COOPERATIVE GROUND-WATER REPORT 1-S
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SUMMARY

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

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

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Preliminary Report on Ground-Water Resources of the Chicago Region, Illinois

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Preliminary Report on Ground-Water Resources of the Chicago Region, Illinois

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This report is a summary of the essential findings of Cooperative Ground-Water Report 1 issued by the State Water Survey and the State Geological Survey. Report 1 discusses the geology and hydrology of the ground-water resources of the Chicago region, along with the history, present conditions, and effects of possible future development. Special emphasis is placed on the deep water-yielding formations, or aquifers, which have been most widely used for large ground-water supplies. Basic geologic, hydrologic, and chemical data applicable to local problems and to regional and long-range interpretations are presented to help formulate future policies regarding planning and development of water resources in northeastern Illinois.

INTRODUCTION

The Chicago region has been one of the most favorable areas for development of ground water in Illinois. It is underlain at depths of 500 feet and more by sandstone formations that have been prolific sources of water for nearly 100 years, and at lesser depths by water-yielding glacial deposits and creviced dolomite bedrock. However, the tremendous industrial and municipal growth in the region has brought about local problems of water supply, including considerable decline in artesian pressure of water from the deep formations.

The region described in this report includes Cook, DuPage, Kane, Kendall, Lake, and McHenry Counties, and parts of Grundy and Will Counties (fig. 1). The land area of 4,169 square miles is 7.5 percent of the state. The population of 5,979,800, estimated in 1957, amounts to 61.3 percent of the population of the state. Although the region contains 75 percent of the manufacturing establishments in Illinois, agriculture, transportation services, and mining and quarrying also contribute to its economic importance.

Largest user of water in the region is the city of Chicago, which serves about 60 municipalities with its water system and pumps more than a billion gallons a day from Lake Michigan. Some 110 municipalities not served by water from Lake Michigan obtain supplies from wells. Suburban and rural water supplies beyond municipal distribution systems are obtained from ground water. Many industries, including a large number of plants within the area served by water from Lake Michigan, have private wells and use ground water for processing and cooling.

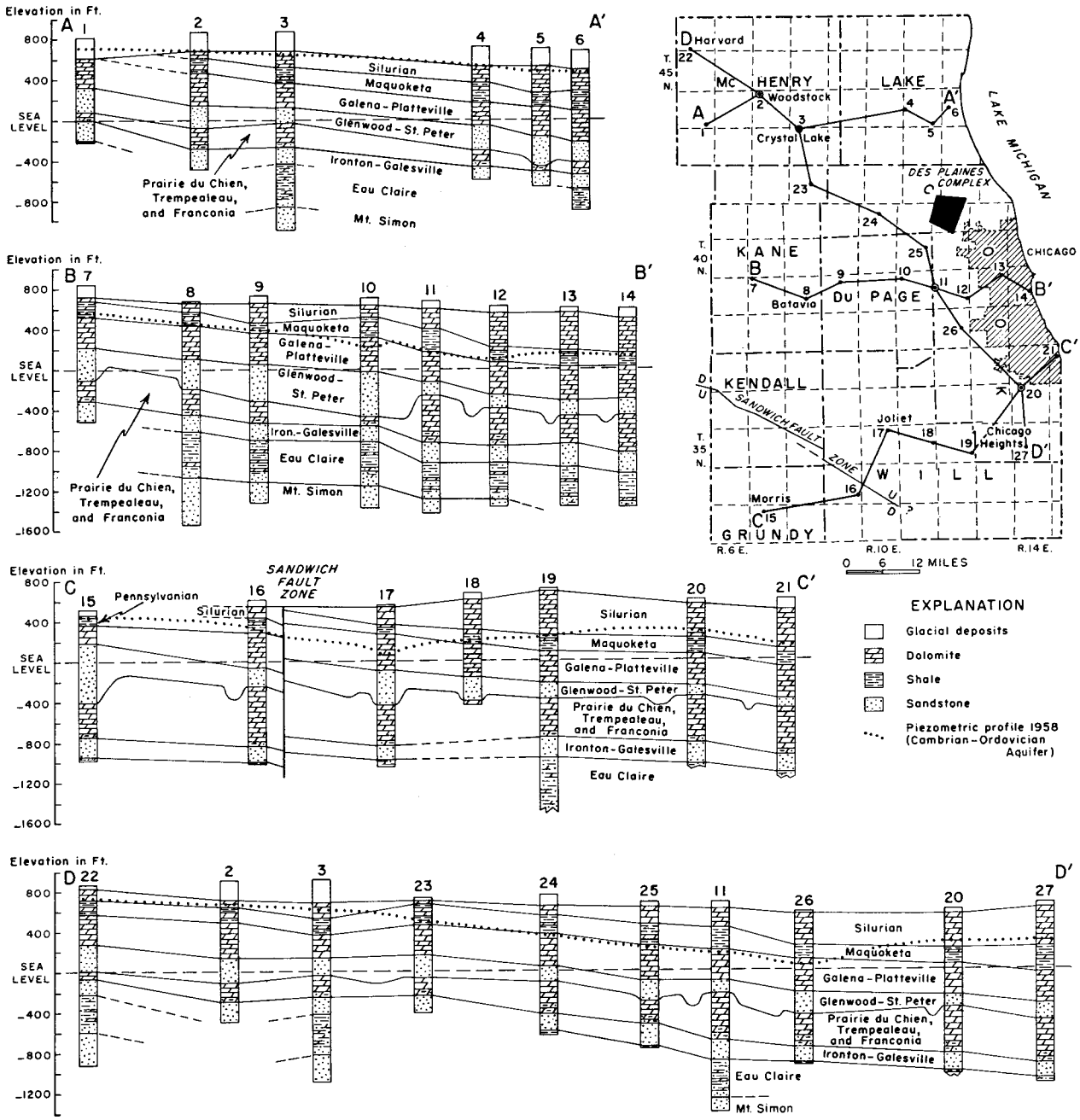

Fig. 1. Cross sections of the structure and stratigraphy of the bedrock and piezometric profile of the Cambrian-Ordovician Aquifer in the Chicago region.

GEOGRAPHY

The landscape of the Chicago region is varied, ranging from the low, flat Chicago lake plain on the east to the poorly drained, hilly belt of DuPage, Kane, Lake, and McHenry Counties to the west. The topography has been shaped primarily by glaciers that covered the region during the geologically recent Pleistocene Epoch, or Ice Age. Many of the ridges are accumulations of rock sediment that were deposited by ice along the margins of a glacier. These ridges, called moraines, are prominent features of the landscape.

Most of the region has an elevation of from 700 to 900 feet above sea level. The level of Lake Michigan is about 580 feet above sea level, and the highest point in the region, northeast of Harvard, has an elevation of 1192 feet. About 362 square miles of the region drain into Lake Michigan and the remaining 3807 square miles drain into the Mississippi River system, by way of the Kishwaukee, Rock, Illinois, Des Plaines, DuPage, Fox, and Kankakee Rivers.

The climate of the Chicago region is classified as continental with warm summers and cold winters. Precipitation, evaporation, and temperature - the most commonly measured climatic factors that are directly related to ground water - vary with the latitude. Aside from variations caused by local influences, such as Lake Michigan and the large urban area of Chicago, the average annual precipitation of the region for the period 1938-1957 ranges from about 32 inches in the north to about 35 inches in the southeast, and the average annual temperature ranges from about 48°F to 51°F.

Climatic factors affect both the percolation of the precipitation into the ground-water reservoir, in the process called recharge, and the withdrawal of water by plants and man. In general, recharge in the Chicago region is greatest in the spring after the ground thaws and before vigorous plant growth begins. It has been estimated that about 10 to 12 percent of the annual precipitation reaches the ground-water reservoir in Illinois, and it is reasonable to believe that recharge in the Chicago region approximates this order of magnitude. Ground-water pumpage is related to temperature because ground water is widely used for air conditioning and for other cooling purposes.

GEOLOGY

The geologic nomenclature, characteristics, drilling and casing conditions, and water-yielding properties of the glacial drift, as well as the layered or sedimentary rocks of the region, are summarized in figure 2. The sequence, structure, and general characteristics of the rocks are shown in figure 1.

As shown in figure 2, 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) the 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.

The glacial drift and shallow dolomite aquifers are connected hydrologically. In most of the region these two aquifers are separated from the Cambrian-Ordovician Aquifer by the relatively water-tight or impermeable Maquoketa Formation, mainly shale, of Ordovician age. Impermeable beds in the middle and upper Eau Claire Formation separate the Cambrian-Ordovician Aquifer from the Mt. Simon Aquifer. The presence of beds that restrict the vertical circulation of ground water accounts for the difference in quality and pressures of waters in the various aquifers.

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 aquifs)		0-465	Dolomite, silty at base, locally cherty.
	Alexandrian	Kankakee Edgewood				
Ordovician	Cincinnatian	Maquoketa	Maquoketa		0-250	Shale, gray or brown; locally dolomite and/or limestone, argillaceous.
	Mohawkian	Galena Decorah Platteville	Galena-Platteville		220-350+	Dolomite and/or limestone, cherty. Dolomite, shale partings, speckled. 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 New Richmond Oneota	Prairie du Chien		0-340	Dolomite, sandy, cherty (oolitic); sandstone. Sandstone, interbedded with dolomite. Dolomite, white to pink, coarse-grained, cherty (oolitic), sandy at base.
Cambrian	St. Croixian	Trempealeau	Trempealeau		0-225	Dolomite, white, fine-grained, geodic quartz, sandy at base.
		Franconia	Franconia		45-175	Dolomite, sandstone, and shale, glauconitic, green to red, micaceous.
		Ironton Galesville	Ironton-Galesville		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. 2. Stratigraphy and water-yielding properties of the rocks,

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			

and character of the ground water in the Chicago region.

Glacial and Recent unconsolidated deposits overlie the much older layered bedrock in nearly all of the region (figs. 1 and 2). The bedrock surface on which the unconsolidated deposits lie was carved primarily by running water before the Pleistocene glaciers advanced across the region from the east and northeast. The bedrock surface slopes downward to the east and is scored by a system of valleys, some of which are completely buried by glacial deposits.

The glacial drift and Recent deposits range in thickness from a foot or less to more than 400 feet, the thicker drift occurring in the northwest part of the region and the thinner drift in Will, Grundy, and Cook Counties. The drift is made up of unsorted rock debris (till) deposited directly by the ice, sorted sand and gravel deposited by meltwaters at the border of the ice or in river channels (outwash), and fine sediments laid down in lakes and ponds. Sand and gravel outwash is the main source of ground water in the glacial drift. The tills and most lake sediments are so fine-grained that they permit little movement of ground water into a well. Deposits of sand and gravel occur locally at the surface or beneath other glacial materials; the thickest deposits of sand and gravel and those most productive of water are in valleys cut into the bedrock.

Beneath the glacial deposits, the bedrock formations, consisting mainly of beds of dolomite (a limestone-like rock), sandstone, and shale, have a regional dip of about 10 feet per mile toward the southeast (fig. 1). The rocks are warped into gentle folds that generally trend in the direction of the regional dip. In some places the rocks are broken and displaced along faults. The Sandwich Fault zone, along which more than 150 feet of displacement occurs locally, crosses the southwest part of the region. Complex faulting occurs in an area of about 25 square miles at Des Plaines. There is no indication that the folds or the faults act as barriers to the regional movement of ground water, but locally they modify its occurrence and movement.

Silurian age dolomite (figs. 1 and 2), which contains ground water in crevices and solution channels that locally yield very large supplies, underlies the drift and overlies the Maquoketa Formation in most of the region. Below the Maquoketa Formation, beds of sandstone generally alternate with beds of dolomite and shale (fig. 2).

The sandstones - Glenwood-St. Peter, Ironton-Galesville, and Mt. Simon-lower Eau Claire - store water and transmit it readily through the tiny pores between sand grains and are thus said to be permeable. From the early days they have been well known as artesian aquifers. The Ironton-Galesville Sandstone is the most consistently permeable and productive formation in the bedrock, though locally the Silurian age dolomite is so highly creviced that it yields much larger quantities of ground water. The Glenwood-St. Peter Sandstone is less permeable than the Ironton-Galesville Sandstone and is of secondary importance as an aquifer. The Mt. Simon Aquifer is also of lesser importance than the Ironton-Galesville Sandstone as a source of water because it is deeper, it contains highly mineralized water in many areas, and it is less consistently permeable.

Below the layered sedimentary rocks, Precambrian crystalline rocks such as granite form a relatively impermeable basement at depths from 3000 to 5000 feet below the surface.

GROUND-WATER PUMPAGE

Pumpage of ground water in the region has generally increased through the years, though pumpage in the Chicago metropolitan area is somewhat less than it was in the

peak year of 1924 just before many of the industries of the area abandoned their wells in favor of water supplies from Lake Michigan. Between 1948 and 1957 ground-water pumpage by municipalities in the Chicago region increased 70 percent. Pumpage from deep wells alone has increased from 200,000 gallons per day (gpd) in 1864 to an estimated 76 million gallons per day (mgd) in 1958. Figure 3 shows the estimated pumpage from deep wells for the period from 1864 to 1958.

Total ground-water pumpage from all sources in the region in 1957 was 127.9 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 is estimated that about 27 percent of the water pumped from deep wells actually came 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.

About 78.9 mgd were pumped for public supplies in 1957, including supplies for municipalities and institutions; 35.2 mgd were for industrial supplies; 13.1 mgd were for rural, non-irrigation supplies; and 0.6 mgd were for irrigation supplies for farms, golf courses, and cemeteries. In general, municipalities with large pumpage obtain water from the deep aquifers, those with small pumpage obtain water from glacial drift aquifers, and those with intermediate pumpage obtain water from the shallow dolomite aquifers.

Cook County with 48.4 mgd, Will County with 22.8 mgd, DuPage County with 21.5 mgd, and Kane County with 20.8 mgd account for almost 90 percent of the total pumpage in the region. Southeastern DuPage County and the adjacent part of Cook County are the areas of heaviest pumpage from the shallow aquifers, and the areas of heaviest pumpage from the deep aquifers are around Aurora, central Cook County, and Joliet.

HYDROLOGY OF AQUIFERS

Cambrian-Ordovician and Mt. Simon Aquifers

Ground water in the Cambrian-Ordovician and Mt. Simon Aquifers is confined under artesian pressure and therefore, in the deep wells, rises above the top of the aquifers. The first deep well drilled at Chicago in 1864 flowed at a rate of about 200,000 gpd with a head of 80 feet above land surface, or to an elevation of 695 feet above sea level. In 1864 the artesian pressure in the Cambrian-Ordovician Aquifer was at elevations of about 690 feet at Joliet, between 700 and 750 feet along the Fox River Valley and between 750 and 850 feet in McHenry, Kane, Boone, and DeKalb Counties.

Elevations to which ground water rises in artesian wells form an imaginary pressure surface, called the piezometric surface. In 1864, the piezometric surface of the Cambrian-Ordovician Aquifer sloped southeast from a ground-water ridge or area of higher artesian pressures in Boone, McHenry, Kane, and DeKalb Counties. The low natural slope (hydraulic gradient) of the piezometric surface, about 2 feet per mile, was sufficient to transmit only about 900,000 gpd from the ground-water ridge toward Chicago. Water entering or recharging the aquifer in Boone, DeKalb, and McHenry Counties was discharged naturally in areas to the east and south by slow leakage upward through the confining Maquoketa Formation and by leakage into the Illinois River Valley.

Pumpage from the deep aquifers after 1864 created depressions in the artesian pressure surface around individual wells and groups of wells. These depressions,

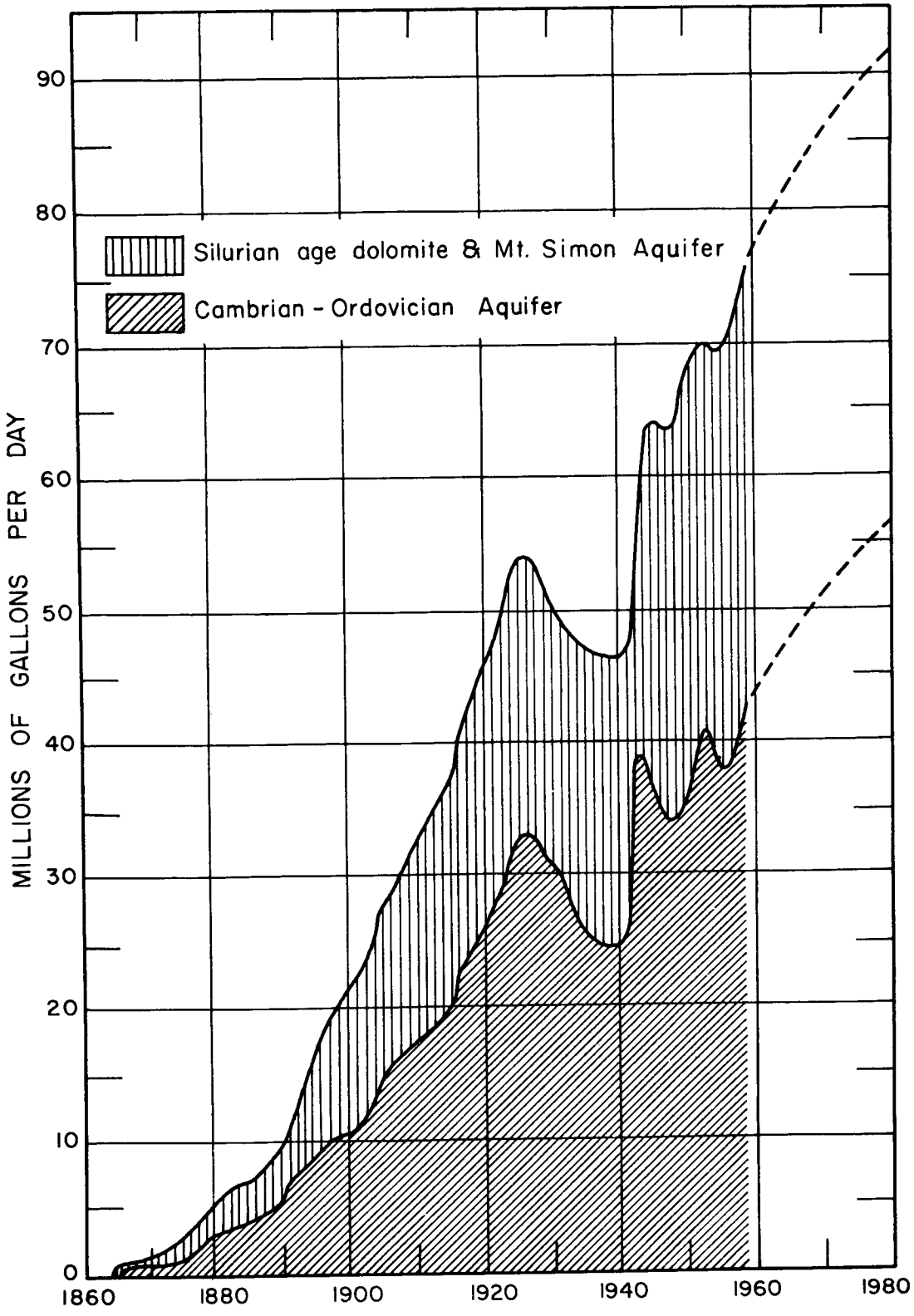

Fig. 3. Pumpage from deep wells, 1864 to 1958, and estimated pumpage to 1980, subdivided by source.

because they are in the approximate form of an inverted cone, are called cones of depression. Under conditions of pumpage at a constant rate, a cone of depression grows at a decreasing rate, as time goes on, until 1) the lowering of artesian pressure results in increased recharge to, or decreased natural discharge from, the aquifer (or a combination of the two effects), and 2) hydraulic gradients are established which bring from recharge areas the amount of water pumped. In the Chicago region, however, the cones of depression did not stabilize because pumpage rates did not remain constant. Instead, after 1864 withdrawals in several areas within the region increased progressively (fig. 3), cones of depression overlapped and spread out in all directions, and the artesian pressure declined at an increasing rate throughout most of the period of development. The table below shows the distribution of pumpage from deep wells in 1958.

Pumping Center	Total Pumpage in mgd
Chicago Area	23.4
Joliet Area	14.0
Elmhurst Area	9.8
Des Plaines Area	6.8
Elgin Area	8.1
Aurora Area	14.0
	76.1

Many deep wells in the Chicago region are either uncased or faultily cased in the Silurian age dolomite and allow leakage. The Mt. Simon Aquifer also is penetrated by a large number of deep wells, particularly along the Fox River in Kane County. The artesian pressure of the Cambrian-Ordovician Aquifer is much lower than that in the Silurian age dolomite and Mt. Simon Aquifer. Ground water therefore moves downward from the dolomite and upward from the Mt. Simon into the Cambrian-Ordovician Aquifer through wells that are open in all three aquifers. Thus, water pumped from deep wells does not come from the Cambrian-Ordovician alone. The amounts of water derived from Silurian age dolomite and the Mt. Simon Aquifer and the Cambrian-Ordovician Aquifer between 1864 and 1958, shown in figure 3, were estimated by studying piezometric-surface maps and data on mineral content and temperature of water, and by evaluating the number, yield, and time of construction of wells open in the various aquifers. Of the 76.1 mgd pumped from deep wells in 1958, 20.5 mgd came from the Silurian age dolomite and 12.8 mgd came from the Mt. Simon Aquifer.

Decline in Artesian Pressure

The changes in artesian pressure produced by pumping since the days of early settlement have been pronounced and widespread. As early as 1895 the artesian pressure had declined about 150 feet at Chicago, 100 feet at Joliet, and 50 feet along the Fox River Valley. By 1915 the artesian pressure had declined, in response to continual increases in withdrawals of water, to elevations of 400 feet above sea level at Chicago and at Joliet. In 1958 the artesian pressure was at elevations of about 50 feet at Chicago and 25 feet at Joliet.

Figure 4 shows the decline of artesian pressure in the Cambrian-Ordovician Aquifer from 1864 to 1958. The greatest declines, more than 600 feet, have occurred

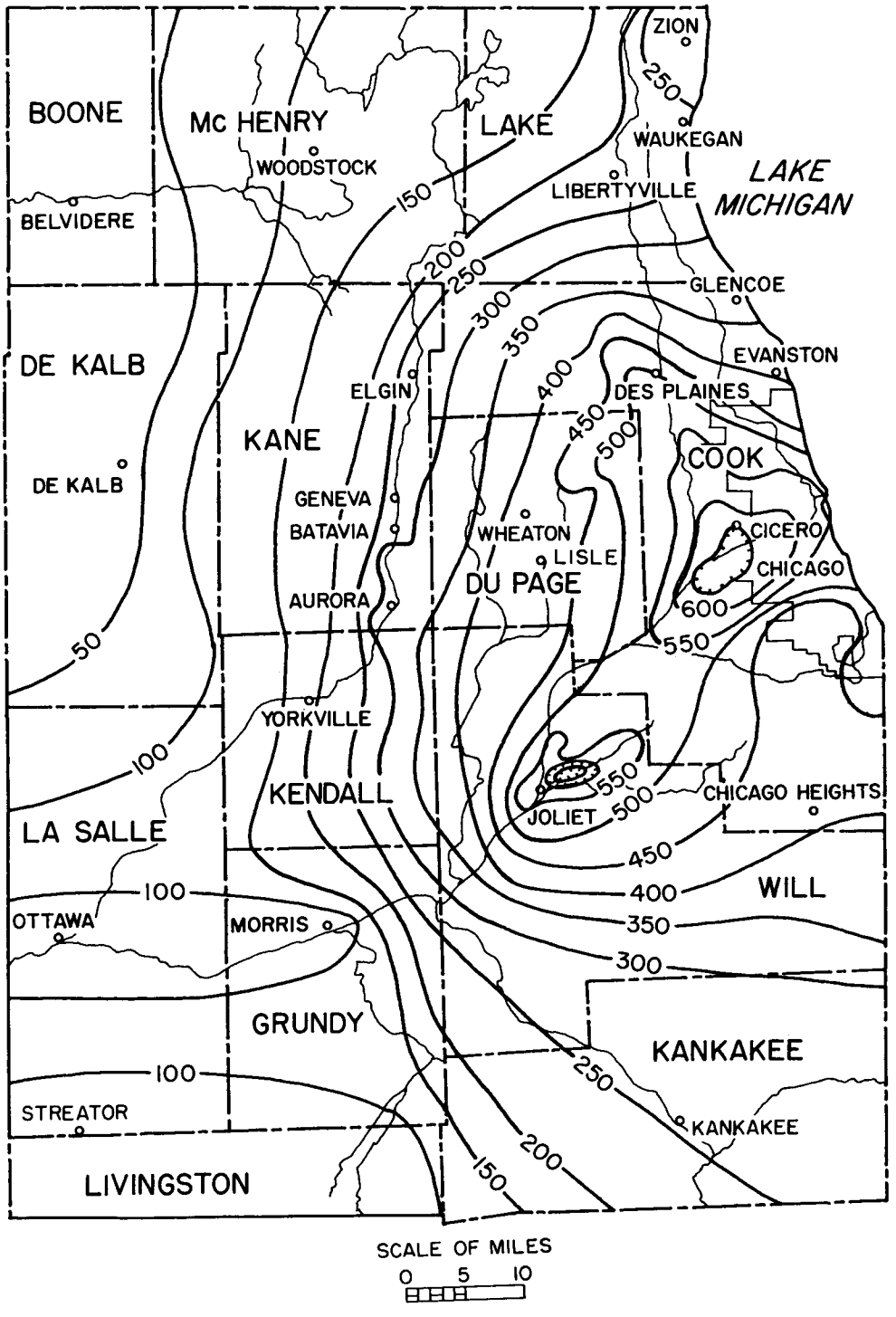

Fig. 4. Decline, in feet, of artesian pressure in Cambrian-Ordovician Aquifer from 1864 to 1958.

in areas of heavy pumpage west of Chicago, at Summit, and at Joliet (note wells 26 and 17, fig. 1). The average rate of decline in the Chicago area, 1864 to 1958, was about 7 feet per year. The artesian pressure has declined about 500 feet at Des Plaines and Elmhurst and about 275 feet along the Fox River Valley. The decline has been least, 10 feet or less, in areas in DeKalb, Boone, and McHenry Counties. Most of the decline in areas in these three counties is due to local pumpage and cannot be attributed to heavy pumping in the Chicago region.

It is estimated that about 340 billion gallons of water were taken from storage within the aquifer during the period 1864 to 1958. The water taken from storage is derived by compaction of the aquifer and by expansion of the confined water itself. The average volumetric rate of decrease in ground-water storage during the period 1949-58 was about 23 mgd.

The general pattern of flow of water through the Cambrian-Ordovician Aquifer at present is slow movement from all directions toward the deep cones of depression centered near Chicago and at Joliet. Some of the water flowing toward Chicago and Joliet is intercepted by cones of depression in the Aurora, Elgin, Des Plaines, and Elmhurst areas.

Geohydrologic Boundaries

Certain geologic conditions and surface hydrologic features have the effect of limiting the growth of the cone of depression or the lateral extent of the Cambrian-Ordovician Aquifer so that the influence of these features (geohydrologic boundaries) must be taken into account in computing drawdowns in wells under past or future conditions. Recharge boundaries occur where an aquifer receives replenishment. Boundaries across which the flow of ground water is prohibited or retarded are called barrier boundaries.

The profiles (fig. 1) and maps of the piezometric surface of the Cambrian-Ordovician Aquifer show high elevations and a ground-water ridge 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. Here the Galena-Platteville Dolomite is well creviced and affords a good hydraulic connection between the Glenwood-St. Peter Sandstone and glacial deposits.

The Ironton-Galesville Sandstone receives water from the Glenwood-St. Peter Sandstone through crevices and other openings in the intervening dolomites (fig. 2). Recharge to the Glenwood-St. Peter Sandstone and eventually to the Ironton-Galesville Sandstone 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 distribution of sulfates in and the temperature of water from the Cambrian-Ordovician Aquifer, and the map showing decline in artesian pressure (fig. 4) indicate approximately the same areas of recharge as do profiles (fig. 1) and maps of the piezometric surface.

It is estimated that in 1958 about 18 mgd of ground water were transmitted from recharge areas in northeastern Illinois and about 2 mgd were transmitted from recharge areas in southeastern Wisconsin toward cones of depression in the Chicago region. It is probable that a small amount of recharge occurs directly through the Maquoketa Formation and from the Illinois River Valley under the influence of extensive and deep cones

of depression in the Cambrian-Ordovician Aquifer. Available data suggest that the recharge effect of Lake Michigan is negligible.

Deep wells in Kankakee County and near the Indiana state line have small yields, indicating that the ability of the aquifer to transmit water decreases rapidly south of Joliet and east of Chicago. Thus, the Cambrian-Ordovician Aquifer is enclosed by barrier boundaries to the east and south and by one recharge boundary to the west. The barrier boundaries increase drawdown in wells and the recharge boundary decreases drawdown in wells.

The results of geologic and hydrologic studies in northern Illinois indicate that the effects of the geohydrologic boundaries on wells in the Cambrian-Ordovician Aquifer can be simulated by mathematical analysis of a hypothetical hydrologic model. The hydrologic model 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. The water-yielding properties of the aquifer, that is its ability to transmit water and to release water from storage, were determined from the results of 63 pumping tests. These properties are summarized in figure 2.

Potential Ground-Water Development and Its Effects

According to an estimate based on the past rate of increase of pumpage (fig. 3), and on the assumption that the total pumpage from deep wells in the Chicago region will increase at a fairly uniform rate from 76 mgd in 1958 to about 92 mgd in 1980, about 56 mgd will be withdrawn from the Cambrian-Ordovician Aquifer in 1980. Declines in nonpumping water levels that may be expected between 1958 and 1980 at Chicago, Joliet, Des Plaines, Elmhurst, Elgin, and Aurora are presented in the table below. The nonpumping water level is the level at which water stands in a well that is not influenced by pumping in the immediate vicinity of the well.

Pumping Center	1958 Nonpumping water level in feet above sea level	1958-1980 Computed future water level decline in feet	1980 Predicted nonpumping water level in feet above (+) or feet below (-) sea level
Chicago Area	50	300	-250
Joliet Area	20	220	-200
Elmhurst Area	150	250	-100
Des Plaines Area	200	300	-100
Elgin Area	490	190	+300
Aurora Area	400	250	+150

Declines were computed by using the hydrologic model described earlier and assuming that the distribution of pumping remains the same as it was in 1958. By 1980 the Galena-Platteville Dolomite and the Glenwood-St. Peter Sandstone will be partially dewatered in parts of the Chicago region, and the specific capacities (yields per foot of drawdown) of deep wells will probably decrease about 10 percent.

Practical Sustained Yield

Aside from economic considerations and quality of water, the practical sustained yield of the Cambrian-Ordovician Aquifer is limited, not by the rate of replenishment in recharge areas, but by the rate at which water can move eastward through the aquifer from recharge areas. It is estimated that the recharge area of the Cambrian-Ordovician Aquifer that affects the Chicago region is about 1200 square miles. If five percent of the average annual precipitation infiltrates into the aquifer in the recharge areas, a conservative figure, the total water available at the recharge areas is about 100 mgd. However, computations assuming a large number of uniformly and widely spaced wells show that the maximum quantity of water that could be transmitted from recharge areas to the Chicago region is only about 65 mgd. Because pumping is not distributed in this ideal manner, development of the full calculated capacity of the aquifer, 65 mgd, is impossible.

The practical sustained yield of the aquifer is the maximum amount of water that can be withdrawn without eventually dewatering the most productive water-yielding formation, the Ironton-Galesville Sandstone. If it is assumed that the distribution of pumpage remains the same as in 1958, the practical sustained yield is estimated to be about 46 mgd. This yield will be developed when the total pumpage from deep wells is about 81 mgd. According to figure 3, the practical sustained yield will be exceeded in about 1965. If pumpage increases to a total of 46 mgd and then remains the same, the nonpumping water 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.

Shallow Dolomite and Glacial Drift Aquifers

Water levels in the shallow dolomite and glacial drift aquifers vary greatly from time to time and place to place; however, at no location is there any apparent permanent decline. The greater part of the pumpage is from the shallow dolomite aquifers in DuPage and Cook Counties. Records of water levels in these counties indicate that the potential yield of the shallow dolomite aquifer is much greater than present withdrawal rates.

The glacial drift aquifers are used as sources of municipal and industrial groundwater supplies at relatively few locations. The largest development is northeast of Joliet. Five gravel wells owned by the city of Joliet produce 650 gpm each. Several areas favorable for sand and gravel wells are presently undeveloped. Present withdrawals from the glacial drift aquifers are probably much less than their potential yield.

Geologic and hydrologic data indicate that the average water-yielding capacities of the shallow dolomite and glacial drift aquifers are greater than those of the Cambrian-Ordovician Aquifer.

QUALITY OF GROUND WATER

Ground waters in the Chicago region vary in mineral quality between the various producing aquifers and also within individual aquifers at different locations. Below an elevation of 1300 feet below sea level, ground water in the deep aquifers is too highly mineralized for most uses. The chemical characteristics and temperatures of waters from the various aquifers are summarized in figure 2.

In general, temperatures of waters increase downward, from an average of 52°F in the glacial drift to 66°F in the Mt. Simon Aquifer at an elevation of 1300 feet below sea level, with higher temperatures below. Within the Cambrian-Ordovician Aquifer the temperatures increase to the east as the aquifer gets deeper.

Ground waters in the glacial drift and shallow dolomite aquifers are similar in quality. The hardness ranges from 100 to 450 parts per million (ppm) and the sulfate and chloride concentrations are low. Locally the waters in the glacial drift and shallow dolomite aquifers have a hardness of more than 1000 ppm. The iron content is significant in 80 percent of the wells.

The mineral quality of the water from the Cambrian-Ordovician Aquifer is relatively uniform in the western two-thirds of the region, with a hardness in the range of 200 to 250 ppm and chloride and sulfate content somewhat higher than in water from the shallow aquifers. Mineralization increases sharply east of DuPage County and south of Joliet to 800 ppm hardness, 400 ppm chlorides, and 800 ppm sulfates near the Indiana state line. The iron content is low.

Because mineral content, particularly hardness and chlorides, of water in the Mt. Simon Aquifer increases rapidly with depth below an elevation of 1275 feet below sea level, drilling below the base of the Ironton-Galesville Sandstone is not recommended in the southeastern third of the region.

CONCLUSIONS AND RECOMMENDATIONS

The present withdrawals from the shallow aquifers are far less than the potential yields of these aquifers, whereas withdrawals from the Cambrian-Ordovician Aquifer have already approached the sustained yield. The shallow aquifers are the most likely sources to investigate for additional ground-water supply. These aquifers are more readily recharged than the Cambrian-Ordovician Aquifer and locally have high water-yielding capacities. Existing data indicate that the undeveloped ground-water resources of the shallow aquifers are large, although their sustained yield is undetermined.

Not enough data are available to permit estimating a water resources budget for the Chicago region. Many additional geologic, hydrologic, meteorologic, and engineering observations, measurements, calculations and methods 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 determine their potential yield and to locate areas favorable for ground-water development.
2) Regional study of the Cambrian-Ordovician and Mt. Simon Aquifers to determine water-yielding capacities of individual units.
3) Study of the possible effects of dewatering the Cambrian-Ordovician Aquifer.
4) Study of possible recharge of the aquifers from Lake Michigan.
5) Study of the relations between the Chicago and Milwaukee pumpage cones.
6) Study of well and aquifer characteristics during and after well construction.
7) Collection of more complete data on pumpage, particularly from shallow aquifers.

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