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GROUNDWATER IN NORTHWESTERN ILLINOIS

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A Preliminary Geologic Report

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ABSTRACT

Possibilities for development of domestic, municipal, industrial, and irrigation groundwater supplies range from poor to excellent in northwestern Illinois. This report presents in general terms a discussion of groundwater principles, summarizes the geologic factors that control the availability of groundwater, and discusses methods of developing groundwater supplies. The maps show: 1) major geographic and geologic features, 2) type and water-yielding character of upper bedrock formations, 3) possibilities for occurrence of sand and gravel aquifers, and 4) elevations of the tops of the Glenwood-St. Peter and Ironton-Galesville sandstones, the principal bedrock aquifers for municipal and industrial groundwater supplies in northwestern Illinois.

INTRODUCTION

The economic well-being of northwestern Illinois depends to a great extent on the availability of water for its farms, industries, and municipalities. Although large quantities of water are available from streams, most water supplies are obtained by wells that tap underground reservoirs. The water obtained by wells from these underground reservoirs is called groundwater.

The availability of groundwater depends on the nature of the earth materials beneath the earth's surface. Any groundwater supply, whether for small domestic needs or for large requirements of a municipality or industry, can be obtained only where suitable geologic conditions exist. Where the earth materials to great depths consist only of tight non-water-yielding formations, it is impossible to make successful wells. Where permeable and water-yielding formations are present, successful wells can be constructed.

Knowledge of the distribution and character of water-yielding material in any area is basic to the proper development of its groundwater resources. For this reason the Illinois State Geological Survey is cooperating with the Extension Service of the Agricultural Engineering Department, University of Illinois, in a program to improve water supplies on the farms of Illinois. This report is the third in a series of reports dealing with groundwater in the agricultural extension districts of the State. The region described is the western part of Agricultural Extension District 1.

The eastern part of District 1 is described in Geological Survey Circular 198, "Groundwater Possibilities in Northeastern Illinois." Agricultural Extension District 3 is described in Circular 192, "Water Wells for Farm Sup-

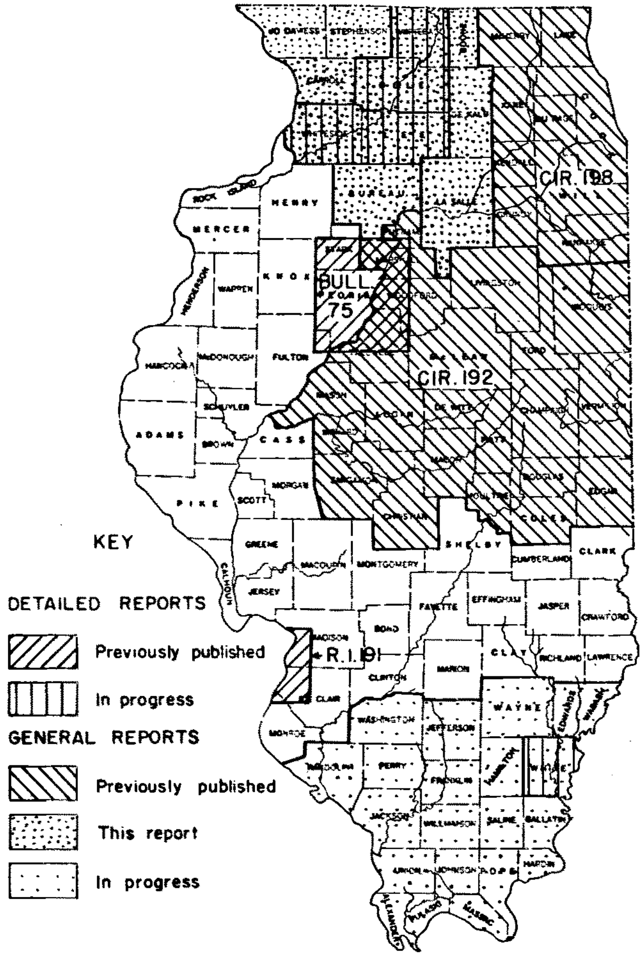

Fig. 1. - Index map of area covered in this report and major groundwater reports published since 1950 or in progress.

ply in Central and Eastern Illinois."* This report also provides information on the availability of groundwater supplies for municipal and industrial purposes and discusses principles of groundwater occurrence and development.

Eleven counties - Boone, Bureau, Carroll, De Kalb, Jo Daviess, LaSalle, Lee, Ogle, Stephenson, Whiteside, and Winnebago - comprise the region designated herein as northwestern Illinois (figs. 1 and 2). The region has an area of about 7300 square miles, an average annual rainfall of about 35 inches, and a population of nearly 570,000.

Northwestern Illinois is chiefly an agricultural area and is the major dairy and livestock region of the State. The major industrial center is Rockford, the third largest city in Illinois. Other cities, such as Streator, Ottawa,

*Both available without charge from the Survey in Urbana.

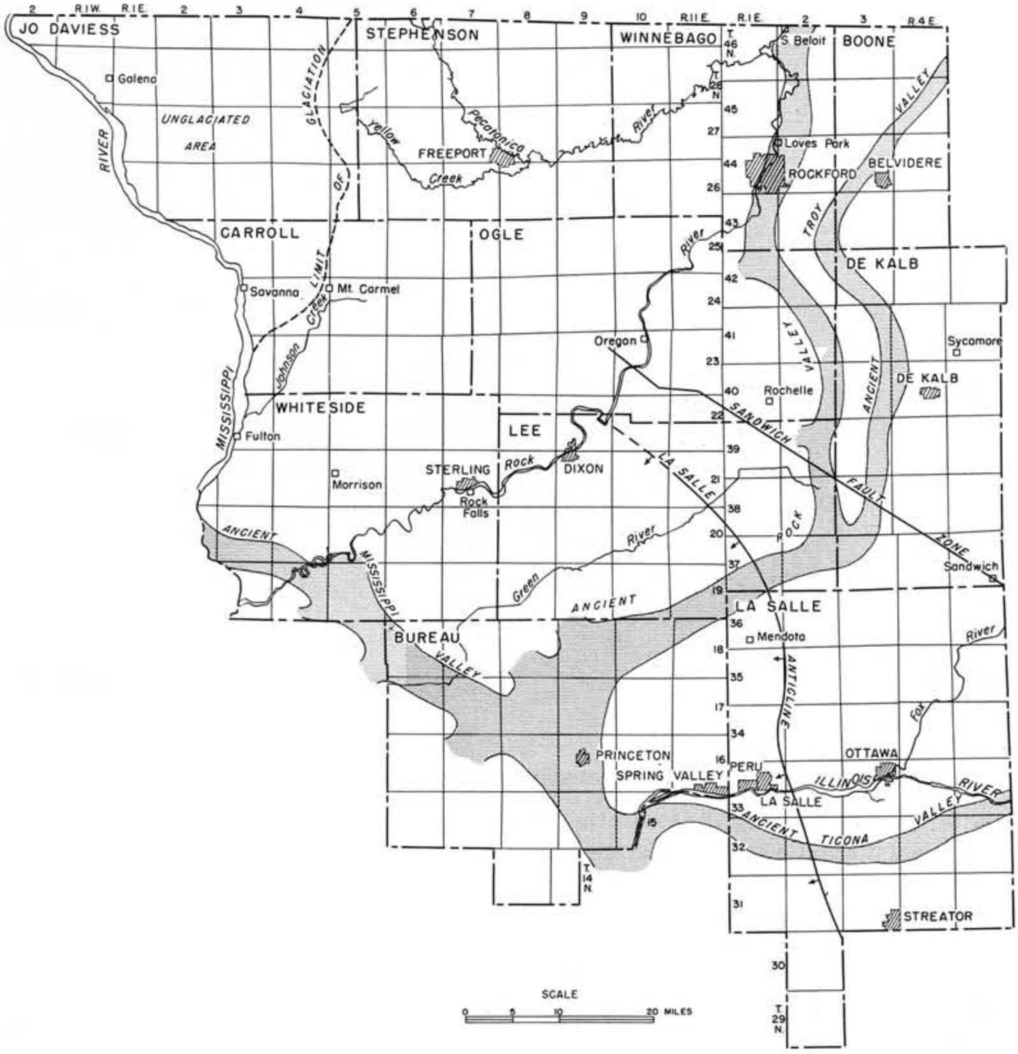

Fig. 2.- Index map of northwestern Illinois.

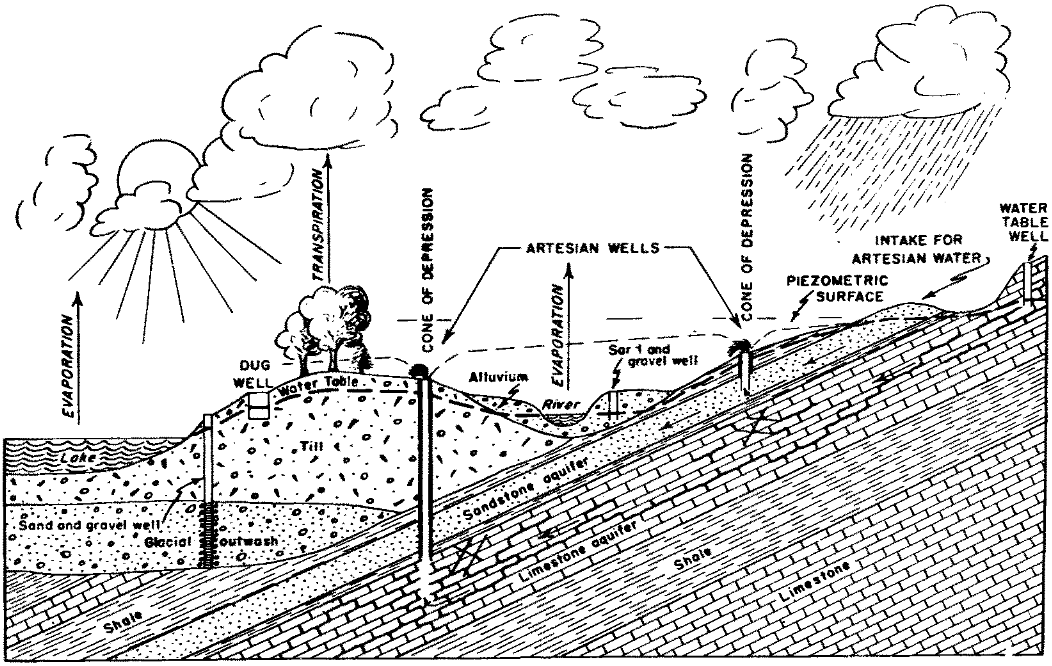

Fig. 3. - Source, movement, and occurrence of groundwater.

LaSalle, Peru, Sterling, Rock Falls, Dixon, Freeport, Belvidere, and De Kalb, also have substantial industrial developments.

The authors wish to acknowledge the helpful assistance given by the drilling contractors of northwestern Illinois. By their generous cooperation in providing large numbers of logs of water wells for the files of the Geological Survey and in discussing specific problems of occurrence of water-yielding materials with members of the Groundwater Division of the Survey in the field, they have contributed in a large measure to this study.

John W. Foster, Wayne A. Pryor, and Lidia F. Selkregg of the Geological Survey assisted materially in collecting, analyzing, and arranging basic data for the report. George B. Maxey and Merlyn B. Buhle provided many helpful comments and criticisms.

GROUNDWATER

Because groundwater occurs beneath the surface of the earth and is therefore hidden from view it is often regarded as somewhat mysterious. Throughout human history many fanciful and wonderful explanations have been presented to describe its source, movement, and occurrence. Scientific study has shown, however, that groundwater obeys certain physical laws or principles which are relatively simple and easily understood, although complex in detail. The modern scientific explanation for source, movement, and occurrence of groundwater is shown diagrammatically in figure 3.

Groundwater is supplied by seepage into the earth of moisture from the atmosphere falling on the earth's surface as rain, snow, or ice. The tremendous quantity of water that falls on the land surface by precipitation is seldom fully realized. However, a simple calculation shows that one inch of rainfall distributed over one square mile is nearly 17 1/2 million gallons, which approximates Rockford's daily municipal pumpage.

Most of the moisture that falls on the earth's surface flows off as runoff to streams or is retained by the soil. A large portion is delivered back into the atmosphere by evaporation from exposed water surfaces and by transpiration by vegetation. Only a small part of the moisture is added to the groundwater reservoir. Because precipitation constantly replenishes the supply, groundwater is a renewable resource. The amount of groundwater available is therefore diminished or depleted only when the quantity removed for use exceeds the quantity replenished by precipitation. The amount of groundwater annually available in northwestern Illinois far exceeds that used for all purposes.

Moisture is added to the groundwater reservoir by slow seepage downward through the openings in the soil and underlying materials until it reaches a zone in the earth below which all available openings, whether minute pores between grains or caverns in dense rock, are filled with water. The upper surface of this saturated zone is known as the water table, and its position is shown by the depth at which water stands in shallow wells, borings, and excavations. The water table generally rises to higher levels under hills than in valleys and is consequently an uneven surface which conforms more or less to the broader features of the land surface. Where the water table is intersected by the land surface, groundwater is discharged as springs, or in perennial streams, lakes, and swamps. The water level in a well reaching the saturated zone beneath the water table (a "water-table" well) will fluctuate as the water table fluctuates. When the water table drops below the well, as may happen, especially during extended dry periods, the well will be above the zone of saturation and consequently will be dry. Water-table wells are common sources of water supply in northwestern Illinois.

Groundwater is said to be confined or under artesian conditions where a deposit of permeable (water-transmitting) material is overlain by relatively impermeable material which restricts the upward movement of groundwater. Under these conditions, the water in the permeable material is subject to pressure which causes the water to rise in a well to a level above the top of the permeable material. Where artesian pressures are sufficient to cause water to rise above land surface, a well will flow without pumping. Much water is obtained from artesian wells in northwestern Illinois.

Groundwater is almost always in movement through earth materials, although this movement is slow when compared to the rate at which water may move on the land surface. Under water-table conditions, groundwater moves from higher levels to lower levels by gravity. Under artesian conditions, groundwater moves in response to differences in the hydrostatic pressure and moves always from areas of higher pressure to areas of lower pressure.

In order to supply a pumping well, groundwater must move through the earth materials toward the well. Pumping of water-table wells lowers the water table at the well and induces groundwater to flow in from adjacent areas. In artesian wells, groundwater moves toward the area of lowered hydrostatic

ROCK CLASSIFICATION		THICKNESS (ft.)	GRAPHIC LOG	WATER-YIELDING CHARACTER; DRILLING AND WELL-CONSTRUCTION DETAILS
PLEISTOCENE (drift, surface, or overburden)*	Unconsolidated glacial deposits, loess (windblown silt), and alluvium.	0-500		Water-yielding character variable. Thick permeable sand and gravel deposits chiefly in bedrock channels present possibilities for large municipal and industrial supplies. Normally requires well screens and careful development. Glacial deposits cased off in bedrock wells.
PENNSYLVANIAN (coal measures)	Principally shale with thin sandstone, limestone, and coal beds.	0-500		Generally unfavorable as an aquifer. Locally domestic and farm supplies obtained from limestone and sandstone beds. May require casing due to shale caving and poor-quality water.
MISSISSIPPIAN - Shale, gray, green		0-25		Not water-yielding. Requires casing.
DEVONIAN - Limestone		50-100		Not normally a source of water due to a lack of cracks or solution openings.
SILURIAN	NIAGARAN - ALEXANDRIAN (Niagaran) Dolomite, mostly pure in upper part to argillaceous near base. Lower part cherty.	300-500		Widely used as an aquifer where sufficiently thick. Cherty zones in lower part may cause drilling difficulties.
ORDOVICIAN	MAQUOKETA Green to blue shale with limestone and dolomite beds.	100-200		Limestone and dolomite beds locally water-yielding for small supplies. Soft, caving shale needs casing.
ORDOVICIAN	GALENA-PLATTEVILLE (Trenton) Largely dolomite with shaly zone near middle and some limestone beds in lower portion.	300-350		Widespread and dependable source of water for smaller municipal and industrial supplies. Some cherty zones may be encountered in drilling.
ORDOVICIAN	GLENWOOD - ST. PETER (St. Peter) Sandstone, clean, white. Dolomite and shale beds may occur at top. Green to red clay at base.	50-400		A dependable source of water for most purposes. Caving zones and hole-bridging particularly in lower part may present difficulties in well construction.
ORDOVICIAN	PRAIRIE DU CHIEN (Lower Magnesian) Dolomite with some sandstone beds.	0-400		Groundwater source for small supplies where near surface. Chert zones common.
CAMBRIAN	TREMPEALEAU Dolomite. Thin sandstone beds may occur at top of formation.	0-200		Water-yielding from crevices. Often a supplementary source in Galesville and Mt. Simon sandstone wells. Some chert zones and large crevices may be encountered.
CAMBRIAN	FRANCONIA - Green sandstone, shale, and dolomite.	80-120		Used as an aquifer only where it immediately underlies the glacial deposits.
CAMBRIAN	IRONTON - GALESVILLE (Dresbach) Sandstone, clean, white. Thin dolomite beds may occur in upper part.	130-250		Widespread important aquifer for all water-supply purposes. Contains one or more zones of high permeability particularly in basal portion. Some caving zones may be encountered.
CAMBRIAN	EAU CLAIRE Predominantly shale and dolomite in upper portion grading to sandstone at base.	400-450		Not important as an aquifer. May produce some water in wells drilled into Mt. Simon sandstone. Casing not generally required.
CAMBRIAN	MT. SIMON Sandstone with a few thin red shale beds.	1000-2000		Water-yielding and upper part sometimes penetrated by larger municipal and industrial wells. Depth to the aquifer restricts its use. Permeability not exceptionally high and water may be of relatively poor quality.
PRE-CAMBRIAN	Granite and other crystalline rocks.			Not an aquifer in northwestern Illinois.

* Drillers' terms in parentheses

Fig. 4. - Column of rock formations in northwestern Illinois.

pressure that was produced by pumping. The depression on the water-table surface or the artesian-pressure surface caused by pumping is in the form of an inverted cone with the well at the center and is called the cone of depression (fig. 3).

Unsuccessful well drilling shows that groundwater is not everywhere available in sufficient quantities to satisfy requirements. The availability of groundwater in humid regions such as northwestern Illinois is basically dependent upon the occurrence of water-yielding materials within the zone of saturation. Earth materials that will yield groundwater to a well are known as aquifers, and the physical characteristics of the aquifers, including extent and distribution, are controlled by the local geology. Some earth materials, such as sand and gravel, have characteristics that make them particularly good aquifers. Other earth materials, such as clay and shale, may contain as much or more water per cubic foot than sand and gravel, yet resist the movement of groundwater through them to such a degree that they will not yield water to a well. The value of an aquifer depends upon the type, size, number, and degree of interconnection of the openings, which may hold water and serve as conduits for groundwater.

In northwestern Illinois, the most important aquifers are deposits of sand and gravel, sandstone, and dolomite (a limestone-like rock rich in magnesium). Sand and gravel deposits are water-yielding because the openings between the individual grains are large enough to allow relatively rapid movement of water. Good water-yielding sand and gravel deposits are composed of grains that are nearly all the same size and coarser than granulated sugar. If large amounts of clay and silt are present in the sand and gravel deposits, the openings between the larger grains are clogged and the movement of water is retarded. Sand and gravel deposits in northwestern Illinois range in thickness from a few inches to hundreds of feet. Deposits a few feet or more thick are often suitable aquifers for drilled wells. Thinner deposits of sand and gravel in otherwise-tight earth materials are suitable aquifers only for dug or augered wells of large diameter.

Water-yielding sandstone formations transmit groundwater through the openings between sand grains. As in sand and gravel deposits, any material that clogs the openings between the sand grains reduces the water-transmitting capacity of the formation. Sandstone formations contain variable amounts of cement, and some sandstones are so thoroughly cemented that water movement occurs primarily through joints and fractures formed in the tight rock.

The major sandstone aquifers in northwestern Illinois, the St. Peter and Galesville sandstones (fig. 4), are thick, well sorted, and loosely cemented, and they are dependable aquifers for municipal and industrial supplies. Fine-grained, poorly sorted, well-cemented sandstones occur in the Pennsylvanian formations in southern Lee, Bureau, and LaSalle counties (figs. 4 and 5).

Tight, compact rocks like limestone and dolomite yield groundwater to wells from interconnected cracks and solution channels. Because these water-filled openings are irregular in size and distribution, the yields of closely spaced limestone or dolomite wells may be quite different.

Groundwater supplies throughout much of northwestern Illinois, particularly for domestic, farm, small industrial and municipal purposes, are obtained from near-surface dolomite formations. The dolomite formations are well-creviced and are a dependable source of groundwater.

GEOLOGY

The landscape of northwestern Illinois has been shaped principally by two geologic agents - running water and glacial ice. Running water is modifying this surface today by cutting into the land and depositing sediments in valley bottoms. The features produced by glacial ice, however, were developed during the past when great continental glaciers covered much of the northern United States. The glacial ice sheets, advancing outward from centers of snow accumulation in Canada, transported a great volume of rock debris and, in melting, deposited it as an irregular blanket that covers the solid layered bedrock in most of northern Illinois.

In Bureau, LaSalle, De Kalb, and southeastern Lee counties, the low broad northeast-trending ridges are thick accumulations of mixed clay, silt, sand, pebbles, and boulders which were heaped up along glacial margins. These ridges are called moraines.

In Carroll, Ogle, Stephenson, Winnebago, and Boone counties, the rolling land surface is underlain by thinner, much eroded glacial deposits from an earlier ice advance.

Northwestern Carroll County and most of Jo Daviess County (fig. 2) are part of the unglaciated area of the Upper Mississippi Valley. This area stood as an island within the ice sheets during the glacial advances of the Ice Age. Here ice-laid deposits are absent, and the rugged topography has been carved by running water.

Advances of glacial lobes greatly modified the drainage of northwestern Illinois. The former course of the Mississippi River south of Fulton was eastward across Whiteside, Henry, and Bureau counties (fig. 2) and down the valley of the Illinois River south of Spring Valley. This eastward course of the Mississippi was blocked by a lobe of ice that advanced westward across southern Whiteside County. A new channel was cut farther west, resulting in the course of the Mississippi as it is today.

The course of the Rock River south of Rockford is the result of a similar westward drainage diversion, produced by glacial ice advancing from the east and burying the old course of the river in eastern Ogle and Lee counties. To the east, in De Kalb and Boone counties, a major valley (Troy) paralleled the Ancient Rock River Valley and was nearly completely buried by glacial deposits (fig. 2).

The glacial deposits in northwestern Illinois are complex. Areas overridden by glaciers were blanketed by unsorted rock debris (called till) deposited as the ice melted. Beyond the ice front, sediment-laden meltwaters escaped down valleys, partially filling them with deposits (called outwash) consisting of sorted sand, gravel, and finer material. River flats, kept free of vegetation by frequent glacial flooding, were subject to wind erosion, and great volumes of silt were blown onto the uplands bordering the valleys to form loess. Loess, till, outwash, and the sediment of modern streams cover the bedrock surface in most of northwestern Illinois.

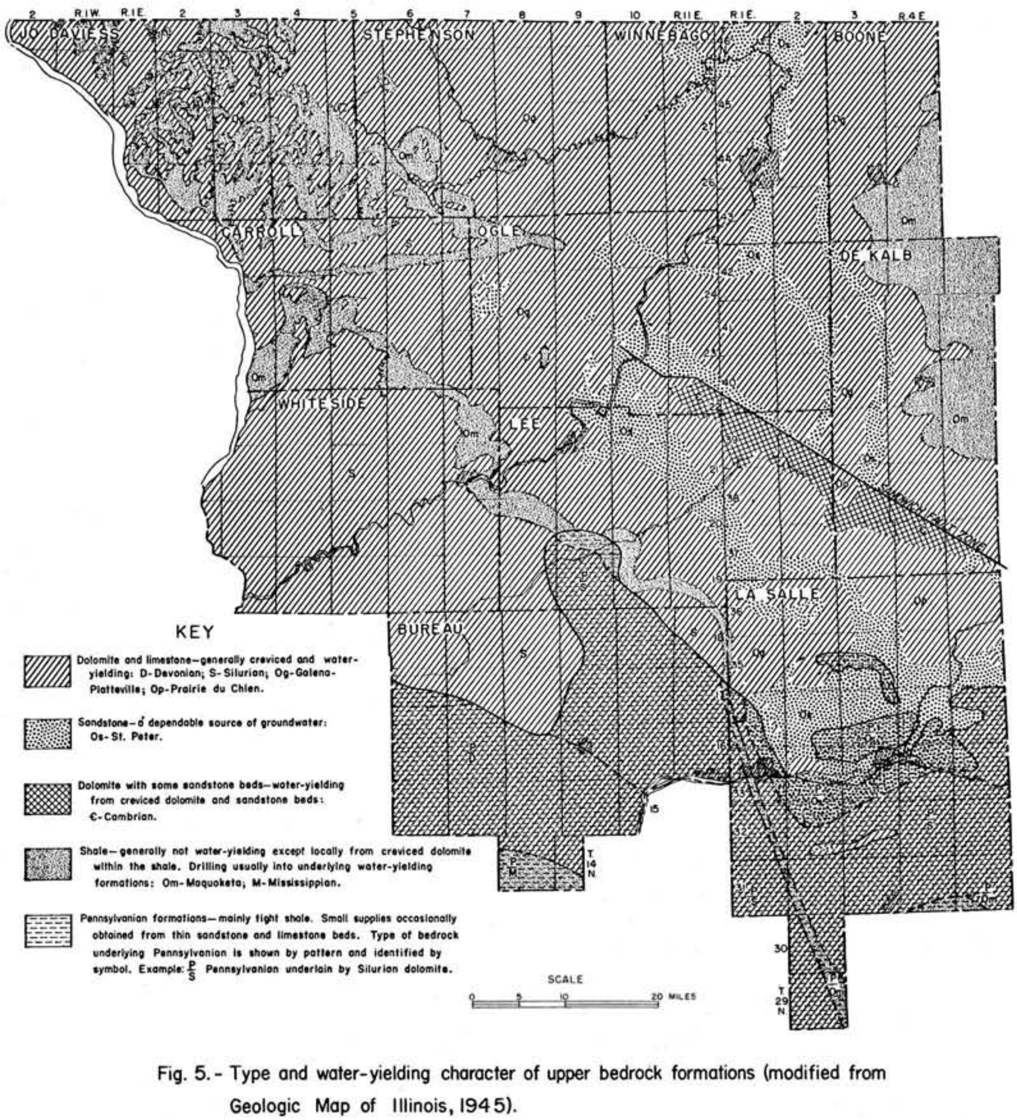

Fig. 5.- Type and water-yielding character of upper bedrock formations (modified from Geologic Map of Illinois, 1945).

Because the great glaciations of the Ice Age occurred recently in geologic time, the landscape of much of northwestern Illinois is fairly young. An older landscape - carved in the bedrock largely before the glaciers advanced into the area - is present beneath the mantle of glacial deposits. A part of this bedrock surface is exposed in the unglaciated area in Jo Daviess and northwestern Carroll counties.

Where glacial deposits cover the bedrock, much of our information about the bedrock topography comes from records of wells and borings. Some surface valleys coincide with older valleys in the bedrock, but in areas of very thick glacial deposits the surface valleys and older bedrock valleys may not correspond. For example, the Ancient Mississippi Valley in Bureau County (figs. 2 and 6) contains over 300 feet of glacial deposits, and no evidence of its presence is seen at the surface.

The bedrock, beneath the glacial deposits in most of northwestern Illinois and at the surface or beneath the loess in the unglaciated area, consists of layers of limestone, dolomite, shale, and sandstone arranged one upon the other like the pages of a thick book (fig. 4). Although they are firm, compact rocks now, they were originally deposited as loose sediments in shallow seas that invaded the continent. They were buried and hardened into solid rock during the several hundred million years after the seas had retreated from Illinois. The rocks were later warped and in some places broken, so that today they are not in the horizontal position in which they were deposited as sediments on the sea floor.

In western LaSalle and Lee counties, the rocks are folded into an asymmetrical arch or anticline with a steeply dipping western limb and gently dipping eastern limb. This structure is called the LaSalle anticline (figs. 2, 5, 7, and 8). Beds on the western limb dip westward as much as 2000 feet per mile, with the result that any given bed is encountered at a greater depth west of LaSalle than east of LaSalle. For example, the St. Peter sandstone is at the surface at Starved Rock State Park, but in wells at Peru the St. Peter is encountered at a depth of some 1400 feet.

Other folds and warps are common in northwestern Illinois, as shown in figures 5, 7, and 8, but they are gentler than the LaSalle anticline and have dips of about 75 feet per mile or less. Because deformation of the bedrock layers has inclined them at some angle to the land surface, a particular rock layer appears at the surface or beneath the glacial deposits in a band or irregular patchwork pattern. The distribution of the various rock layers at the surface or immediately beneath the glacial deposits is shown in figure 5.

The bedrock layers have been fractured as well as folded in some places in northwestern Illinois. Fractures along which there has been a sliding movement of the rocks are called faults. One long fault zone - the Sandwich fault zone - extends southeastward through Ogle, northeastern Lee, and De Kalb counties (figs. 2, 5, 7, and 8). Movements along the fault have resulted in rocks being displaced as much as 900 feet vertically.

Beneath the layered rocks is a basement of ancient crystalline rock. The crystalline rock is mainly granite, as shown by a few very deep borings in Illinois. Oil tests in Winnebago, Boone, De Kalb, and Lee counties have struck the granite basement at depths ranging from 2650 feet to 3845 feet. In much

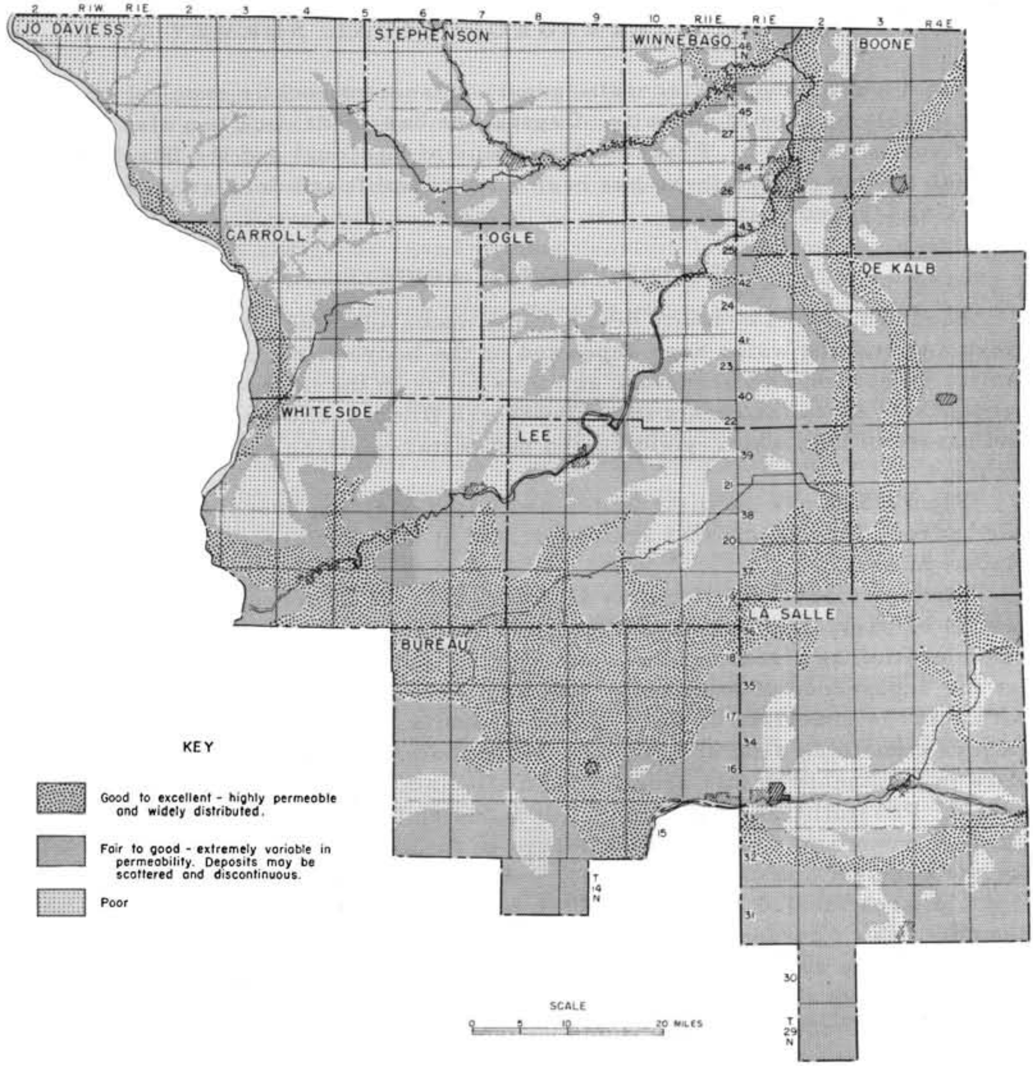

Fig. 6. - Possibilities for occurrence of sand and gravel aquifers.

of central and northern Wisconsin, granite basement rock is exposed or is covered only by glacial deposits. Crystalline basement rock can also be seen at the surface in the St. Francois Mountains of Missouri and the Black Hills of South Dakota, where there has been marked uplift and deep erosion of the overlying layered rocks.

DISTRIBUTION OF AQUIFERS

Sand and gravel deposits occur in the unconsolidated material that glaciers and running water have deposited on the bedrock surface (fig. 3). Dolomite, limestone, and sandstone aquifers occur in the bedrock. The vertical sequence of earth materials in northwestern Illinois, showing the occurrence and nature of both water-yielding and non-water-yielding beds, is given in figure 4.

Figure 5 shows the distribution and water-yielding properties of the upper bedrock formations that are penetrated at land surface or beneath the glacial material.

In many places, particularly along the courses of present streams or of glacial or preglacial drainage ways, sand and gravel deposits merit careful consideration as a source of groundwater. Figure 6 shows the possibilities for the occurrence of sand and gravel aquifers. The area labeled "good to excellent" is underlain by thick glacial deposits, especially in major bedrock valleys containing sand and gravel. Groundwater for domestic and farm supplies is obtainable in this area from small-diameter drilled wells in sand and gravel. Possibilities for municipal or industrial wells are good to excellent, although some test drilling is necessary to locate the best formation and site for the construction of high-capacity wells.

The area labeled "fair to good" in figure 6 has moderately thick glacial deposits, which border the deep channels of bedrock valleys or fill minor valleys, and some sand and gravel. Groundwater for domestic and farm supplies is obtainable locally in this area from drilled wells in sand and gravel, but at some locations these deposits are absent and bedrock wells are necessary. The possibilities for obtaining supplies of water for industrial and municipal purposes are poor to fair. Extensive test drilling is likely to be necessary to locate water-yielding sand and gravel deposits suitable for such purposes.

The area labeled "poor" is primarily bedrock upland with glacial deposits thin or absent. Sand or gravel capable of supplying groundwater is rare, and drilled wells generally penetrate bedrock.

Figures 7 and 8 show elevations above or below sea level of the tops of two major bedrock aquifers of northern Illinois: the Glenwood - St. Peter sandstone and the Ironton-Galesville sandstone. Depth to these formations at any location can be calculated by subtracting the formation elevation from land-surface elevation obtained from topographic maps. For example, if land-surface elevation is 625 feet and the Glenwood - St. Peter elevation is 200 feet, depth to the formation is 625 minus 200, or 425, feet. If land-surface elevation is 700 feet and the elevation of the Ironton-Galesville is −400 feet (below sea level), depth to the formation is 700 minus (−400), or 1100, feet.

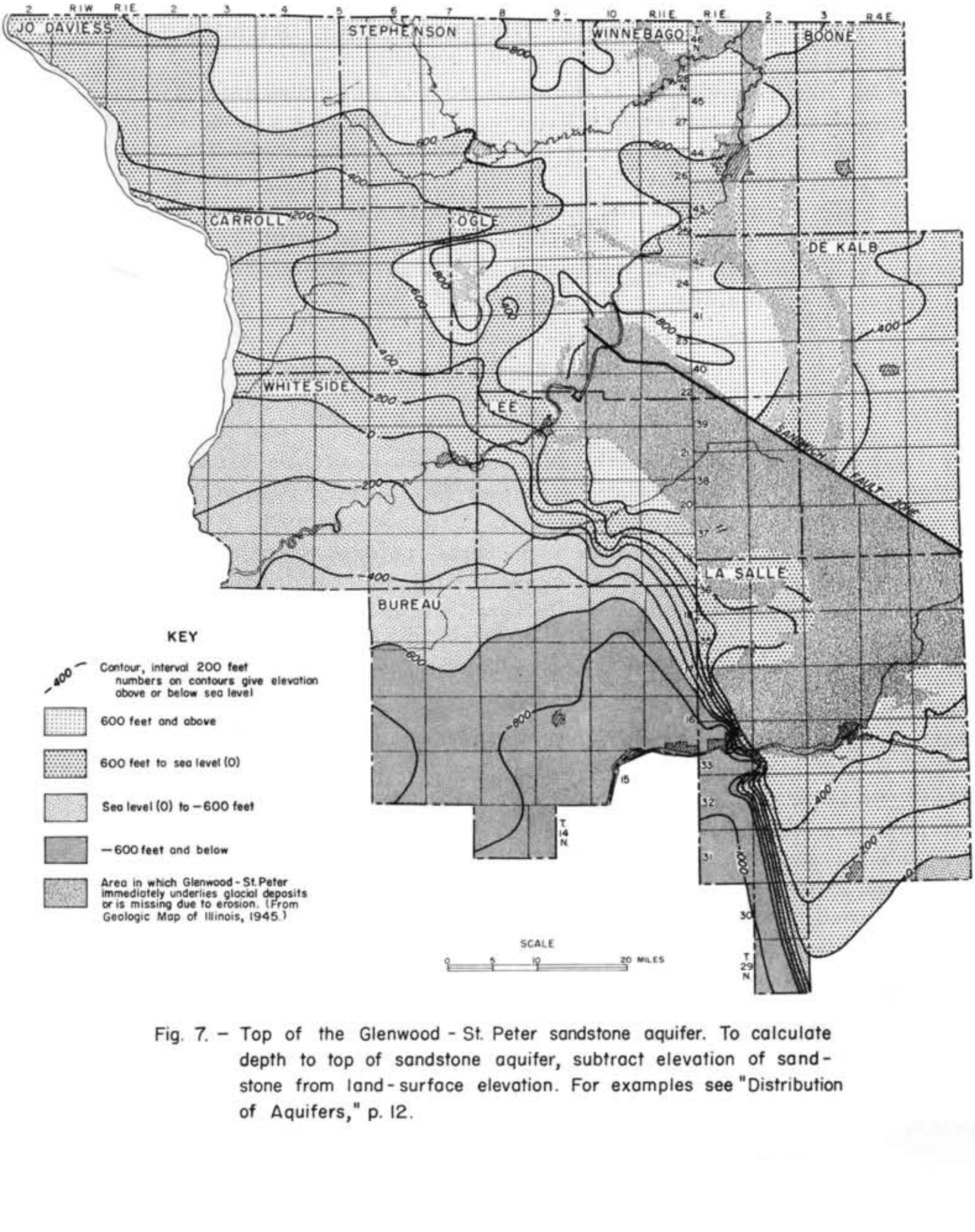

Fig. 7. – Top of the Glenwood - St. Peter sandstone aquifer. To calculate depth to top of sandstone aquifer, subtract elevation of sandstone from land-surface elevation. For examples see "Distribution of Aquifers," p. 12.

The St. Peter sandstone is the main source of groundwater for many municipal supplies in northwestern Illinois. Its value as a groundwater source is somewhat limited by variations in thickness and permeability and, in some areas, by poor water quality.

Hundreds of industrial and municipal wells obtain water from the Galesville sandstone, considered the best bedrock aquifer in Illinois because of its consistent permeability and thickness. Many deep wells also obtain part of their yields from the deeper Mt. Simon sandstone.

GROUNDWATER DEVELOPMENT

Drilled Wells

Conditions in most of northwestern Illinois are favorable for the use of drilled wells. Drilled wells are the most satisfactory type of well and their use is recommended wherever geologic conditions permit. A drilled well produces water directly from the aquifer; therefore, its production during pumping cannot exceed the water-transmitting capacity of the aquifer. An important limitation of drilled wells is a lack of storage in the well bore.

Municipal, Industrial, and Irrigation Supplies

Development of groundwater supplies for large-scale use, such as for municipal, industrial, and irrigation purposes, requires technical assistance and careful planning based on all available geologic and hydrologic data. It is necessary to know the type of aquifers present and their extent, thickness, depth, distribution in the area, and water-yielding character. It is also desirable to know those characteristics of the geologic formation that may affect well construction. Hydrologic data, such as yield of existing wells, pressure potential of the various formations, and water quality, are also important considerations.

Information on geologic conditions pertaining to groundwater supplies at prospective well locations is available upon request from the State Geological Survey. The Geological Survey provides basic geologic studies of a regional nature and maintains a current file of subsurface information, including drillers' logs and samples of drill cuttings, from which specific data on formation characteristics are available for many areas in the State. Information on well yields, water levels, and water quality is furnished by the State Water Survey.

There is an increasing interest in northwestern Illinois in the development of groundwater supplies from the extensive deposits of highly permeable sand and gravel. Sand and gravel aquifers have many advantages for large-scale groundwater developments: 1) they may yield more water to a specific well than the bedrock formations; 2) they are generally shallower than bedrock aquifers; and 3) they generally have higher static water levels, colder water, and, in some places, water of better mineral and bacterial quality.

Groundwater development from sand and gravel sources generally requires, however, special well-construction techniques to take full advantage of the water-yielding capacity of the material. Sand and gravel wells require use of screens, which will allow free movement of water while preventing intrusion of sand or gravel into the well bore. Proper well construction in sand

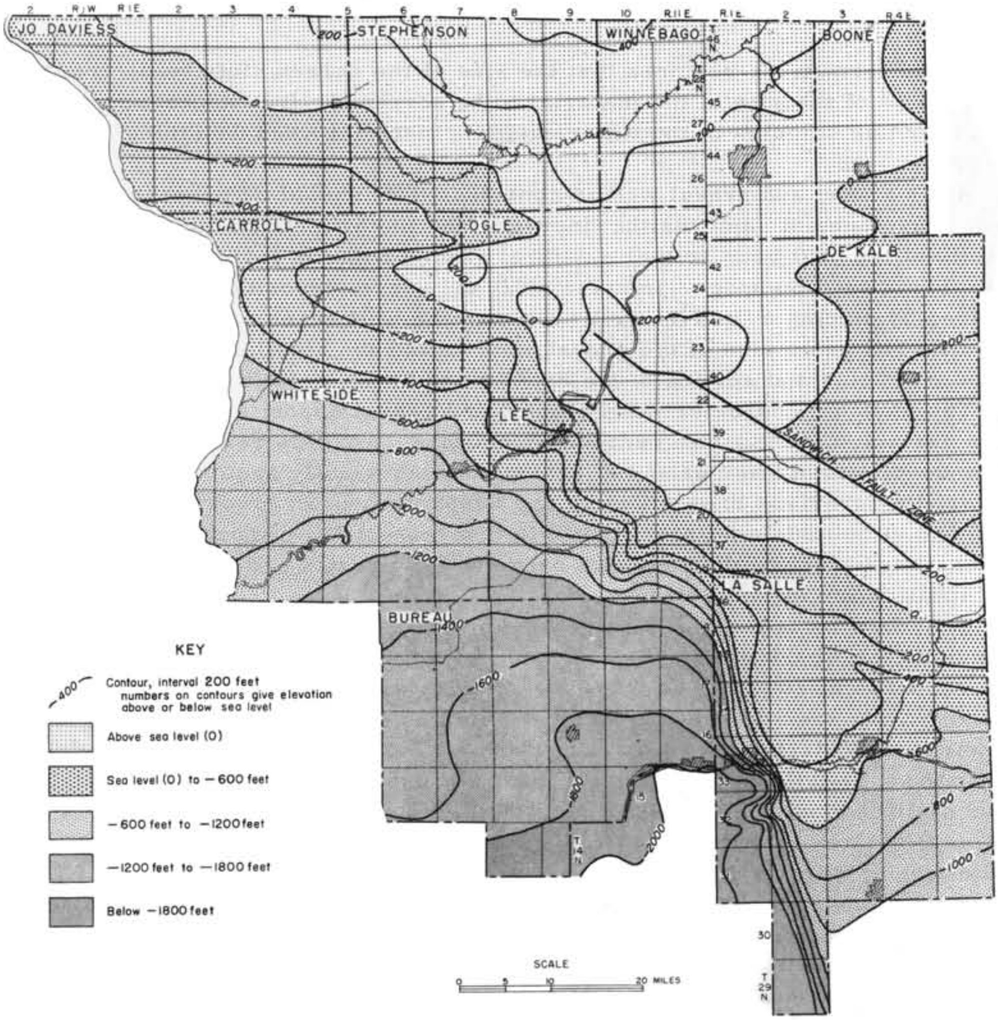

Fig. 8.- Top of the Ironton-Galesville sandstone aquifer. To calculate depth to top of sandstone aquifer, subtract elevation of sandstone from land-surface elevation. For examples see "Distribution of Aquifers," p. 12.

and gravel formations requires that the size of the screen slots be determined on the basis of the size of the material to be screened. It is necessary, therefore, to obtain samples of the water-yielding material when designing a sand and gravel well.

After a sand and gravel well is constructed, it should be properly developed. Development removes the finer-grained material from the immediate vicinity of the well bore so that a natural graded filter is formed that reduces or prevents sand pumpage. In some sand and gravel deposits, best results are obtained by placing a "gravel pack" between the well screen and the natural deposit. The grain size of the gravel pack must have a definite relationship to the grain size and sorting of the deposit and to the well-screen slot size.

The physical characteristics of sand and gravel deposits are generally more variable than those of bedrock formations. For this reason, groundwater development from sand and gravel sources usually requires extensive test drilling previous to well design and construction. In areas where the presence of suitable aquifers is uncertain, a test-drilling program is necessary to determine whether suitable deposits are present and, if present, the best location for the well site.

Test drilling is most generally done by drilling small-diameter holes with cable tool (percussion) or with rotary drilling equipment. The test driller's report is an important part of the groundwater development program and should include the following information when obtainable: 1) driller's log of formations penetrated, 2) static water level and changes in water levels during drilling, 3) drilling time of the individual formations, 4) weight and viscosity of drilling mud, and 5) loss of mud or fluid during drilling. Samples of drill cuttings should be saved at five-foot intervals and where there are changes in the type of material.

Wells constructed in bedrock aquifers are generally less difficult to design because the well bore is usually left uncased and because the aquifers are more consistent over wider areas. Test drilling in bedrock aquifers is rarely used, particularly where records of prior drilling in the area are available.

In northwestern Illinois the most important geologic factors affecting well construction in bedrock aquifers are: 1) type, thickness, depth, and permeability of aquifers, 2) ability of formations to sustain open hole without casing or lining, and 3) tendency of formations to yield silt or sand during pumping.

Creviced dolomite and limestone do not normally require casing or lining. However, where groundwater supplies are obtained from near-surface dolomite or limestone formations, with less than about 35 feet of overburden, there is danger of bacterial pollution. The open crevices provide little filtering action, and polluted water may travel long distances through these openings.

Normal drilling procedure in the development of bedrock aquifers is to install surface casing to firm bedrock and to continue into the bedrock with an open hole. Where bedrock formations are too weak to sustain an open hole, it may be necessary to continue the surface casing through the weak formation into a more competent underlying formation or to set liners. The most important caving zones requiring casing are in the Pennsylvanian and Maquoketa shales and, at some localities, shale beds in the lower part of the St. Peter formation (fig. 4). Casing also may be required to prevent contamination by poorer quality water from upper formations.

Caving of loose zones in sandstone formations, principally in the lower portion of the St. Peter and the Galesville, presents drilling difficulties. Normally these zones cannot be cased without drastically reducing the well yield. Wells to the lower portion of the St. Peter sandstone commonly use a "rat hole" drilled into the underlying formations to serve as a collector of loose sand.

The pumping of some fine sand or silt from high-capacity wells is unavoidable in most instances. Silt or sand pumpage is sometimes excessive, and remedial measures must be taken. The Illinois Geological Survey frequently assists in the solution of these problems by identifying the source of the materials. The most common sources of earth materials pumped with water are: 1) silt and clay from glacial deposits, caused by leaks in surface casing or poorly seated casing, 2) silt and clay from weak shale zones that have been left uncased or are improperly cased, 3) silt and clay from open crevices in dolomite, particularly directly beneath the glacial deposits, and 4) silt and fine sand from sandstones.

Most of these problems can be corrected by installing casing or liners. In sandstone formations, however, casing may drastically affect the well yield. There are three common causes of excessive silt and sand pumpage from sandstone formations; attention to these causes should result in reducing sand pumping: 1. Drilling too small a hole in loose sandstone formations. The smaller the diameter of the well bore, the greater the velocity of water moving through the formation immediately around the well bore. Enlarging the diameter of the well bore or reducing the pumping rate decreases the velocity of water movement. 2. Setting the pump bowls opposite unprotected loose zones in the sandstone. Turbulence in the vicinity of the pump bowls causes enlargement of the hole. 3. Shooting loose sandstone zones with too much explosive and with too little regard for the condition of the sandstone.

Domestic and Stock Supplies

Groundwater developments for domestic and stock use differ from municipal, industrial, and irrigation developments in three important aspects: 1) the quantity of water needed for domestic and stock purposes is considerably smaller and may, therefore, be provided from considerably thinner and less-permeable aquifers, 2) the area within which a well can be constructed for domestic or stock purposes is normally small, usually a farmyard or a suburban lot, and 3) the cost of well construction must be low, which prohibits deep drilling.

In northwestern Illinois, geologic conditions are generally favorable for obtaining private water supplies at minimum cost. Throughout most of the area, creviced dolomite and water-yielding sandstone underlie the glacial deposits or are at sufficiently shallow depth to be within reach of private wells. Water-yielding sand and gravel are widespread, particularly in areas of thicker glacial deposits.

Only in southern Bureau and LaSalle counties are geologic conditions locally unsatisfactory for drilled wells. Here thin glacial deposits are underlain by tight Pennsylvanian shale formations, and drilled wells are successful only where drilling penetrates water-yielding sandstones in the Pennsylvanian rocks. At some locations construction of shallow large-diameter dug or augered wells is necessary to obtain satisfactory water supplies.

Subsurface geologic conditions will normally vary little within the limited area of the individual homesite. However, there may be considerable variation in geologic conditions with depth. Information on depth of aquifers will be valuable in planning the size, type, and depth of the intended well.

Perhaps the most important considerations in location of private well sites are sanitation and convenience of location. All wells should be located with consideration for geologic conditions, surface drainage, topography, and land use, so as to provide maximum protection from harmful bacteria and objectionable inorganic material.

The following suggestions may be helpful in planning for suburban and farm groundwater supplies.

1. Inventory the water requirements - check on the amount of water needed for domestic use, stock use, milk cooling, and fire protection.

2. Obtain available information on the occurrence of water-yielding formations at the location. The maps in this report are designed to give a basic understanding of the occurrence and distribution of aquifers so that the most suitable type of well may be planned. If additional, more specific information is desired, contact the State Geological Survey, Urbana, Illinois. In the request a description of the property by section, township, and range should be given in addition to the intended use of the water supply, an estimate of the quantity desired, and all information on existing wells on the property or previous drilling attempts.

3. Select a well driller with a reliable reputation for constructing wells that have proved to be trouble-free. Make sure the driller is capable of properly handling the types of aquifers at the location. If the well is to be finished in sand and gravel, select a driller experienced in setting well screens.

4. Check with the State Department of Public Health for regulations and suggestions on proper well construction and location and proper pump housing. The State Department of Public Health discourages the use of well pits on Grade A milk farms unless they are built to very rigid specifications. Properly constructed well pits are more expensive than other approved methods of pump installation.

5. Make periodic bacterial analyses of the water supply. Dug wells are more difficult to keep sanitary than are properly constructed drilled wells. Wells drilled into creviced dolomite and limestone formations are, however, also susceptible to bacterial pollution, particularly where the creviced formation is overlain by less than 35 feet of cover.

Role of the Drilling Contractor

Much of the success of any drilled well depends on the skill and knowledge of the drilling contractor. A drilling contractor has certain duties and responsibilities to his customers.

1. The driller should provide an accurate log of the boring at the time it is completed. The log should include a description of the formations, information on the static water level, basic construction features of the well (length and size of well casing and screen, etc.), and an indication of the capacity of the well as determined by a pumping test. In accordance with the mining laws of Illinois, copies of the driller's log must be filed with the State Geological Survey and the State Water Survey. Log books may be obtained by drillers without charge from the State Geological Survey.

2. The well should be constructed in accordance with accepted sanitary practices. The top of the well should be constructed to prevent surface pollution from entering the well or seeping downward around the casing. It is also desirable that well construction allow for measurement of the depth to water without requiring removal of the pumping equipment.

3. The driller should endeavor to take full advantage of any water-yielding formations he may encounter. In areas where groundwater conditions are generally unfavorable, it takes a skillful driller to obtain the maximum amount of water from a poor formation. Where sand and gravel aquifers are used as a source of groundwater, the driller should select a well screen on the basis of size and sorting of the formation material. After construction the well should be properly developed. A properly screened and developed well in sand and gravel will not pump an objectionable amount of sand or silt during service. Use of slotted pipe or open-bottom casing should be avoided except in very coarse sand or gravel where the ability of the well to yield water far exceeds the demand.

4. It is desirable to save samples at five-foot intervals for the total depth of drilling, for municipal, industrial, irrigation, and school-well construction, particularly. The State Geological Survey files samples of drill cuttings received from drillers. The samples may be sent express collect to the Survey where they will be studied and permanently filed. Information obtained from samples is vital in effective rehabilitation of oil wells.

Driven Wells

In many areas in northwestern Illinois, geologic conditions are particularly favorable for the use of driven wells. Driven wells are the quickest and most economical method of well construction and are practical where groundwater can be obtained from sand and gravel at depths not exceeding 50 to 60 feet. Suitable conditions for driven wells are in bottomlands of many rivers, such as the Rock, Mississippi, and the Illinois west of Utica, and in extensive outwash flats, such as are present in southwestern Lee and southern Whiteside counties and north and east of Belvidere in Boone County.

Large-Diameter Wells

Large-diameter wells that are excavated by hand or by power auger are widely distributed in northwestern Illinois. At one time they were the most common type of well for private supplies. In some areas where geologic conditions are generally unfavorable for drilled wells, the large-diameter well still serves a useful purpose. However, in areas where conditions are favorable for drilled wells, the use of large-diameter wells is not recommended, owing to the difficulty of keeping them free of pollution.

The chief advantage of a large-diameter well is that it can store large quantities of water. When this type of well is intermittently pumped for short periods, the well can refill slowly during the intervening periods. This is a distinct advantage in areas where the earth materials are generally too tight to support the pumping demands of a drilled well. Construction of large-diameter wells is, however, restricted to the softer unconsolidated material overlying bedrock, and its use is usually practical only in areas where the thickness of this cover exceeds 15 feet.

COUNTY GROUNDWATER SUMMARIES

Detailed information on groundwater supplies in the counties of northwestern Illinois follows. These discussions supplement the geologic information shown on the maps in figures 2, 5, 6, 7, and 8.

BOONE COUNTY

Shallow and deep sand and gravel deposits are potential groundwater sources. Shallow deposits of glacial outwash underlie the lowlands north and east of Belvidere and extend east to the high moraines in McHenry County. The outwash flats contain sand and gravel and are suitable for dug wells and driven sand-points.

Deep sand and gravel deposits occur north and southwest of Belvidere in and bordering the buried Troy Valley (figs. 2 and 6). Many successful sand and gravel wells have been constructed at depths less than 50 feet in the northern part of the county. Also, in the north, glacial deposits as much as 400 feet thick are reported in the Troy Valley. Glacial deposits south and east of Belvidere are thinner, and most wells are completed in the Galena-Platteville dolomite.

BUREAU COUNTY

Deposits of water-yielding sand and gravel occur at various depths. Deposits more than 400 feet below land surface lie within the buried Mississippi and lower Rock valleys (figs. 2 and 6). Although the deposits in these channels are permeable, their depth makes it desirable to develop shallower aquifers where the latter are present. Locally, drive-point wells in shallow sand and gravel aquifers are used, particularly in northwestern Bureau County. Sand and gravel aquifers at intermediate depths commonly contain gas except in the northwestern portion. Drillers report that water from sand and gravel deposits in northwestern Bureau County often appears rusty.

In southwestern Bureau County, glacial deposits locally are thin, and drilling is continued into the underlying bedrock. Much of Bureau County is covered by Pennsylvanian formations (fig. 5). These formations are chiefly tight shales and are water-yielding only where more-permeable sandstone beds are present. The Pennsylvanian formations are underlain by the Silurian dolomite in the northern and eastern parts of the county, by the Devonian limestone in the southwest, and by Mississippian shale in the extreme south. Of these, only the Silurian dolomite is a dependable source of groundwater.

CARROLL COUNTY

The glaciated upland south and east of Mt. Carroll contains thin glacial deposits with poor possibilities for drilled wells in sand and gravel. Thick permeable sand and gravel deposits occur in the Mississippi Valley, and favorable deposits may also be present in the valley of Johnson Creek south and east of Mt. Carroll.

The Silurian and Galena-Platteville dolomites are creviced and water-yielding. Most domestic wells obtain water from these formations at depths of less than 250 feet.

DeKALB COUNTY

Thick glacial deposits, exceeding 100 feet at most places, mantle the bedrock surface in the four southern tiers of townships in De Kalb County. Here sand and gravel deposits suitable for drilled and dug wells are widespread. The thickest sand and gravel occurs in the buried Troy Valley (figs. 2 and 6). In the northern part of the county, glacial deposits are thin, and most drilled wells penetrate bedrock.

The Sandwich fault zone (figs. 2, 5, 7, and 8), along which older rocks - mainly dolomite with some sandstone beds - have been brought into contact with the Galena-Platteville dolomite, crosses southern De Kalb County. The Galesville sandstone is at least 400 feet shallower south of the fault zone than north of it.

Drilled wells in the upper bedrock obtain groundwater from the Galena-Platteville dolomite north of the Sandwich fault zone. In eastern De Kalb County limestone and dolomite beds in the Maquoketa shale are locally water-yielding.

JO DAVIESS COUNTY

Most of Jo Daviess County, as shown in figure 2, is in the unglaciated area, where the landscape is rugged, bedrock is widely exposed, and water-yielding sand and gravel deposits are rare. Wells completed in Silurian dolomite, which caps many of the ridges, obtain groundwater that is "perched" on the less-permeable Maquoketa shale.

Water-yielding limestone and dolomite beds are present in the upper part of the Maquoketa in some places. The Galena-Platteville dolomite below the Maquoketa is creviced and is a dependable source of groundwater for farm and domestic wells.

Thick permeable sand and gravel deposits are present in the Mississippi Valley. The lower portions of tributary valleys contain considerable fine-grained material deposited in ponded streams during glacial high-water stages of the Mississippi River, but locally sand and gravel deposits are present.

LaSALLE COUNTY

Most domestic drilled wells obtain water from the St. Peter and Galena-Platteville formations, except in buried bedrock valleys where the glacial deposits are thick. The bedrock surface falls off sharply along the Ancient Rock Valley northwest of Mendota (fig. 2), and glacial fill, containing thick sand and gravel deposits, locally attains a thickness of about 500 feet. In the buried Ticona Valley (fig. 2), glacial deposits are over 200 feet thick at most places, and sand and gravel is present 100 feet or more beneath the land surface. The upper parts of sand and gravel deposits in the Ticona Valley are reported by drillers as "dry" in some places. Permeable sand and gravel deposits occur beneath the valley flat of the Illinois River in the LaSalle-Peru area.

The St. Peter sandstone, the Galena-Platteville dolomite, and the Prairie du Chien dolomites are dependable groundwater sources for domestic wells. West of the LaSalle anticline, these formations are too deeply buried to be exploited for domestic wells. In southern LaSalle County, Pennsylvanian rocks overlap older rocks of several ages. Where groundwater is not available in the glacial deposits of the LaSalle-Peru area, there is some chance of obtaining domestic supplies from the LaSalle limestone, one of the Pennsylvanian formations. In general, the Pennsylvanian rocks - mainly shale - are not dependable groundwater sources. They are cased off in wells drilled to deeper formations.

The deep sandstone formations in southern LaSalle County contain highly mineralized water.

LEE COUNTY

The thickest, most permeable sand and gravel deposits in Lee County are in the buried Rock Valley (figs. 2 and 6). The depth to these deposits may exceed 200 to 300 feet on the highlands in southeastern and eastern Lee County; consequently, drilling costs in that area are higher than in other parts of the county. Near-surface deposits locally suitable for drive points are present in the flat low-lying area near the western margin of Lee County and northeastward along the Green River to the Lee-Ogle county line south of Rochelle. Shallow sand and gravel deposits locally suitable for driven wells are also present in the valley of the Rock River in northwestern Lee County.

The majority of groundwater supplies in northern Lee County are obtained from bedrock. Southwest of a line drawn through Dixon in Lee County and Mendota in northwestern LaSalle County, bedrock aquifers are creviced Silurian and Galena-Platteville dolomites and limestone and dolomite beds within the Maquoketa shale formation. In a portion of southern Lee County (fig. 5), the glacial deposits are underlain by tight Pennsylvanian formations. In this area, particular attention should be directed toward development of sand and gravel aquifers.

The glacial deposits in northeastern and eastern Lee County are underlain by the St. Peter sandstone, Prairie du Chien dolomite, and dolomites and sandstones of Cambrian age. These formations are normally water-yielding, although the dolomites may not be as extensively creviced as the Galena-Platteville and Silurian dolomites. Municipal and industrial supplies are obtainable from the St. Peter, Galesville, and, in northeastern Lee County, the Mt. Simon sandstones. As shown in figures 7 and 8, the depths to these formations vary greatly.

OGLE COUNTY

Excellent sand and gravel aquifers suitable for municipal and industrial groundwater supplies are present in western Ogle County. These deposits are concentrated in the buried Rock Valley along the western border of the county and in the buried Troy Valley in the northeastern corner of the county (figs. 2 and 6). Between the Rock and Troy valleys, however, bedrock is very near land surface, and water-yielding sand and gravel deposits are generally absent.

Sand and gravel deposits suitable for farm and domestic supplies are also restricted to valleys in the surface of the bedrock. An old valley south of a line between Oregon and Rochelle contains sand and gravel locally suitable for farm and domestic groundwater supplies. Sand and gravel aquifers are locally present west of Oregon but are thin and discontinuous. Drilling here is generally continued into the underlying water-yielding bedrock. Shallow sand and gravel deposits along the Rock River are suitable for drive-point wells.

Groundwater is obtainable from bedrock aquifers with little difficulty throughout most of Ogle County. As shown in figure 5, however, the type of bedrock at or near the surface changes rapidly within short distances south and east of Oregon. The thickness of the St. Peter sandstone is quite variable, particularly at Rochelle and eastward.

STEPHENSON COUNTY

Glacial deposits throughout most of Stephenson County are thin and bedrock is exposed over much of the area. Water-yielding sand and gravel deposits are restricted to deeper valleys in the bedrock surface. The Pecatonica Valley at Freeport and eastward contains sand and gravel suitable for municipal and industrial wells. Thinner but consistent sand and gravel deposits are present along an older valley now occupied by Yellow Creek and in a valley in the bedrock surface southwest of Freeport (fig. 6).

In southwestern Stephenson County, groundwater is obtained from the Silurian dolomite and from limestone and dolomite beds within the Maquoketa shale (fig. 5). In some places drilling penetrates through these formations into the underlying creviced Galena-Platteville dolomite or the St. Peter sandstone.

WHITESIDE COUNTY

Sand and gravel deposits in the Ancient Mississippi Valley (figs. 2 and 6) are thick and permeable and suitable for municipal and industrial groundwater developments. Shallow sand and gravel deposits cover most of southern Whiteside County in the low sand plain south of a line from Morrison to Sterling-Rock Falls. Locally, where these deposits lie directly on the permeable deposits in the buried valleys, there may be more than 275 feet of continuous permeable sand and gravel from ground surface to bedrock. Outside the area of the buried valleys, the more-extensive shallow deposits are generally less than 75 feet thick and are suitable for driven and drilled wells.

Sand and gravel aquifers in northern Whiteside County are thinner and less numerous, except in the Mississippi Valley in northwestern Whiteside

County (fig. 6). Most of the groundwater supplies in northern Whiteside County are obtained from bedrock aquifers. The major bedrock aquifer is the Silurian dolomite. Drilling into the deeper St. Peter and Galesville sandstones is generally necessary only for large municipal and industrial needs. The Maquoketa shale, which occurs at shallow depths near Sterling-Rock Falls, contains creviced limestone and dolomite beds that are utilized as groundwater sources.

WINNEBAGO COUNTY

Excellent sand and gravel aquifers occur in the Ancient Rock Valley (figs. 2 and 6). Both municipal and industrial supplies are obtained from permeable sand and gravel fill in this valley at Rockford, where over 350 feet of clean coarse sand and gravel have been penetrated in drilling. There has been little development of sand and gravel aquifers in the Pecatonica Valley in Winnebago County, and little is known about the valley fill.

Most individual water supplies in the upland areas are obtained from the widespread creviced Galena-Platteville dolomite or the underlying Glenwood-St. Peter sandstone. These formations are also sources of supply for smaller municipalities and industries. Pollution of water supplies from the Galena-Platteville dolomite has occurred in populated areas. Drilling into the underlying St. Peter sandstone formation and casing-out polluted water from the Galena-Platteville formation is a possible solution in some places.

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Topographic maps are available for most of the area covered in this report. In the Rockford region these maps are on a scale of approximately 2 1/2 inches to the mile. In the remainder of the area they are on a scale of 1 inch to the mile. They are printed by quadrangles and can be obtained from the Illinois State Geological Survey, Urbana, Illinois, or from the United States Geological Survey, Washington 25, D. C., for 20 cents each. Index maps showing the topographic map coverage of the State are free.

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