conditions precluded any recharge from the lake basin. However, with the decline of the piezometrie surface due to pumpage in future years to a level well below lake level and the indicated possibilities of some movement of water through the Maquoketa Formation barrier, minor amounts of recharge may be derived in the future from the Lake Michigan basin. The present study indicates no significant amount of recharge from Lake Michigan at this time.

MOVEMENT OF WATER IN CAMBRIAN-ORDOVICIAN AQUIFER

The quantity of water percolating through a given cross section of an aquifer is proportional to the hydraulic gradient (slope of the piezometric surface) and the coefficient of transmissibility, and it can be computed by using the following modified form of the Darcy equation (see Ferris, 1951, p. 226):

$$Q = TIL \qquad (3)$$

in which Q is the discharge in gallons per day; T is the coefficient of transmissibility in gallons per day per foot; I is the hydraulic gradient in feet per mile; and L is the width of the cross section through which discharge occurs in miles.

A study was made of the movement of ground water towards Chicago in response to the natural hydraulic gradient of the piezometric surface. Flow lines were drawn from McHenry and Kane Counties toward the northern and southern boundaries of Cook County at right angles to the estimated piezometric surface contours for 1864 given in figure 32. These two flow lines delimit the section of the Cambrian-Ordovician Aquifer through which water was transmitted to Chicago under natural conditions. Considering the section of the aquifer midway between the 750-foot and 700-foot contours, the hydraulic gradient was 1.7 feet per mile and the distance between the limiting flow lines was 30 miles. Based on the data summarized in figure 30, the average coefficient of transmissibility of the section of the aquifer between the 750-foot and 700-foot lines is about 17,000 gpd per foot. Using equation (3) and the data given above, the quantity of water moving towards Chicago is computed to be about 900,000 gpd which was all that moved in this direction under the natural hydraulic gradient of the piezometric surface before pumping started.

In 1958 the amount of water moving through the Cambrian-Ordovician Aquifer southeastward from McHenry and Kane Counties was determined to be about 19 mgd, or about 20 times that flowing under natural conditions. This results from about a tenfold increase in hydraulic gradient (fig. 34) and an increase in the distance between limiting flow lines.

The cone of depression at Joliet was studied to check the accuracy of the coefficients of transmissibility computed from the results of pumping tests. The area bounded by isopiestic lines having elevations of 200 and 150 feet (fig. 34) was selected for the analysis.

From equation (3)

$$T = \frac{Q}{IL} \qquad (4)$$

The quantity of water, Q, moving midway between the 200-foot and 150-foot isopiestic lines is equal to the total pumpage (11.6 mgd, fig. 36B) from the Cambrian-Ordovician Aquifer in the Joliet area minus the amount of water taken from storage within the area enclosed by the 150-foot isopiestic line. The amount of water taken from storage is very small; therefore, Q is essentially equal to 11.6 mgd. The hydraulic gradient, I, and the length of cross section, L, midway between the 200-foot and 150-foot isopiestic lines, were scaled from figure 34. Computations made using the data mentioned above and equation (4) indicate that the average coefficient of transmissibility of the part of the Cambrian-Ordovician Aquifer within the Joliet cone of depression is 16,600 gpd per foot. This value compares favorably with the coefficients of transmissibility computed from the results of pumping tests in the Joliet area (table 15).

Quantity of Water from Recharge Areas in 1958

The piezometric-surface map given in figure 34 indicates that in 1958 some water was transmitted from recharge areas in Walworth County in southeastern Wisconsin to cones of depression in northeastern Illinois. Because of the lack of piezometric data for the aquifer where it extends under Lake Michigan, it is impossible to compute with any degree of accuracy the quantity of water involved. A reasonable estimate, based on the hydraulic gradient midway between the 700-foot and 650-foot lines in McHenry County, is about 2 mgd.

Based on a study of the movement of water through sections of the Cambrian-Ordovician Aquifer near the border of the Maquoketa Formation, it is estimated that in 1958 approximately 20 mgd were transmitted from recharge areas in northeastern Illinois and southeastern Wisconsin toward cones of depression along the Fox Valley, in the vicinity of Chicago, and at Joliet.

Limiting flow lines were drawn from recharge areas through DeKalb, Kendall, LaSalle, and Grundy Counties to the Joliet cone of depression. The quantity of water transmitted in 1958 from recharge areas toward Joliet was computed to be 5.8 mgd. The calculation was based on the movement of water through the section of the aquifer midway between the 500-foot and 450-foot lines near the border of the Maquoketa Formation and enclosed by the limiting flow lines. The total quantity of water pumped from the Cambrian-Ordovician Aquifer is derived from recharge areas and from storage within the aquifer. Thus, of the total 11.6 mgd of water pumped from the Cambrian-Ordovician Aquifer in 1958 in the Joliet area, 5.8 mgd of water, or 50 percent, was derived from storage within the aquifer.

Quantity of Water Moving into Cones of Depression in 1958

The quantities of water percolating in 1958 through sections of the Cambrian-Ordovician Aquifer into the cones of depression in the Aurora, Elgin, Des Plaines, Elmhurst, Joliet, and Chicago areas were computed, by using data in figures 30 and 34 and equation (3), to be as given in table 20.

TABLE 20. AMOUNT OF WATER MOVING INTO THE CONES OF DEPRESSION OF PUMPING CENTERS IN 1958

Pumping center	Water (mgd)
Chicago area	11.0
Joliet area	11.6
Elmhurst area	5.3
Des Plaines area	3.5
Elgin area	4.1
Aurora area	7.3
Total	42.8

Many deep wells in the Chicago-Joliet-Fox Valley area are uncased in the Mt. Simon Aquifer as well as in the Cambrian-Ordovician Aquifer and the Silurian age dolomite. Thus, a large portion of the water pumped from deep wells is obtained from the aquifers above and below the Cambrian-Ordovician Aquifer. The difference, 33.3 mgd, between the' total pumpage of 76.1 mgd from deep wells in the Chicago-Joliet-Fox Valley area and the total of 42.8 mgd of water diverted into the cones of depression is the amount of water derived from the Mt. Simon Aquifer and the Silurian age dolomite.

DISCHARGE FROM DEEP WELLS

Pumpage

The first deep well in Chicago, drilled at the corner of Chicago and "Western Avenues in 1864, had an artesian flow estimated at about 150 gpm or about 200,000 gpd. The estimated pumpage from deep wells in the Chicago-Joliet-Fox Valley area increased gradually from 200,000 gpd in 1864 to more than 76 mgd in 1958. Figure 36 shows estimated withdrawal rates for 1864-1958 in the six major pumping centers of the Chicago-Joliet-Fox Valley area. Records of pumpage are fairly complete for the period 1942-1958; very few records of pumpage are available for years prior to 1942. The graphs in figure 36 were constructed by piecing together fragments of information on pumpage found in published reports and in the files of the State Water Survey, by making evaluations based on the number of wells, their reported yields, and their time of construction, and by taking into consideration population growth and per capita consumption.

TABLE 21. DISTRIBUTION OF PUMPAGE FROM DEEP WELLS IN 1908 AND 1958

Pumping center	1908 Total pumpage (mgd)	1958 Total pumpage (mgd)
Chicago area	21.3	23.4
Joliet area	1.8	14.0
Elmhurst area	0.4	9.8
Des Plaines area	0.4	6.8
Elgin area	2.6	8.1
Aurora area	3.9	14.0
Total	30.4	76.1

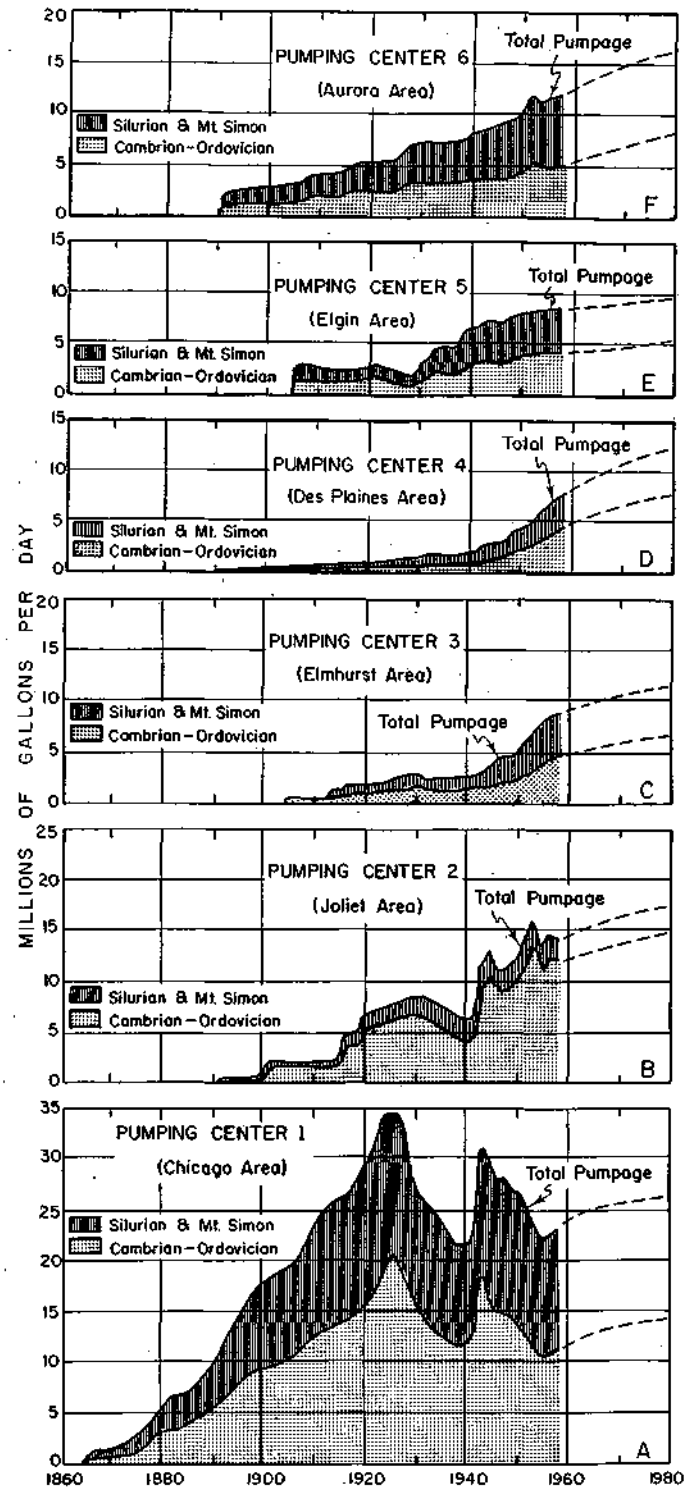


Fig. 36. Pumpage from the deep wells for the period of record.

Figure 37 and table 21 show the distribution of estimated pumpage from deep wells in 1958. The greatest quantities of water were withdrawn from deep wells in the Chicago; Joliet, and Aurora areas.

In 1908, 50 years ago, there was very little pumpage outside Chicago except at Aurora and Elgin (table 21). Since that time the net increase in pumpage at Chicago has been only about 10 percent although in the 1920's and 1940's much higher pumping rates were obtained. Pumpage in areas near Chicago (Elmhurst and Des Plaines) has increased to 15 times that recorded in 1908. During the past 50 years, pumpage at Joliet has increased from 1.8 to 14.0 mgd and pumpage along the Fox Valley in the Aurora and Elgin areas has more than tripled.

As shown in figures 36C and D, prior to about 1940 pumpage in the Elmhurst and Des Plaines areas increased fairly uniformly at an average rate of about 50,000 gpd per year. The total pumpage in 1940 was 2.3 mgd in the Elmhurst area and 1.7 mgd in the Des Plaines area. During and after World War II, pumpage in these two areas increased very rapidly at an average rate of 400,000 gpd per year, or at a rate 8 times that recorded for the period prior to 1940.

The rate of increase in withdrawal in the Aurora area has been very uniform since 1890 and has averaged about 110,000 gpd per year. Pumpage in the Elgin area increased gradually during the period 1904-1928 after which it increased rapidly until about 1952. From 1952 to 1958 pumpage at this center has remained fairly constant at about 8 mgd.

As shown in figure 36B, pumpage in the Joliet area greatly increased during World Wars I and II and the Korean War in response to water demands of manufacturing industries. Pumpage at Joliet has also fluctuated with economic conditions as indicated by the decrease in pumpage during the 1930's.

Pumpage in the Chicago area increased at a rapid rate from about 200,000 gpd in 1864 to a maximum of 34.4 mgd in 1924. During the period, 1925-1937, pumpage decreased rapidly as many industries, including the Stock Yards, abandoned deep wells owing to the great decline in artesian pressure and began using the city of Chicago water supply. Economic conditions during the depression in the 1930's also contributed to the decrease in pumpage at Chicago. From 1940 to 1942 pumpage increased rapidly from 21.6 to 31 mgd, and after that it decreased to 22 mgd in 1954 and was 23.4 mgd in 1958.

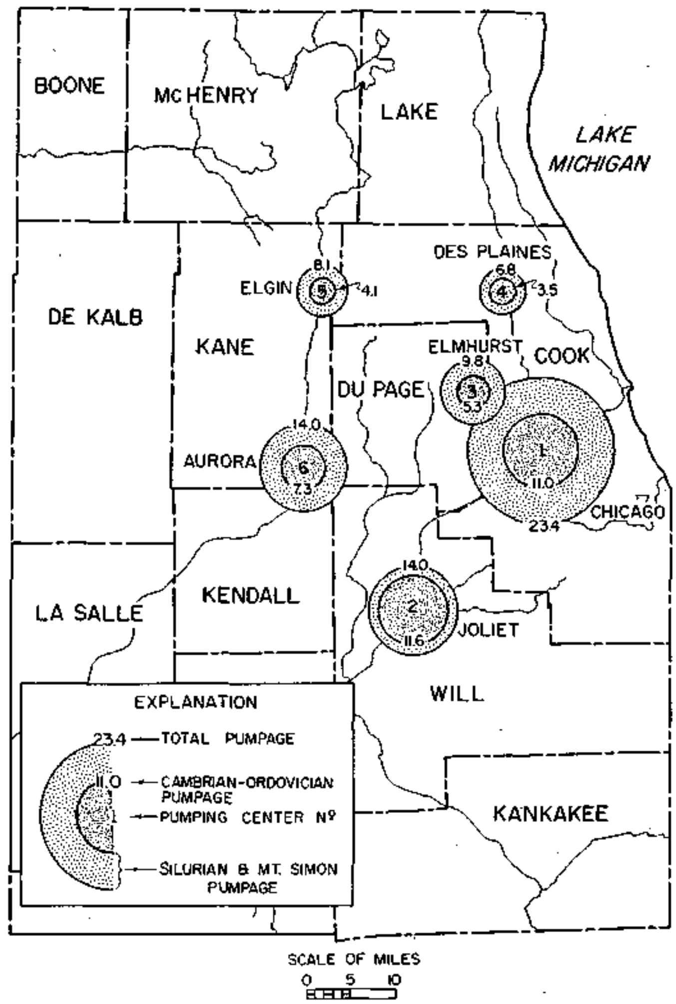


Fig. 37. Distribution of estimated pumpage from deep wells in 1958. Pumpage is proportional to radius of circle.

Quantity of Water Derived from Silurian Age Dolomite and Mt. Simon Aquifer

The amount of water derived in 1958 from the Silurian age dolomite and the Mt. Simon Aquifer was calculated using figures 30 and 34 and equation (3) by subtracting the amounts of water moving through the Cambrian-Ordovician Aquifer into the pumping centers from the total withdrawals from deep wells in the pumping centers. Figure 37 shows the distribution of estimated pumpage from the Silurian age dolomite and Mt. Simon and Cambrian-Ordovician Aquifers in 1958. In 1958 about 33.3 mgd or 43 percent of the total amount of 76 mgd pumped from deep wells was derived from the Silurian age dolomite and the Mt. Simon Aquifer. Based on an inventory of well construction and quality of water studies, it is estimated that in 1958 about 20.5 mgd were derived from the Silurian age dolomite and about 12.8 mgd were obtained from the Mt. Simon Aquifer. A large part of the water derived from the Mt. Simon Aquifer was pumped from deep wells in the Fox Valley.

Figure 36 gives approximate amounts of water derived from Silurian age dolomite and the Mt. Simon and Cambrian-Ordovician Aquifers in the pumping centers prior to 1958. The figure was constructed after considering mineral content and temperature data and by evaluating the number of wells open in the Cambrian-Ordovician Aquifer, the Silurian age dolomite, and/or the Mt. Simon Aquifer, their yield, and their time of construction. It is estimated that the amount of water derived from sources other than the Cambrian-Ordovician Aquifer increased from about 16.4 mgd in 1915 to 33.3 mgd in 1958. Also considered was the fact that leakage of water from the Silurian age dolomite into deep wells remains fairly constant after the artesian pressure in the Cambrian-Ordovician Aquifer declines below the base of the Silurian age dolomite.

DECLINE OF ARTESIAN PRESSURE IN CAMBRIAN-ORDOVICIAN AQUIFER

In 1864 the artesian pressure in the Cambrian-Ordovician Aquifer was sufficient to cause wells to flow in many parts of the Chicago-Joliet-Fox Valley area. The estimated isopiestic lines in figure 32 indicate that in 1864 the average elevation of the piezometric surface at Chicago and Joliet was about 700 feet. By 1895 the pressure had dropped in response to withdrawals of water to elevations of about 550 feet at Chicago and 600 feet at Joliet. In a period of 31 years, water levels at Chicago had declined about 150 feet or at a rate of about five feet per year because large amounts of water were being taken from storage within the aquifer. As pumping continued, the nonpumping water levels continued to decline, and by 1915 were 400 feet above sea level at Chicago and Joliet. The average rate of decline and total decline in artesian pressure at Chicago, 1895-1915, were about 7.5 feet per year and 150 feet respectively.

As a result of continued heavy pumping, the nonpumping water levels in deep wells declined from an elevation of 400 feet in 1915 to about 50 feet at Chicago and about 25 feet at Joliet in 1958 (fig. 34). The average rate of decline at Chicago in the 43-year period, 1915-1958, was eight feet per year. In many areas the average rate of decline has increased during recent years to more than 10 feet per year in response to progressive increases in pumpage.

Since 1864 the artesian pressure at Chicago has declined about 660 feet. The average rate of decline, 1864-1958, was 7.1 feet per year. Figures 38 and 39 show the rates of decline of artesian pressure at Chicago and at Joliet.

The estimated piezometric surface map for 1864 (fig. 32) was compared with the piezometric surface map for 1958 (fig. 34). Figure 40 shows the decline of water levels in the Cambrian-Ordovician Aquifer, 1864-1958. The lines representing decline closely conform in most areas to the 1958 isopiestic lines. The greatest declines, amounting to more than 600 feet, have occurred in areas of heavy pumpage just west of Chicago, at Summit, and at Joliet. The decline has been 10 feet or less west of the margin of the Maquoketa Formation in recharge areas in DeKalb, Boone, and McHenry Counties. Most of the decline in the recharge areas is due to local pumpage and cannot be attributed to heavy pumping at Chicago and Joliet.

There has been fairly widespread decline of more than 100 feet west of the margin of the Maquoketa Formation in southwestern Kendall County, northwestern Grundy County, and LaSalle County. The hydraulic gradients in these areas have been readjusted to divert large quantities of water from the recharge areas into the Joliet and Chicago cones of depression.

The lines representing decline are distorted around the Illinois River in Grundy County, lending support to the conclusion that there is some hydrologic connection between the Cambrian-Ordovician Aquifer and the Illinois River west of the border of the Maquoketa Formation.

Quantity of Water Taken from Storage Within Cambrian-Ordovician Aquifer

The volumetric change of ground-water storage cannot be determined precisely owing to the lack of water-level data for the area underlying Lake Michigan and the areas southeast of Chicago and south of Kankakee. However, conditions in areas not covered by the map in figure 40 can be estimated with reasonable accuracy by extrapolating existing data. Based largely on the data given in figure 40 and using a coefficient of storage of 0.0006, it is estimated that about 340 billion gallons of water were taken from storage within the aquifer during the period 1864-1958. The average rate of volumetric decrease of ground-water storage, 1864-1958, was about 10 mgd.

The average rate of decline of water levels in the Chicago-Joliet-Fox Valley area from 1864 to 1958 was 5.2 feet per year or a little less than one half the annual rate of 11 feet for the period 1949-58. Computations show that the average rate of volumetric decrease in ground-water storage, 1949-58, was about 23 mgd. Thus, in 1958 about 23 mgd were taken from storage within the aquifer to balance pumpage.

APPLICATION OF HYDROLOGIC SYSTEM TO PAST RECORDS

Records of past pumpage and water levels were used to determine whether or not the hypothetical hydrologic system discussed earlier in this report satisfies the geohydrologic limits of the aquifer. The reason for doing this is to test the assumed model against past performance and thereby establish the validity of this mechanism to predict future water levels in the region.

The water-level decline in the Lisle area in DuPage County from 1864 through 1958 was computed as a test (fig. 40), using calculated coefficients of transmissibility and storage and estimated pumpage data, taking into account one recharge and two barrier boundaries. The computed decline was then compared with the actual decline.

The pumpage from the Cambrian-Ordovician Aquifer in the Chicago-Joliet-Fox Valley area was grouped into six centers of pumping. Figure 37 shows the location of these centers and also the amount of pumpage from each in 1958. Pumpage from the Cambrian-Ordovician Aquifer, 1864 through 1958, was distributed among the six centers and further broken into step increments.

The six centers of pumping and the geohydrologic boundaries were drawn to scale on a map and the image wells were located. The distances between the observation point in the Lisle area and the six pumping centers and the image wells associated with the geohydrologic boundaries were scaled from the map.

The water-level decline at the observation point resulting from each increment of pumpage at each of the six pumping centers was determined, using the nonequilibrium formula (equation 2) to compute the effects of

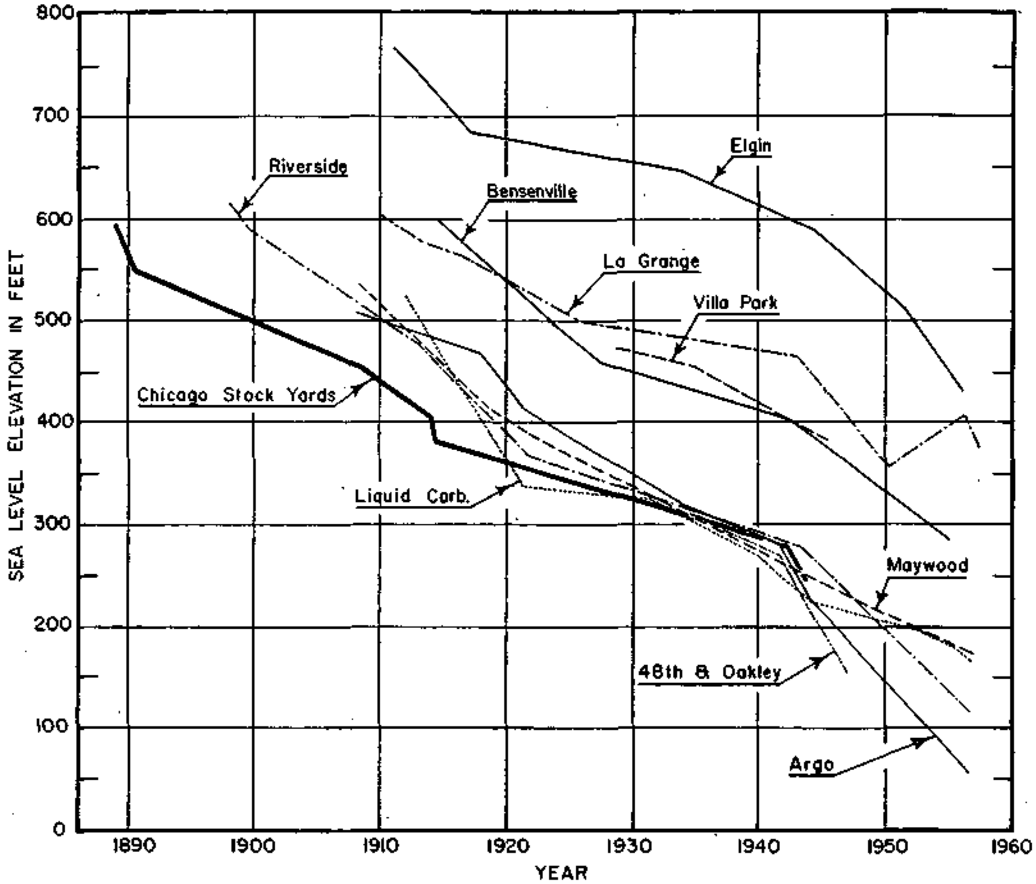


Fig. 38. Decline of artesian pressure in deep wells in the Chicago region for period of record.

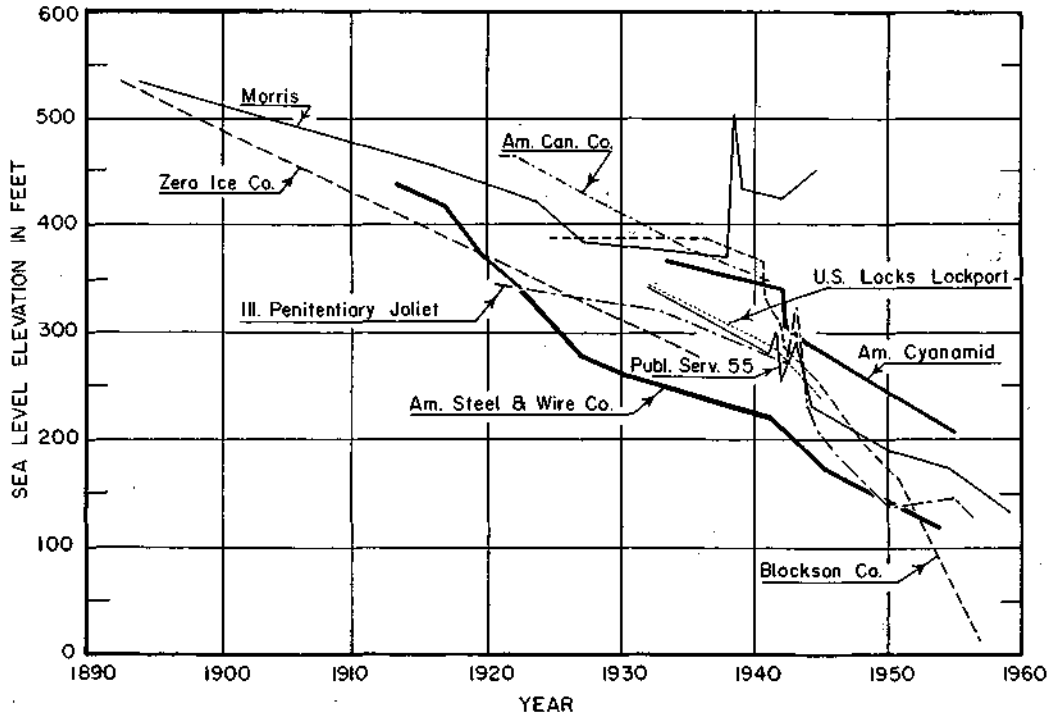


Fig. 39. Decline of artesian pressure in deep wells at Joliet for period of record.

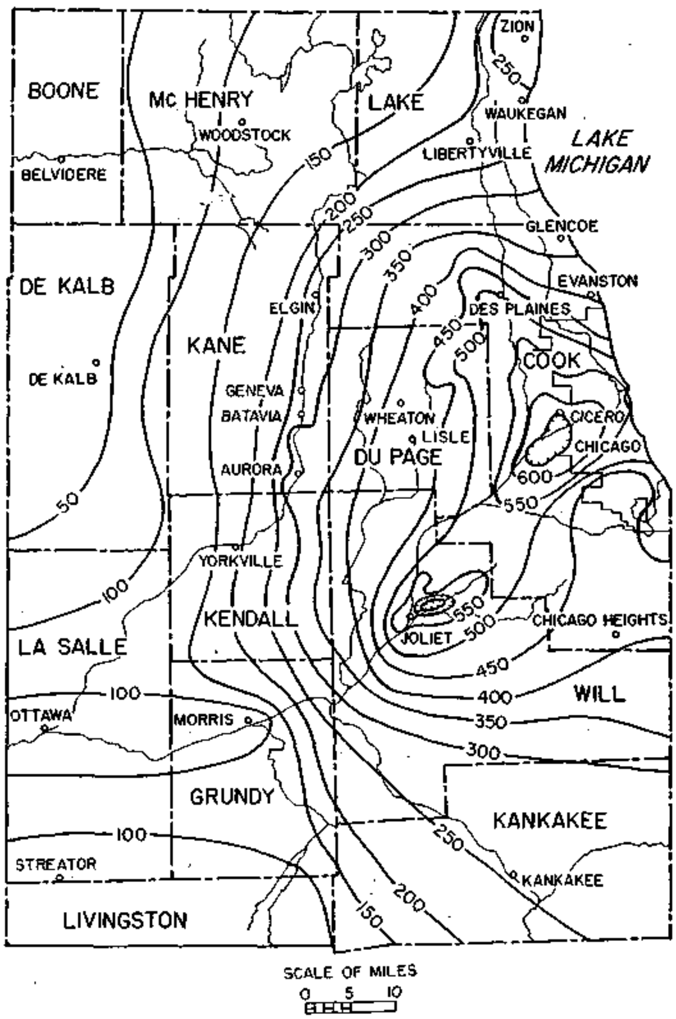


Fig. 40. Decline of artesian pressure in Cambrian-Ordovician Aquifer, 1864-1958.

the real and image wells. The computed nonpumping water-level decline in the Lisle area resulting from past withdrawals of water from each pumping center is given in table 22.

The computed total decline in nonpumping water level in the Lisle area, 1864 through 1958, is 450 feet. The actual decline, obtained from figure 40, is 420 feet.

TABLE 22. COMPUTED NONPUMPING WATER-LEVEL DECLINE IN THE LISLE AREA

Pumping center	Fractional decline in feet
Chicago area	215.5
Joliet area	80.4
Elmhurst area	55.0
Des Plaines area	16.8
Elgin area	27.2
Aurora area	55.1
Total	450.0

The computed decline is within about 7 percent of the actual decline. Even though the estimates of pumpage upon which calculations are based may be about 10 percent in error, the close agreement between computed and actual decline indicates that the hypothetical hydrologic system used closely describes the geohydrologic limits of the Cambrian-Ordovician Aquifer. It is believed that the hydrologic system may be used to predict with reasonable accuracy the effects of future ground-water development.

POTENTIAL GROUND-WATER DEVELOPMENT AND ITS EFFECTS

Pumpage between the present time and any future date must be estimated before further declines in water levels in wells in the Cambrian-Ordovician Aquifer can be calculated. Graphs showing the pumpage from 1864 through 1958 in each of the six pumping centers in the Chicago-Joliet-Fox Valley area are given in figure 36. Pumpage in the centers from 1958 through 1980 was extrapolated taking into consideration the past rates of growth of pumpage. Assuming that the total pumpage from deep wells in the six centers will increase at fairly uniform rates, from 76 mgd in 1958 to about 92 mgd in 1980, the daily withdrawal from the Cambrian-Ordovician Aquifer in 1980 will be about 56 mgd.

Decline in water levels which may be expected on the basis of these assumptions, from 1958 through 1980, at Chicago, Joliet, Des Plaines, Elmhurst, Elgin, and Aurora, were calculated using the same principles outlined in the preceding section. Computed declines in each pumping center which are presented in table 23 are

TABLE 23. COMPUTED FUTURE NONPUMPING WATER-LEVEL DECLINE, 1958-1980

Pumping center	Decline, 1958-1980 in feet	Predicted elevation, 1980, in feet
Chicago area	300	—250
Joliet area	220	—200
Elmhurst area	250	—100
Des Plaines area	300	—100
Elgin area	190	+300
Aurora area	250	+150

based on the assumption that the distribution of pumping remains the same and that the pumpage increases at the rates given in figure 36. It should be emphasized that the declines in water levels cited are nonpumping water levels. Pumping levels will decline about the same amount as the nonpumping water levels if the present rates of pumping from individual wells are maintained.

Considering the great complexity of ground-water conditions in the Chicago-Joliet-Fox Valley area, the accuracy of the predicted future declines in water levels is probably about ± 15 percent.

By 1980 the Galena-Platteville Dolomite and the Glenwood-St. Peter Sandstone will be partially dewatered in parts of the Chicago-Joliet-Fox Valley area. The effects of partial dewatering on future declines in water levels in deep wells were estimated on the basis of available geologic and hydrologic data. It is important that collection of water-level and pumpage records be continued so that the effects of dewatering can be appraised. It may be necessary to recompute future declines in water levels within ten years on the basis of data collected under dewatering conditions.

PRACTICAL SUSTAINED YIELD OF THE CAMBRIAN-ORDOVICIAN AQUIFER

Aside from economic considerations and quality of the water, the sustained yield of the Cambrian-Ordovician Aquifer is dependent on the rate of recharge, on the coefficient of transmissibility, and on the spacing of wells and well fields. The quantity of water that can be withdrawn indefinitely from the Cambrian-Ordovician Aquifer depends in part upon the quantity of water that can be induced to enter the aquifer in recharge areas, which in turn is dependent on the rate at which precipitation enters the ground. It is estimated that the recharge area of the Cambrian-Ordovician Aquifer that affects the Chicago-Joliet-Fox Valley area is about 1200 square miles. If five percent of the average annual precipitation can be induced to infiltrate into the aquifer in recharge areas, a conservative figure, the total available water at the recharge areas would be about 100 mgd.

The coefficient of transmissibility of the Cambrian-Ordovician Aquifer is low. To transmit 25 mgd from recharge areas, at a hydraulic gradient of 20 feet per mile, would require a cross section 73 miles wide. The maximum hydraulic gradient that theoretically could be developed from recharge areas toward pumping centers in the Fox Valley, in the Chicago area, and in the Joliet area, without dewatering a portion of the Ironton-Galesville Sandstone and thereby greatly decreasing the coefficient of transmissibility of the Cambrian-Ordovician Aquifer, is about 44 feet to the mile. It is estimated that the width of the cross section through which movement from recharge areas could occur is about 85 miles. Computations made with equation (3) show that the maximum quantity of water that could be transmitted down-dip from recharge areas is about 65 mgd. This quantity is less than the estimated recharge rate. Thus the sustained yield of the Cambrian-Ordovician Aquifer depends on the coefficient of transmissibility and the maximum available gradient of the aquifer rather than on potential replenishment to the aquifer.

The maximum amount of water that can be transmitted from recharge areas cannot be developed unless water is withdrawn from a large number of uniformly and widely spaced wells. However, pumping has been and probably will continue to be concentrated in industrial and municipal centers. From a hydrologic standpoint concentrated pumping is inefficient, and development of the full capacity of the aquifer is impossible under existing and foreseeable pumping conditions. Thus, the practical sustained yield of the Cambrian-Ordovician Aquifer is less than the maximum amount of 65 mgd which can be transmitted down-dip from recharge areas.

As explained earlier in this report, considerable time passes before water levels reach approximate equilibrium and the full effects of pumping are realized. Computations made using the nonequilibrium formula (2), the image-well theory, and the hydrologic system previously described indicate that, if the distribution and amount of pumping, 43 mgd, from the Cambrian-Ordovician Aquifer in the Chicago-Joliet-Fox Valley area remain indefinitely the same as in 1958, the nonpumping water level at Chicago will eventually decline to an elevation of about 550 feet below sea level under equilibrium conditions. The nonpumping water level at Chicago would be about 200 feet above the top of the Ironton-Galesville Sandstone. Withdrawal rates could be slightly increased over those of 1958 without dewatering the Ironton-Galesville Sandstone. Therefore, the practical sustained yield of the Cambrian-Ordovician Aquifer is somewhat greater than 43 mgd.

Computations made, taking into consideration dewatering, indicate that if the distribution of pumpage remains the same as in 1958 and the amount of pumpage from the Cambrian-Ordovician Aquifer increases to a total of 46 mgd and then remains the same, the nonpumping level in Chicago will eventually decline to a position about 100 feet above the top of the Ironton-Galesville Sandstone and at an elevation of about 650 feet below sea level. Pumping levels in wells, if the present rates of pumping from individual wells are maintained, would be within a few feet of the top of the Ironton-Galesville Sandstone. The pumping levels locally would be below the top of the Galena-Platteville Dolomite, the Glenwood-St. Peter Sandstone, the Prairie du Chien Series, Trempealeau Dolomite, and the Franconia Formation, and these formations would be dewatered. The dolomites and the Franconia Formation generally are not very permeable, and dewatering of these formations would not appreciably decrease the coefficient of transmissibility of the entire Cambrian-Ordovician Aquifer. However, the Glenwood-St. Peter Sandstone has some permeability. The specific capacities of deep wells would probably decrease on the average about 15 percent as the result of dewatering the Glenwood-St. Peter Sandstone.

The practical sustained yield of the Cambrian-Ordovician Aquifer is, therefore, estimated to be about 46 mgd. The practical sustained yield of this aquifer will be developed when the total pumpage from deep wells in the Chicago-Joliet-Fox Valley area is about 81 mgd. If pumpage increases at the rates assumed in figure 36, the practical sustained yield will be exceeded in about 1965 although equilibrium conditions will not yet have been achieved. The practical sustained yield of the Cambrian-Ordovician Aquifer could be increased by shifting centers of pumping to the west and by spacing wells at greater distances.

SHALLOW DOLOMITE AQUIFERS

The shallow dolomite aquifers consist of Silurian rocks in most of the region (note extent of Silurian in fig. 16) and dolomites of the Maquoketa and Galena-Platteville Formations in the western part of the region.

Ground water occurs in joints, fissures, and solution channels that range in size from hairline cracks to caverns. The locations of these openings cannot be predicted from the surface. Locally such openings may be partly filled with silt and clay which may be troublesome in development of wells. However, the upper part of the dolomite is usually the most productive. The thickness of the Silurian rocks ranges from a feather edge in the western part of the area to more than 450 feet in the southeast (fig. 27). Silurian rocks are the primary source of water for most household and farm wells and for many municipal and industrial wells. Many of the wells penetrate only the upper part of the dolomite, as shown in figure 41. Usually only the municipal and industrial wells penetrate the entire thickness of the aquifer.

The daily pumpage during 1957 from wells penetrating the shallow dolomite aquifers is given in table 13. The greater part of this pumpage occurs in Cook and DuPage Counties. Many high capacity wells have been constructed in parts of these counties where many crevices have been encountered.

A study was made of the specific capacities of municipal and industrial supply wells in the shallow dolomite in Cook, DuPage, Kane, Lake, McHenry, and Will Counties. Specific-capacity data obtained from the files of the State Water Survey, for 154 wells, are given in table 24. The data for the counties are summarized in table 25.

Specific capacities listed in the tables range from 0.1 to 550 gpm per foot. Wells in DuPage County have the highest average specific capacity (54.5 gpm per foot), and wells in Lake County have the lowest average specific capacity (5.0 gpm per foot). The average specific capacity per foot of penetration of wells in DuPage County is much greater than that of wells in other counties.

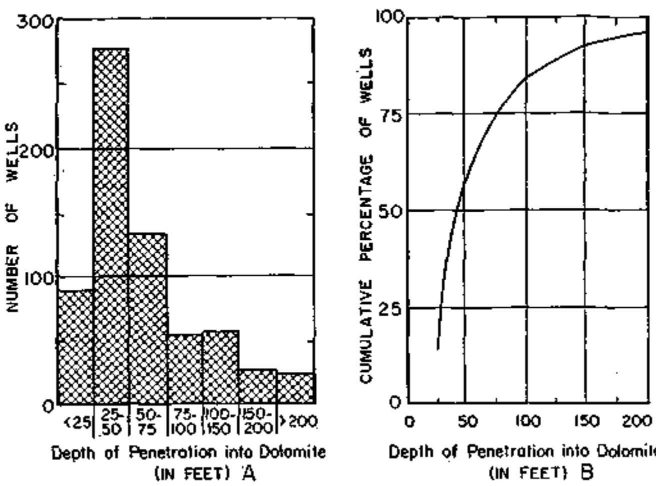


Fig. 41. Depth-frequency histogram (A) and depth-cumulative percentage curve (B) of wells completed in shallow dolomite in 17 townships in Will and Cook Counties.

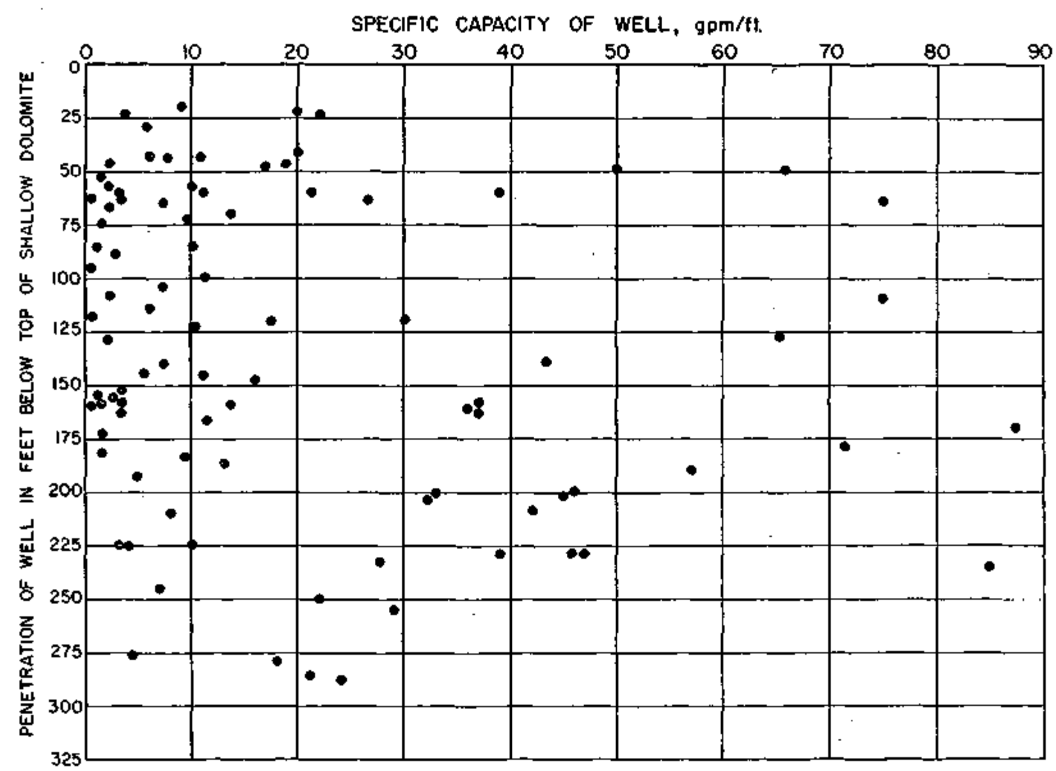


Fig. 42. Penetration versus specific capacity of wells in shallow dolomite aquifers.

TABLE 24. SPECIFIC-CAPACITY DATA FOR WELLS IN SHALLOW DOLOMITE

Location and owner of well	Well No.	Depth of well *(feet)*	Diameter of casing *(inches)*	Penetration of well below top of aquifer *(feet)*	Date of test	Nonpumping level *(feet)*	Pumping rate *(gpm)*	Draw-down *(feet)*	Specific capacity *(gpm/ft)*
Cook County									
Arlington Heights									
Village	1	140	10	23	1946	25	240	61.5	3.9
State Highway Garage	1	172			1951	25	37	16	2.3
Jockey Club	3	761			1946	37	86	150	0.6
National Mortgage Co.	1	201			1949	33	120	117	1.0
Barrington									
Village	1	305	12–10	60	1943	66.1	200	9.3	21.5
Village	2	210	16	60	1946	53	400		
Barrington Woods		250			1953	44	22.3	161.5	0.13
Village	1	305	12–10	60	1933	60.8	350	3.7	96
Village	2	210	16	60	1929	53.5	540	13.8	39
Bartlett									
Village	1	200	8	49	1923	33	265	4	66
Village	1	200	8	49	1946	37	200	4	50
Berkeley									
Village	2	151	10	47	1930	44	150	8	19
Village	2	151	10	47	1944	60	200	12	17
Chicago									
Chicago-United Air Lines	1	410			1946	49	108	67	1.6
Chicago Heights									
City	15	193	24	158	1946	88	1000	27	37
City	18	251	26	209	1941	Flowing	1650	39	42
City	19	330		288	1946	20	400	17	24
City	21	203	30–24	161	1945	22	870	24	36
City	21	203	30–24	161	1945	22	1670	45.5	37
City	22	270	33–22	200	1946	26	960	21	46
City	23	260	30–24	202	1946	33.5	1800	55	33
City	23	260	30–24	202	1956	33.5	1270	28	45
American Locomotive Co.	3	222			1942	56	1150	2.1	550
Flintkote Co.	3	300			1946	106	310	107	2.9
Penn Salt Co.	1	215	16–266		1954	7	108		
Victor Chemical	3	433			1947	37	118	215	0.5
Victor Chemical	4	250			1947	56	347	111	3.1
Flossmoor									
Village	1	275	10	210	1945	90	300	20+	
Village	2	351	12–10	286	1945	40	425	20	21
Village	3	467	16–14–12	402	1941	64.5	395	89.5	4.4
Village	1	275	10	210	1940	47	300	38	8
Glencoe									
H. Levy	1	206			1937	72	27	13	2.1
Hillside									
Village	2	180	8–6	158	1937	35	40	25	1.6
Hinsdale									
Suburban Sanatorium	1	357			1952	39	322	112	2.9
Homewood									
Village	1	252	12–10	182	1923	29	170	22	7.7
Village	Tw 1-46	460	6	351	1945	29	210	59	3.5
Village	1	252	12–10	182	1945	34	245	133	1.8
Village	3	436	22	364	1945	35	250	242	1.0
Dixmoor	4	226	10	162	1946	17	240	73	3.3
Oaklawn Cemetery	2	302			1946	42	175	16	11
Ravisloe CC	3	420			1953	41	530	38	14
La Grange									
Cornet Development	1	420			1953	81	367	49	7
Lyons School No. 105	1	377	13–154		1951	54	90	86	1
La Grange Park									
M. Magisano	1	327			1950	66	38	7	5.4
Lambert									
Univ. of Chi. Exp. Station	1	308			1944	153	65	14	4.6
Lemont									
Coghill CC	2	173			1941	71.7	127	5.3	24.0
Fournier Inst.	1	370			1947	104	390	12.5	31.2
Matteson									
Village	1	282	10		1945	14	200	8	25
Public Service Co.	1	156			1948	27	313	7.5	41.7
Mt. Prospect									
Village	1	200	12–8	105	1937	36	160	103	
Village	2	210	12–10	108	1945	45	100	40	2.5
Northfield									
Woods Subdivision	1	300			1954	55	60	179	0.3
Test Well	1	316			1947	19	133	119	1.1
Oak Forest									
Village	2	297			1952	15	520	55	9.4

TABLE 24. (Continued)

Location and owner of well	Well No.	Depth of well *(feet)*	Diameter of casing *(inches)*	Penetration of well below top of aquifer *(feet)*	Date of test	Nonpumping level *(feet)*	Pumping rate *(gpm)*	Draw-down *(feet)*	Specific capacity *(gpm/ft)*
Cook County (continued)									
Oak Lawn									
School District No. 111		215			1945	54	76	34	2.2
School District No. 111		286			1948	40	30	103	0.3
School District No. 220	1	298			1942	49	49	34	1.4
School District No. 220	2	375			1948	60.5	61	30	2.0
Orland Park									
Village	1	329	6	119	1938	40	238	8	30
Capitol Dairy	1	355	6	295	1943	12	100	0	
Palatine									
Village	5	209	12	67	1945	2	210	96	2.2
Park Forest									
Village	2	300	24–15	205	1947	57.5	1150	12	96
Village	3	350	24–16	255	1948	41	1045	36.5	29
Village	5	345	24–17	250	1953	50	575	5	115
Commercial Well	4	345	12	250	1952	39	1020	46	22
Prospect Meadows		201			1950	33	135	68	2
Stickney									
Nat'l. Alum. Co.	1	393			1936	79.5	84	105.5	0.8
Nat'l. Alum. Co.	2	233			1937	85	63	87	0.7
Stone Park									
Village	1	291	12–11	245	1943	172	86	13	7
Sacred Heart Sem.		250			1940	173	57	6.5	9
Thornton									
Village	2	408	12	225+	1946	237	120	33	4
Village	3	250	8	225	1944	97	100	10	10
Tinley Park									
State Hospital	1	491	24–20	347	1952	23	685	143	5
State Hospital	1	491	24–20	347	1952	23	625	100	6
State Hospital	3	515	28–19	347	1951	14	680	80	8.5
Western Springs									
Village	1	385	16	350	1946	56	550	24	23
Village	2	313	15	278	1946	67	500	27.5	18
Wheeling									
Village	1	200	12–10	140	1926	15	150	20	7.5
Du Page County									
Addison									
Village	1	155	10	65	1916	18	150	2	75.0
Belmont	2	295		235	1954	84	340	4	85.0
Clarendon Hills									
Village	1	295			1953	102	210	24	8.8
Village	2	250	12	110	1947	113	300	4	75.0
Village	3	354	12	203	1945	91	385	12	32.1
Downers Grove									
Village	Lee	250	30	178	1947	46	860	12	71.5
Village	Park	291	30	127	1945	96	980	15	65.4
Glen Ellyn									
Village		310	8	145	1916	42	500	93	5.4
Village	2	352	12	145	1947	76	750	68	11.0
Village	3	422	18	123	1947	98	750	72	10.4
Village	Park	325			1936	17	352	33	10.8
Village	4	422			1954	85	995	27	36.8
Hinsdale									
Village	1	209	12	149	1924	17	520	3	176
Village	2	271	20	229	1924	37	1100	24	45.8
Village	2	271	20	229	1942		1460	14	104
Village	3	210			1943		1400	11	124
Lisle									
(St. Procopius 2)		245			1935	62	218	15	14.5
Lombard									
Village	1	84	8	24	1947	10	465	21	22.1
Village	3	175	20	103	1948	10	600	80	7.5
Naperville									
City	4	178	30	134	1943	11	1000	23	43.5
City	5	190	30	158	1947	12	560	41	13.7
City	6	202	27	172	1947	13	285	166	1.7
Roselle									
Village	1	182	10	43	1926	37	110	14	7.9
Village	2	183		43	1953	47	372	60	6.2
Villa Park									
Village	3	285	8	225	1949	55	257	82	3.1
Village	4	251	12	193	1949	60	176	36	4.9
West Chicago									
City	2	322	12	233	1947	82	500	18	27.8
City	3	310			1950	73	510	41	12.4
Westmont									
Village	2	313	16	190	1938	101	600	1.2	500
Village	3	302	17	167	1936	122	320	28	11.4

TABLE 24. (Continued)

Location and owner of well	Well No.	Depth of well *(feet)*	Diameter of casing *(inches)*	Penetration of well below top of aquifer *(feet)*	Date of test	Nonpumping level *(feet)*	Pumping rate *(gpm)*	Draw-down *(feet)*	Specific capacity *(gpm/ft)*
Wheaton									
City	4	350	18	64	1946	44	985	37	26.8
McHenry County									
Cary									
Village		300	10	146	1947	30	113	70	1.6
Crystal Lake									
City		280	10	20	1947	107	415	46	9.0
Nat. Grain Yeast		319			1940	106	140	63	2.2
Pure Oil Co.		423			1948	74	75	85	0.9
Fox River Grove		145	13	43	1947	9	250	23	10.9
Kane County									
Aurora									
Hanson Greenhouse	1	103	8	85	1937	7	25	21	1.2
Marviray Manor	1	300		85	1946	27	50	5	10.0
Batavia									
Campana	1	281	10	60	1945	37	280	90	3.1
Geneva									
Burgess Norton No. 2	2	220		74	1950	50	200	120	1.7
Montgomery									
Village	1	175	10–8	23	1947	54	100	5	20.0
North Aurora									
Village	West Well	190		57	1953		20	2	10.0
Lake County									
Fox Lake									
Chain O'Lakes St. Pk.	1	270			1940	54.5	40	97	0.4
Half-Day									
E. Ryerson, Jr.	1	200			1940	6	25	119	0.2
Lake Zurich									
Village	3	443	6	65	1949	135.5	209	29	7.2
Mt. St. Joseph	1	400			1949	106	121	74	1.6
Libertyville									
Village	5	251	24–16	64	1935		442	129	3.4
Village	7	287	12	114	1947	15	495	82	6.0
Village	5th Ave	250		95	1950	7	96	161	0.6
Village	TW	215		58	1950	33	210	19	11
Village		227		70	1951	39	590	43	13.7
Mundelein									
Village	2	285	12	46	1930	64	125	57	2.2
Village	3	213	10	57	1947	90	125	60	2.1
Round Lake									
Village	1	350	6	120	1945	40	175	10	17.5
Village	2	359	10	89	1945	51	288	107	2.7
Beach	1	342		117	1948	41	100	158	0.6
Park	1	279	6	29	1939	46	150	26	5.8
Park	3	313	10	53	1944	46	100	74	1.4
Wauconda									
Village	1	230		73	1939	39	270	28.5	9.5
Village	2	257		100	1939	67	400	36	11.1
Zion									
City	2	220	10–8	63	1932	12	50	105	0.5
Will County									
Channahan									
Div. of Waterways	1	269			1942	47	7	88.5	0.1
Canal State Park	1	266			1942	60	35	15.2	2.3
Crete									
Village	1	192	10	42	1945	48.5	169	8.5	20.0
Village	2	264	12–10	184	1924	45	300	32	9.4
Elwood									
Arsenal	G3	388		155	1941	21	246	92.5	2.7
Arsenal	G3A	137			1941	21	241	87.7	2.8
Batch Plant	3	187		155	1941	18	100	35.0	2.9
Batch Plant	2A	100			1941	8.5	215	60.0	3.6
Mokena									
Village	2	225	8	190	1920	67	57	1	57
Monee									
Cardox Corporation	2	408	20–18–17¼	277	1945	59	195	43	4.5
New Lenox									
Suburban Water Co.	1	378		155	1948	53	65	103	0.6
Lincoln Way School	1	356		155	1953	30	120	107	1.1
Plainfield									
Village	1	200	26–16–15	158	1929	12	200	61.3	3.3
Village	2	201	26–16–15	153	1929	10	200	61.5	3.3
Steger									
Village	1	318	12	171	1945	43	350	4	87.6

TABLE 25. SPECIFIC-CAPACITY DATA FOR WELLS IN SHALLOW DOLOMITE, SUMMARY BY COUNTY

County	No. of wells for which data are available	Average depth of well (feet)	Average dia. of well (inches)	Average penetration (feet)	Average pumping rate (gpm)	Average specific capacity (gpm/ft)	Range of specific capacity (gpm/ft)	Average specific capacity per foot of penetration (gpm/ft)
Cook	77	295	14	194	393	27.8	550–0.1	0.14
DuPage	30	265	17	148	593	54.5	500–1.7	0.37
Kane	6	212	9	64	113	7.7	20.0–1.2	0.12
Lake	20	288	10	79	207	5.0	17.5–0.2	0.06
McHenry	5	293	11	70	199	7.8	16.1–0.9	0.11
Will	16	262	12	164	169	13.1	87.6–0.1	0.08

A graph (fig. 42) of specific capacity versus penetration of well below the top of the shallow dolomite was prepared using the data in table 24, which is based primarily on the larger municipal and industrial wells. The graph indicates that there is no definite relation between depth of penetration and the specific capacity of a well. The data are widely scattered because the distribution of the water-bearing openings in the shallow dolomite is not uniform from depth to depth and from place to place. Most of the data are aligned vertically in the range of specific capacity from 0-20 gpm per foot indicating that the water-bearing openings in the shallow dolomite are normally more abundant and larger in the upper part of the aquifers and that the specific capacity of a well is not greatly increased with large depths of penetration.

Rough estimates of the coefficient of transmissibility of the shallow dolomite were made by substituting in the non-equilibrium formula (2) an artesian coefficient of storage, and well-construction data and average specific capacities from table 25. Based on average specific-capacity data, the coefficient of transmissibility of the shallow dolomite averages about 100,000 gpd per foot in DuPage County, 52,000 gpd per foot in Cook County, 24,000 gpd per foot in Will County, 14,000 gpd per foot in Kane and McHenry Counties, and 9,000 gpd per foot in Lake County. The estimated average coefficient of transmissibility of the shallow dolomite in DuPage, Cook, and Will Counties is much greater than the average coefficient of transmissibility of the Cambrian-Ordovician Aquifer in these counties.

The shallow dolomite immediately underlies and is readily recharged by precipitation through the glacial deposits.

The water levels in the dolomite vary greatly from time to time and place to place; however, at no location is there any apparent permanent decline. The differing water levels are caused by pumpage and by variations in recharge from precipitation. A typical example is at Chicago Heights where water levels are extremely responsive to fluctuations in precipitation as shown in figure 43. The water levels rise when precipitation is above normal and fall when precipitation is below normal.

Recharge by individual storms has been observed by variable water-level rises in wells. Such variation results from a number of factors, such as permeability of the overlying glacial drift, degree of crevices connecting with the overlying drift, and the extent of saturation produced locally by an individual storm.

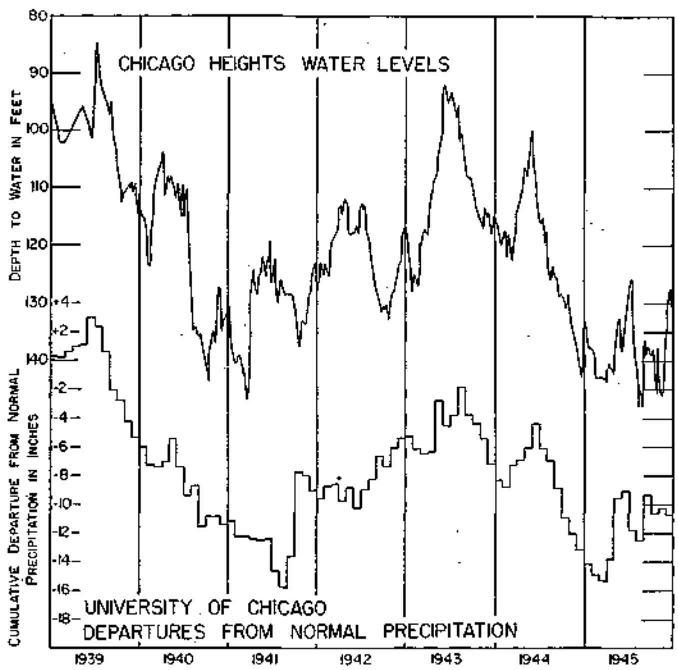


Fig. 43. Water levels compared with departure from normal precipitation at Chicago Heights.

GLACIAL DRIFT AQUIFERS

Numerous rural and residential water supplies, but only a few large supplies, are drawn from the glacial drift. The largest supplies are withdrawn from the fill of the buried Hadley Valley northeast of Joliet. The city of Joliet constructed five gravel wells that produce 650 gpm each. Several other municipal and industrial installations that obtain water from the drift are located in the region, none of which is overpumping the aquifer at the present time.

Specific-capacity data for municipal and industrial wells in the glacial drift aquifers throughout northeastern Illinois are summarized in table 26. This tabulation indicates that the range in specific capacity is from 2.1 to 66 gpm per foot and averages about 12 gpm per foot. The average depth and diameter of wells is 126 feet and 12 inches respectively, and the average aquifer thickness is 107 feet. Of the 40 wells listed only 4 were unscreened. The average length of screen used in the

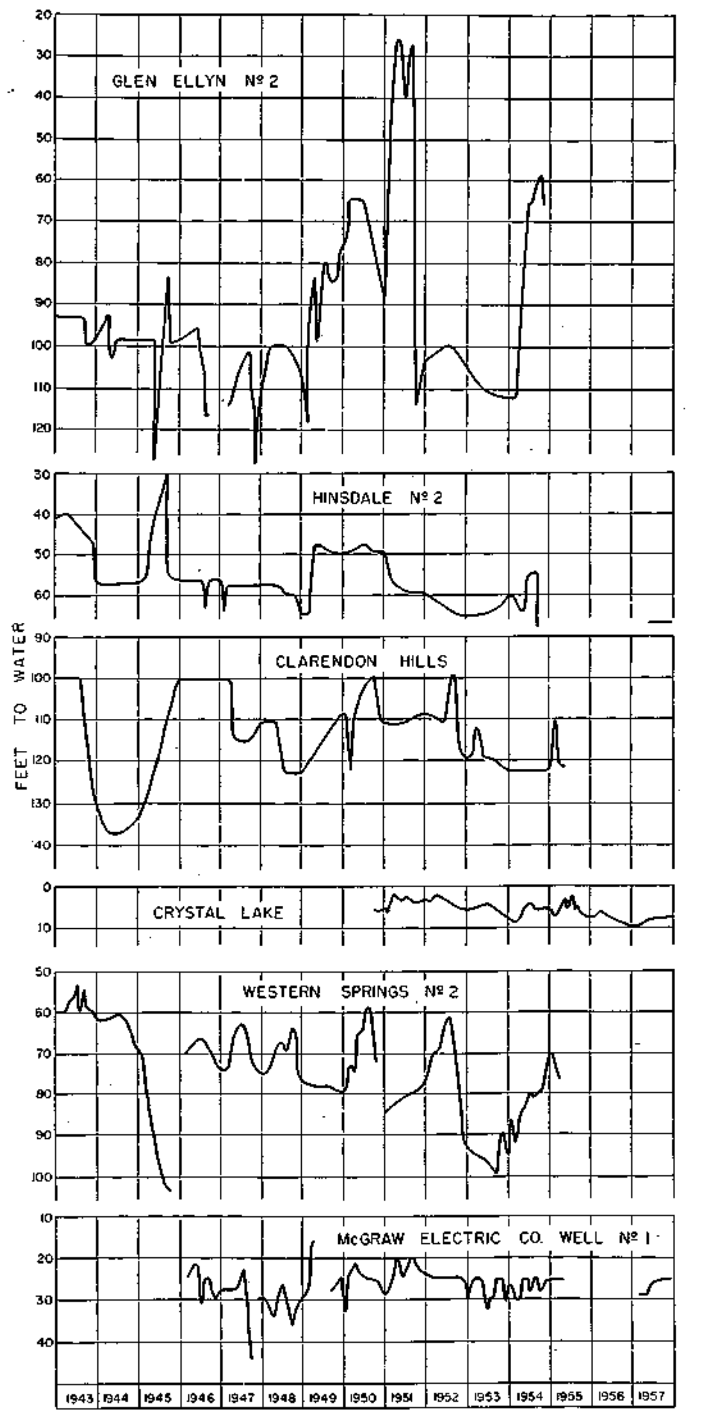
36 screened wells was 25.5 feet. The data in table 26 indicate that the coefficient of transmissibility of the sand and gravel aquifers in northeastern Illinois ranges between 3,400 and 100,000 gpd per foot and averages 25,000 gpd per foot.

POTENTIAL YIELD OF SHALLOW AQUIFERS

The glacial drift and shallow dolomite aquifers yielded more than 75 mgd of ground water in 1957, over half of the pumpage of the region. Of the 75 mgd, 41.2 mgd were from wells finished in shallow dolomite aquifers and 14.2 mgd were from wells finished in glacial drift aquifers (table 13). The remaining 20 mgd were obtained mainly from Silurian age dolomite through deep wells that were uncased or were ineffectively cased below the drift (see section on Quantity of Water Derived from Silurian Age Dolomite and Mt. Simon Aquifer and fig. 37).

The most concentrated pumpage from the shallow aquifers in 1957 (table 14) occurred in southeastern DuPage County and adjoining Cook County around La Grange (fig. 28), where most of the wells are finished in Silurian age dolomite.

Figure 44 shows hydrographs of water levels in the shallow aquifers. Most of the hydrographs are from wells in the area of concentrated pumpage in southeastern DuPage County. Although the water levels vary greatly from time to time and from place to place, the hydrographs indicate no general or permanent decline in water levels.



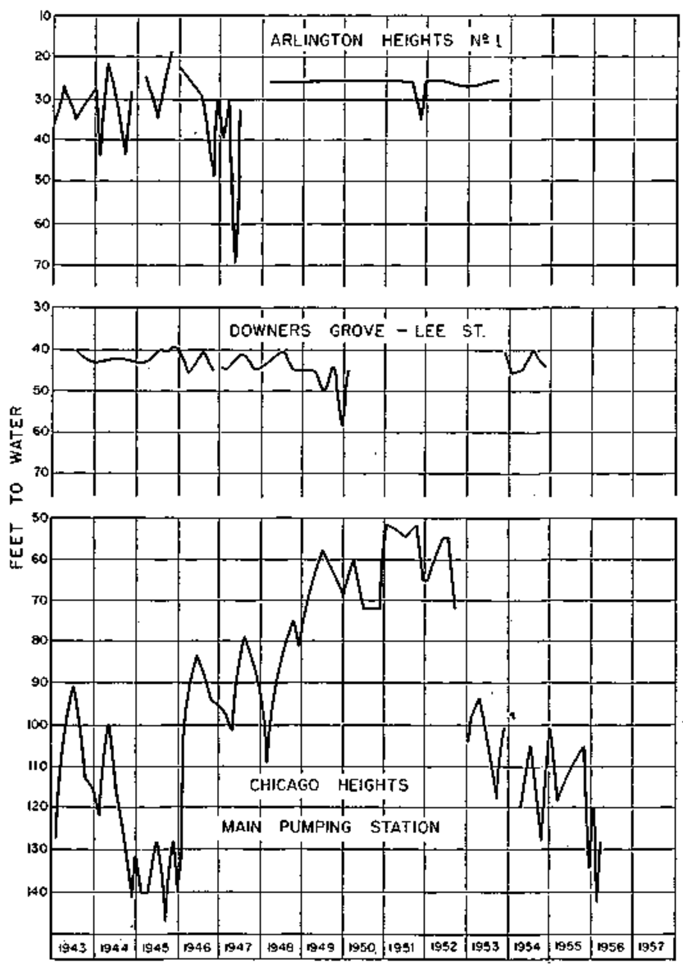


Fig. 44. Hydrographs of water levels in the shallow aquifers.

TABLE 26. SPECIFIC-CAPACITY DATA FOR WELLS IN GLACIAL DRIFT

Location and owner of well	Well No.	Depth of well (*feet*)	Diameter of casing (*inches*)	Screen length-dia. (*ft. - in.*)		Thickness of aquifer (*feet*)	Date of Test	Non-pumping level (*feet*)	Pumping rate (*gpm*)	Drawdown (*feet*)	Specific capacity (*gpm/ft*)
Lake County											
Antioch											
Village	2	226	10	20		70	1946	39	200	22	9.1
Fox Lake											
Village	2	135	16	16	15	215	1941	35.7	284	4.3	66.0
Gurnee											
Hoag Farm	1	145	12	25		110	1949	31.5	289	77	3.8
Island Lake											
Village	19–u	116	10	24	10	150	1940	29	503	11	46.0
Village	K–9	87	8	10	7	150	1943	9	280	16	17.5
Lake Villa											
Village	1	167	12–10	26	10	233	1938	55	154	4.5	34.2
Libertyville											
Village	6	83	8	30	8	167	1943	28	380	14	27
Fould's Milling	2	202	8	14	8	190	1945	7	275	84.5	3.3
Milburn											
Traer Well		190	12	17		90	1948	42	127	13	9.8
Mundelein											
Village	3	213	10	None			1946	90	125	60	2.1
Round Lake											
Village	2	225	10	None		56	1945	51	290	107	2.7
McHenry County											
Crystal Lake											
City	Tw 1–48	45				250	1948	15	307	28.7	10.7
City	3	48	12	10	10	25	1948	17.8	250	17.8	14
Harvard											
City	3	71	14	15			1947	17	600	50.0	12
City	4	69	26	20		120	1946	17	375	29.0	12.9
Huntley											
Village	2	74	6			55	1947	23	100	3.0	33.3
Village	3	69	10			52	1953	22	317	11.0	28.8
Marengo											
City	2	21	240			19+	1947	7.3	150	4.3	34.9
McHenry											
City	6	104	24	20		95+	1947	9	400	22.0	18.2
Richmond											
Village	1	170	10	10	14	140	1947	23	150	42.0	3.6
Woodstock											
City	1	196	13–24	80		155	1921	49.5	648	37.5	17.3
City	2	207	13–24	70		155	1947	57.0	1000	46.0	21.7
City	3	198	18	50		155	1947	56.5	1150	34.5	33.4
Kane County											
Burlington											
Village		111	6	15			1941	33.0	40	5.0	8
Elburn											
Village	2	153	8–10	11		68	1947	85	75	20	3.7
Elgin											
St. Charles		105	16			92	1945	13.0	950	60.0	15.8
N. State		43	25	18		27	1946	28.5	215	5.5	39
Crighton		53	25	12		34+	1946	8.3	200	23.7	8.5
Ill. Tool Works		249					1944	23.5	237	21.5	11
Sugar Grove											
Village	1	104				135	1948	49.6	106	5.8	18.3
Will County											
Joliet											
Hadley Valley	Tw 2	114	6	17	6	32	1945	45.0	180	45	4
Hadley Valley	Tw 5	103	6	10	6	86	1945	16.5	169	72.5	2.3
Hadley Valley	Tw 6	90	6	20	6	57	1946	33.0	270	38	7.1
Hadley Valley	Tw 7	97	6	30	6	60	1946	37.0	330	12	27.5
Hadley Valley	Tw 8	145	6	30	6	94	1945	51.0	335	12.5	27
Hadley Valley	Tw 1	175	10	None		115	1943	19.5	268	24.5	10.9
Hadley Valley		85	18	27	18	93	1950	37.3	420	6.6	63.7
Hadley Valley		94	18	35	18	112	1950	18	967	43.0	22.5
Hadley Valley		115	18	40	18	94	1950	36	1130	58	19.5
Hadley Valley		135	6	35	6	113	1949	22	260	14	18.6

Therefore, the present withdrawal of 75 mgd is within the potential yield of the shallow aquifers. The fact that there has been no decline even in the area of heaviest pumpage indicates that the potential yield of the shallow aquifers probably is considerably larger than the present withdrawal.

The pumpage per square mile of 68,400 gpd in DuPage County is equivalent to a yearly infiltration from precipitation of 1.43 inches or about 4 percent of the average annual total. Actual infiltration of precipitation must be greater than 1.43 inches since water levels have not declined and ground water is discharged as base flow of streams in the area. It has been estimated for the state as a whole that about 10 to 12 percent of the annual precipitation reaches the ground-water reservoir, and it is reasonable to believe that recharge in the Chicago region is within this order of magnitude.

The shallow aquifers are the most likely sources to investigate for additional ground-water supplies. These aquifers are more readily recharged than the deep aquifers and locally have coefficients of transmissibility considerably higher than the Cambrian-Ordovician Aquifer. The present yield of the shallow aquifers is well within their potential yield, whereas, withdrawal of water from the deep aquifers has already approached the calculated sustained yield.

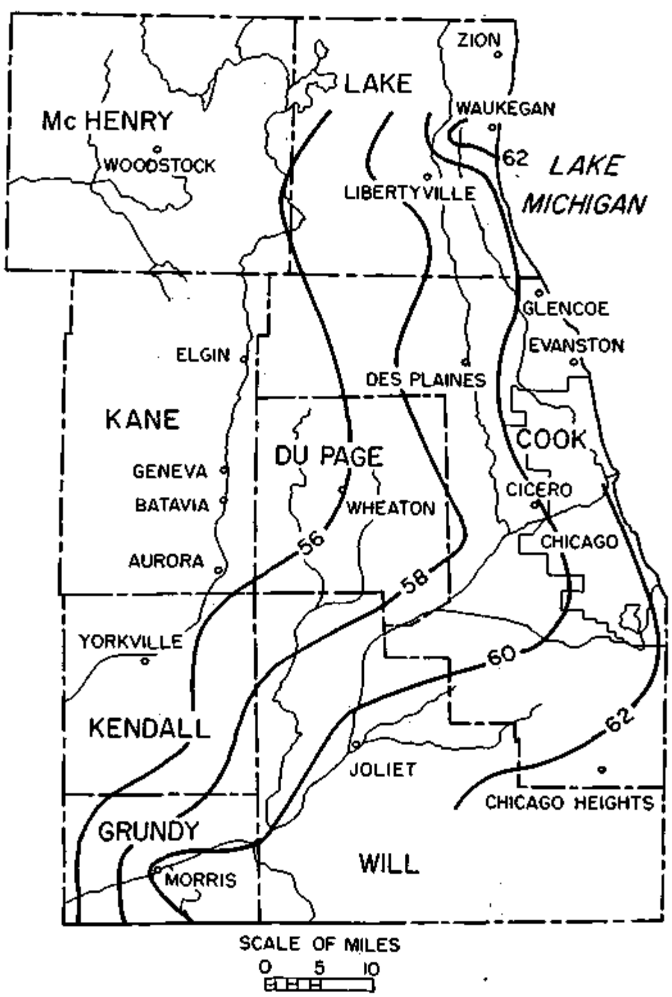


Fig. 45. Temperature of water from Ironton-Galesville Sandstone.

Additional studies of precipitation, infiltration, runoff, aquifer characteristics, and aquifer distribution are needed before the potential yield of the shallow aquifers can be determined quantitatively.

WATER QUALITY

Many of the approximately 1600 mineral analyses which have been made in the Chicago region are given in State Water Survey Bulletins 34, 35, 36, 40 and Supplement 1 to Bulletin 40. Typical analyses are given in Appendix A (Larson, 1957, p. 11-15).

Ground waters in the Chicago region vary in quality between the different producing aquifers and also within individual aquifers at different geographical locations. Below an elevation of 1300 feet below sea level, ground water in the deep aquifers is too highly mineralized for most purposes.

This section discusses temperature and the mineral content of the waters from a) the drift and shallow dolomite aquifers, b) Cambrian-Ordovician Aquifer, and c) the Mt. Simon Aquifer.

The quality of water obtained from any well depends not only on the geological formations penetrated during drilling, but also on the geographical location, the relative productivity of the various formations, the relative artesian head of the various formations, and often on the rate of pumping as well as the idle period and time of pumping prior to collection of the sample. In some areas, open and unplugged wells may permit water from one aquifer to migrate to another aquifer.

TEMPERATURE

The temperature of water from 213 drift and dolomite wells of 100 to 300 feet depth in the region averaged 51.6° F. with 71 percent of the temperatures ranging from 50.5° F. to 52.5° F. Temperatures above 52.5° F. were noted at 34 wells with a maximum of 54° F., and below 50.5° F. at 27 wells with a minimum of 46° F. It may be assumed that these "abnormal" temperatures were due to the entrance of water from depths less than 100 feet during warm or cold seasons respectively.

The temperatures of water from wells entering the Cambrian-Ordovician. Aquifer are influenced by the proportions of water entering the well from the shallow drift and dolomite aquifers. The following observations have been made on wells which were constructed in such a way as to case out and seal with cement grout all waters from above the base of the Maquoketa Formation. Certain inconsistencies, even at many of these wells, may be due to the presence of water from shallow aquifers or the deeper Mt. Simon Aquifer by entrance to the well through the crevices in the Trempealeau or Galena-Platteville Formations from nearby wells.

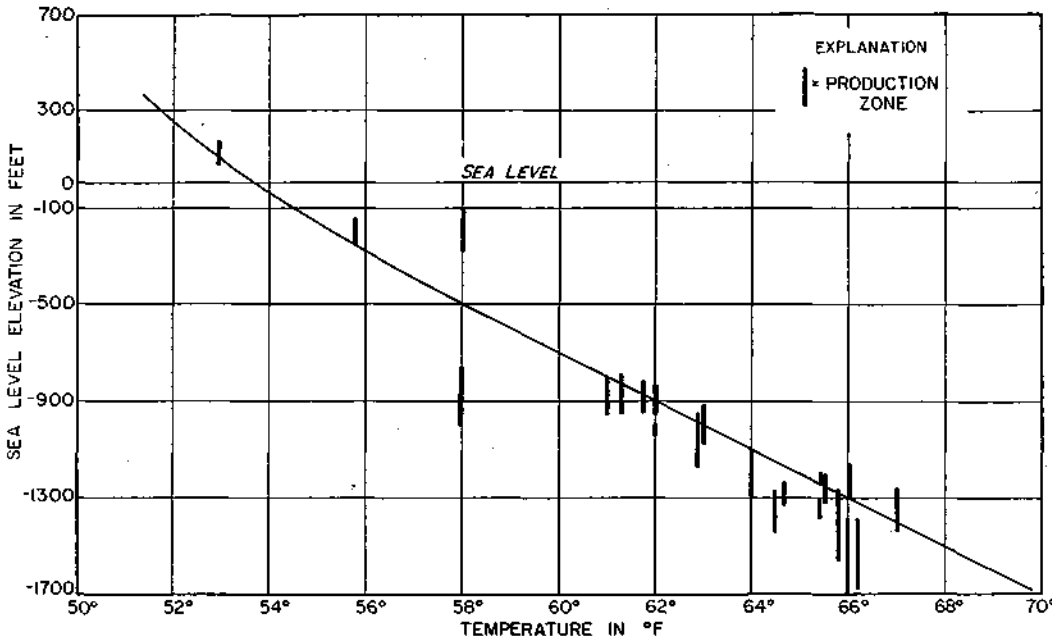


Fig. 46. Elevafion versus water temperature in the deep aquifers.

Waters from the Glenwood-St. Peter Sandstone range in temperature from 53° F. in Kendall County (elevation 175 feet to 0) to 56° F. in the vicinity of Mt. Prospect (50 feet above to 100 feet below sea level) and 58° F. near the lake shore in Lake County.

Waters from the Ironton-Galesville Sandstone (fig. 45) range in temperature from about 55° F. in the Fox Valley to 59-61° F. near Joliet and the southern and western boundary of Chicago. At Chicago Heights and near the Indiana state line the temperatures are about 62° F. The temperatures of these waters depend not only on the elevation of the Ironton-Galesville Sandstone (fig. 21A) but also on the proportion of water contributed by the Glenwood-St. Peter Sandstone. The sandstones in this region dip to the east and south (figs. 21A and 22A) and figure 45 indicates the temperatures of the waters from the Ironton-Galesville Sandstone with little or no contribution from the Glenwood-St. Peter Sandstone. In the western third of the area the data are not sufficient for greater definition, but such water is of less than 56° F. temperature and in isolated areas may be as low as perhaps 53° F.

The temperatures of water from the Ironton-Galesville Sandstone in the western third of the region are lower than that indicated by the "normal" gradient of temperature with depth or elevation (fig. 46). It therefore appears probable that the Cambrian-Ordovician Aquifer may have become cooled by inflow of water from the recharge areas to the west.

Water from the Mt. Simon Aquifer appears to increase in temperature by about one degree per 100 feet of additional depth from 66° F. at elevation 1300 feet below sea level as shown in figure 46. Again the temperature at the well discharge depends largely on the amount of blending with water from shallower aquifers.

MINERAL QUALITY

Shallow Drift and Dolomite Aquifers

Waters from glacial deposits and the shallow dolomites are generally considered as associated. This is due to the creviced structure and eroded top of the dolomite which permits movement of water to as well as from the overlying drift. No attempt has been made to distinguish between their qualities.

In and near McHenry and northern Kane County many waters are characterized by the absence of sulfate. The occurrence of methane gas is not infrequent. These are essentially bicarbonate waters having an alkalinity greater than the hardness and almost equal to the total mineral content. About 80 percent of approximately 60 samples contained more than 0.3 ppm iron. The hardness ranges from 100 to 450 ppm with a median of 275 ppm, with half the samples ranging from 225 to 325 ppm.

Waters of less than 100 ppm hardness are found only along the eastern edge of the region and near the Indiana border toward the southern end of Cook County. A number of areas of exceptionally hard water, more than 1000 ppm, are indicated. These waters occur in a band extending from southwestern Lake County through Western Springs and Palos Park to Chicago Heights, coinciding roughly with the upland produced by the Valparaiso moraine (fig. 5). Geographic distribution is shown in figure 47.

Cambrian-Ordovician Aquifer

Waters from the Glenwood-St. Peter and Ironton-Galesville Sandstones are in general of similar mineral quality. As the major availability and use of water is from the Ironton-Galesville Sandstone, this discussion is concerned primarily with this part of the Cambrian-Ordovician Aquifer.

The mineral quality of the water from the Ironton-Galesville Sandstone is relatively uniform over an extensive area in the western two thirds of the region and generally exemplified by that at Montgomery near Aurora (Appendix A) (fig. 48). The mineralization increases eastward at an increasingly rapid rate as the formation becomes deeper (fig. 21A). From the eastern edge of DuPage County and southward from Joliet, the hardness increases from 290 to 800 ppm (fig. 48), the sulfate content increases from 100 to 800 ppm (fig. 35), and the chloride content increases from 25 to 400 ppm (fig. 49), at the northern end of the Indiana state line,

The quality of water at individual wells may be influenced by the proportion of water from the Glenwood-St. Peter Sandstone present in the sample. The thickness of the Glenwood-St. Peter Sandstone may range from 100 to 650 feet (fig. 22B) ; it locally yields abundant water and thereby influences the proportions of minerals in the water. In general, water from the Glenwood-St. Peter Sandstone tends to have a chloride content and hardness higher than water from the Ironton-Galesville.

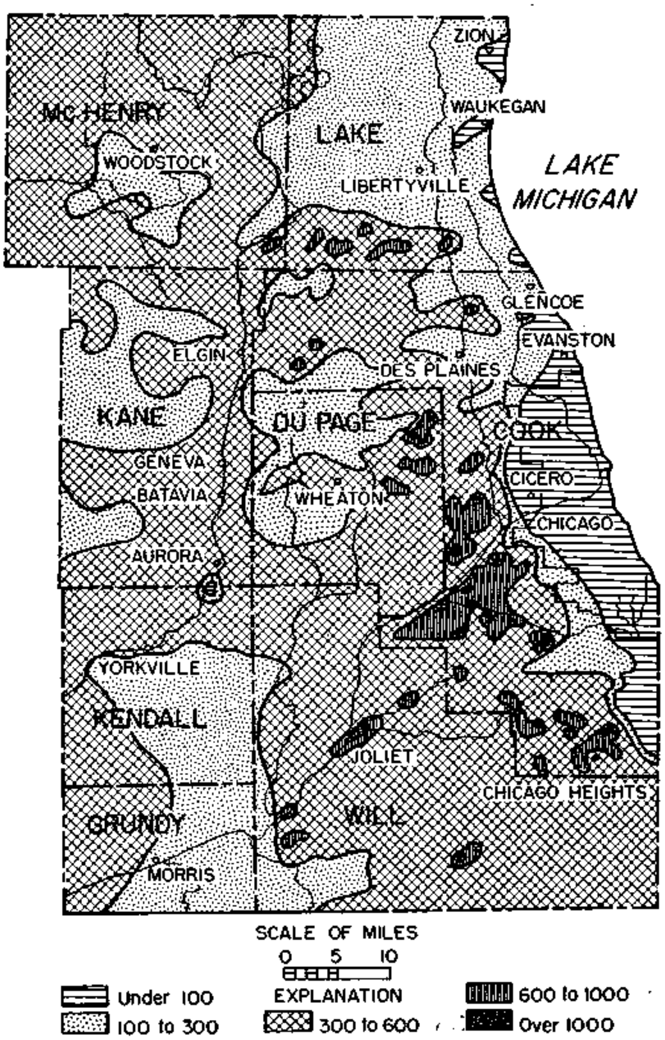


Fig. 47. Hardness of water from shallow drift and dolomite aquifers.

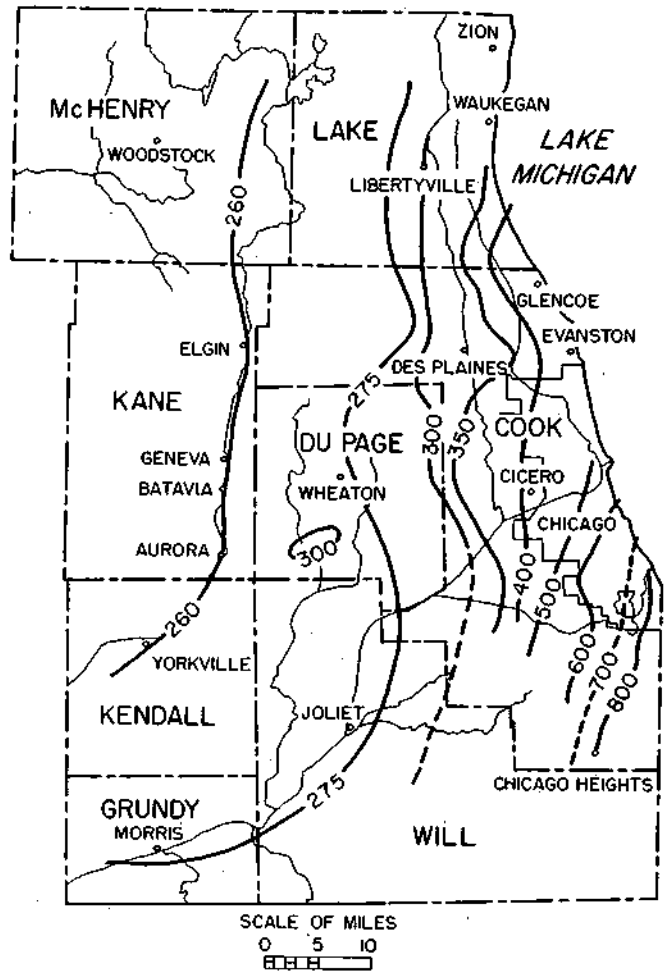


Fig. 48. Hardness of water from Cambrian-Ordovician Aquifer

The quality may also be influenced by small quantities of water from the Galena-Platteville Dolomite which is characterized by high alkalinity (above 350 ppm), low hardness (less than 100 ppm), absence of sulfates, and usually sufficient hydrogen sulfide to be detected by its odor (Appendix A).

If the deeper wells are not cased through the shallow drift and dolomite aquifers with a pressure-grouted annular envelope of cement around the casing, the water from shallow aquifers, by virtue of its higher hydrostatic pressure, will enter the well bore during idle periods as well as pumping periods. Although this contribution may be relatively small, the iron content and hardness may be seriously high in the pumped water, particularly at the beginning of, the pumping period. Such iron-bearing water entering the well bore during idle periods will also tend to penetrate permeable formations, depositing the iron at or near the face of the bore hole, thereby causing loss in well capacity. This effect is serious because the penetration is selective, being greater in the more permeable and productive zones.

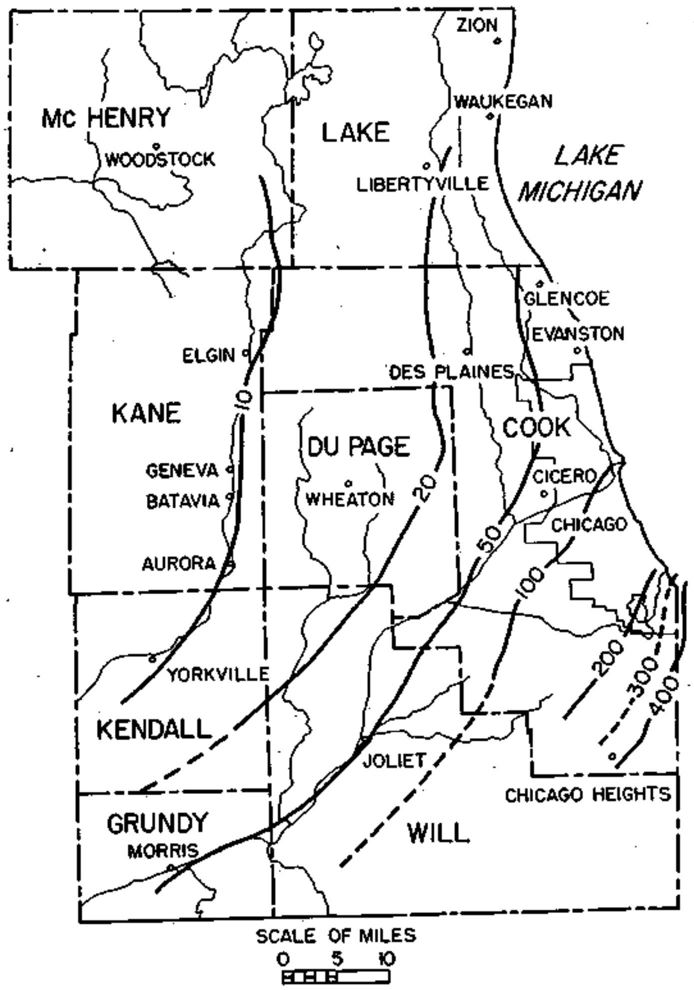


Fig. 49. Chloride content of water from Cambrian-Ordovician Aquifer.

When not blended with waters from other formations, waters from the Glenwood-St. Peter and Ironton-Galesville Sandstones usually have low iron content (0.2-0.4 ppm) and an almost uniform concentration of 1.0 ppm fluoride.

Mt. Simon Aquifer

The primary characteristic of the quality of water from the Mt. Simon Aquifer is its rapid increase in chloride concentration with depth of penetration or lower elevation, as shown in figure 50. With increasing penetration below an elevation of 1275 feet below sea level, greater quantities of water with high chloride content and high hardness are permitted to enter a well. The rate of increase in chloride concentration with increasing depth in the aquifer approaches 400 ppm per additional 25 feet of penetration. This rate is based largely on data from a sample collected from an oil test well in Kankakee County at an elevation of 2200 feet below sea level (Appendix A).

Abandoned wells penetrating Mt. Simon Aquifer in the region may contribute high chloride water to the

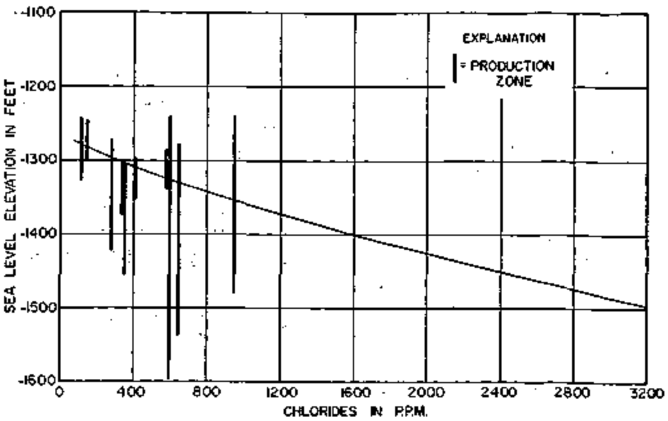


Fig. 50. Elevation versus chlorides in the Mt. Simon Aquifer.

overlying Cambrian-Ordovician Aquifer because the major pumpage and water-level decline is in the latter. Therefore the upper aquifer in the immediate area of such abandoned wells may yield an increasing proportion of Mt. Simon water with continued water-level decline.

RECOMMENDATIONS FOR FURTHER STUDY

The presently available data are insufficient to form a basis for a complete or accurate water resources budget of the Chicago region. More detailed geologic, hydrologic, meteorologic, and engineering data, bearing on both ground water and surface water, are needed. With respect to ground water the following investigations are recommended:

1) Study of the shallow aquifers to delineate favorable and unfavorable areas for additional ground-water development, and to determine recharge, hydraulic properties, and potential yield.
2) Regional study of the stratigraphy of the deeper formations to determine variations in permeability, nature of barrier boundaries, role of the dolomites of the Prairie du Chien and Trempealeau Formations as contributors of water, and the detailed character of the Eau Claire Formation.
3) Study of the effects that dewatering parts of the Cambrian-Ordovician Aquifer has on water-level declines.
4) Study of possible recharge of the aquifers from Lake Michigan.
5) Study of the relations between the Chicago and Milwaukee pumpage cones.
6) Application of more extensive geophysical logging and well testing to obtain additional geologic and hydrologic data on individual units of the aquifers.
7) Collection of more complete data on pumpage, particularly from the shallow aquifers.

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APPENDIX A

SELECTED MINERAL ANALYSES OP WATER

Abbreviations used:

ppm = parts per million

epm = equivalents per million

ppm X .0583 = grains per gallon

GLACIAL DRIFT AQUIFER

Sample of water collected from 6-inch well owned by the Morton Salt Co. between Woodstock and Crystal Lake, Illinois, in McHenry County. Location of well: 6 feet from 1200 feet E and 300 feet S of NW corner of Section 16, T44N, R7E. Depth of well: 231 feet.

LABORATORY NO. 134325

		ppm	epm
Turbidity		14.	
Color		0.	
Odor		0.	
Iron (total)	Fe	2.3	
Manganese	Mn	0.0	
Calcium	Ca	81.	4.05
Magnesium	Mg	47.	3.87
Ammonium	NH_4	0.6	0.03
Sodium	Na	7.	0.31
Silica	SiO_2	22.7	
Fluoride	F	0.2	
Boron	B	Tr.	
Chloride	Cl	8.	.23
Nitrate	NO_3	0.2	Tr.
Sulfate	SO_4	5.3	.11
Alkalinity	(as $CaCO_3$)	396.	7.92
Hardness	(as $CaCO_3$)	396.	7.92
Total Dissolved Minerals		392.	

SHALLOW DOLOMITE AQUIFER

Sample of water collected October 18, 1945, from Well No. 5 owned by the Village of Palatine, Illinois. Location of well: 2000 feet S and 2000 feet W of NE corner of Section 22, T42N, R10E. Depth of well: 209 feet. Rate of pumping: 235 gpm for 6 hours.

LABORATORY NO. 104554

		ppm	epm
Turbidity		30.	
Color		0.	
Odor		0.	
Iron (total)	Fe	1.4	
Manganese	Mn	0.2	
Calcium	Ca	75.8	3.79
Magnesium	Mg	58.5	4.80
Ammonium	NH_4	Tr.	Tr.
Sodium	Na	62.	3.70
Silica	SiO_2	18.0	
Chloride	Cl	4.	.11
Nitrate	NO_3	4.2	.07
Sulfate	SO_4	422.5	8.79
Alkalinity	(as $CaCO_3$)	116.	2.32
Hardness	(as $CaCO_3$)	430.	8.59
Total Dissolved Minerals		756.	
Temp. (reported)		51° F.	
pH (reported)		7.6	

SHALLOW DOLOMITE AQUIFER

Sample of water collected March 18, 1958, from a well owned by the Midwest-Justice Water Co. near Justice, Illinois, in Cook County. Location of well: 500 feet E and 1430 feet S of NW corner of Section 35, T38N, R12E. Depth of well: 145 feet. Sample collected 5 minutes after pumping began while pumping at a rate of 137 gpm.

LABORATORY NO. 146026

		ppm	epm
Turbidity		16.	
Color		0.	
Odor		0.	
Iron (total)	Fe	2.6	
Manganese	Mn	0.1	
Calcium	Ca	283.0	14.15
Magnesium	Mg	201.6	16.58
Ammonium	NH_4	0.7	.04
Sodium	Na	41.	1.78
Silica	SiO_2	25.3	
Fluoride	F	0.2	
Boron	B	0.3	
Chloride	Cl	10.	.28
Nitrate	NO_3	0.4	.01
Sulfate	SO_4	1079.1	22.50
Alkalinity	(as $CaCO_3$)	488.	9.76
Hardness	(as $CaCO_3$)	1536.	30.73
Total Dissolved Minerals		2025.	
Temp. (reported)		52° F.	

GALENA-PLATTEVILLE DOLOMITE

Sample of water collected October 5, 1936, from a well owned by the Illinois Watch Case Co., Elgin, Illinois. Location of well: Section 12, T41N, R8E. Depth of well: 981 feet.

LABORATORY NO. 78810

		ppm	epm
Turbidity		10.	
Color		0.	
Odor (at well)		H_2S	
Iron (total)	Fe	1.2	
Manganese	Mn	0.0	
Calcium	Ca	17.5	.88
Magnesium	Mg	8.4	.69
Ammonium	NH_4	0.7	.04
Sodium	Na	112.	4.87
Silica	SiO_2	12.	
Chloride	Cl	4.	.11
Nitrate	NO_3	5.3	.09
Sulfate	SO_4	0.0	.00
Alkalinity	(as $CaCO_3$)	314.	6.28
Hardness	(as $CaCO_3$)	79.	1.57
Total Dissolved Minerals		349.	

CAMBRIAN-ORDOVICIAN AQUIFER

Sample of water collected January 13, 1957, from the No. 3 Well owned by the Caterpillar Tractor Company near Montgomery, Illinois, in Kendall County. Location of well: 2500 feet N and 2170 feet E of SW corner of Section 6, T37N, E8E. Depth of well: 1352 feet. Sample collected 24 hours after pumping began while pumping at a rate of approximately 1277 gpm.

LABORATORY NO. 142509

		ppm	epm
Turbidity		0.	
Color		0.	
Odor		0.	
Iron (total)	Fe	0.3	
Manganese	Mn	0.0	
Calcium	Ca	63.7	3.19
Magnesium	Mg	23.0	1.89
Ammonium	NH_4	0.8	0.04
Sodium	Na	32.	1.41
Silica	SiO_2	7.4	
Fluoride	F	0.7	
Boron	B	0.4	
Chloride	Cl	10.	0.28
Nitrate	NO_3	0.3	Tr.
Sulfate	SO_4	39.1	0.81
Alkalinity	(as $CaCO_3$)	272.	5.44
Hardness	(as $CaCO_3$)	254.	5.08
Total Dissolved Minerals		336.	

CAMBRIAN-ORDOVICIAN AQUIFER

Sample of water collected August 21, 1942, from well owned by Carnegie Illinois Steel Corp., South Chicago, Illinois. Location of well: 2500 feet N and 2600 feet E of SW corner of Section 32, T38N, E15E. Depth of well: 1660 feet.

LABORATORY NO. 93750

		ppm	epm
Turbidity		10.	
Color		0.	
Odor		0.	
Iron (total)	Fe	0.9	
Manganese	Mn	0.0	
Calcium	Ca	198.8	9.94
Magnesium	Mg	74.3	6.11
Ammonium	NH_4	0.5	0.03
Sodium	Na	230.	9.99
Silica	SiO_2	11.0	
Chloride	Cl	207.	5.84
Nitrate	NO_3	1.1	0.02
Sulfate	SO_4	757.8	15.77
Alkalinity	(as $CaCO_3$)	222.	4.44
Hardness	(as $CaCO_3$)	802.	16.05
Total Dissolved Minerals		1626.	

MT. SIMON AQUIFER

Sample of water collected October 8, 1930, by C. McRoberts from a well being drilled one-fourth mile west of Momence, Illinois, Section 24, T31N, R13E. Depth of well: 2800 feet.

LABORATORY NO. 67647

		ppm	epm
Iron (total)	Fe	0.2	
Manganese	Mn	0.4	
Calcium	Ca	1140.	57.00
Magnesium	Mg	296.4	24.36
Ammonium	NH_4	9.0	.50
Sodium	Na	13153.	572.90
Silica	SiO_2	11.0	
Chloride	Cl	22480.	633.94
Nitrate	NO_3	1.8	.03
Sulfate	SO_4	833.5	17.34
Alkalinity	(as $CaCO_3$)	120.	2.40
Hardness	(as $CaCO_3$)	4068.	81.36
Total Dissolved Minerals		38002.	

APPENDIX B

SELECTED WELL RECORDS

Wells listed below are shown in figure 2 and can be identified by the location method of numbering described in the right-hand column. Abbreviations:

COK = Cook
DUP = DuPage
GRY = Grundy
KNE = Kane
KEN = Kendall
LKE = Lake
MCH = McHenry
WIL = Will

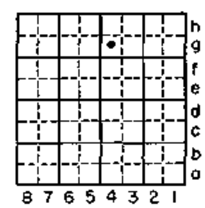
P = Publie Supply
I = Industrial Supply
R = Rural (non-irrigation) Supply
IR = Irrigation Supply
SL = Sea Level
Dr = Drift
Sil = Silurian
Maq = Maquoketa
C-0 = Cambrian-Ordovician
G-P = Galena-Platteville
G-SP = Glenwood-St. Peter
PdC = Prairie du Chien
Tr = Trempealeau
Fr = Franconia
I-G = Ironton-Galesville
EC = Eau Claire
MS = Mt. Simon
S & G = sand and gravel
Dol = dolomite
Ss = sandstone
SS = State Geological Survey sample set
DL = driller's log

WELL NUMBERING SYSTEM

The well numbering system used in the appendix is based on the location of the well, and uses the township, range, and section for identification.

The well number consists of five parts: county abbreviation, township, range, section, and coordinate within the section. Sections are divided into rows of one-eighth mile squares. Each one-eighth mile square contains 10 acres and corresponds to a quarter of a quarter of a quarter section. A normal section of one square mile contains eight rows of eighth-mile squares; an odd-size section contains more or fewer rows. Rows are numbered from east to west and lettered from south to north as shown below.

Cook County
T. 41 N., R. 11 E.,
sec. 25



The number of the well shown in sec. 25 above is as follows:
COK 41NllE-25.4g

Where there is more than one well in a 10-acre square they are identified by arabic numbers after the lower case letter in the well number.

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
COOK COUNTY								
COK 35N13E-1.2c	Flossmoor #1	P	1925	675	467	Sil	Sil Dol	SS 6296; DL
COK 35N13E-26.8b	Matteson #2	P	1956	706	305	Sil	Sil Dol	SS 26488; DL
COK 35N14E-6.7g	Homewood #3	P	1945	660	435	Maq	Sil Dol	SS 12318; DL
COK 35N14E-19.4a	Chicago Hts. #25	P	1958	691	450	Sil	Sil Dol	SS 30746; DL
COK 35N14E-21.3h	Calumet Steel #4	I	1951	640	1805	EC	C-O	SS 21216; DL
COK 35N14E-21.7e	Chicago Heights #20	P	1942	657	1794	EC	C-O	SS 6283; DL
COK 35N14E-21.2h	Chicago Heights #2	P	1918	638	1797	EC	C-O	DL
COK 35N14E-28.8h	Chicago Heights	P	1926	690	1832	EC	C-O	SS 534; DL
COK 35N14E-29.1c2	South Chicago Heights #2	P	1956	706	250	Sil	Sil Dol	DL
COK 35N14E-30.7f	Park Forest #2	P	1948	720	300	Sil	Sil Dol	SS 16187; DL
COK 35N15E-29.5h	E J & E RR	I	1929	630	1785	I-G	C-O	SS 1207; DL
COK 36N12E-4.1a	Orland Park #2	P	1956	710	397	Sil	Sil Dol	SS 26541; DL
COK 36N12E-9.2h	Capital Dairy	I	1943	705	355	Sil	Sil Dol	SS 10209; DL
COK 36N13E-1.2c	Miller Potato Co.	I	1958	600	1651	EC	C-O	SS 30712; DL
COK 36N13E-16.4h	Oak Forest #2	P	1952	655	295	Sil	Sil Dol	SS 22677
COK 36N13E-31.1g3	Tinley Park Hosp. #3	P	1951	697	515	Maq	Sil Dol	SS 20978
COK 36N14E-2.8e	Hokin Aluminum Co.	I	1955	590	1730	EC	C-O	SS 25165; DL
COK 36N14E-3.1g	Dolton Realty #1	P	1954	589	1704	EC	C-O	DL
COK 36N14E-3.6a	Dolton City	P	....	602	1312	Tr	G-SP/Tr	SS 27618; DL
COK 36N14E-5.2b	City Ice & Fuel Co.	I	1944-45	600	1657	EC	C-O	SS 12698; DL
COK 36N14E-17.4e	Publix Gr. St. Theatres	P	1941	603	470	Maq	Sil Dol	SS 5977; DL
COK 36N14E-27.5a	Thornton #3	P	1943	622	250	Sil	Sil Dol	DL
COK 36N14E-31.5d	Homewood #2	P	1933	652	1350	Tr	G-SP/Tr	SS 1303; DL
COK 36N14E-32.3h	Washington Park	P & IR	....	623	1686	EC	C-O	DL
COK 36N14E-34.5g	Frederick's Brewing	I	1944	617	1756	EC	C-O	SS 11473
COK 36N14E-34.5d1	Thornton #1	P	1923	617	477	Maq	Sil Dol	DL
COK 36N14E-34.5d2	Thornton #2	P	1954	621	1780	EC	C-O	SS 24558
COK 36N15E-6.2g	Red River #1	I	1941	585	1625	I-G	C-O	SS 6739; DL
COK 36N15E-31.2d	Lansing #1	P	1921	623	1632	I-G	C-O	DL
COK 37N11E-29.5f	Lemont City Well	P	1925	735	1235	G-SP	G-SP	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
			COOK COUNTY—(Continued)					
COK 37N13E-4.5a	Oak Lawn #1	P	1931	611	1946	MS	C-O/MS	DL
COK 37N13E-5.1a	Oak Lawn #2	P	1937	614	1600	EC	C-O	SS 2171; DL
COK 37N13E-19.1b	Jurge Humphries	..	1925	596	1385	Tr	G-SP/Tr	SS 513; DL
COK 37N13E-26.1g	Oak Hill Cemetery #2	I	1958	617	1636	EC	C-O	DL
COK 37N13E-36.2e	Blue Island #3	P	1909-10	640	1650	EC	C-O	DL
COK 37N14E-13.1d	By-Products Coke #1	I	1916	588	1733	EC	C-O	DL
COK 37N14E-17.6g	Washington Hts.	P	1889	618	1308	Tr	G-SP/Tr	DL
COK 37N14E-22.1d	Sherwin-Williams	I	1907	587	1634	EC	C-O	DL
COK 37N15E-5.6h	Illinois Steel #2	I	1930	594	1680	EC	C-O	DL
COK 37N15E-6.4e	John Mohr & Sons	I	1926-27	587	1601	I-G	C-O	SS 868
COK 37N15E-8.3e	A. Schwill Co. #2	I	1944	602	1735	EC	C-O	SS 11008; DL
COK 37N15E-18.8h	....	..	1913	592	1706	EC	C-O	DL
COK 38N12E-1.8g	Lyons City Well	P	....	618	2020	MS	C-O/MS	DL
COK 38N12E-4.8d	Public Service Co. #3	P	....	647	1982	EC	C-O	DL
COK 38N12E-4.2d	Public Service Co.#4	P	1928	629	2008	MS	C-O/MS	SS 814; DL
COK 38N12E-5.1h	Nazareth Acad. H.S.	P	1926-27	642	1902	EC	C-O	DL
COK 38N12E-5.3e	La Grange #6	P	1950	680	203	Sil	Sil Dol	SS 20292
COK 38N12E-5.8c	Western Springs #1	P	1924	671	385	Maq	Sil Dol	DL
COK 38N12E-5.8b	Western Springs #2	P	1923	671	385	Maq	Sil Dol	DL
COK 38N12E-6.5a	Western Springs	P	....	646	2046	MS	C-O/MS	DL
COK 38N12E-10.5d	Electro-Motive #1	I	1935	620	1590	EC	C-O	SS 1682
COK 38N12E-10.8d	Electro-Motive #2	I	1937	647	1989	MS	C-O/MS	SS 2402; DL
COK 38N12E-11.3e	Lewis Tar #2	I	1943	607	1172	Tr	G-SP/Tr	SS 10746; DL
COK 38N12E-11.7c	Universal Oil Co.	I	1939	607	1564	I-G	C-O	DL
COK 38N12E-18.8g	Cook Co. TB San #3	P & IR	1958	689	1540	EC	C-O	SS 31261; DL
COK 38N12E-23.1h	Corn Products #11	I	1942	595	1543	EC	C-O	SS 7501; DL
COK 38N12E-24.8g	Corn Products #12	I	1942	597	1507	EC	C-O	SS 8547; DL
COK 38N12E-24.7f	Corn Products #14	I	1944	612	1481	I-G	C-O	SS 11481; DL
COK 38N12E-28.7d	Buick Jet #2	I	1952	600	1535	EC	C-O	SS 22426
COK 38N12E-29.1d	Buick Motor #1	I	1952	605	1515	EC	C-O	SS 22425; DL
COK 38N13E-12.8e	International Rolling Mills #1	I	1947	598	1620	I-G	C-O	SS 16353; DL
COK 38N13E-19.4g	Visking Corp.	I	1938	617	1515	I-G	C-O	SS 3354; DL
COK 38N13E-21.7f	Continental Can	I	1936	615	1500	I-G	C-O	SS 1754; DL
COK 38N13E-21.1f	Cracker Jack Co.	I	1940	622	1500	I-G	C-O	SS 5131; DL
COK 38N13E-27.5e	Ford #2	I	1956	617	1560	I-G	C-O	SS 27785
COK 38N14E-4.7h	Mullen's Brewery	I	1913	594	1632	I-G	C-O	DL
COK 38N14E-5.3b	Prod. 45th St. Stock Yds.	R	1951	594	1605	EC	C-O	SS 21641
COK 38N14E-6.1f	Wilson Packing Co.	I	1929	593	1700	EC	C-O	SS 823
COK 38N14E-7.7h	Fleischman's Yeast	I	1919	594	1962	EC	C-O	DL
COK 38N14E-7.7c	Fleischman Malting Co.	I	1936	595	1966	EC	C-O	SS 1988; DL
COK 38N14E-8.1g	Nutriment Co.	I	1899	593	1308	Tr	G-SP/Tr	DL
COK 39N12E-4.3h	Indiana H. B. RR. #4	I	1925	634	2007	MS	C-O/MS	DL
COK 39N12E-4.2b	Richardson Co.	I	1940	632	1960	MS	C-O/MS	SS 5130; DL
COK 39N12E-5.5d	C. & N.W. RR. Co. #3	I	1912	644	1830	EC	C-O	SS 62; DL
COK 39N12E-6.5e	C. & N.W. Freight Hse.	I	1926-28	657	1555	EC	C-O	DL
COK 39N12E-9.6f	Bellwood Village #2	P	1929	634	1960	EC	C-O	DL
COK 39N12E-9.2h	Solar-Sturges Mfg.	I	1927	632	1550	EC	C-O	SS 1117; DL
COK 39N12E-9.5a	Bellwood Village	P	1949	631	1951	EC	C-O	DL
COK 39N12E-11.7e	Maywood City #4	P	1918	626	2048	MS	C-O/MS	DL
COK 39N12E-12.1f	Wieboldt's Store	P	1937	631	1620	I-G	C-O	DL
COK 39N12E-12.3e	Bowman Dairy Co.	I	1930	632	2060	MS	C-O/MS	SS 1041; DL
COK 39N12E-13.1e	Borden Dairy Co.	I	1923	620	1615	I-G	C-O	DL
COK 39N12E-14.–	Modern Milk Stores	I	1947	628	372	Sil	Sil Dol	DL
COK 39N12E-15.2g	Maywood City #5	P	1922	628	2076	MS	C-O/MS	DL
COK 39N12E-17.2a	Alum. Co. of America #1	I	1947	630	1495	EC	C-O	SS 16355; DL
COK 39N12E-18.1e	Hillside City #1	P	1940	670	1970	MS	C-O/MS	SS 4997; DL
COK 39N12E-18.4b	Mt. Carmel Cemetery	IR	1926	677	1960	MS	C-O/MS	SS 321; DL
COK 39N12E-23.4e	Ed. Hines, Jr. Mem. Hospital	P	1922	623	2010	MS	C-O/MS	SS 232
COK 39N12E-25.5d	Riverside #4	P	1931	621	1980	MS	C-O/MS	DL
COK 39N12E-35.6f	Chicago Zoo. Gardens	P & IR	1927	620	2081	EC	C-O	DL
COK 39N12E-35.3h	Chicago Zoo. Gardens	P & IR	1937	615	2061	MS	C-O/MS	SS 2208; DL
COK 39N12E-36.8d	Riverside #3	P	1924	617	2047	MS	C-O/MS	DL
COK 39N13E-6.1e	Taylor Park	IR	1937	636	990	G-SP	G-SP Ss	SS 3049; DL
COK 39N13E-7.9f	The Fair	P	1937	631	1615	I-G	C-O	SS 2271
COK 39N13E-11.–	Bunte Candy #2	I	1937	603	1940	EC	C-O	SS 2026
COK 39N13E-17.7d	Public Utilities	P	1913	618	1896	EC	C-O	DL
COK 39N13E-21.7h	Kropp Forge	I	1955	610	1635	EC	C-O	SS 26182
COK 39N13E-21.5g	Nat'l. Malleable Casting	I	....	608	1975	MS	C-O/MS	DL
COK 39N13E-24.3h	American Malting	I	1897	593	1303	Tr	G-SP/Tr	DL
COK 39N13E-27.7g	Western Electric #3	I	1941	600	1574	I-G	C-O	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
			COOK COUNTY—(Continued)					
COK 39N13E-35.1h	Liquid Carbonic Co.	I	1935	597	1558	EC	C-O	SS 1735; DL
COK 39N14E-4.5e	Oscar Mayer	I	1909	592	1626	I-G	C-O	DL
COK 39N14E-4.8h	Crystal Ice	I	1897	592	1614	I-G	C-O	DL
COK 39N14E-5.5h	Chicago Brewery	I	....	591	1875	EC	C-O	DL
COK 39N14E-7.8h	Fleischman's Yeast	I	1919	600	1962	EC	C-O	DL
COK 39N14E-7.2d	Consolidated Bottling	I	1912	600	1625	I-G	C-O	DL
COK 39N14E-16.1f	Chicago Post Office	P	1902	587	1350	Tr	G-SP/Tr	DL
COK 39N14E-16.7g	Fortune Bros. Brewery	I	1912	593	1679	EC	C-O	DL
COK 39N14E-19.5c	Nat'l. Brewing Co.	I	1901	593	1948	EC	C-O	DL
COK 39N14E-19.4d	Nat'l. Beverage Co.	I	1924	593	1948	EC	C-O	DL
COK 39N14E-20.1h	U. S. Brewing Co.	I	1910	592	1609	I-G	C-O	DL
COK 39N14E-21.7b1	Western Shade Cloth #1	I	1940	590	1620	EC	C-O	DL
COK 39N14E-21.7b2	Western Shade Cloth #2	I	1945	590	1603	EC	C-O	SS 14399; DL
COK 39N14E-22.6a	R. R. Donnelly & Sons	I	1935	596	1995	MS	C-O/MS	SS 1681; DL
COK 39N14E-28.2h	Gottfried Brewing Co.	I	1912	593	1658	I-G	C-O	DL
COK 39N14E-28.2d	Inland Rubber Co.	I	1932	605	1936	MS	C-O/MS	DL
COK 40N12E-8.7g	Twin Orchard Country Club	IR	1925	645	1410	Tr	G-SP/Tr	SS 569; DL
COK 40N12E-18.6c	James B. Clow & Sons	R	1956	660	1457	Tr	G-SP/Tr	SS 28042; DL
COK 40N12E-27.8h	Franklin Park #3	P	1931	635	1949	MS	C-O/MS	SS 1114; DL
COK 40N12E-31.2h	North Lake #2	P	1946	648	316	Maq	Sil Dol	DL
COK 40N12E-31.4d	Automatic Electric Co. #1	I	1956	655	1833	EC	C-O	SS 27117; DL
COK 40N12E-31.4c	Automatic Electric Co. #2	I	1956	650	1900	MS	C-O/MS	SS 27118; DL
COK 40N12E-33.6d	Buick Aviation Eng. #1	I	1941	640	1601	EC	C-O	SS 7076; DL
COK 40N13E-15.8a	Sears Roebuck	P	1939	611	1612	EC	C-O	DL
COK 40N13E-31.4g	Shriner's Hospital	P	1930	650	1580	EC	C-O	SS 979; DL
COK 40N13E-31.4e	Mars, Inc. #1	I	1928	650	2033	MS	C-O/MS	DL
COK 40N13E-32.6d	C. M. & St. P. RR.	I	1905	633	1819	EC	C-O	DL
COK 40N13E-34.6d	Hales & Hunter	I	1943	607	1548	EC	C-O	SS 9842; DL
COK 40N14E-17.5d	Graceland Cemetery	IR	1895	599	1568	I-G	C-O	DL
COK 40N14E-20.8c	American Colortype	I	....	598	1580	I-G	C-O	DL
COK 40N14E-30.7c	Durkee Famous Foods	I	1935	590	1945	MS	C-O/MS	SS 1755; DL
COK 40N14E-30.5b	Brand Brewing Co.	I	1915	592	1598	I-G	C-O	DL
COK 40N14E-32.6f	Birk Bros. Brewing	I	1943	597	1600	EC	C-O	SS 10735; DL
COK 40N14E-33.5g	U. S. Brewing (Schmidt)	I	1901	602	1593	I-G	C-O	DL
COK 41N9E-34.1b1	Bartlett #1	P	1923	810	200	Sil	Sil Dol	SS 327; DL
COK 41N9E-34.1b2	Bartlett #2	P	1945	810	200	Sil	Sil Dol	DL
COK 41N10E-15.4f	F & S Industries	I	1955	755	1391	EC	C-O	SS 25944; DL
COK 41N11E-10.3f	Hatlin Heights #2	P	1958	675	1760	EC	C-O	DL
COK 41N11E-12.8h	Mt. Prospect #3	P	1945	670	1348	EC	C-O	SS 12335; DL
COK 41N11E-21.1b	Elk Grove Water & Sewer	P	1958	717	1415	EC	C-O	SS 30233; DL
COK 41N12E-12.8b	Eugenia Subdiv. #1	P	1956	656	1415	I-G	C-O	SS 26400; DL
COK 41N12E-14.–	J. P. Leonard & Co.	I	1939	650	1147	G-SP	G-SP Ss	SS 3554; DL
COK 41N12E-15.5a	Croatian Orphanage	P	1926(?)	635	1763	EC	C-O	SS 553
COK 41N12E-16.8g	Camp Kiwanis	P	1941	633	435	Maq	Sil Dol	SS 6431
COK 41N12E-16.5e	G. R. Fourche	R	1945	630	1000	G-SP	G-SP Ss	SS 12099
COK 41N12E-18.6a	Des Plaines #1	P	....	650	1735	MS	C-O/MS	DL
COK 41N12E-18.7a	Des Plaines #2	P	1946	655	1813	MS	C-O/MS	SS 15889; DL
COK 41N12E-19.5c	Des Plaines #3	P	1953	655	1843	MS	C-O/MS	SS 23436; DL
COK 41N12E-19.5e	Des Plaines #4	P	1955	654	1805	MS	C-O/MS	SS 25852; DL
COK 41N12E-21.8g	Des Plaines	P	1924	630	1600	EC	C-O	SS 178
COK 41N13E-8.6d	Glen View Country Club	IR	....	650	2050	MS	C-O/MS	SS 628
COK 41N13E-20.7f	Morton Grove #1	P	....	627	1462	I-G	C-O	DL
COK 41N13E-20.2d	Poehlman Bros.	R	....	628	1966	MS	C-O/MS	SS 646
COK 41N13E-22.5h	New Evanston Golf Club	IR	....	608	1463	Tr	G-SP/Tr	DL
COK 41N13E-23.2b	Petrol Agar	I	1931	597	1680	EC	C-O	SS 1149
COK 41N13E-26.2h	Northwest. Gas, Light & Coke Co.	P	1912	597	1871	MS	C-O/MS	DL
COK 41N13E-29.8d	Lex-Paul Corp. #1	I	1957	624	1465	EC	C-O	SS 27838
COK 42N9E-1.7h	Barrington #2	P	1929	815	310	Sil	Sil Dol	SS 950; DL
COK 42N9E-2.7e	Alex Reichman	R	1929	845	880	G-SP	G-SP Ss	SS 937
COK 42N10E-14.2b	Palatine	P	1954	733	1380	EC	C-O	SS 24960
COK 42N10E-22.4e	Palatine #5	P	1945	740	209	Maq	Sil Dol	SS 13508; DL
COK 42N10E-24.8a	Arlington Park Jockey Club	IR	....	724	920	G-SP	G-SP Ss	SS 959
COK 42N10E-25.7e	Rolling Meadows #1	P	1953	711	1535	EC	C-O	SS 25025; DL
COK 42N10E-25.1h	Rolling Meadows #2	P	1954	710	1401	EC	C-O	SS 24400; DL
COK 42N11E-5.1g	Buffalo Utility #1	P	1957	688	1342	I-G	C-O	DL
COK 42N11E-11.8b	Ekco Foil #2	I	1955	645	1320	EC	C-O	DL
COK 42N11E-11.7e	Wheeling	P	1956	644	1370	EC	C-O	DL
COK 42N11E-29.5a	Arlington Hts. #5	P	1946	689	1525	EC	C-O	SS 14483; DL
COK 42N11E-30.3e	Arlington Hts. #2	P	....	725	1345	EC	C-O	SS 1504 SS 16990; DL
COK 42N11E-30.5b	Arlington Hts. #6	P	1952	705	1475	EC	C-O	SS 22691

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
	COOK COUNTY—(Continued)							
COK 42N11E-33.3c	Mt. Prospect #4	P	1949	689	1375	EC	C-O	SS 19845
COK 42N11E-34.8f	Mt. Prospect # 5	P	1954	676	1820	MS	C-O/MS	SS 25168
COK 42N11E-36.4b	St. Mary's Academy	P	1923-26	643	1535	MS	C-O/MS	SS 506
COK 42N12E-5.7d	Marshall Salzman	R	1957	687	1404	G-SP	G-SP Ss	SS 28043; DL
COK 42N12E-9.3c	Northbrook City	P	....	646	1345	EC	C-O	SS 49; DL
COK 42N12E-14.7f	St. Mary's #2	P & IR	1931	666	1983	MS	C-O/MS	SS 1118; DL
COK 42N12E-29.1a	Ill. Municipal #4	P	1957	677	1405	I-G	C-O	SS 27885; DL
COK 42N12E-29.6b	E. S. Beck	R	....	684	1935	MS	C-O/MS	SS 1039; DL
COK 42N12E-33.4b	Glenview C'tryside #1	P	1940	681	570	G-P	G-P Dol	SS 5199; DL
COK 42N12E-33.7b	Glenview C'tryside #2	P	1941	680	606	G-P	G-P Dol	SS 6596; DL
COK 42N12E-33.1c	Glenview #3	P	1954	671	917	G-P	Sil Dol	SS 24480; DL
COK 42N12E-34.4d	Glenview #2	P	....	652	1431	EC	C-O	SS 540
COK 42N12E-35.4d	Baxter Lab.	I	1939	628	1050	Tr	G-SP/Tr	SS 3740; DL
COK 42N12E-36.8e	North Shore C.C. #1	IR	1923	647	1330	I-G	C-O	SS 322
	DU PAGE COUNTY							
DUP 37N11E-3.8a	Argonne Nat'l. Lab.	I	1950	676	1595	EC	C-O	DL
DUP 38N9E-5.5a	Public Ser. Co. No. Ill.	P	1928	730	1333	I-G	C-O	SS 774; DL
DUP 38N9E-13.2b1	Naperville	P	....	673	1425	I-G	C-O	DL
DUP 38N9E-13.2b2	Naperville #3	P	1922	675	130	Sil	Sil Dol	SS 357
DUP 38N9E-17.8d	C. B. & Q. RR.	I	1919	714	1428	I-G	C-O	DL
DUP 38N10E-18.3d1	Naperville #5	P	1930	695	205	Sil	Sil Dol	SS 1140; DL
DUP 38N10E-18.3d2	Naperville #6	P	1937	698	202	Maq	Sil Dol	SS 2173; DL
DUP 38N11E-1.3a	Hinsdale #2	P	1924	686	268	Sil	Sil Dol	SS 766
DUP 38N11E-1.6a	Hinsdale #3	P	1928	687	210	Sil	Sil Dol	DL
DUP 38N11E-4.4f	Liberty Park #2	P	1956	745	275	Maq	Sil Dol	SS 26960; DL
DUP 38N11E-7.6d	Downers Grove	P	1927	699	250	Maq	Sil Dol	SS 687; DL
DUP 38N11E-7.1e	Downers Grove	P	1906-07	716	2021	MS	C-O/MS	DL
DUP 38N11E-8.4b	Downers Grove	P	1930	742	295	Sil	Sil Dol	SS 1046; DL
DUP 38N11E-8.7e	Downers Grove	P	1951	715	268	Maq.	Sil Dol	SS 20945
DUP 38N11E-9.1h	Westmont #2	P	1926	752	313	Maq	Sil Dol	SS 560; DL
DUP 38N11E-10.7a	Westmont #3	P	1935	760	302	Sil	Sil Dol	SS 1687; DL
DUP 38N11E-10.8e	Westmont #4	P	1958	755	313	Maq	Sil Dol	SS 30748; DL
DUP 38N11E-10.2f	Clarendon Hills	P	1923	730	970	G-SP	G-SP Ss	DL
DUP 38N11E-10.1e	Clarendon Hills #2	P	1932	730	250	Sil	Sil Dol	SS 1231
DUP 38N11E-11.5a	Clarendon Hills #3	P	1945	730	354	Sil	Sil Dol	SS 12835; DL
DUP 39N9E-4.1b	West Chicago #3	P	1950	768	310	Maq	Sil Dol	DL
DUP 39N9E-10.7f	Chicago & NW. RR.	I	....	760	2082	MS	C-O/MS	SS 401
DUP 39N9E-13.6h	Winfield #1	P	1926	720	200	Sil	Sil Dol	DL
DUP 39N9E-13.6b	Winfield #2	P	1957	778	335	Maq	Sil Dol	SS 27666; DL
DUP 39N10E-9.2f	Wheaton #5	P	1954	752	341	Maq	Sil Dol	SS 24881; DL
DUP 39N10E-11.7c	Glen Ellyn #2	P	1922	761	352	Maq	Sil Dol	SS 1048
DUP 39N10E-11.8d	Glen Ellyn #3	P	1941	789	422	Maq	Sil Dol	SS 6215; DL
DUP 39N10E-16.6c1	Wheaton #3	P	1930	739	184	Maq	Sil Dol	SS 961; DL
DUP 39N10E-16.6c2	Wheaton #4	P	1946	745	350	Maq	Sil Dol	SS 15659
DUP 39N11E-1.8g	Elmhurst #1	P	1915	684	1480	EC	C-O	SS 4229; DL
DUP 39N11E-2.2f	Elmhurst #3-A	P	1942-43	690	1502	EC	C-O	SS 10228; DL
DUP 39N11E-4.1f	Villa Park #6	P	1958	704	1420	EC	C-O	DL
DUP 39N11E-6.5a	Lombard #4	P	1953	700	2062	MS	C-O/MS	SS 23911; DL
DUP 39N11E-8.7h	Lombard #2	P	1926	703	2038	MS	C-O/MS	DL
DUP 39N11E-9.1h	Villa Park #1	P	....	695	2125	MS	C-O/MS	DL
DUP 39N11E-10.8e	Villa Park #4	P	1923	702	223	Maq	Sil Dol	SS 128
DUP 39N11E-10.4g	Wander Co. #1	I	1927	677	1970	MS	C-O/MS	DL
DUP 39N11E-10.1h	Elmhurst #4	P	1928	665	2205	MS	C-O/MS	DL
DUP 39N11E-10.3g	Wander Co. #11	I	1946	675	1920	MS	C-O/MS	SS 15336
DUP 39N11E-12.8d	Elmhurst #5	P	1940	675	1480	I-G	C-O	DL
DUP 40N9E-29.6a	Howard Aircraft Corp.	I	1942	755	1006	G-SP	G-SP Ss	SS 9843; DL
DUP 40N9E-32.2d	Elgin, Joliet & Eastern RR.	I	1931	755	1378	EC	C-O	SS 1169; DL
DUP 40N9E-36.6h	Mark Morton #1	R	1930	802	912	G-SP	G-SP Ss	SS 1045; DL
DUP 40N10E-14.4c	Glendale Country Club	IR	....	757	853	G-SP	G-SP Ss	SS 436
DUP 40N10E-15.2f	Suncrest Highlands	P	1956	722	1395	EC	C-O	SS 27477
DUP 40N11E-11.5a	Mohawk Country Club	IR	1935	677	1456	EC	C-O	DL
DUP 40N11E-13.8e	Bensenville #2	P	1929	672	1442	EC	C-O	SS 956; DL
DUP 40N11E-13.3c	C. M. & St. P. RR. #1	I	1912	665	2290	MS	C-O/MS	DL
DUP 40N11E-13.5b	C. M. & St. P. RR. #6	I	1950	672	1461	EC	C-O	SS 20203; DL
DUP 40N11E-14.1d	Bensenville #3	P	1956	677	1445	EC	C-O	SS 25024
DUP 40N11E-28.3f	Addison	P	1924	690	155	Sil	Sil Dol	DL
DUP 40N11E-35.5e	Elmhurst #6	P	1954	700	1476	EC	C-O	SS 24957
	GRUNDY COUNTY							
GRY 33N6E-3.3a	M. B. Wilson	R	....	570	353	G-SP	G-SP Ss	DL
GRY 33N6E-3.1a	M. B. Wilson	R	1941	570	330	G-SP	G-SP Ss	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
				GRUNDY COUNTY—(Continued)				
GRY 33N6E-4.2h	Andrew Johnson	R	....	605	330	G-SP	G-SP Ss	DL
GRY 33N6E-8.4h	....	..	....	580	388	G-SP	....	DL
GRY 33N6E-8.2d	Sam Holderman	R	1918	605	338	G-SP	G-SP Ss	DL
GRY 33N6E-9.2d	Sam Holderman	R	....	535	290	G-SP	G-SP Ss	DL
GRY 33N6E-10.6f	S. J. Holderman	R	1950	530	300	G-SP	G-SP Ss	DL
GRY 33N6E-11.4f	Morris Clay Products	I	1955	530	406	G-SP	G-SP Ss	DL
GRY 33N6E-12.6e	Graver Packing Co.	I	1951	518	372	G-SP	G-SP Ss	DL
GRY 33N6E-15.6f	....	..	....	500	291	G-SP	....	DL
GRY 33N6E-21.7h	Alice Wahe	R	....	500	285	G-SP	G-SP Ss	DL
GRY 33N6E-22.4d	W. H. Croft	R	....	595	374	G-SP	G-SP Ss	DL
GRY 33N6E-27.2d	Dr. A. G. Harrison	R	....	608	494	G-SP	G-SP Ss	DL
GRY 33N6E-29.4e	Du Pont #6	I	1955	610	1530	EC	C-O	SS 25493
GRY 33N6E-30.6g	Prairie States	I	1950	495	310	G-SP	G-SP Ss	DL
GRY 33N7E-4.4c	Morris #5	P	1954	505	1462	EC	C-O	SS 24398
GRY 33N7E-4.2a	Cater Contracting #3	I	1915	523	720	G-SP	G-SP Ss	SS 47
GRY 33N7E-5.5h	F. W. Anderson	R	1949	550	480	G-SP	G-SP Ss	DL
GRY 33N7E-6.6h	Morris Country Club	IR	1926	548	385	G-SP	G-SP Ss	DL
GRY 33N7E-9.3h	Morris #4	P	1938	510	1501	EC	C-O	DL
GRY 33N7E-12.4a	F. J. Holderman	R	1915	525	608	G-SP	G-SP Ss	DL
GRY 33N7E-13.1d	F. J. Holderman	R	1904	543	623	G-SP	G-SP Ss	DL
GRY 33N7E-19.8g	Lory Dempsey	R	....	580	449	G-SP	G-SP Ss	DL
GRY 33N7E-20.8g	Peter Dittmyer	R	1939	518	428	G-SP	G-SP Ss	DL
GRY 33N7E-26.6e	Frank Young	R	1914	550	535	G-SP	G-SP Ss	DL
GRY 33N7E-33.5a	Grundy Co. Poor Farm #1	P	1929	570	730	PdC	G-SP Ss	SS 698; DL
GRY 33N8E-11.5g	Ill. Clay Products Co.	I	....	510	500	G-SP	G-SP Ss	SS 329
GRY 33N8E-18.4c	Jno. Holderman	R	....	540	660	PdC	G-SP Ss	DL
GRY 33N8E-34.6g	Carbon Hill	P	1942	560	650	G-SP	G-SP Ss	SS 8899; DL
GRY 33N8E-34.5a	E. J. & E. RR.	I	1910	565	1346	EC	C-O	DL
GRY 34N6E-3.1a	O. J. Larson	R	1901	610	200	G-SP	G-SP Ss	DL
GRY 34N6E-5.1g	P. David	R	1916	668	202	G-SP	G-SP Ss	DL
GRY 34N6E-5.6a	Andrew Holland	R	1913	665	186	G-SP	G-SP Ss	DL
GRY 34N6E-8.4a	O. Dix (O. J. Frey)	R	....	650	301	G-SP	G-SP Ss	DL
GRY 34N6E-8.d	Hi. Wicks	R	1916	649	192	G-SP	G-SP Ss	DL
GRY 34N6E-9.1h	Frank H. Hayes	R	1942	628	220	G-SP	G-SP Ss	SS 8477; DL
GRY 34N6E-13.8h	O. Gunderson	R	....	590	249	G-SP	G-SP Ss	DL
GRY 34N6E-14.7h	John Cunnea	R	1902	605	218	G-SP	G-SP Ss	DL
GRY 34N6E-15.8h	John Cunnea	R	....	604	229	G-SP	G-SP Ss	DL
GRY 34N6E-17.8f	Sidney Jorstad	R	1949	645	295	G-SP	G-SP Ss	DL
GRY 34N6E-17.8d	Barton Johnson	R	....	643	295	G-SP	G-SP Ss	DL
GRY 34N6E-18.8c	Herbert Wildey	R	....	665	266	G-SP	G-SP Ss	DL
GRY 34N6E-18.1e	Ami Morcusson	R	....	650	321	G-SP	G-SP Ss	DL
GRY 34N6E-19.3h	Crist Hendrickson	R	....	646	285	G-SP	G-SP Ss	DL
GRY 34N6E-19.1b	Wm. E. Jelm	R	....	627	282	G-SP	G-SP Ss.	DL
GRY 34N6E-19.7g	Arthur C. Wildey	R	....	660	353	G-SP	G-SP Ss	DL
GRY 34N6E-20.4e	B. C. Nicholson	R	1955	620	240	G-SP	G-SP Ss	DL
GRY 34N6E-20.8a	Nettie Gray	R	1913	625	250	G-SP	G-SP Ss	DL
GRY 34N6E-23.2a	....	..	....	585	278	G-SP	....	DL
GRY 34N6E-23.1e	....	..	....	585	325	G-SP	....	DL
GRY 34N6E-25.7g	Abe Hoge	R	1875	590	1865	MS	C-O/MS	DL
GRY 34N6E-26.8d	Hoge School	P	1941	595	320	G-SP	G-SP Ss	SS 7149; DL
GRY 34N6E-26.8c	W. M. Hoge	R	....	595	370	G-SP	G-SP Ss	DL
GRY 34N6E-28.2b	G. D. Hoge	R	....	605	250	G-SP	G-SP Ss	DL
GRY 34N6E-30.8e	Mrs. Brewe	R	....	642	303	G-SP	G-SP Ss	DL
GRY 34N6E-31.1h	Lava Olsen	R	1941	630	333	G-SP	G-SP Ss	DL
GRY 34N6E-36.8a	F. W. Gebhard	R	1937	560	343	G-SP	G-SP Ss	DL
GRY 34N7E-18.5h	Munson Heirs	R	1939	585	285	G-SP	G-SP Ss	SS 3650; DL
GRY 34N7E-19.4h	....	..	....	570	303	G-SP	....	DL
GRY 34N7E-20.8h	D. Neushwander	R	1952	576	302	G-SP	G-SP Ss	DL
GRY 34N7E-30.4a	....	..	....	550	334	G-SP	....	DL
GRY 34N7E-31.5a	Tenes Olson	R	1939	540	360	G-SP	G-SP Ss	SS 3953; DL
GRY 34N7E-32.1h	....	..	....	545	357	G-SP	....	DL
GRY 34N7E-33.1a	Chas. Muffler	R	1949	520	355	G-SP	G-SP Ss	DL
GRY 34N7E-34.8d	State of Illinois	R	1955	525	400	G-SP	G-SP Ss	SS 25673; DL
GRY 34N7E-35.8e	....	..	....	525	408	G-SP	....	DL
GRY 34N8E-35.1g	Dresden Nuclear #1	I	1957	514	788	PdC	G-SP Ss	SS 30332; DL
GRY 34N8E-35.1e	Dresden Nuclear #2	I	1957	530	1500	I-G	C-O	SS 29050; DL
				KANE COUNTY				
KNE 38N8E-3.8g	North Aurora #1	P	1938	695	807	G-SP	G-SP Ss	SS 2761; DL
KNE 38N8E-10.9d	Kane Co. Springbrook San. #2	P	1932	670	772	G-SP	G-SP Ss	SS 1197
KNE 38N8E-13.8a	Western Wheeled Scraper #2	I	1917	695	1461	EC	C-O	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
			KANE COUNTY—(Continued)					
KNE 38N8E-15.3h	Aurora #12A	P	1935	670	2251	MS	C-O/MS	SS 1690; DL
KNE 38N8E-15.5h	Aurora #4	P	1895	635	2445	MS	C-O/MS	DL
KNE 38N8E-21.5g	Aurora #10	P	1924	682	2299	MS	C-O/MS	DL
KNE 38N8E-22.6h	American Well Works	I	....	675	701	G-SP	G-SP Ss	DL
KNE 38N8E-22.7d	Tivoli Theatre	P	1940	652	1410	EC	C-O	SS 5080; DL
KNE 38N8E-22.8d	Walker Laundry	I	1931	650	1438	I-G	C-O	SS 1134; DL
KNE 38N8E-23.1h	Aurora #15	P	1950	694	2150	MS	C-O/MS	SS 20577; DL
KNE 38N8E-28.4e	Aurora #7	P	1914-15	630	2163	MS	C-O/MS	SS; DL
KNE 38N8E-32.2d	C. B. & Q. RR. #2	I	1947	640	740	G-SP	G-SP Ss	SS 17443
KNE 38N8E-32.2e	Lyon Metal	I	....	635	659	G-SP	G-SP Ss	DL
KNE 38N8E-32.3c	Montgomery	P	1928	642	175	Maq	Sil Dol	SS 653; DL
KNE 38N8E-32.3d	Montgomery #2	P	1949	640	735	G-SP	G-SP Ss	DL
KNE 38N8E-32.4f	Montgomery #4	P	1958	642	1353	I-G	C-O	SS 30751; DL
KNE 38N8E-33.8c	Montgomery #3	P	1957	633	1336	I-G	C-O	SS 30477; DL
KNE 38N8E-34.7g	Aurora #16	P	1952	655	1460	EC	C-O	SS 22141; DL
KNE 38N8E-35.5h	Aurora City Park	P	1909	700	2460	MS	C-O/MS	DL
KNE 39N6E-3.4a	Kaneland School	P	1956	838	930	G-SP	G-SP Ss	SS 26864
KNE 39N7E-2.6c	Scott Bros. #2	R	1930	815	655	G-SP	G-SP Ss	SS 1042
KNE 39N7E-5.8f	Elburn	P	1899	850	1375	I-G	C-O	DL
KNE 39N7E-6.2g	Elburn Packing #4	I	1954	845	1345	I-G	C-O	SS 23939
KNE 39N7E-9.4d	B. L. Palmer	R	1933	805	670	G-SP	G-SP Ss	DL
KNE 39N7E-24.1e	Sumpter #1	P	1950	720	596	G-SP	G-SP Ss	DL
KNE 39N8E-3.5e	Burgess Norton	I	1950	740	1340	I-G	C-O	SS 21805; DL
KNE 39N8E-3.8g	Geneva #3	P	1929	758	2300	MS	C-O/MS	SS 970; DL
KNE 39N8E-3.2b	Geneva #4	P	1944	719	2267	MS	C-O/MS	SS 10863; DL
KNE 39N8E-15.6f	Campana #1	I	1936	712	275	G-P	Sil Dol	SS 1919; DL
KNE 39N8E-22.3e	Batavia #3	P	1941	667	2200	MS	C-O/MS	SS 6901; DL
KNE 40N6E-1.4e	Hyman Freed #1	R	1948	920	747	G-SP	G-SP Ss	DL
KNE 40N6E-26.2e	J. & E. Winterhalter	R	1936	872	641	G-SP	G-SP Ss	DL
KNE 40N7E-12.4g	J. B. Ward	R	1940	855	965	G-SP	G-SP Ss	SS 5637; DL
KNE 40N7E-20.1g	Clifton Bowgren #1	R	1950	910	729	G-SP	G-SP Ss	DL
KNE 40N7E-23.4g	School Dist. 303 #2	P	1951	825	670	G-SP	G-SP Ss	DL
KNE 40N8E-21.5f	Crane Estate #1	R	....	740	695	G-SP	G-SP Ss	DL
KNE 40N8E-24.3c	G. C. Moseley #1	R	1945	800	765	G-SP	G-SP Ss	SS 14518; DL
KNE 40N8E-27.6a	St. Charles #3	P	1919	690	2200	MS	C-O/MS	DL
KNE 40N8E-27.7g	Potowattomie Park	P	1937	690	851	G-SP	G-SP Ss	SS 2411
KNE 40N8E-28.1c	Paramount Distillery	I	1937	725	897	G-SP	G-SP Ss	SS 2113
KNE 40N8E-31.6f	St. Charles Training Sch. #1	P	1955	765	1322	EC	C-O	SS 25474
KNE 40N8E-34.6f	St. Charles #6	P	1956	750	2240	MS	C-O/MS	SS 25360
KNE 40N8E-35.8c	Christ Strown #1	R	1936	700	670	G-SP	G-SP Ss	DL
KNE 41N6E-3.1g	Burlington	P	1941	920	111	Dr	S & G	DL
KNE 41N8E-11.2g	Elgin #5	P	1950	725	1225	EC	C-O	SS 20946
KNE 41N8E-12.3f	Modern Dairy	I	1937	790	800	G-SP	G-SP Ss	SS 2166; DL
KNE 41N8E-14.8b	Elgin (Schuyler St.) #5	P	1931	823	1940	MS	C-O/MS	SS 1098
KNE 41N8E-14.2e	Pearsall Butter #1	I	1936	730	655	G-SP	G-SP Ss	SS 2081; DL
KNE 41N8E-23.3c	Ill. State Hospital	P	1931-32	738	2000	MS	C-O/MS	SS 1153; DL
KNE 41N8E-23.6b	Elgin State Hospital #2	P	1947	772	2000	MS	C-O/MS	SS 21248; DL
KNE 41N8E-24.1a	Elgin (La Voie Ave)	P	1931	733	1978	MS	C-O/MS	SS 1150
KNE 41N8E-24.3b	Elgin #6	P	1954	760	1255	EC	C-O	SS 24582
KNE 41N8E-27.5e	Elgin State Hosp. Farm	R	1935	810	800	G-SP	G-SP Ss	SS 1737
KNE 41N8E-35.8g	South Elgin #1	P	1929, '38	760	1250	I-G	C-O	SS 773 & 2669
KNE 42N6E-21.1a	Hampshire	P	1923	900	1180	I-G	C-O	DL
KNE 42N8E-17.5c	Felix Estate	R	1937	910	952	G-SP	G-SP Ss	SS 2354; DL
KNE 42N8E-22.4g	Carpentersville	P	1940	728	1140	I-G	C-O	SS 5731; DL
KNE 42N8E-23.7a	Haeger Pottery	I	1940	730	734	G-SP	G-SP Ss	DL
KNE 42N8E-27.5e	West Dundee	P	1957	760	1240	EC	C-O	DL
			KENDALL COUNTY					
KEN 35N6E-1.7e	Thomas Weeks #2	R	1953	718	275	G-SP	G-SP Ss	DL
KEN 35N6E-5.b	Nils Nilson	R	1941	670	225	G-SP	G-SP Ss	DL
KEN 35N6E-7.8b	L. P. Dauber	R	1943	632	98	G-SP	G-SP Ss	SS 9580
KEN 35N6E-16.7h	Henry Fatland	R	1953	770	225	G-SP	G-SP Ss	DL
KEN 35N6E-24.1b	....	..	....	670	135	G-SP	....	DL
KEN 35N6E-25.1h	Dr. W. B. Huey	R	1940	670	202	G-SP	G-SP Ss	SS 4845
KEN 35N6E-27.5f	....	..	....	725	233	G-SP	....	DL
KEN 35N6E-29.5c	Virginia Nitterhouse	R	1948	710	235	G-SP	G-SP Ss	DL
KEN 35N6E-31.2e	Paul DeLucia	R	1948	710	317	G-SP	G-SP Ss	DL
KEN 35N6E-32.7h	Paul DeLucia	R	1950	655	920	Tr	G-SP/Tr	SS 20192
KEN 35N6E-32.8h	Paul DeLucia	R	1948	670	225	G-SP	G-SP Ss	DL
KEN 35N7E-30.9g	Elmer Torkelson	R	1940	665	150	G-SP	G-SP Ss	SS 4957
KEN 36N6E-4.4d	Camp Milhurst (YWCA)	P	1926	575	425	G-SP	G-SP Ss	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
			KENDALL COUNTY—(Continued)					
KEN 36N6E-16.5e	Milbrook School	P	1940	630	140	G-SP	G-SP Ss	DL
KEN 36N6E-16.8a	Pees Bros.	R	1941	635	145	G-SP	G-SP Ss	DL
KEN 36N6E-17.–	E. A. Pionke #1	R	1953	615	109	G-SP	G-SP Ss	DL
KEN 36N6E-25.8b	C. R. Johnson	R	1946	720	265	G-SP	G-SP Ss	DL
KEN 36N6E-30.6f	G. L. Harris	R	1947	565	67	G-SP	G-SP Ss	SS 17754
KEN 36N6E-32.4e	Nelson #1	R	1954	775	425	G-SP	G-SP Ss	DL
KEN 36N6E-33.8d	Harry Hughes	R	1947	712	201	G-SP	G-SP Ss	SS 17751; DL
KEN 36N8E-29.8d	Christian	R	1924	620	500	G-SP	G-SP Ss	DL
KEN 36N8E-30.4f	Hill	R	1924	615	500	G-SP	G-SP Ss	DL
KEN 36N8E-36.1d	Rose Procter #1	R	1943-44	647	2325	MS	....	SS 10744; DL
KEN 37N6E-4.4d	Chicago YWCA	P	....	695	425	G-SP	G-SP Ss	DL
KEN 37N6E-7.3g	Clarence Smith	R	....	710	302	G-SP	G-SP Ss	DL
KEN 37N6E-32.5e	W. L. Scantlin	R	1941	640	160	G-SP	G-SP Ss	SS 7623; DL
KEN 37N6E-33.1a	Burr Oak	R	1937	639	550	G-SP	G-SP Ss	DL
KEN 37N7E-22.8g	T. A. Gantt #1	R	1939	628	575	G-SP	G-SP Ss	DL
KEN37N7E-28.4e	John Demetralis	R	1941	640	620	G-SP	G-SP Ss	SS 7977
KEN 37N7E-32.1e	Yorkville	P	1923	584	590	G-SP	G-SP Ss	DL
KEN 37N8E-6.2d	Caterpillar #3	I	1957	661	1352	I-G	C-O	SS 27403; DL
KEN 37N8E-17.6b	Oswego #2	P	1932	656	720	G-SP	G-SP Ss	SS 1219; DL
KEN 37N8E-17.4f	Oswego #3	P	1957	642	1380	EC	C-O	DL
			LAKE COUNTY					
LKE 43N10E-20.2e	Lake Zurich #3	P	1949	885	443	Maq	Sil Dol	SS 19018; DL
LKE 43N11E-2.8g	Covington, W. S. #1	R	1942	677	966	G-SP	G-SP Ss	DL
LKE 43N11E-2.8e	Von Beck, Baroness M #1	R	1940	675	919	G-SP	G-SP Ss	SS 5198; DL
LKE 43N11E-2.5e	Morse	R	1951	690	965	G-SP	G-SP Ss	SS 21395; DL
LKE 43N11E-3.1d	Voevodsky, George	R	1941	680	955	G-SP	G-SP Ss	SS 7044; DL
LKE 43N11E-28.2g	Geo. Willand Greenhouse	IR	1927	680	835	G-SP	G-SP Ss	DL
LKE 43N12E-7.8e	A.D . Lasker #2	R	1930	695	2000	MS	....	SS 955; DL
LKE 43N12E-15.2h	Chi., Milwk., Elect. RR.	I	1904	691	1753	EC	C-O	DL
LKE 43N12E-23.5b	Highland Park City	P	1886-87	690	1590	EC	C-O	SS 1317; DL
LKE 43N12E-25.4d	E. V. Price	R	....	657	1514	EC	C-O	DL
LKE 43N12E-27.5e	C. & NW. RR.	I	....	650	1760	EC	C-O	DL
LKE 43N12E-31.8f	Vernon Ridge C. Club	IR	1925	672	1443	I-G	C-O	DL
LKE 44N9E-26.1c	Wauconda #3	P	1939	800	257	Sil	Sil Dol	SS 3271; DL
LKE 44N11E-1.4f	Thos. E. Wilson	R	....	710	1055	G-SP	G-SP Ss	DL
LKE 44N11E-4.2e	K. K. Budd Home	P	1925-26	680	1274	EC	C-O	SS 611; DL
LKE 44N11E-4.8g	Chancellor, Gustine, Jr.	R	1950	682	976	G-SP	G-SP Ss	SS 20033; DL
LKE 44N11E-11.5g	Ascension Cemetery	IR	1926	695	1715	MS	C-O/MS	DL
LKE 44N11E-16.2c	Libertyville "Second St."	P	1928-29	680	251	Sil	S & G	DL
LKE 44N11E-18.4a	St. Mary of the Lake Sem. #3	P	1930	765	1919	MS	C-O/MS	DL
LKE 44N11E-19.3b	Cardinal Stritch #2	P	1950	733	295	Maq	Sil Dol	SS 20809
LKE 44N11E-24.4e	C. M. & St. P. RR.	I	1946	680	1107	Tr	G-SP/Tr	SS 15350; DL
LKE 44N11E-24.2a	Knollwood C. Club	IR	1925	670	1602	EC	C-O	DL
LKE 44N11E-27.1a	McDougal	R	1951	665	1005	G-SP	G-SP Ss	SS 21396
LKE 44N11E-27.2b	Carpenter, Keith	R	1946	660	1000	G-SP	G-SP Ss	SS 18410; DL
LKE 44N11E-35.4b	Dillon Subdivision	P	1931	708	1600	EC	C-O	SS 1105; DL
LKE 44N11E-35.1d	Mrs. J. O. Armour Estate	IR	1929	702	1357	I-G	C-O	SS 876; DL
LKE 44N11E-35.1a	Paul Llewellyn	R	....	688	1036	G-SP	G-SP Ss	SS 619; DL
LKE 44N11E-35.6c	Elding	R	1951	663	995	G-SP	G-SP Ss	SS 21394; DL
LKE 44N12E-6.1e	N. Shore Vista School	P	1952	725	1070	G-SP	G-SP Ss	SS 22675
LKE 44N12E-9.4c	Dewey, C. E. #1	R	1939	645	1077	G-SP	G-SP Ss	SS 3351
LKE 44N12E-16.4h	Arden Shore Camp #3	P	....	655	964	G-SP	G-SP Ss	SS 1370 & 1510
LKE 44N12E-18.3a	Austin Deep Freeze #1	I	1951	678	1630	EC	C-O	SS 21463; DL
LKE 44N12E-21.6g	Methodist Orphanage	P	....	667	900	G-SP	G-SP Ss	DL
LKE 45N9E-9.2g	Fox Lake City	P	1927	770	945	G-SP	G-SP Ss	SS 676
LKE 45N10E-16.1b	Round Lake Golf Club	IR	1931	780	1056	G-SP	G-SP Ss	DL
LKE 45N10E-16.5a	Round Lake Beach (Shorewood)	P	1947	777	342	Sil	S & G	DL
LKE 45N10E-17.7h	Rd. Lake Beach (Indian Hills)	P	1948	770	174	Dr	S & G	DL
LKE 45N10E-26.7c	Wisconsin Cond. Milk Co.	I	1916	790	1040	G-SP	G-SP Ss	SS 6
LKE 45N10E-26.7b	Grays Lake City	P	1924	785	1323	EC	C-O	SS 411
LKE 45N10E-29.5h	Round Lake #3	P	1945	790	359	Maq	Sil Dol	SS 12701
LKE 45N11E-5.5c	F. S. Rickord #1 & 2	..	1929-30	750	1255	EC	C-O	SS 974
LKE 45N11E-23.4f	Gurnee High School	P	....	675	916	G-SP	G-SP Ss	DL
LKE 45N11E-29.8a	Wildwood Subdivision	P	1951	785	1310	EC	C-O	SS 21332
LKE 45N11E-32.7d	Johnson	R	1934	760	196	Sil	Sil Dol	DL
LKE 45N11E-34.1e	Wm. Bartholomay, Jr., Estate	R	1928	730	1672	MS	C-O/MS	DL
LKE 45N11E-36.4c	Duffield Farms	R	....	725	1008	G-SP	G-SP Ss	DL
LKE 45N12E-15.8e	Greiss-Pflager Tanning Co.	I	1928	588	1670	MS	C-O/MS	SS 726; DL
LKE 45N12E-33.4d	Abbott Laboratories	I	1921	655	1600	EC	C-O	DL
LKE 45N12E-33.2f1	Am. Steel & Wire #1	I	....	595	2153	MS	C-O/MS	DL
LKE 45N12E-33.2f2	Am. Steel & Wire #2	I	....	597	2058	MS	C-O/MS	DL

Well No. (location)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (ft.)	Deepest formation reached	Main aquifer	Type of record
				McHENRY COUNTY				
LKE 45N12E-33.2f3	Am. Steel & Wire #3	I	1891	597	2004	MS	C-O/MS	DL
LKE 46N10E-8.7c1	Antioch #1	P	1907	231	780	Dr	S & G	DL
LKE 46N10E-33.8a	Lake Villa #1	P	1937	294	798	Sil	S & G	SS 2281
LKE 46N11E-27.2a	Central Fur Farm Coop.	I	1957	673	1230	EC	C-O	SS 29299
LKE 46N11E-33.–	J. R. Simpson, Jr.	R	1932	680	1364	EC	C-O	SS 1265
LKE 46N12E-21.1a	Zion City #3	P	1935	629	995	G-SP	G-SP Ss	SS 1618; DL
LKE 46N12E-21.1b	Zion City #1	P	1925	631	1025	G-SP	G-SP Ss	SS 485; DL
LKE 46N12E-27.–	Beach State Park	P	1947	590	1002	G-SP	G-SP Ss	SS 17181
MCH 43N7E-33.8h	Dean Milk Co.	I	1946	900	62	Dr	S & G	DL
MCH 43N8E-5.4g	Crystal Lake City	P	1930	915	2000	MS	C-O/MS	SS 902
MCH 43N8E-13.1g	Cary	P	1913	815	300	Sil	Sil Dol	DL
MCH 43N8E-21.1a	Material Service #1	I	....	835	1255	EC	C-O	SS 25854; DL
MCH 43N8E-28.5f	Lake in the Hills #4	P	1954	800	114	Sil	S & G	SS 25494; DL
MCH 43N9E-18.3a1	Fox River Grove	P	1928	738	145	Sil	Sil Dol	SS 695; DL
MCH 43N9E-18.3a2	Fox River Grove	P	1957	740	120	Sil	Sil Dol	SS 26965; DL
MCH 44N5E-35.5h	Arnold Engineering #1	I	1948	819	846	Fr	G-SP/Tr	SS 18763; DL
MCH 44N5E-35.3g	Borden Milk (Marengo)	I	1951	815	1028	EC	C-O	SS 21477; DL
MCH 44N7E-5.7d2	Woodstock City #2	P	1899	910	2079	MS	C-O/MS	DL
MCH 44N7E-5.7d3	Woodstock #3	P	1939	920	198	Dr	S & G	DL
MCH 44N8E-33.5a	Crystal Lake City	P	1953	929	1355	I-G	C-O	SS 22983
MCH 45N8E-26.5a	McHenry #6	P	1938	755	104	Dr	S & G	DL
MCH 46N5E-33.8a	Dean Milk, Chemung	I	1946	870	1783	MS	C-O/MS	SS 14396; DL
MCH 46N5E-35.2a	Bowman Dairy #2	I	1920	940	804	G-SP	G-SP Ss	DL
MCH 46N7E-8.1a	Hebron	P	1904	930	269	Dr	S & G	DL
MCH 46N8E-9.4f	Richmond #2	P	1956	819	146	Dr	S & G	SS 26359; DL
				WILL COUNTY				
WIL 33N9E-1.5e	Kankakee Ord. Works #5A	I	1942	570	1650	EC	C-O	SS 8207; DL
WIL 33N9E-10.8f	Fisher, W. #203	R	....	531	688	G-SP	G-SP Ss	DL
WIL 33N9E-12.1g	Kankakee Ord. Works #11	I	1942	575	1644	EC	C-O	DL
WIL 33N9E-22.8d	T. F. Anderson	R	....	554	635	G-SP	G-SP Ss	DL
WIL 33N9E-25.6b	Wilmington #2	P	1936	540	1566	I-G	C-O	SS 1830; DL
WIL 33N10E-9.4h	Elwood Ordnance	I	1941	640	1645	EC	C-O	DL
WIL 33N10E-9.1f	Elwood Ordnance	I	1941	647	1672	EC	C-O	DL
WIL 33N10E-10.5h	Elwood Ordnance #2	I	1941	642	834	PdC	G-SP Ss	SS 6357; DL
WIL 33N10E-16.2h	Elwood Ordnance #1	I	1941	643	803	PdC	G-SP Ss	SS 6356; DL
WIL 33N14E-15.7a	D. D. Van Voorhees #1	R	1933	695	1458	PdC	G-SP Ss	SS 1314; DL
WIL 34N9E-11.7g	Amoco Chemical #1	I	1957	571	1422	EC	C-O	SS 30479; DL
WIL 34N9E-11.2e	Stepan Chemical #1	I	1955	542	1407	EC	C-O	SS 25945
WIL 34N9E-25.5a	Kankakee Ord. #8	I	1941	606	1627	EC	C-O	SS 6225; DL
WIL 34N9E-25.5d	Kankakee Ord. #9	I	1941	589	1603	EC	C-O	SS 6199; DL
WIL 34N9E-25.5b	Kankakee Ord. #10	I	1941	591	1571	EC	C-O	DL
WIL 34N9E-34.4a	Kankakee Ord. #3	I	1941	528	1593	EC	C-O	SS 5865; DL
WIL 34N9E-34.7a	Kankakee Ord. #4	I	1941	522	1551	EC	C-O	DL
WIL 34N9E-35.5a	Kankakee Ord. #1	I	1941	539	1597	EC	C-O	SS 5867; DL
WIL 34N9E-35.8a	Kankakee Ord. #2	I	1941	532	1612	EC	C-O	SS 5866; DL
WIL 34N9E-36.5b	Kankakee Ord. #6	I	1941	577	1653	EC	C-O	SS 6405; DL
WIL 34N9E-36.4e	Kankakee Ord. #7	I	1941	601	1655	EC	C-O	SS 6198; DL
WIL 34N10E-29.6g	Elwood City	P	1942	645	934	PdC	G-SP Ss	SS 7997; DL
WIL 34N10E-31.6a	Kankakee Ord. #12	I	1942	625	1710	EC	C-O	SS 7996; DL
WIL 34N11E-20.3g	Wabash RR.	I	1942	685	187	Sil	Sil Dol	DL
WIL 34N14E-8.1a	Crete #2	P	1924	725	264	Sil	Sil Dol	SS 533
WIL 35N9E-13.1c	Joyce 7-Up Co.	I	1940	627	725	G-SP	G-SP Ss	DL
WIL 35N9E-21.5a	Gardner #1	P	1943	584	960	G-SP	G-SP Ss	DL
WIL 35N9E-29.3f	Gaskill, E. #1	R	1954	580	565	G-SP	G-SP Ss	SS 24458; DL
WIL 35N9E-32.4a	Connell, Ellen	R	1938	560	575	G-SP	G-SP Ss	DL
WIL 35N10E-2.8b	Joliet City	P	1924	555	1608	EC	C-O	SS 416; DL
WIL 35N10E-3.4e	Illinois State Pen. #3	P	1948	558	1600	EC	C-O	SS 18350; DL
WIL 35N10E-4.1f	Calumet Chemical	I	1924	558	1596	EC	C-O	DL
WIL 35N10E-9.2e	Joliet City & Canal Div.	P	....	532	1570	EC	C-O	SS 98; DL
WIL 35N10E-9.1h	Joliet City, Ruby St.	P	1915	545	1560	EC	C-O	DL
WIL 35N10E-9.7f	St. Francis Convent	P	1937	648	943	G-SP	G-SP Ss	SS 2120; DL
WIL 35N10E-10.4b	Joliet Citizens Brewing Co.	I	1938	545	1483	PdC	G-SP Ss	SS 2815; DL
WIL 35N10E-10.7b	Joliet City, Van Buren St.	P	1913	540	1550	EC	C-O	SS 249; DL
WIL 35N10E-10.1a	Wm. E. Pratt Mfg. Co.	I	1943	550	795	G-SP	G-SP Ss	SS 9869; DL
WIL 35N10E-11.6g	E. J. & E. RR.	I	1950	558	1589	EC	C-O	SS 19958; DL
WIL 35N10E-14.6h	Joliet City, Washington St.	P	1937	565	1608	EC	C-O	DL
WIL 35N10E-14.5e	Prairie State Paper Co.	I	....	585	1603	EC	C-O	DL
WIL 35N10E-15.8e	Joliet City, Spruce Slip	P	....	540	1530	EC	C-O	SS 320; DL
WIL 35N10E-16.2h	Joliet City, Des Plaines St.	P	....	540	1560	I-G	C-O	SS 248; DL
WIL 35N10E-16.5g	Joliet City, Jasper St.	P	1924	574	1565	EC	C-O	SS 417; DL

Well No. (*location*)	Owner	Use	Year drilled	Surface elevation above sea level	Depth (*ft.*)	Deepest formation reached	Main aquifer	Type of record
			WILL COUNTY—(Continued)					
WIL 35N10E-16.6a	U. S. Engineer's #1	I	1937	540	855	PdC	G-SP Ss	SS 2155; DL
WIL 35N10E-19.1f	American Can #2	I	1942	555	1594	EC	C-O	SS 7994; DL
WIL 35N10E-20.7g	Rockdale #2	P	1944-45	556	1586	EC	C-O	SS 11923; DL
WIL 35N10E-20.6a	Commonwealth Edison #2	I	1958	530	1494	EC	C-O	SS 30747; DL
WIL 35N10E-21.4b	American Cyn. & Chem. #2	I	....	583	1612	EC	C-O	SS 14684; DL
WIL 35N10E-22.3f	Will Co. TB San. #3	P	1944	615	865	PdC	G-SP Ss	SS 11111; DL
WIL 35N10E-22.7g	Amer. Inst. of Laundering #1	I	1929	562	1603	EC	C-O	DL
WIL 35N10E-29.8c	Blockson Chem. #5	I	1952-53	550	1535	EC	C-O	DL
WIL 35N10E-29.8g	Pub. Ser. Co. Sta. #9, Well #1	P	1940	530	1509	EC	C-O	DL
WIL 35N10E-30.1e	Blockson Chem. #4	I	1951	595	1555	EC	C-O	SS 20977; DL
WIL 35N10E-30.7e	Caterpillar #2	I	1950	545	1420	I-G	C-O	SS 20576; DL
WIL 35N11E-5.7d	Joliet Site #5, #2 (?)	P	1951	670	1700	EC	C-O	SS 20836; DL
WIL 35N11E-5.7h	Joliet #6-1	P	1950	650	103	Dr	S & G	SS 20230
WIL 35N11E-5.7h	Joliet Site #6, #1	P	1949	645	1645	EC	C-O	SS 19944; DL
WIL 35N11E-8.8f	Joliet Site #5, #2	P	1950	655	1650	EC	C-O	DL
WIL 35N11E-13.6a	Mokena City Oil Test	..	1922	666	1085	PdC	....	SS 269; DL
WIL 35N11E-21.1c	McIntosh Sub.	P	1932	703	320	Sil	Sil Dol	SS 1296
WIL 35N12E-25.3e	J. R. McGlashan #1	..	1934	712	2700	MS	....	SS 1492
WIL 35N12E-28.1b	E. J. & E. RR.	I	1929	763	365	Maq	Sil Dol	SS 887; DL
WIL 36N9E-9.1g	Plainfield #1	P	1929	612	200	Sil	Sil Dol	DL
WIL 36N9E-10.8d	Plainfield #3	P	1956	608	1480	I-G	C-O	SS 26207; DL
WIL 36N9E-23.1h	E. L. Herren #1	R	1944	602	1958	MS	C-O/MS	SS 11831; DL
WIL 36N10E-2.7f	Pub. Ser. #1	P	1952	585	1505	EC	C-O	SS 22423; DL
WIL 36N10E-2.8h	Public Ser. #2	P	1952	585	1535	EC	C-O	SS 22424; DL
WIL 36N10E-16.4c	Globe Corp. Aircraft Div. #3	I	1953	668	1523	EC	C-O	SS 23494; DL
WIL 36N10E-23.6c	Lockport #2	P	1927	582	1475	EC	C-O	SS 707; DL
WIL 36N10E-23.5a	Lockport #3	P	1940	662	1571	EC	C-O	SS 6680; DL
WIL 36N10E-23.2f	Lockport #4	P	1954	648	1560	EC	C-O	SS 24934; DL
WIL 36N10E-27.7b	Chicago Sanitary Dist.	P	1935	548	850	G-SP	G-SP Ss	SS 1704; DL
WIL 36N10E-28.6h	Ill. State Pen. #3	P	1926	650	1527	I-G	C-O	DL
WIL 36N10E-28.6f	Stateville #4	P	1936-37	640	2007	MS	C-O/MS	SS 1782; DL
WIL 36N10E-29.6g	Stateville #5	P	1951	645	1535	I-G	C-O	SS 21217; DL
WIL 36N10E-32.1a	Lidice City #3	P	1945	656	1652	EC	C-O	SS 14377; DL
WIL 36N10E-33.6h	Public Ser., No. Ill.	P	1932	597	1558	EC	C-O	SS 1217; DL
WIL 36N10E-33.5c	Chaney Sch. Dist. 88	P	1941	640	950	G-SP	G-SP Ss	DL
WIL 36N10E-34.8a	Rubberoid Co.	I	1937	550	790	G-SP	G-SP Ss	SS 2043; DL
WIL 36N11E-31.8a	Joliet Site #1, Well #3	P	1949	637	1656	EC	C-O	SS 19943; DL
WIL 36N11E-32.4a	Joliet #3-5	P	1951	585	94	Dr	S & G	SS 22877
WIL 37N10E-25.7b	Thiophene Prod. Co.	I	1930	585	1456	I-G	C-O	DL