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GROUNDWATER GEOLOGY IN SOUTHERN ILLINOIS

A Preliminary Geologic Report

by

Wayne A. Pryor

Service activities concerning groundwater are performed jointly by the Illinois State Geological Survey and the Illinois State Water Survey

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ABSTRACT

The likelihood of finding groundwater for private, municipal, and industrial supplies in southern Illinois ranges from poor to excellent. This report summarizes, in general, the geologic conditions controlling the occurrence and availability of groundwater and suggests efficient ways to obtain it under prevailing conditions. Maps indicate probable occurrence of (1) water-yielding sand and gravel deposits, (2) water-yielding bedrock formations, and (3) undeveloped groundwater sources that may be suitable for private, municipal, industrial, and water-flood supplies.

The best potential sources of large supplies of water are sand and gravel deposits in the major valley systems. Unfavorable conditions generally prevail elsewhere because water-yielding sand and gravel is absent, the bedrock formations are tight, or the available groundwater is of poor quality.

INTRODUCTION

Expansion of the economy of any area is dependent in large part on the availability of water for domestic supplies, farms, municipalities, and industries. Large quantities of water for these users are obtained from streams and lakes, but in southern Illinois even larger quantities are taken from wells. Water obtained by wells is called groundwater.

The availability, quantity, and quality of groundwater is controlled by the geologic conditions beneath the earth's surface. In some areas groundwater is readily available for all purposes and in others very little, if any, groundwater is available. Any groundwater supply, whether for small domestic needs or for the large requirements of municipalities or industries, can be obtained only under suitable geologic conditions. The physical characteristics of the strata underlying the surface control the availability of groundwater for well supplies; that is, where the strata are water-transmitting or permeable, successful wells can be constructed, but where the strata are not water-transmitting or relatively impermeable, it is impossible to construct successful wells.

Knowledge of the distribution and character of water-yielding strata in any area is necessary in developing groundwater resources properly. This report provides information on the availability of groundwater supplies for private, municipal, and industrial purposes and discusses principles of groundwater occurrence and development. The Illinois State Geological Survey is cooperating with the Extension Service of the Agricultural Engineering Depart-

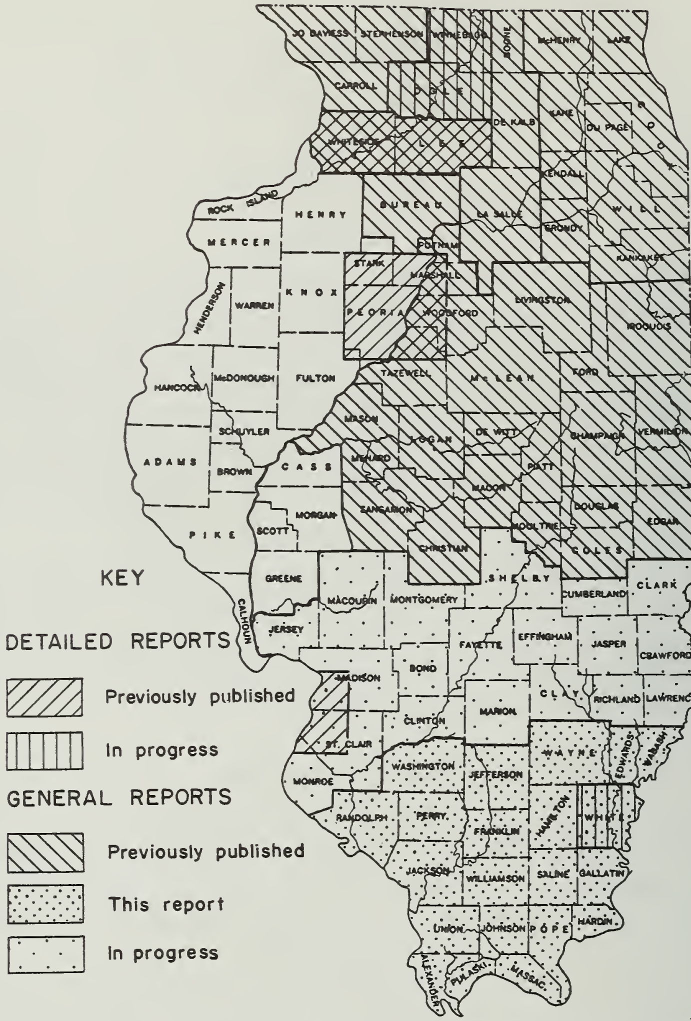

Fig. 1.– Index map of reports on groundwater geology in Illinois published since 1950 or in progress

ment, University of Illinois, in a program aimed toward improving water supplies on Illinois farms. This report is the fourth in a series; the region described is Agricultural Extension District 5.

District 3 is described in Geological Survey Circular 192, "Water Well for Farm Supply in Central and Eastern Illinois." The eastern part of District 1 is described in Circular 198, "Groundwater Possibilities in Northeastern Illinois," and the western part of District 1 is described in Circular 20 "Groundwater in Northwestern Illinois."*

This report provides information on the occurrence and character of water-yielding strata in the following 21 counties: Alexander, Edwards, Franklin, Gallatin, Hamilton, Hardin, Jackson, Jefferson, Johnson, Massac, Perry, Pope, Pulaski, Randolph, Saline, Union, Wabash, Washington, Wayne, White,

* All available without charge from the Survey in Urbana.

and Williamson. These counties comprise the region designated as southern Illinois (fig. 1). Southern Illinois has an area of about 8,460 square miles and a population of over 450,000.

I wish to acknowledge the helpful assistance given by the drilling contractors of southern Illinois. They have materially contributed to this study, both by discussing the occurrence of water-yielding strata with the Survey staff in the field and by their cooperation in providing large numbers of records of water wells for the files of the Geological Survey. James E. Hackett and Robert C. Parks assisted me in the field, and Robert E. Bergstrom, Merlyn B. Buhle, James E. Hackett, George B. Maxey, and Lidia Selkregg, all members of the Groundwater Geology Division, provided many helpful comments and criticisms.

OCCURRENCE OF GROUNDWATER

The surficial material and underlying bedrock that form the crust of the earth are filled with water from a shallow depth to thousands of feet. The water occurs in the pores in rocks, and in joints, fractures, and solution channels and is called groundwater. Though the occurrence of groundwater has a relatively simple scientific explanation, it has long been considered something mysterious. Throughout the history of man many fanciful myths and legends have sprung up about the occurrence and distribution of groundwater, some of which are still believed today. Our present knowledge of the source, movement, and occurrence of groundwater is shown diagramatically in figure 3.

Groundwater is nearly all supplied by precipitation in the form of rain or snow. Not all precipitation reaches open spaces in the ground. Much of it falls into the oceans or is intercepted by vegetation before it reaches the land surface, some runs off in streams, and some is returned to the atmosphere by evaporation and transpiration.

Of the water left on the land surface, some evaporates quickly, some penetrates the soil and is held in the unsaturated portion, and the remainder filters slowly down into the ground until it reaches a level below which all available openings are filled with water. This level is the top of the zone of saturation. Because there is replenishment by precipitation, groundwater is a renewable resource and is "mined" only when the quantity removed from the zone of saturation exceeds the quantity replenished.

Groundwater flows slowly through rocks because of the friction between the water particles and the pore or crack surfaces. It moves always under the influence of gravity or in response to other natural pressure differentials toward the point of lowest pressure, which is nearly always natural or artificial discharge.

The upper surface of the zone of saturation in ordinary permeable soil or rock is called the water table. If a well is drilled it remains dry until the zone of saturation is penetrated. The position of the water table is shown by the level at which water stands in the well. This is normally only several feet below the land surface in southern Illinois, although it varies with topography. The water table is not a level surface but conforms more or less with the principal features of the land surface. Where the water table is intersected by the land surface, groundwater is discharged in the form of springs, which feed per-

Fig. 2.- Principal geographic and geologic features.

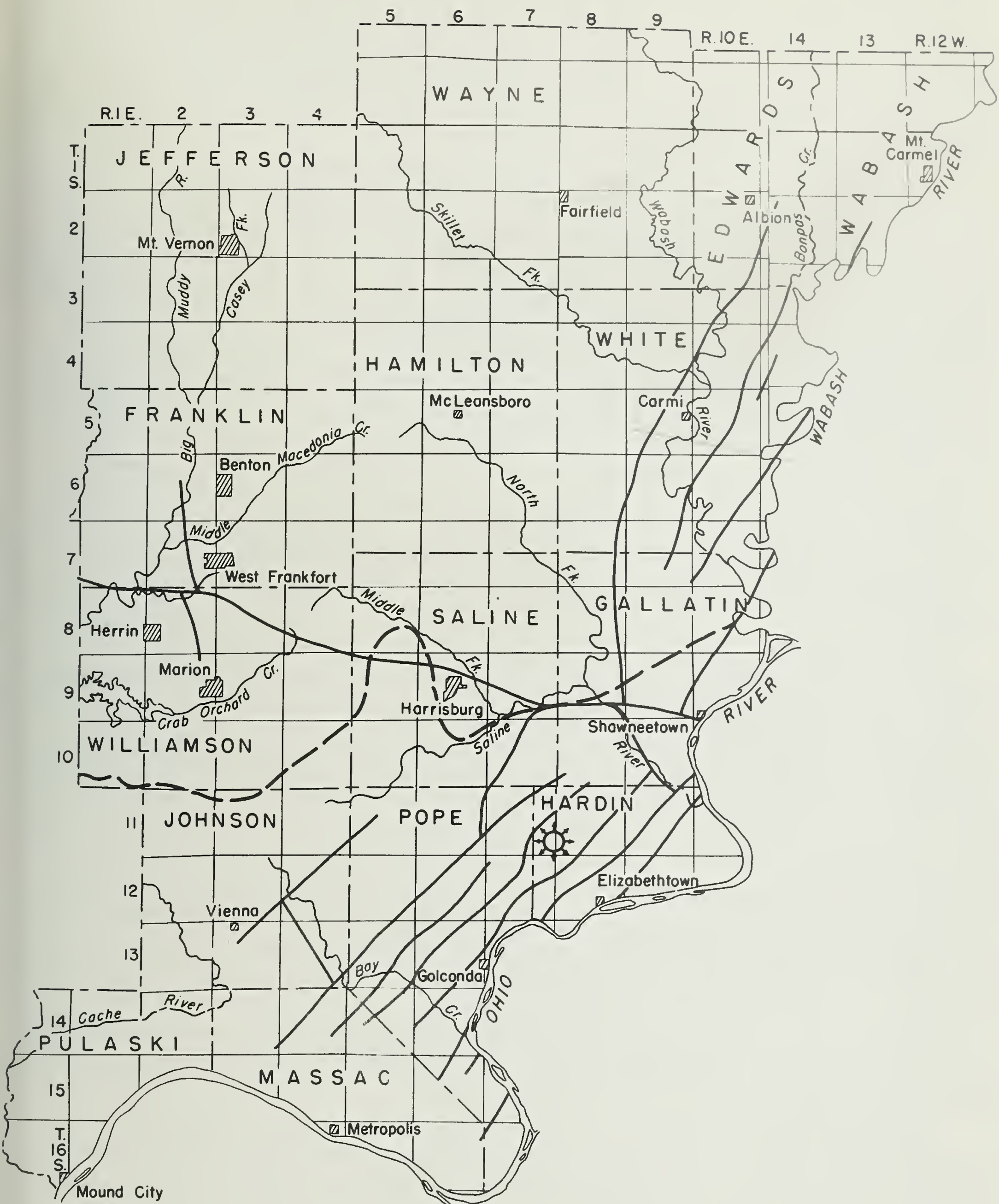

Fig. 2. (continued).

ennial streams, lakes, and swamps. The water table does not remain stationary but fluctuates in response to the loss or gain of groundwater.

Groundwater is said to be under water-table conditions where the top of the zone of saturation is free or not confined under pressure other than surface atmospheric pressure. Under these conditions and under the control of gravity, groundwater moves freely, hindered only by friction, in the direction of the slope of the water table.

Groundwater is said to be confined or under artesian conditions where the saturated permeable aquifer is overlain by a less permeable material which restricts the upward movement of the groundwater. Under these conditions the water in the confined strata has a natural pressure which causes the water in a well to rise above the top of the aquifer. Where sufficient pressures are encountered in an artesian well, the water may rise above the land surface, causing the well to flow without pumping.

To supply a pumped or flowing well, groundwater must move through the earth materials toward the well. Under water-table conditions, pumping lower the water table in the vicinity of the well and induces the flow of groundwater toward the well from adjacent areas. Under artesian conditions, pumping causes a reduction of hydrostatic pressure in the vicinity of the well, which induces the flow of groundwater toward the well. The depression in the water table or in the artesian pressure surface resulting from pumping is in the forn of an inverted cone with the well at the center and is called the cone of depression (fig. 3).

Although water is to be found everywhere below the top of the saturated zone, it is not everywhere available for withdrawal. Successful wells can be constructed only where strata are present that will easily transmit and yield water. Water-yielding strata are known as aquifers. The capacity of earth materials to absorb, store, and yield water depends on the abundance, the size and shape, and the degree of interconnection of the openings in them. These physical characteristics, together with distribution and extent, are controlled by local geologic features. Some earth materials, such as sand, gravel, and sandstone, are permeable and are good aquifers. Other materials, such as clay and shale, may contain as much or more water per cubic foot than sand and gravel, but they are relatively impermeable because the openings in the clay and shale are relatively small and water does not move readily through them.

The most important aquifers in southern Illinois are deposits of sand and gravel, sandstone, limestone, chert, and dolomite (a rock similar to limestone but rich in magnesium).

Sand and gravel deposits are water-yielding because of their relatively high porosity and permeability. Porosity and permeability are related to the grain size and degree of sorting of the sand and gravel particles in an aquifer. A good sand and gravel aquifer should have a grain size that is coarser than granulated sugar, without much mixed silt and clay. When silt and clay are present in sand and gravel they occupy the space between the larger particles and retard the flow of water.

Sand and gravel aquifers in southern Illinois are from several inches to over 100 feet thick.

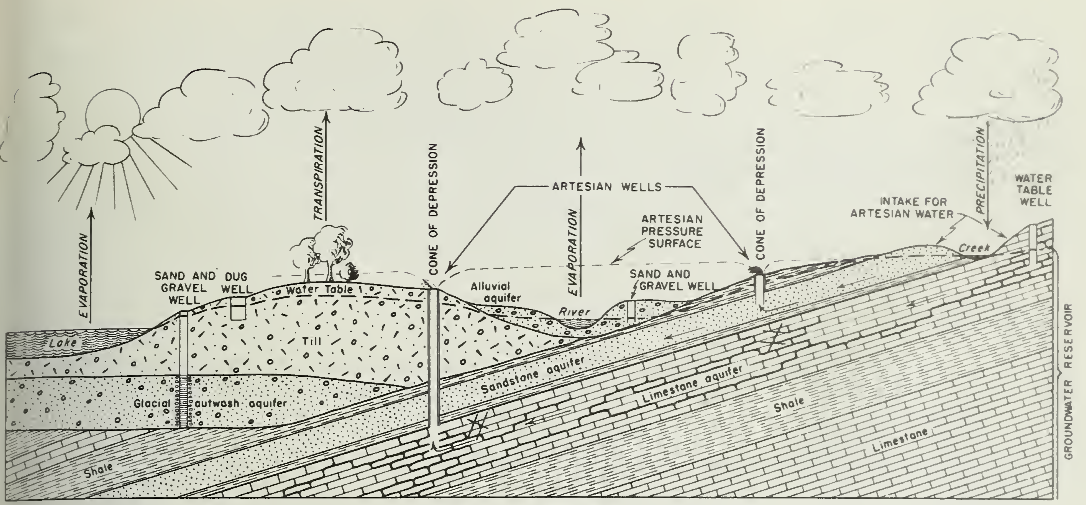

Fig. 3 - Source, movement, and occurrence of groundwater

The water-yielding characteristics of sandstone, like those of sand and gravel, are dependent upon grain size and sorting, but sandstone sometimes has a cementing agent that binds the grains together and reduces the porosity and permeability. The sandstone strata in southern Illinois are generally fine-grained and cemented and have relatively low permeabilities.

Limestone, dolomite, and chert generally have low porosities and permeabilities and yield water only from interconnected cracks and crevices. The success of a well drilled into these rocks depends upon the well bore encountering the water-bearing openings. Because the occurrence of these openings in limestone and dolomite is irregular, their presence at any specific location is difficult to predict.

GEOLOGY

The landscape of southern Illinois has been shaped and modified principally by two geologic agents - running water and glacial ice. Running water is the more important agent in southern Illinois. It is modifying the surface today by cutting into the land, carrying soil and rock particles away, and depositing them in stream and river bottoms. This erosion has occurred, almost without interruption, for hundreds of thousands of years. The features produced by glacial ice in the northern part of this area (see boundary of glacial advance in figs. 2 and 6) were developed long ago when great continental glaciers covered much of northern United States. The ice sheets advanced from centers of snow accumulation in Canada, carrying abundant rock debris which was deposited as the ice melted, leaving an irregular deposit that thinly covers much of the bedrock north of the glacial boundary (figs. 2 and 6).

Both during advance and retreat of the glaciers, sediment-laden meltwater coursed down the valleys that led away from the glaciers and partially filled them with outwash of sand, gravel, and finer deposits. Between periods of flooding these outwash fills, barren of vegetation, were subject to wind erosion, and great quantities of silt and sand were picked up and deposited on the uplands adjacent to the valleys. These wind-laid silt deposits are called loess.

SYSTEM	SERIES OR GROUP	GRAPHIC LOG	FORMATION OR AQUIFER NAME	WATER-YIELDING CHARACTERISTICS; DRILLING AND WELL CONSTRUCTION DETAILS
PLEISTOCENE 0-200'				Water-yielding characteristics variable. Thick deposits of sand and gravel in major stream valleys present possibilities for municipal and industrial supplies. Normally requires well screens and careful development.
TERTIARY	0-495'		LAFAYETTE WILCOX PORTERS CREEK CLAYTON	Water-yielding characteristics variable. Thick deposits of sand present excellent possibilities for domestic and farm supplies and locally possibilities for municipal and industrial supplies. Normally requires well screens and careful development.
CRETACEOUS	0-300'		MC NAIRY	Water-yielding characteristics variable. Thick deposits of sand present excellent possibilities for domestic and farm supplies and locally possibilities for municipal and industrial supplies. Normally requires well screens and careful development.
PENNSYLVANIAN	McLeansboro 0-1100' Carbondale 0-300' Tradewater-Caseyville 0-1300'			Water-yielding characteristics extremely variable; locally over a widespread area domestic and farm supplies are obtained from sandstone and limestone beds. Water quality is an important aspect of the sandstone aquifers. May require casing of caving shales and heaving underlays.
MISSISSIPPIAN	Chester 0-1400		KINKAID DEGONIA CLORE PALESTINE MENARD WALTERSBURG VIENNA TAR SPRINGS GLEN DEAN HARDINSBURG GOLCONDA CYPRESS PAINT CREEK BETHEL RENAULT	Yields water from sandstone and limestone strata. Widespread and used chiefly for farm and domestic supplies. Water quality variable. Caving shale requires casing or liners.
			AUX VASES	Water-yielding characteristics of sandstone variable; locally municipal and industrial supplies are obtained. Water quality variable.
	Valmeyer 0-450'		STE. GENEVIEVE ST. LOUIS SALEM-WARSAW	Widespread and dependable aquifer for domestic and farm supplies; locally a source of water for municipal and industrial supplies. Some trouble keeping a straight line in faulted areas. St. Louis limestone very cherty and generally well creviced.
			OSAGE GROUP	Small supplies locally available from thin limestone strata. Caving shale requires casing or liners.
	Kinderhook 0-400'		CHOUTEAU NEW ALBANY	
DEVONIAN	0-1400'		DUTCH CREEK CLEAR CREEK BAILEY	Widespread and dependable aquifer for domestic and farm supplies; locally a source of water for municipal and industrial supplies. Locally trouble is encountered with crooked holes. Chert may cause drilling difficulties.
SILURIAN	0-400'			Dependable aquifer for domestic and farm supplies in local area from creviced limestone and dolomite.
Upper part of ORDOVICIAN	570-1300'		MAQUOKETA	Not considered a dependable source of groundwater. Caving shales require casing or liners.
			THEBES	A source of groundwater for small supplies in a small area in Alexander County from sandstone and fractured limestone and dolomite.
LOWER ORDOVICIAN AND CAMBRIAN STRATA				Water-yielding characteristics and water quality unknown from sandstones, dolomites, and limestones.

Fig. 4. - Rock units in southern Illinois.

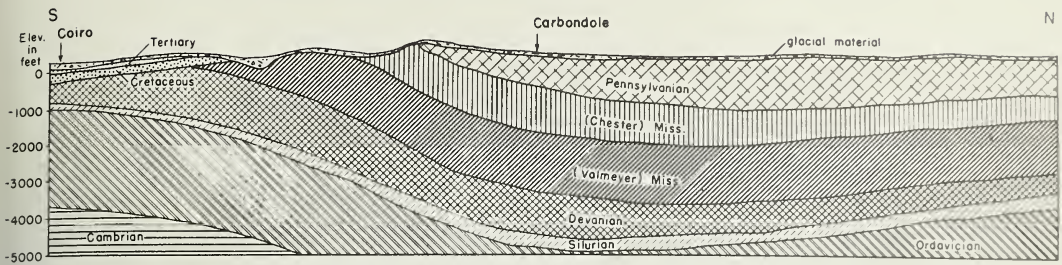

Fig. 5. - North-south cross section through southern Illinois showing structure of the bedrock in the basin. (Modified from Geologic Map of Illinois, 1945.)

Loess covers the bedrock in most of southern Illinois with maximum thickness in places exceeding 80 feet.

The bedrock, at the surface or beneath the glacial materials and loess, consists of layers of shale, sandstone, limestone, dolomite, and chert arranged one upon the other like the pages of a book (figs. 4 and 5). Although most of them are firm, solid rocks now, they were deposited originally as loose sediments and precipitates in shallow seas that invaded the continent. Subsequent burial and compaction hardened them into solid rock during the hundreds of millions of years after the seas retreated from the continent. The layers of rocks or strata were later warped and broken, so that today they are not horizontal as they were when deposited as sediment on the sea floor.

The rock strata have been warped into the form of a basin in southern Illinois. The rocks on the western side of the area dip eastward, in the southern part dip northward (figs. 5 and 7), in the eastern part dip westward, and in the northern part dip southward. The central and deepest part of the basin is in the White County area where the same rock formations exposed at the surface along the Mississippi River north of Cairo lie several thousand feet below the surface.

The bedrock strata have been fractured as well as tilted and folded. Fractures along which there has been a sliding movement of the rocks are called faults. One of the most striking areas of faulting in Illinois is in the southeastern part of this area (fig. 2). This long fault zone - the Shawneetown fault zone - extends southwestward through the eastern part of the area. Movements along the fault zone have resulted in rocks being displaced as much as 3500 feet. Another long fault - the Rattlesnake Ferry Fault - occurs in the western part of the area and trends southeastward through Jackson and Union counties. In Hardin County, in a structure called Hicks Dome, the strata dip away in all directions from a high central area (fig. 2).

Underlying the layered strata are ancient crystalline rocks which form the basement. The crystalline rock is chiefly granite, as is indicated by a few very deep borings in Illinois. An oil-test well in Monroe County, near East St. Louis, encountered granite at a depth of 2560 feet. This crystalline rock can be observed at the surface in the Ozark Mountains in Missouri and is estimated to occur at a depth of about 12,000 feet at Carmi, Ill.

DISTRIBUTION OF AQUIFERS

Sand and gravel deposits occur with other unconsolidated materials that have been deposited by running water or glacial ice. The sandstone, limestone,

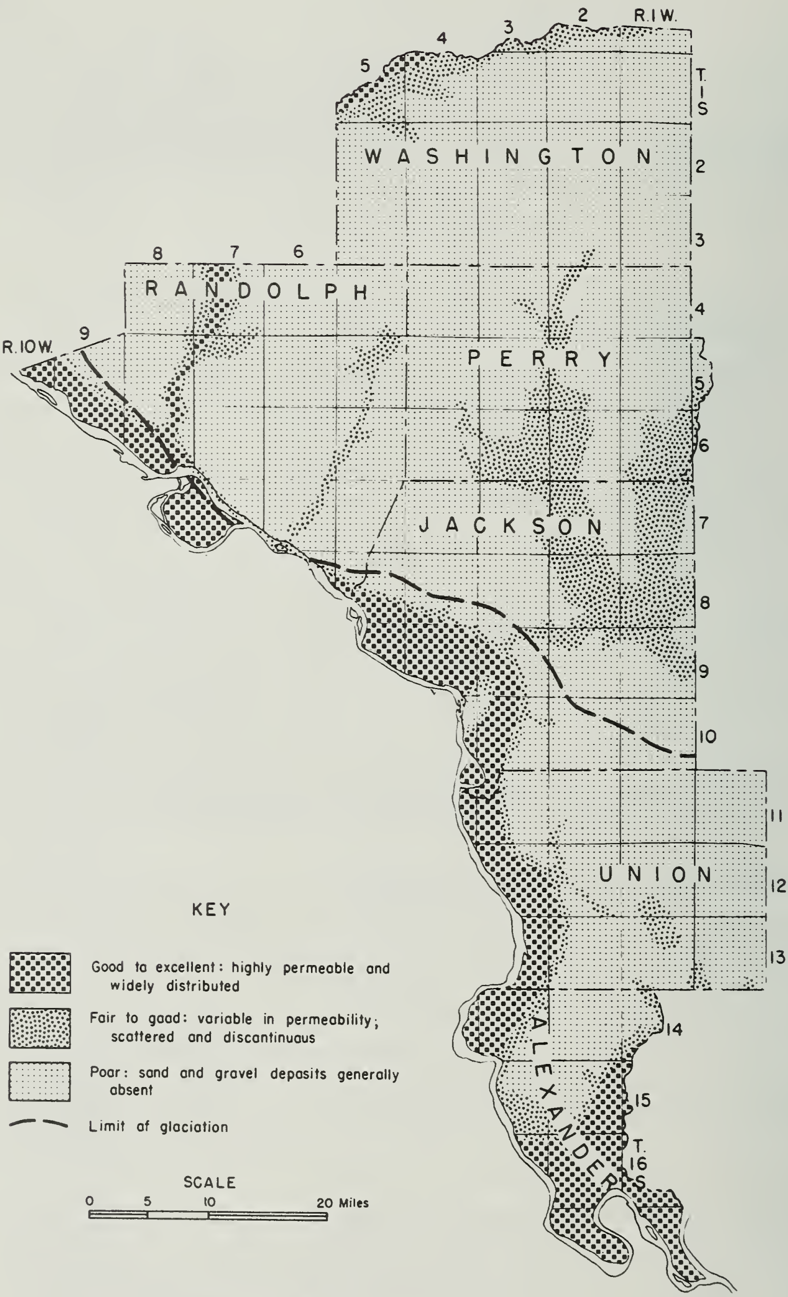

Fig. 6. - Probabilities of occurrence and distribution of sand and gravel aquifers.

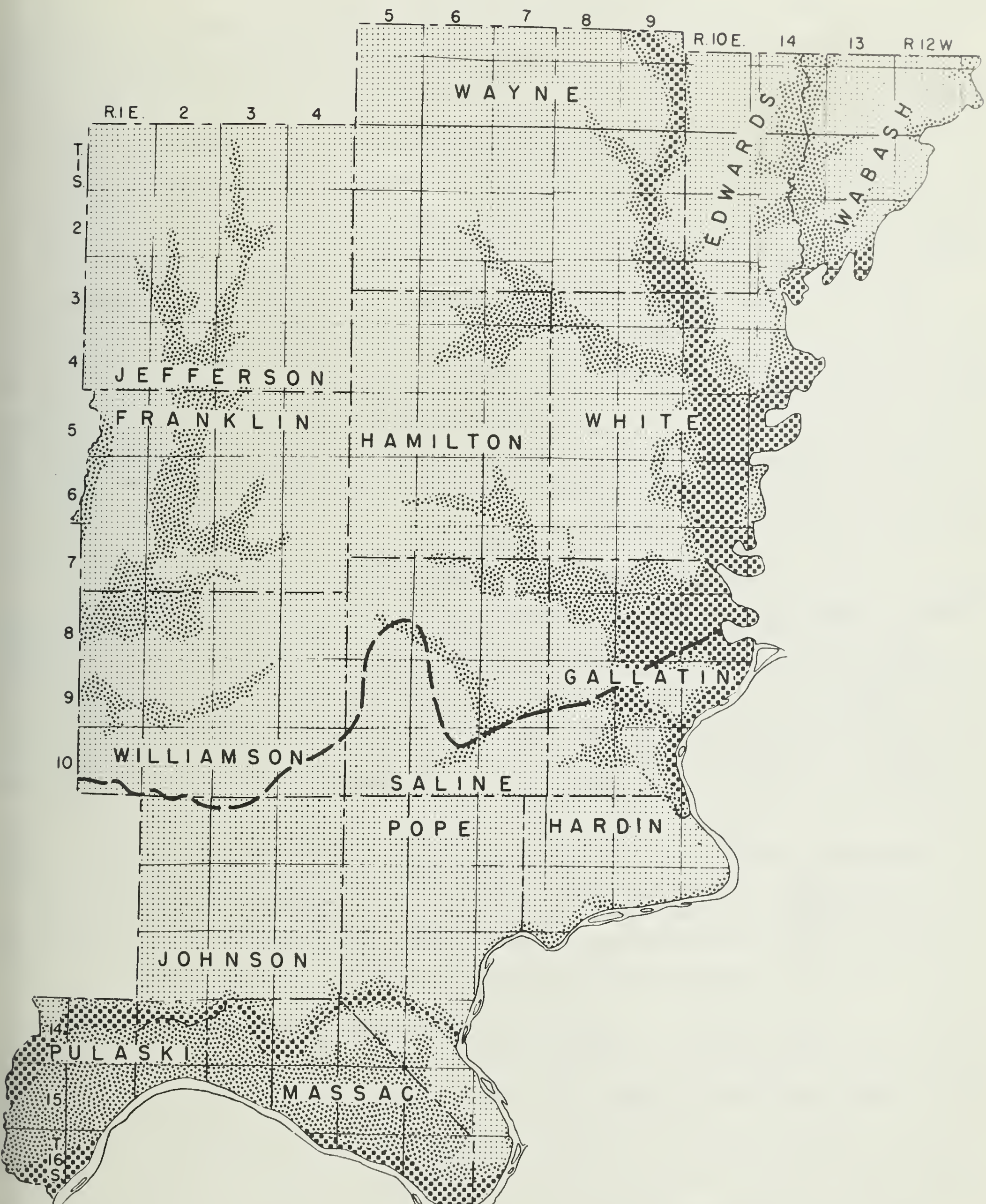

Fig. 6. (continued).

dolomite, and chert aquifers occur in the solid bedrock. Figure 4 shows the sequence of aquifers and other earth materials in southern Illinois and indicate their occurrence and water-yielding characteristics.

Sand and gravel deposits are limited chiefly to areas along the courses of streams and in the Tertiary and Cretaceous uplands. Figure 6 shows the probabilities of occurrence of sand and gravel aquifers. The area designated "good to excellent" is underlain by unconsolidated materials containing thick permeable deposits of sand and gravel. Groundwater is obtained with little difficulty for domestic and farm supplies in this area from small-diameter wells in these deposits. Probabilities for municipal and industrial supplies are good to excellent, although test drilling is needed to locate the more permeable aquifers.

The areas labeled "fair to good" in figure 6 are underlain by moderate thicknesses of unconsolidated materials filling minor valleys or bordering the main valleys and have some thin or discontinuous deposits of sand and gravel. Groundwater for domestic and farm supplies is locally obtainable in this area from drilled wells in sand and gravel, but in some places good water-yielding deposits are absent and wells are drilled into the bedrock. The probabilities for obtaining supplies of groundwater for municipal and industrial purposes are poor to fair, and extensive geophysical and test-drilling explorations for sand and gravel deposits are necessary.

The area labeled "poor" is principally upland where glacial drift is thin or absent. Wells generally penetrate bedrock because sand or gravel deposits capable of supplying appreciable quantities of groundwater are rare.

The areas labeled "Tertiary and Cretaceous" in figure 7 are underlain by semiconsolidated materials containing thick deposits of sand and are included in the "fair to good" areas in figure 6. Groundwater for domestic and farm supplies is obtainable with little difficulty from these rocks. Municipal and industrial water supplies may be found in parts of the area, but test drilling is necessary to locate the best formations and sites for the construction of high-capacity wells.

Figure 7 shows the distribution and water-yielding characteristics of the bedrock formations that crop out at the surface or lie directly beneath the glacial and alluvial materials. The areas within the Pennsylvanian boundary, which are shown as favorable for groundwater, are underlain by sandstone aquifers in which the possibilities for domestic and farm water supplies are fair to good.

Suitable groundwater supplies for domestic purposes may be derived from Chester rocks underlying the Pennsylvanian rocks in a narrow strip around the edge of the Pennsylvanian (fig. 7). The supply probabilities are generally fair to good within the arcuate band of Chester outcrop. The probabilities are poor to fair in the southern part, whereas in the western part they are fair to good, and several municipal wells withdraw supplies from lower Chester rocks.

The thick limestones of the Mississippian Valmeyer series (figs. 4, 5, and 7) are generally well creviced, and probabilities for obtaining domestic and farm supplies of water are good to excellent.

The limestone and chert formations of the Devonian system (figs. 4, 5, and 7) are well creviced throughout the outcrop area and where they underlie Tertiary, Cretaceous, and Valmeyer rocks. The groundwater probabilities here fr domestic and farm supplies are good to excellent and for municipal and industrial supplies, fair to good.

Where the well-creviced Silurian and Ordovician limestones (figs. 4, 5 and 7) underlie the Mississippi River alluvium and the outcrop area of Devonian rocks, probabilities of obtaining domestic and farm supplies of groundwater are good to excellent and for municipal and industrial supplies, fair to good.

GEOLOGIC CONDITIONS THAT AFFECT GROUNDWATER DEVELOPMENT

Development of water supplies from groundwater sources is closely related to the geologic conditions that prevail in any locality. In southern Illinois two broad classes of aquifers are present: 1) unconsolidated deposits, primarily glacial or alluvial in origin, containing areally restricted sand and gravel deposits interbedded with finer materials, and 2) bedrock deposits that range widely in permeability but that are distributed over broad areas. However, just the presence of permeable aquifers does not assure a satisfactory supply of groundwater. Care must be taken to select the appropriate type of well for any given aquifer so that the aquifer may be most efficiently developed. Water quality and temperature vary considerably from place to place and depend primarily on geologic conditions. These factors should be considered carefully before a well site is selected.

Unconsolidated Deposits

Where water-yielding sand and gravel deposits are present in an area, attempts should be made to develop wells in them rather than in the underlying bedrock. Some of the advantages of utilizing sand and gravel wells are shallower water levels, colder water, generally greater water yield in a specific well, and in some areas water of better mineral and bacterial quality. The disadvantage of sand and gravel wells is the special construction needed to take full advantage of the water-yielding capacity of the aquifer.

Sand and gravel wells require the use of screens, which allow the free flow of water into the bore and exclude intrusion of sand and gravel. It is important in the development of sand and gravel wells that the size of the screen openings or slots be chosen on the basis of the size of the material to be screened. Therefore it is necessary that samples of the aquifer be obtained and analyzed for particle size to determine the correct screen-opening size.

Development necessarily follows construction of a sand and gravel well. For proper development, the finer-grained materials in the immediate vicinity of the well bore should be removed, which will leave a natural graded filter that will reduce or prevent pumping of sand and silt. Better results and yields may be obtained from some sand and gravel deposits by placing an "envelope" or "pack" of selected gravel or coarse sand between the deposit and the screen. The grain size of the particles in the gravel pack must have a proper relationship to the grain size and sorting of the formation and to the screen slot size to achieve the best results.

Sand and gravel deposits vary more in their physical and water-yielding characteristics than do bedrock aquifers. Because of the extreme variation within short distances, it is often desirable to make test borings to locate the better parts of the formation prior to well design and construction. In areas in

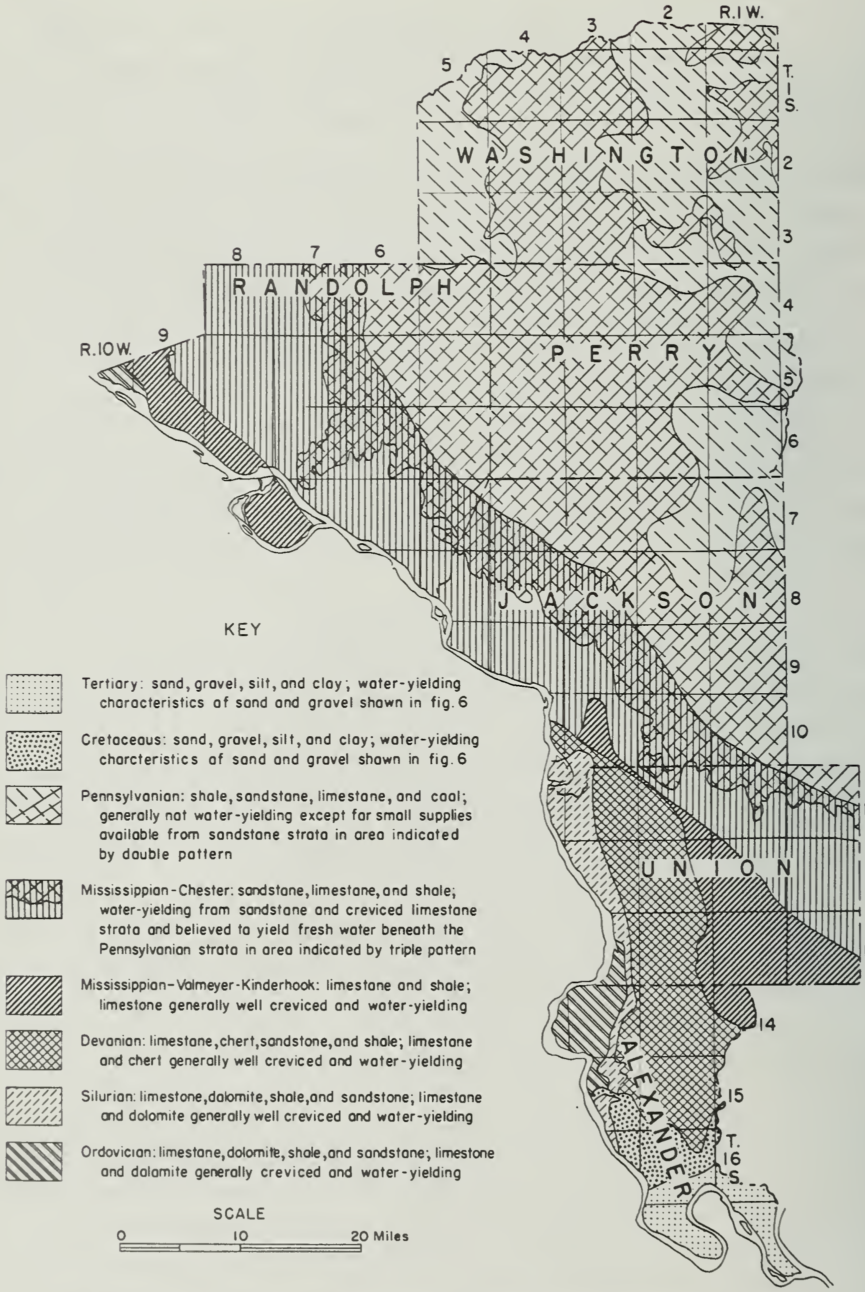

Fig. 7. – Areal distribution of bedrock and Cretaceous-Tertiary units (excluding Lafayette gravel); type and water-yielding characteristics.

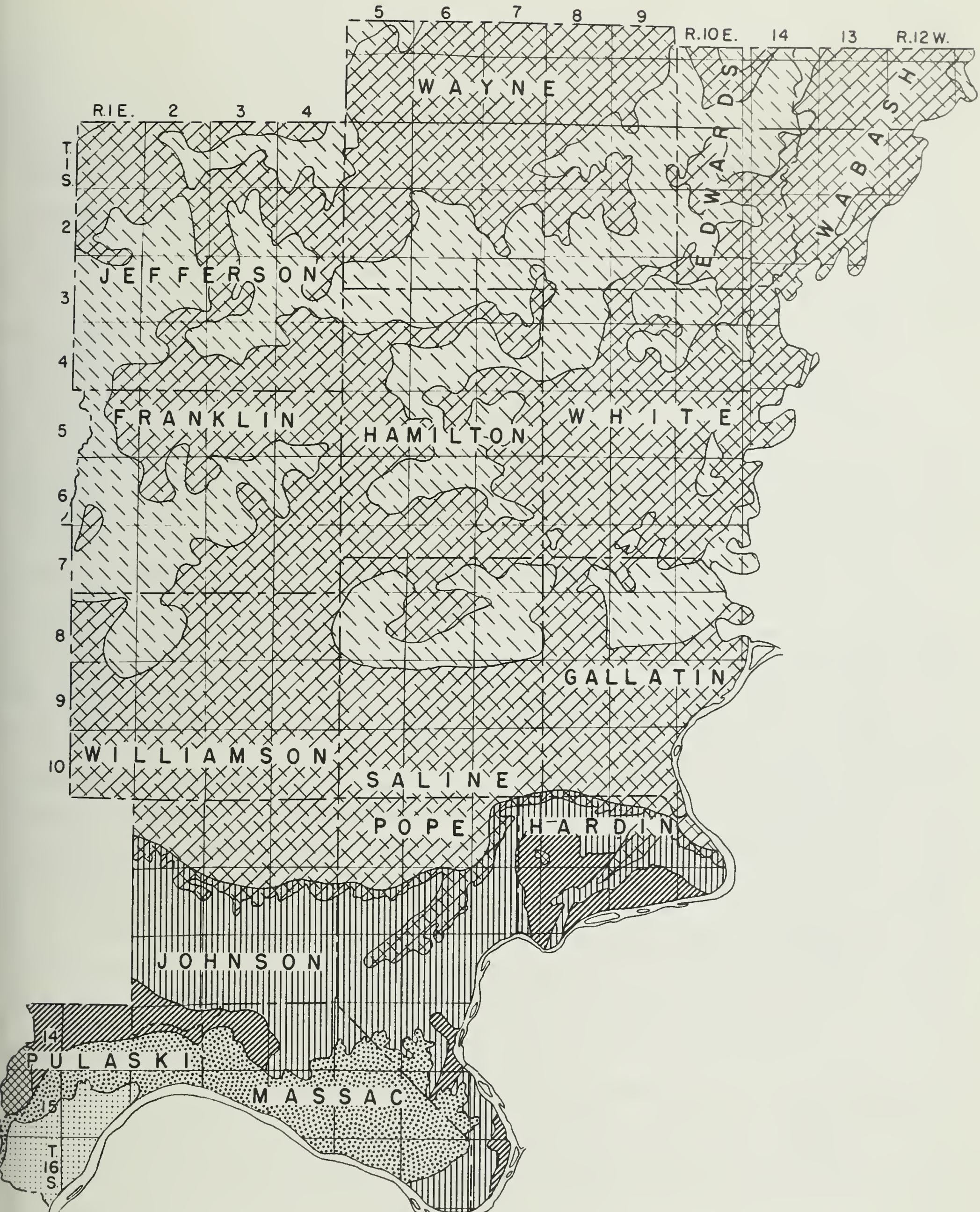

Fig. 7.– (continued).

which the presence and distribution of suitable aquifers is in doubt, a test-drilling program is necessary to determine whether suitable deposits for the specific need are present and, if present, the best location for the well site.

Test drilling is generally done by drilling small-diameter holes with rotary or cable tool (percussion) equipment. The test-driller's report is an important part of the development program and should include the following information when obtainable: 1) driller's log of formations penetrated, 2) static water levels and changes in level during drilling, 3) drilling time per interval (2 to 5 feet) of the individual formations, 4) weight and viscosity of drilling fluid, 5) amount of drilling fluid lost during drilling, and 6) approximate depth of hole at time of fluid loss. Samples of drill cuttings should be saved at regular intervals of five feet or less and at changes in formation.

Conditions favorable for drilled wells in sand and gravel in southern Illinois are generally restricted to partially buried valley areas and to the Cretaceous-Tertiary uplands. Drilled wells are the most satisfactory for sand and gravel deposits, and their use is recommended wherever geologic conditions permit. Drilled wells produce water directly from the aquifers, and therefore their production cannot exceed the water-transmitting capacity of the aquifers. One disadvantage of a drilled well is the small amount of storage space in the well bore.

Driven wells are the quickest and most economical method of well construction. They are practical where only small supplies of groundwater are needed and where such supplies may be available from sand and gravel at shallow depths. Conditions are suitable for driven wells in the bottomlands of the Mississippi, Ohio, Wabash, and Cache rivers. The "sand hills" area in Gallatin County, west of Shawneetown, is particularly favorable for this type of well construction.

Large-diameter dug wells are most suitable in areas where the unconsolidated materials are fine-grained and cannot yield water readily to a drilled or driven well; therefore they are used widely throughout much of the area in which glacial material is thin and tight and is underlain by impermeable Pennsylvanian rocks. Large-diameter wells are excavated by hand, power auger, shovel, or bucket and can be excavated to depths up to 100 feet. In areas in which conditions are favorable for drilled or driven wells, the use of large-diameter dug wells is not recommended because of the difficulty of keeping them free of pollution. The chief advantage of a large-diameter well (2 to 5 feet in diameter) is that it can store large quantities of water. Short intermittent pumping of a large-diameter well does not require immediate release of water from the surrounding materials, and the well can refill slowly in several hours. Special sanitary precautions should be taken with large-diameter wells. (See Circular 14A, Illinois State Department of Public Health, Springfield.)

Bedrock Deposits

Wells constructed in bedrock aquifers are usually less difficult to design because the well bore is generally left uncased and because the water-yielding strata are more consistent over wider areas than are the sand and gravel aquifers.

Many conditions must be considered when designing and constructing wells in bedrock in southern Illinois. These include: 1) depth and thickness of the aquifer and depth to the water level, and 2) permeability, kind, and structure of the rock in the aquifer. For example, many rocks are friable, poorly consolidated, or tend to flow, and therefore must be supported by a casing or liner. Some formations yield mud, silt, and sand when the well is pumped, and others are very difficult to penetrate with a straight hole, primarily because of structure within the rock.

Creviced limestone, dolomite, and chert normally do not require casing or lining. However, there is danger of bacterial pollution where groundwater supplies are obtained from creviced formations with a thin unconsolidated cover. Open crevices provide very little filtering action and polluted water may travel long distances through the openings.

Normal procedure when developing bedrock aquifers is to install surface casing to firm bedrock and to continue with open hole into the bedrock. Where bedrock formations are too weak to sustain open hole or where "heaving formations," such as underclay, are encountered, it may be necessary to continue the surface casing through the weak formations to a more competent underlying formation or to set liners opposite the weak or heaving formations. The caving formations that most require casing or liners are the weak shales and heaving underclays associated with coal beds in the Pennsylvanian system, the Kinderhook shales, and the Maquoketa shales (fig. 4).

The tendency of holes to become crooked during drilling, especially in the Valmeyer, Devonian, and Silurian limestones, presents drilling difficulties that normally cannot be avoided.

Pumping some mud, silt, or sand in high-capacity wells cannot always be avoided. Remedial measures must be taken when the pumping of fine materials becomes excessive. The State Geological Survey frequently assists in the solution of this problem by identifying the source and approximate depth of the materials, so that by installing casing or liners at the proper positions the discharge of materials may be slowed down or halted. The most common sources of materials pumped with water are: 1) silt and clay from overlying glacial deposits, caused by leaks in surface casing or improperly seated surface casing, 2) silt and clay from weak shale or underclay zones that have been left uncased or are improperly cased, 3) clay and silt from open crevices and caves in the limestone, which is quite common in some areas, and 4) silt and fine sand from fractured sandstones.

Conditions are generally favorable in southern Illinois for drilled wells in bedrock. In areas in which the bedrock formations are water-yielding, drilled wells are the most satisfactory method of obtaining water for most purposes.

Driven wells are difficult to construct in solid bedrock and are seldom used. Dug or augered wells also are difficult to construct in solid bedrock and should be used only where geologic conditions are unsatisfactory for drilled wells.

ROLE OF THE DRILLING CONTRACTOR

The success of any well depends upon the competence of the drilling contractor. A drilling contractor has certain duties and obligations to his customers, which are here summarized briefly.

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 siz of well casing and screen, etc.), and an indication of the capacity of the well as determined from a pumping test. In accordance with the Mining Laws of Illinoi, copies of the driller's log must be filed with the State Geological Survey and th State Water Survey. Log books may be obtained by drillers without charge fror 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 down around the casing. It is also desir able 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 and imaginative driller to obtain the maxi mum amount of water from a poor formation. Where sand or gravel aquifers are used as a source of groundwater, the driller should select a well screen or the basis of the size and sorting of the aquifer material. After construction th well should be properly developed. A properly screened and developed well in sand or gravel will not pump significant amounts of sand or silt during service Use of slotted pipe or open-bottom casing should be avoided except in very coase gravel where the ability of the well to yield water far exceeds the demand.

4. For municipal, industrial, irrigation, water-flood, and school well construction, it is particularly desirable to save samples at regular 2- to 5-foot intervals for the total depth of drilling. The State Geological Survey studies ar files samples of drill cuttings received from drillers. The samples may be set to the Survey express collect. Information obtained from samples is vital in e fective rehabilitation of old wells.

UTILIZATION

Domestic and Stock Supplies

Geologic conditions in most of southern Illinois are favorable for obtainin small supplies of groundwater for private purposes. Deposits of water-yieldir sand and gravel are limited to certain well-defined areas (fig. 6). Throughout most of the area where sand and gravel is absent, water-yielding bedrock forma- tions are present at sufficiently shallow depths to be within the reach of privat wells. Shallow drilled wells obtain water from bedrock sandstones throughout most of the central part of southern Illinois. In areas of thin drift and low-per meability sandstones, construction of shallow large-diameter dug or augered wells may be necessary to obtain satisfactory supplies.

Subsurface geologic conditions will generally vary little within the limited area of an individual homesite or farm. However, there may be great variatic in geologic conditions with depth. Information on depth of aquifers is valuable in planning the type, depth, and size of the intended well.

Perhaps the most important considerations in locating private wells are sanitation and convenience of location. Wells should be located with regard to geologic conditions, surface drainage, topography, and land usage so as to pro vide maximum protection from harmful bacteria and their objectionable inorganic material.

The following suggestions may be helpful in planning for individual or farm supplies.

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

2. Obtain all available information on the occurrence of water-yielding formations at your location. The maps in this report are designed to give a fundamental understanding of the occurrence and distribution of the water-yielding formations in this area, so that the most suitable type of well can be planned. If additional, more specific information is desired, contact the State Geological Survey, Urbana, Illinois. It is essential that a description of the property be given by section, township, and range; also describe the intended use of the water supply, make an estimate of the quantity desired, and give 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 been proved to be trouble-free. Make sure the driller is capable of properly handling the types of aquifers he may encounter at your 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.

5. Make periodic bacterial analyses of the water supply. Dug wells are nore difficult to keep sanitary than are properly constructed drilled wells. Wells lrilled into creviced limestones, dolomites, and cherts are, however, suscepible to bacterial pollution, particularly when the creviced formation is overlain y thin deposits of overburden.

lunicipal, Industrial, Irrigation, and Water-Flood Supplies

Development of groundwater supplies for municipal, industrial, irrigation, nd water-flood purposes requires technical assistance and careful planning ised on all available geologic and hydrologic data. The type of aquifers presnt, their extent, thickness, depth, distribution in the area, and water-yielding iaracteristics should be determined not only so that the available quantity of ater may be estimated but also for purposes of well construction. Hydrologic ita, such as yield of existing wells, pressure potential of various formations, id water quality, should also be determined as accurately as possible.

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

COUNTY GROUNDWATER SUMMARIES

Detailed information on groundwater supplies in the counties of southern

Illinois is given in the following pages. These discussions supplement the geologic information shown in figures 5 and 6.

Alexander County

Shallow and deep sand and gravel deposits are potential groundwater sources in much of Alexander County. Sand and gravel deposits underlie the ground surface at most places in the southern part of the county. The bottomlands of the Mississippi, Ohio, and Cache rivers contain thick deposits of water-yielding material (fig. 6). Successful sand and gravel wells have been constructed in the bottomlands at depths greater than 50 feet. Wells have been constructed also in some places in the uplands in semiconsolidated Cretaceous and Tertiary sands.

In the uplands in the northern part of the county, where the unconsolidated material is thin, the Mississippian, Devonian, and Silurian limestones, dolomites, and cherts are creviced and water-yielding. Most domestic wells obtain water from these formations at depths less than 200 feet. These creviced formations are potential sources of groundwater for municipal and industrial supplies.

Edwards County

The glaciated uplands north and south of Albion contain thin glacial deposits with poor possibilities for successful drilled wells in sand and gravel. Thin deposits of sand and gravel occur in the Bonpas Creek and Little Wabash River bottoms on the eastern and western sides of the county, respectively.

The Pennsylvanian sandstones are water-yielding in much of the county. Most domestic wells obtain water from these sandstones at depths greater than 100 feet.

Franklin County

The glacial deposits are generally thin and are not water-yielding. The thickest unconsolidated material is in the valley of the Big Muddy River, where the deposits of silt and clay attain a maximum thickness of about 120 feet. Thin scattered deposits of sand and gravel are locally present in the lower part of the valley fill. Most private wells in the Big Muddy River bottoms go through the unconsolidated material into bedrock.

Pennsylvanian sandstones are water-yielding in the northern and southeastern parts of Franklin County. Most domestic wells obtain water from these sandstones at depths ranging from 100 to 200 feet.

Gallatin County

Thick permeable sand and gravel deposits are present in the Wabash Valley in the eastern part of the county and conditions are favorable for driven sand points. Thin sand and gravel deposits are locally present in the valley of the Saline River.

Sandstone aquifers of the Pennsylvanian system are present and water-yielding in most of the county. Most domestic wells range in depth from 150 to 250 feet.

Hamilton County

The glacial deposits are thin; sand and gravel wells are constructed only the valley fill of the Saline River and Skillet Fork, where thin scattered deposits are present. These valleys contain considerable amounts of fine-grained deposits.

Most domestic wells obtain water from Pennsylvanian sandstones. These sandstones are 200 to 400 feet deep and have low permeabilities.

Hardin County

Thin sand and gravel deposits occur in a narrow band along the Ohio River. The uplands are essentially bare of glacial deposits, and rocks of Pennsylvanian and Mississippian age are exposed at the surface in many places.

Domestic wells obtain water from thick Pennsylvanian sandstones in the northern part of the county. Most wells in the southern part of the county are finished in the faulted and creviced Mississippian (Valmeyer) limestones, especially the St. Louis limestone. Where the Valmeyer limestones are overlain by thin Chester rocks, it is common practice to penetrate the Chester rocks and drill into the Valmeyer limestones.

Jackson County

Excellent sand and gravel aquifers suitable for municipal and industrial groundwater supplies are present in southwestern Jackson County. These thick permeable deposits are concentrated in the bottomlands of the Mississippi River. Some thin scattered deposits of sand and gravel suitable for farm and domestic supplies are present in the partially buried bedrock valley of the Big Muddy River in the eastern part of the county.

Groundwater from bedrock aquifers can be obtained with little difficulty throughout most of the county. As shown in figure 7, the bedrock is Pennsylvanian in the northeast, where the sandstone aquifers are present, and Mississippian (Valmeyer) in the southwest, where creviced limestones are present. Chester rocks are favorable for groundwater supplies for several miles east of the Pennsylvanian boundary. In the southeastern part of the county, wells obtain water from the Kinkaid limestone and the Degonia sandstones at depths of 500 to 600 feet. In the extreme southwestern part of the county, Devonian limestones lie directly beneath the valley fill and are water-yielding.

Jefferson County

Glacial deposits are thin throughout most of the county, and Pennsylvanian bedrock crops out in many places. Water-yielding sand and gravel deposits are thin and are restricted to the deeper parts of the Big Muddy River and its tributaries (fig. 6).

Groundwater is available from sandstone strata in the upper part of the Pennsylvanian system in Jefferson County, but, as shown in figure 7, the sandstones have irregular distribution. Domestic supplies from the sandstone strata are available at depths ranging from 150 feet to 350 feet.

Johnson County

Glacial deposits are thin or absent in Johnson County, and bedrock is exposed over much of the area. Water-yielding sand and gravel deposits are restricted to the Cache River Valley, where they are very thick and permeable and suitable for the development of municipal and industrial supplies. Thin scattered deposits of sand and gravel are sometimes present in the valleys tributary to the Cache Valley.

Groundwater is obtainable from sandstones in Pennsylvanian bedrock at depths below 100 feet. Chester shales, limestones, and sandstones, which crop out in a series of east-west trending ridges in the southern part of Johnson County, are water-yielding in the lower part and drilling is usually carried to depths of 300 to 400 feet. In the area south of Vienna, little difficulty is encountered in obtaining water supplies from creviced Valmeyer limestones.

Massac County

Sand and gravel deposits in the Cache and Ohio river valleys are thick and permeable and suitable for municipal and industrial developments. Extensive deposits of Cretaceous sand on the uplands are potential sources of groundwater for municipal and industrial supplies.

In the northern part of Massac County and underlying the Cretaceous deposits lower Chester rocks and Valmeyer limestones are water-yielding, and many domestic wells are finished in them. The Valmeyer limestones are extensively faulted and creviced and are potential sources of groundwater for municipal and industrial supplies.

Perry County

Glacial deposits throughout most of Perry County are thin, and bedrock crops out in many places. Thin water-yielding sand and gravel deposits are restricted to deeper parts of the Beaucoup Creek Valley and the Little Muddy River Valley and are suitable only for domestic water supplies. The thin sand and gravel deposits in these valleys are concentrated in the lower part of the fill and are generally below a depth of 40 feet.

In northern and eastern Perry County, groundwater is obtained from shallow Pennsylvanian sandstones (fig. 7) at depths less than 100 feet. In the southwestern part of the county, permeable Pennsylvanian sandstones occur at depths ranging from 300 to 600 feet.

Pope County

Bedrock is exposed in much of Pope County. Thick permeable deposits of sand and gravel are restricted to the Cache and Ohio river valleys. Cretaceous sands are water-yielding along the southwestern border of the county. Thick deposits of sand and gravel in the valley bottoms are potential sources of groundwater for industrial and municipal purposes.

Sandstone strata in the Pennsylvanian system in northern Pope County are sources of groundwater for domestic supplies. Faulting and crevicing make the Chester rocks better sources of groundwater in Pope County than they are farther west in Johnson County. Where the Chester rocks are not water-yielding, it is common practice to drill through them into the creviced Valmeyer limestones, which in some areas are potential sources of groundwater for municipal and industrial supplies.

Pulaski County

In Pulaski County the thickest, most permeable sand and gravel deposits are in the Cache and Ohio river valleys. Thick deposits of Tertiary and Cretaceous sand are present on the uplands in central and eastern Pulaski County. These sand and gravel deposits are excellent sources of groundwater, especially in the valleys.

Underlying the unconsolidated deposits, the well-creviced Valmeyer limestones are water-yielding and good sources of groundwater for municipal and industrial supplies. The creviced Devonian limestones, dolomites, and cherts in southern Pulaski County are sources of groundwater for municipal and industrial supplies although they generally are deep, as much as 900 feet deep north of Mound City and deeper at Cairo.

Randolph County

The upland in Randolph County contains thin glacial deposits unfavorable for drilled wells in sand and gravel. Thick permeable sand and gravel deposits occur in the Mississippi Valley and are favorable for sources of industrial and municipal groundwater supplies. Some favorable deposits also may be present in the Kaskaskia Valley in the northwestern part of the county. Thin discontinuous deposits of sand and gravel are present in the valley fill of Marys River.

Drilled wells in the upper bedrock obtain groundwater from Lower Pennsylvanian sandstones in the northeastern half of Randolph County. The depth to these thick sandstones ranges from less than 100 feet along the western border of Pennsylvanian outcrop (fig. 6) to over 600 feet east of Sparta and Percy. Chester rocks are water-yielding for a slight distance east of the Pennsylvanian border, but the distribution of these water-bearing strata is not well known. Aux Vases sandstone is water-yielding in the northwestern part of the county and is a source of water for industrial and municipal supplies in restricted areas. Domestic supplies are obtained without difficulty from Chester beds where they underlie the glacial deposits.

Saline County

Glacial deposits are thin in Saline County. Sand and gravel wells are constructed only in the valley fill of the Saline River, where some thin discontinuous deposits are present.

Most domestic wells obtain water from sandstone strata in the Pennsylvanian system. These water-yielding sandstones are at depths below 100 feet in the area north of Harrisburg. South of Harrisburg water-yielding sandstones are at depths below 300 feet.

Union County

Sand and gravel deposits in the Mississippi Valley are thick and permeable and suitable for municipal and industrial water supplies. Some possibilities exist for obtaining domestic supplies of groundwater from thick deposits of Lafayette gravel (fig. 4) in an area southeast of Jonesboro (fig. 6). Some thin continuous deposits of sand and gravel are present in the streams tributary to the Mississippi River.

The sandstones and limestones of the Chester series, which form a series of southeast-trending ridges in the northeastern part of Union County, are wate-yielding. Most domestic wells are finished in the Chester at depths below 100 feet. Little difficulty is encountered in obtaining domestic water supplies fron the well-creviced and fractured Valmeyer, Devonian, and Silurian limestones in the southwestern part of Union County. In areas where Devonian limestones are near the surface (fig. 7), they are well-creviced and potential sources of water for municipal and industrial supplies.

Wabash County

Glacial deposits in central Wabash County are thin and are not suitable fo sand and gravel wells. South of Mt. Carmel, in the Wabash River Valley, grou-water possibilities are excellent in thick sand and gravel deposits. Thin scatte deposits of sand and gravel are present in the valley of Bonpas Creek.

Pennsylvanian sandstones are water-yielding throughout most of Wabash County, and most domestic wells obtain water from these sandstones at depths of 100 feet or more.

Washington County

Glacial deposits are generally thin and are not water-yielding in most of Washington County. Good possibilities exist for the occurrence of sand and gravel in the Kaskaskia River bottoms along the northern border of the county (fig. 6).

Water-yielding Pennsylvanian sandstones occur in the central part of the county. They range in depths from 70 feet in the northeast to over 500 feet in the central part of the county.

Wayne County

Thick permeable deposits of sand and gravel that are potential sources of groundwater for municipal and industrial supplies are present in the eastern part of Wayne County in the bottomlands of the Little Wabash River. Thin dis-continuous deposits of sand and gravel are locally present in Skillet Fork Vally in the southern part of the county.

Domestic supplies are obtainable in most of the county from sandstone aci-fers in the upper 250 feet of the bedrock (fig. 7).

White County

In the bottomlands of the Wabash and Little Wabash Rivers, thick deposit of permeable sand and gravel are sources of water for municipal and industri supplies. Some thin sand and gravel deposits occur in the Skillet Fork Valley

Groundwater is available from sandstone strata in the upper part of the Pennsylvanian rocks in White County. Most wells obtain domestic supplies frm the upper 300 feet of the bedrock without much difficulty.

Williamson County

The glacial deposits are thin and are not water-yielding. The thickest va-ley-fill material is in the Big Muddy Valley, where thin sand and gravel depo:ts are locally present within thick sections of silt and clay.

Sandstone aquifers in the Pennsylvanian system are water-yielding throughout most of the county. Domestic water supplies are obtained with little difficulty at depths ranging from 50 feet to 800 feet.

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The story of the geologic making of southern Illinois: Stuart Weller, Illinois Geol. Survey Educ. Series 1, 1927.

Well, dug, drilled, driven: C. W. Klassen, Illinois Dept. of Public Health Circ. 14, 1951.

list of State Geological Survey publications is available upon request.

uadrangle topographic maps are available for the area covered by this report. Most of them are on a scale of about 1 inch to the mile but for some areas they are on a scale of about 2 1/2 inches to the mile. They are printed by quadrangles and can be obtained from the Illinois State Geological Survey, or from the U. S. Geological Survey, Washington 25, D. C. for 20 cents each upon request. Index maps showing the topographic coverage of the State are free.

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