REPORT OF INVESTIGATION 55

Yields of Wells in Pennsylvanian and Mississippian Rocks in Illinois

by SANDOR CSALLANY

AUG. 26th 1818

Printed by authority of the State of Illinois—Ch. 127, IRS, Par. 58.29

STATE OF ILLINOIS
HON. OTTO KERNER, Governor

DEPARTMENT OF REGISTRATION AND EDUCATION
JOHN C. WATSON, Director

STATE WATER SURVEY DIVISION
WILLIAM C. ACKERMANN, Chief

URBANA

1966

CONTENTS

Appendices

ILLUSTRATIONS

TABLES

Yields of Wells in Pennsylvanian and Mississippian Rocks in Illinois

by Sandor Csallany

ABSTRACT

In areas of the southern three-fourths of Illinois where the glacial drift is thin or practically impermeable, water supplies for domestic, livestock, industrial, and public use are obtained from wells in thick rocks of Pennsylvanian and Mississippian ages. Thin sandstone and limestone beds of Pennsylvanian rocks and of the Chesterian Series, the Keokuk-Burlington Formation, and the Ste. Genevieve-St. Louis-Salem-Warsaw Formations of Mississippian age yield small quantities of ground water. Although wells in these rocks commonly yield less than 25 gallons per minute (gpm), they are the only available source of water supply for several thousand farms and homes and several hundred small municipalities and industries. The average depths of wells in Pennsylvanian and Mississippian rocks are 170 and 250 feet, respectively. Wells are often finished 6 to 12 inches in diameter.

During the period 1920 to 1963 about 250 well-production tests were made on more than 200 wells penetrating Pennsylvanian and Mississippian rocks. Statistical analysis of specific-capacity data provided a basis for comparing the productivity of individual formations.

It is concluded that the average productivity of the Keokuk-Burlington Formation is greater than the average productivity of the Ste. Genevieve-St. Louis-Salem-Warsaw Formations and Chesterian Series of Mississippian age. The average productivity of the Chesterian Series is much less than that of the Keokuk-Burlington Formation but much greater than that of the Ste. Genevieve-St. Louis-Salem-Warsaw Formations. The average productivity of the Keokuk-Burlington Formation of Mississippian age is greater than the productivity of Pennsylvanian rocks. The median specifiic capacities of wells in Pennsylvanian rocks and in the Keokuk-Burlington, Chesterian, and Ste. Genevieve-St. Louis-Salem-Warsaw are 0.32, 1.02, 0.30, and 0.12 gallons per minute per foot of drawdown (gpm/ft), respectively. The average productivity of Pennsylvanian and Mississippian rocks is much less than that of Silurian and Ordovician rocks in northern Illinois.

Several wells show marked improvement in yield as the result of shooting. Yields are increased because 1) the hole is enlarged and 2) fine materials and inerusting deposits on the well face and in the well wall are removed.

Probable ranges of yields of wells in undeveloped areas can be estimated from the specific-capacity frequency graphs and information on the availability of ground water from Pennsylvanian and Mississippian rocks in 88 counties.

INTRODUCTION

In Illinois several thousand farm and domestic wells and a few hundred municipal and industrial wells obtain ground water from rocks of Pennsylvanian and Mississippian ages. These rocks are encountered at depths ranging from a few feet to several hundred feet; the parts of these rocks functioning as aquifers consist largely of thin beds of sandstone and limestone. Generally Pennsylvanian rocks are developed for small water supplies in areas east and south of the Illinois River where the glacial drift is thin or practically impermeable. The Mississippian rocks are important aquifers west of the Illinois River and in areas of the southern and southwestern parts of the state.

Despite the fact that the yields of wells in Pennsylvanian and Mississippian rocks are inconsistent and low and that the limestone and sandstone beds are often greatly limited in areal extent and thickness, these rocks have been important sources of water especially for farm and domestic supplies for more than a century. Total withdrawal from Pennsylvanian and Mississippian rocks in 1960 was about 46.6 million gallons per day (mgd). The city of Anna and the villages of Roodhouse, Red Bud, Millstadt, and St. Francisville are the largest municipalities to use these rocks for water supply.

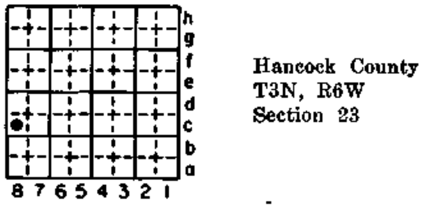
Pennsylvanian rocks range in thickness from a few feet to more than 2400 feet; the maximum known thickness of the Mississippian rocks is 3400 feet. Wells usually penetrate only the upper few hundred feet, or less, of these rocks because the water quality becomes poorer with increasing depth.

Many data on the performance of wells in Pennsylvanian and Mississippian rocks have been collected by the Illinois State Water Survey. The results of aquifer tests and well-production tests made on several hundred wells provide important information concerning the influence of location, depth, construction features, and age of a well on its yield. The effects of well treatment are apparent from data for tests made before and after treatment.

This report summarizes the results of studies made to date on the yields of wells in Pennsylvanian and Mississippian rocks and on the availability of these groundwater supplies in 88 of the 102 counties in Illinois. A summary of published information concerning the geology and hydrology of the formations uncased in wells is presented to serve as a background for interpretation of the records.

Well-Numbering System

The well-numbering system used in this report is based on the location of the well, and uses the township, range, and section for identification. The well number consists of five parts: county abbreviation, township, range, section, and coordinate within the section. Sections are divided into rows of ⅛-mile squares. Each ⅛-mile square contains 10 acres and corresponds to a quarter of a quarter of a quarter section. A normal section of 1 square mile contains eight rows of ⅛-mile squares; an odd-sized section contains more or fewer rows. Rows are numbered from east to west and lettered from south to north as shown in the diagram. The number of the well shown is: HAN 3N6W-23.8c. Where there is more than one well in a 10-acre square they are identified by arabic numbers after the lower case letter in the well number.



The abbreviations used for counties are:

Adams	ADM	Henderson	HND	Piatt	PIA
Bond	BND	Jackson	JKS	Pike	PKE
Brown	BRN	Jasper	JAS	Pope	PPE
Bureau	BUR	Jersey	JER	Putnam	PUT
Clark	CLK	Johnson	JHN	Randolph	RAN
Clinton	CLN	Lawrence	LAW	Richland	RCH
Coles	COL	Livingston	LIV	Rock Island	RIS
Crawford	CRF	Logan	LOG	St. Clair	STC
DeWitt	DWT	McDonough	MCD	Saline	SAL
Douglas	DGL	Macoupin	MCP	Schuyler	SCH
Edgar	EDG	Madison	MAD	Shelby	SHL
Effingham	EFF	Marion	MRN	Stark	STK
Fayette	FAY	Marshall	MRS	Union	UNI
Fulton	FUL	Menard	MEN	Vermilion	VER
Gallatin	GAL	Monroe	MNR	Wabash	WAB
Grundy	GRY	Montgomery	MTG	Warren	WAR
Hancock	HAN	Moultrie	MOU	Wayne	WAY
Hardin	HAR	Perry	PRY	White	WHT
				Williamson	WLM

Acknowledgments

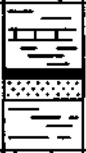
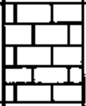
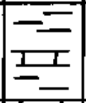
This report was prepared under the general supervision of William C. Ackermann, Chief of the Illinois State Water Survey, and H. F. Smith, Head of the Hydrology Section. W. C. Walton and R. J. Schicht reviewed the final manuscript. J. W. Brother prepared the illustrations. Many former and present members of the State Water Survey and State Geological Survey participated in well-production tests, wrote earlier special reports, or aided the writer indirectly in preparing this report. Consulting engineers, well drillers, and municipal officials were most cooperative and helpful in making data available on well-production tests.

GEOLOGY AND HYDROLOGY

Bedrock wells in Illinois may penetrate rocks of Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, and Cambrian ages. The yields of bedrock wells in Devonian, Silurian, Ordovician, and Cambrian ages have been described by Walton and Csallany (1962) and Csallany and Walton (1963). This report is concerned primarily with bedrock wells penetrating Pennsylvanian and Mississippian rocks. Other rocks are considered only with respect to their relation to the geohydrologic conditions of Pennsylvanian and Mississippian rocks.

The geologic nomenclature and characteristics, drilling and casing conditions, and water-yielding properties of Pennsylvanian, Mississippian, Devonian, and Silurian rocks and overlying unconsolidated deposits are summarized for seven geographic districts of the state in tables 1-7. The sequence, structure, and general characteristics of the rocks are shown in figure 1; the locations of geologic cross sections and district boundaries are shown in figure 2. For a detailed discussion of the geology of the rocks the reader is referred to the several publications on regional studies listed in the references. The following sections on geology and hydrology were largely abstracted from these reports.

Table 1. Generalized Column of Rocb in Northeastern Illinois

SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-350	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS, ALLUVIUM	BOULDERS, HEAVING SAND LOCALLY; SAND AND GRAVEL WELLS USUALLY REQUIRE SCREENS AND DEVELOPMENT; CASING REQUIRED IN WELLS INTO BEDROCK	SAND AND GRAVEL, PERMEABLE; SOME WELLS YIELD MORE THAN 1000 GPM; SPECIFIC CAPACITIES FROM 2.1 TO 66 GPM/FT, AVG 12 GPM/FT; COEFFICIENT OF TRANSMISSIBILITY FROM 3400 TO 100,000 GPD/FT, AVG 25,000 GPM/FT
PENNSYLVANIAN				0-175	SHALE, SANDSTONE LIMESTONE AND COAL	SHALE REQUIRES CASING	JOINTED BEDS YIELD SMALL SUPPLIES LOCALLY
MISSISSIPPIAN	VALMEYERAN			0-365	LIMESTONE AND SHALE (PRESENT ONLY AT DES PLAINES)		LIMITED AREAL EXTENT; NOT USED AS AQUIFER
	KINDER-HOOKIAN						
DEVONIAN	UPPER	NEW ALBANY		0-25			
SILURIAN	NIAGARAN	RACINE WAUKESHA JOLIET		0-465	DOLOMITE, SILTY AT BASE, LOCALLY CHERTY	UPPER PART USUALLY WEATHERED AND BROKEN; EXTENT OF CREVICING VARIES WIDELY	NOT CONSISTENT; SOME WELLS YIELD MORE THAN 1000 GPM. CREVICES AND SOLUTION CHANNELS MORE ABUNDANT NEAR SURFACE; SPECIFIC CAPACITIES FROM 0.1 TO 550 GPM/FT HIGHEST AVG SPECIFIC CAPACITIES (54.4 GPM/FT) IN DU PAGE COUNTY WELLS, LOWEST (5 GPM/FT) IN LAKE COUNTY; COEFFICIENT OF TRANS. AVG 100,000 GPD/FT IN DU PAGE COUNTY, 9000 GPD/FT IN LAKE COUNTY
	ALEXANDRIAN	KANKAKEE EDGEWOOD					

AFTER SUTER et al. (1959)

Pennsylvanian Rocks

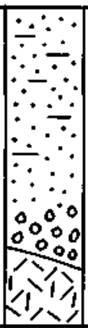
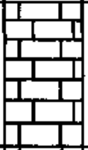
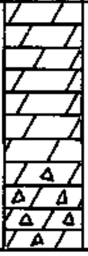
The bedrock surface in about four-fifths of Illinois is formed by Pennsylvanian rocks (figure 3). According to Horberg (1950) the bedrock surface formed by rocks of Pennsylvanian age can be divided into two major preglacial physiographic divisions, the Pennsylvanian Upland and the Pennsylvanian Lowland. The Pennsylvanian Upland includes that part of the state underlain by Pennsylvanian rocks mostly west of the Illinois River Valley, as shown in figure 4, but a small part extends east of the Illinois River in Tazewell County. The Pennsylvanian Lowland covers about three-fifths of the state and includes about three-fourths of the state underlain by Pennsylvanian rocks.

In the Pennsylvanian Upland area the rocks dip to the southeast at an average rate of 12 feet per mile. Pennsylvanian rocks attain thicknesses of 500 feet in the upland. Where valleys occur in the bedrock surface (figure 5) the Pennsylvanian rocks have been deeply eroded and are thinned. Structurally the upland is situated along the northwest flank of the Illinois Basin. Minor folds tend to strike down-dip toward the deep part of the basin in southeastern Illinois.

Within the Pennsylvanian Lowland area the rocks dip toward an area in southeastern Illinois near the intersection of Wayne, Edwards, and White Counties. The rocks slope from a rather uniform bedrock elevation between 600 and 650 feet in the northern two-thirds of the lowland to an average elevation of 500 feet in the southern one-third of the division. The lowest bedrock elevation is about 220 feet in the southeast part of the division. The thickness of the rocks exceeds 2000 feet in places. The principal structure within the Pennsylvanian Lowland is the LaSalle anticlinal belt which extends for over 200 miles (figure 6). Inliers of Mississippian, Devonian, and Silurian rocks occur along this structure in Ford, Champaign, and Douglas Counties.

Pennsylvanian rocks are overlain by glacial drift and other unconsolidated deposits. They overlie rocks of

Table 2. Generalized Column of Rocks in Northwestern Illinois

SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-500	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS AND ALLUVIUM	NORMALLY REQUIRES WELL SCREENS AND CAREFUL DEVELOPMENT; GLACIAL DEPOSITS CASED OFF IN BEDROCK WELLS	WATER-YIELDING CHARACTER VARIABLE; THICK PERMEABLE SAND AND GRAVEL DEPOSITS CHIEFLY IN BEDROCK CHANNELS PRESENT POSSIBILITIES FOR LARGE MUNICIPAL AND INDUSTRIAL SUPPLIES
PENNSYLVANIAN				0-500	PRINCIPALLY SHALE WITH THIN SANDSTONE, LIMESTONE AND COAL	MAY REQUIRE CASING DUE TO SHALE CAVING AND POOR-QUALITY WATER	GENERALLY UNFAVORABLE AS AN AQUIFER; LOCALLY DOMESTIC & FARM SUPPLIES OBTAINED FROM LIMESTONE AND SANDSTONE BEDS
MISSISSIPPIAN	KINDERHOOKIAN	NEW ALBANY		0-25	SHALE	REQUIRES CASING	NOT WATER YIELDING
DEVONIAN	MIDDLE	CEDAR VALLEY WAPSIPINICON		50-100	LIMESTONE		NOT NORMALLY A SOURCE OF WATER DUE TO A LACK OF CRACKS OR SOLUTION OPENINGS
SILURIAN	NIAGARAN	PORT BYRON RACINE WAUKESHA JOLIET		300-500	DOLOMITE, MOSTLY PURE IN UPPER PART TO ARGILLACEOUS NEAR BASE; LOWER PART CHERTY	CHERTY ZONES IN LOWER PART MAY CAUSE DRILLING DIFFICULTIES	WIDELY USED AS AN AQUIFER WHERE SUFFICIENTLY THICK
	ALEXANDRIAN	KANKAKEE EDGEWOOD					

AFTER HACKETT & BERGSTROM (1956)

Mississippian age (figure 7) in a large part of the Pennsylvanian Upland and Lowland. In the extreme northern part of the lowland Pennsylvanian rocks overlie rocks of Devonian, Silurian, and Ordovician ages.

The rocks, commonly called "coal measures," in the Pennsylvanian Lowland are similar lithologically to the rocks in the upland. The Pennsylvanian System is divided into the McLeansboro, Kewanee, and McCormick Groups. These groups are dominantly weak shales but include thin limestones (generally less than 25 feet thick), thin sandstone formations of limited areal extent, and coal beds.

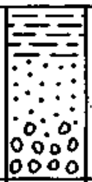
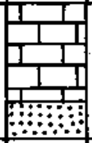
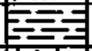
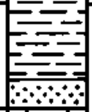
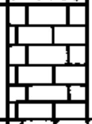
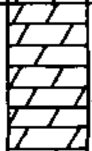
Domestic, farm, and small municipal water supplies are developed from the Pennsylvanian rocks in a large part of the state where sand and gravel aquifers are not present or are thin. The Pennsylvanian rocks generally have low porosities and permeabilities and yield small amounts of water to wells from interconnected pores, cracks, fractures, crevices, joints, and bedding planes. Water-bearing openings are variable from place to place and are best developed near the surface in thin limestones and sandstones. Water in the Pennsylvanian rocks becomes highly mineralized with increasing depth, and production wells seldom penetrate more than 200 or 300 feet into the bedrock.

Recharge to the Pennsylvanian rocks is derived locally from vertical leakage through the glacial drift and other unconsolidated materials that are in turn recharged from precipitation. Water occurs in these rocks mainly under leaky artesian conditions.

Mississippian Rocks

The bedrock surface in Illinois is formed by Mississippian rocks in parts of the western tier of counties from Henderson County south to Alexander County; in parts of Johnson, Pulaski, Pope, Hardin, and Massac

Table 3. Generalized Column of Rocb in Western Illinois, North Part

SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-250	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS AND ALLUVIUM	WELLS USUALLY REQUIRE SCREENS AND CAREFUL DEVELOPMENT	VARIABLE; LARGE YIELDS FROM THICKER SAND AND GRAVEL DEPOSITS IN BEDROCK VALLEYS
PENNSYLVANIAN				0-475	MAINLY SHALE WITH SANDSTONE, LIMESTONE AND COAL	CASING USUALLY REQUIRED	GENERALLY UNFAVORABLE AS AQUIFER; LOCALLY DOMESTIC AND FARM SUPPLIES OBTAINED FROM THIN LIMESTONE AND SANDSTONE BEDS
MISSISSIPPIAN	VALMEYERAN	ST. LOUIS SALEM SONORA		0-100	LIMESTONE AND SANDSTONE		WATER-YIELDING WHERE CREVICED; TOO THIN TO BE IMPORTANT SOURCE OF WATER IN AREA
		WARSAW		0-100	SHALE	CASING REQUIRED	NOT WATER-YIELDING AT MOST PLACES
		KEOKUK BURLINGTON		0-225	LIMESTONE		GENERALLY CREVICED AND WATER-YIELDING; WELLS PENETRATE LIMESTONE FROM 30 TO MORE THAN 150 FEET; DEPENDABLE AQUIFER FOR FARM SUPPLIES IN MUCH OF AREA
	KINDER-HOOKIAN			0-275	SHALE WITH LIMESTONE	CASING REQUIRED	NOT WATER-YIELDING AT MOST PLACES; LOCALLY LIMESTONES WITHIN SHALE ARE SOURCE OF SMALL FARM SUPPLIES
DEVONIAN	UPPER			25-200	SHALE AND SANDSTONE		DEVONIAN LIMESTONE LOCALLY WATER-YIELDING FROM CREVICES; SILURIAN DOLOMITE MORE DEPENDABLE AQUIFER FOR FARM SUPPLIES IN MOST AREAS; SATISFACTORY WELLS MAY REQUIRE PENETRATION FROM 25-150 FEET INTO SILURIAN; DOLOMITE USUALLY "TIGHTER" IN LOWER HALF; OIL SAND ("HOING") OCCURS IN LOWER PART OF DEVONIAN IN SW MC DONOUGH COUNTY
	MIDDLE	CEDAR VALLEY WAPSIPINICON			LIMESTONE		
SILURIAN	NIAGARAN			0-350	DOLOMITE, CHERTY AT BASE		
	ALEXANDRIAN						

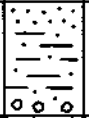
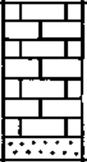
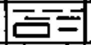
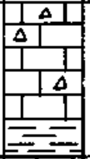
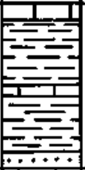
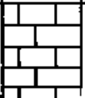
AFTER BERGSTROM (1956)

Counties in southern Illinois; and along the Illinois River Valley south of Mason and Pulton Counties. In addition, Mississippian rocks form the bedrock surface in small parts of Ford, Champaign, and Douglas Counties along the LaSalle anticlinal belt. In northern Illinois Mississippian rocks are known only in the area of the DesPlaines complex and in the extreme southern part of Bureau County. As shown in figure 7, Mississippian rocks are overlain by Pennsylvanian rocks in a large part of western, east-central, and southern Illinois, and almost all of south-central Illinois.

In western Illinois Mississippian rocks dip eastward at a rate of about 15 to 50 feet per mile. The regional dip is inward toward the deepest part of the Illinois Basin, in White County, where the maximum thicknesses of the Mississippian rocks occur.

The Mississippian rocks are divided into three series which are, in ascending order: the Kinderhookian Series, the Valmeyeran Series, and the Chesterian Series. The Kinderhookian Series is present in almost two-thirds

Table 4. Generalized Column of Rocks in Western Illinois, South Part

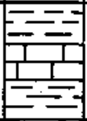
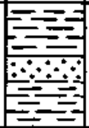
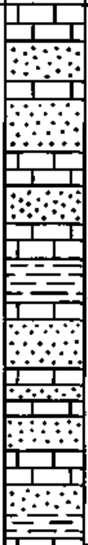
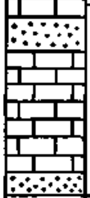
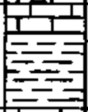
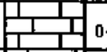
SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-250	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS AND ALLUVIUM	WELLS USUALLY REQUIRE SCREENS AND CAREFUL DEVELOPMENT	WATER-YIELDING CHARACTER VARIABLE; LARGE YIELDS FROM THICK SAND AND GRAVEL DEPOSITS IN BEDROCK VALLEYS
CRETACEOUS	GULFIAN	BAYLIS		0-100	SAND AND CLAYEY SAND; GRAVEL AT BASE		
PENNSYLVANIAN				0-430	MAINLY SHALE, WITH SANDSTONE, LIMESTONE AND COAL	CAVING SHALES REQUIRE CASING	GENERALLY UNFAVORABLE AS WATER SOURCE; LOCALLY, DOMESTIC AND FARM SUPPLIES OBTAINED FROM THIN SANDSTONE, LIMESTONE AND COAL BEDS
MISSISSIPPIAN	VALMEYERAN	STE GENEVIEVE ST. LOUIS SALEM SONORA		0-325	LIMESTONE AND LITTLE SANDSTONE		THIN, USUALLY NOT WATER-YIELDING WEST OF ILLINOIS RIVER; THICKER, OCCASIONALLY WATER YIELDING EAST OF RIVER AND IN SOUTHERN CALHOUN COUNTY
		WARSAW		0-125	SHALE WITH SOME LIMESTONE	CASING REQUIRED	NOT WATER-YIELDING AT MOST PLACES
		KEOKUK BURLINGTON FERN GLEN SEDALIA		0-275	CHERTY LIMESTONE AND SHALE		GENERALLY CREVICED AND WATER-YIELDING; MAIN AQUIFER FOR DOMESTIC SUPPLIES; WELLS PENETRATE LIMESTONE FROM 30 TO 150 FEET; TIGHT AT SOME LOCATIONS
	KINDER-HOOKIAN	NEW ALBANY GROUP		0-325	SHALE AND LIMESTONE; SOME SANDSTONE	CASING REQUIRED	NOT WATER-YIELDING AT MOST LOCATIONS; LOCALLY LIMESTONES YIELD SMALL QUANTITIES OF WATER
DEVONIAN	UPPER						
	MIDDLE			0-225	LIMESTONE		NOT IMPORTANT GROUND WATER SOURCE, EXCEPT LOCALLY FOR SMALL SUPPLIES IN CALHOUN COUNTY; GAS, OIL OR SALT WATER FOUND AT SOME LOCATIONS
SILURIAN					CHERTY LIMESTONE AND DOLOMITE		

AFTER BERGSTROM & ZEIZEL (1957)

of Illinois. It forms the bedrock surface in parts of Iroquois and Henderson Counties and in places along the Mississippi and Illinois Rivers. The elevation of the base of the Kinderhookian (New Albany) shale, considered as a major bedrock structure (Bell, 1943), is shown in figure 6. The structural relief on the base of the Kinderhookian (New Albany) shale is over 5000 feet and the regional dip from northwest to southeast is about 20 feet per mile. The Kinderhookian Series consists largely of shale with thin limestone and sandstone beds. Thicknesses of 400 feet are attained in southern Illinois. The Kinderhookian Series yields very little water to wells and is not an important aquifer.

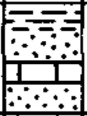
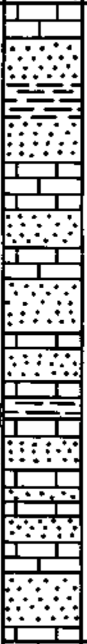
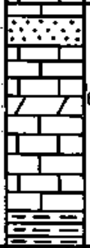
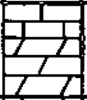
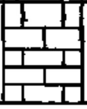
The most important formations of the Valmeyeran Series in ascending order are: the Keokuk-Burlington cherty limestone; the Warsaw shale; the St. Louis-Salem limestone; and the Ste. Genevieve limestone. The Keokuk-Burlington Formation forms the bedrock surface in western Illinois in small parts of Hancock and Adams Counties; in large parts of Pike, Calhoun, Scott, and

Table 5. Generalized Column of Rocks in East-Central Illinois

SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-500	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS, AND ALLUVIUM	WELLS USUALLY REQUIRE SCREENS AND CAREFUL DEVELOPMENT	WATER-YIELDING CHARACTER VARIABLE; LARGE YIELDS FROM THICKER SAND AND GRAVEL DEPOSITS IN BEDROCK VALLEYS; CHIEF AQUIFER IN AREA
PENNSYLVANIAN		MC LEANSBORO GROUP		0-1000	SHALE, LIMESTONE, SANDSTONE AND COAL	MAY REQUIRE CASING	WATER-YIELDING CHARACTER VARIABLE; LOCALLY SHALLOW SANDSTONE AND CREVICED LIMESTONE YIELD SMALL SUPPLIES; WATER QUALITY USUALLY BECOMES POORER WITH INCREASING DEPTH
		KEWANEE GROUP		0-200			
		MC CORMICK GROUP		0-600			
MISSISSIPPIAN	CHESTERIAN	MENARD WALTERSBURG VIENNA TAR SPRINGS GLEN DEAN HARDINSBURG HANEY FRAILEYS BEECH CREEK CYPRESS RIDENHOWER BETHEL DOWNEYS BLUFF YANKEETOWN RENAULT		0-500	LIMESTONE, SANDSTONE AND SHALE		TOO DEEP TO BE CONSIDERED AS A SOURCE OF GROUND WATER IN THIS AREA
	VALMEYERAN	AUX VASES STE. GENEVIEVE ST. LOUIS SALEM SONORA		0-150	LIMESTONE WITH SOME SANDSTONE AND SHALE		MAY BE WATER-YIELDING IN MASON COUNTY WHERE THESE FORMATIONS ARE PRESENT AT A SHALLOW DEPTH; IN THE REST OF THE AREA TOO DEEP TO BE CONSIDERED A SOURCE OF GROUND WATER
		WARSAW		0-130			
		KEOKUK-BURLINGTON		0-300			
	KINDER-HOOKIAN	CHOUTEAU NEW ALBANY GROUP		0-200	SHALE AND LIMESTONE		NOT WATER-YIELDING
DEVONIAN				0-70	LIMESTONE		WATER-YIELDING FROM CREVICES WHERE ENCOUNTERED AT A SHALLOW DEPTH; IN MOST OF THE AREA TOO DEEP TO BE CONSIDERED A SOURCE OF GROUND WATER
SILURIAN	NIAGARAN			0-350	DOLOMITE AND LIMESTONE		
	ALEXANDRIAN			0-100			

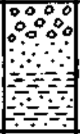
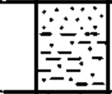
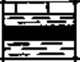
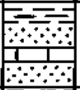
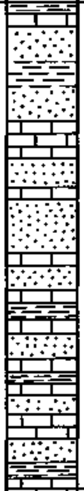
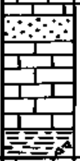
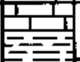
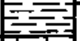
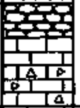
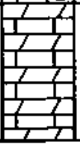
AFTER SELKREGG & KEMPTON (1958)

Table 6. Generalized Column of Rocks in South-Central Illinois

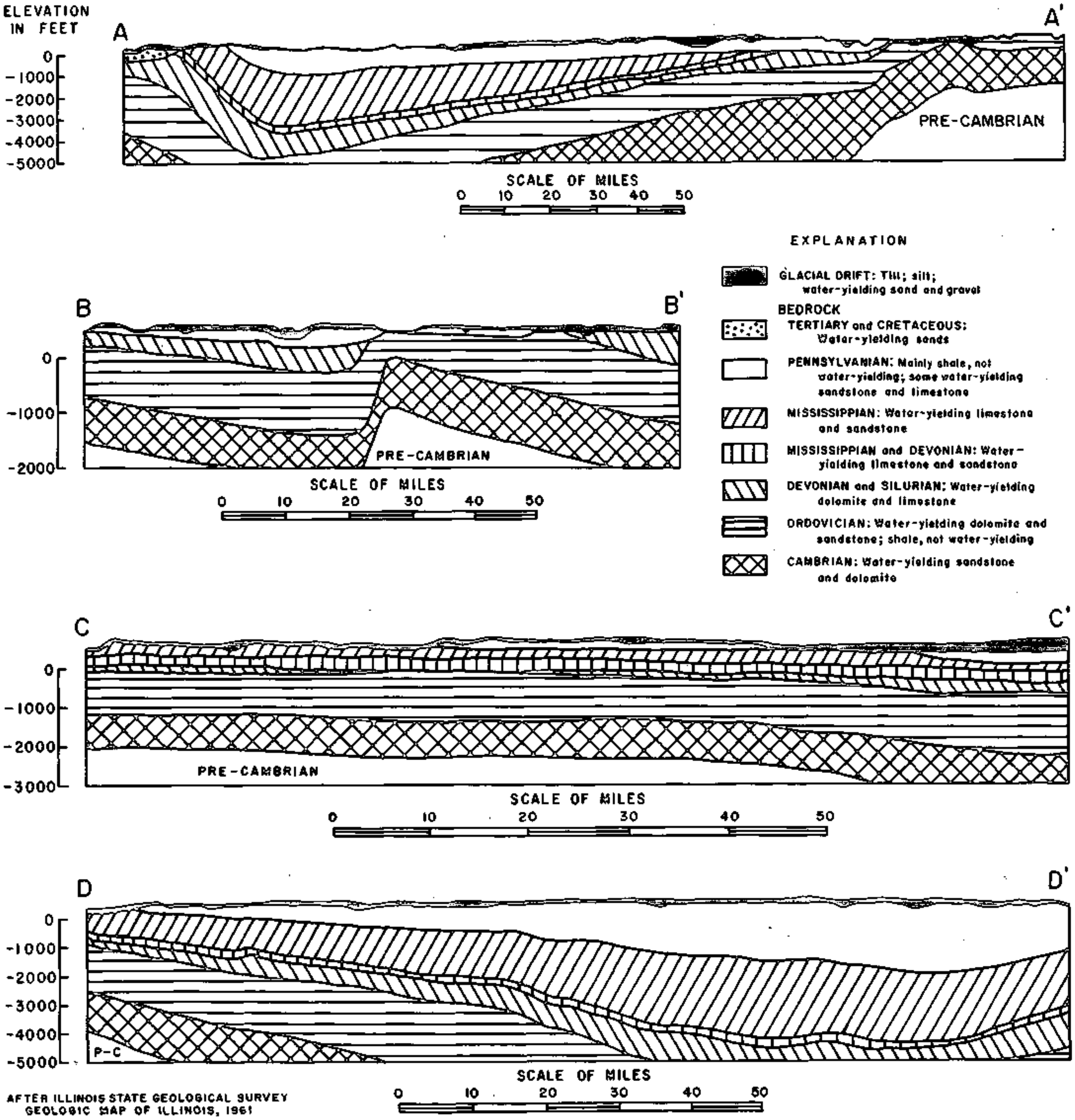
SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUARTERNARY	PLEISTOCENE			0-200	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS AND ALLUVIUM	REQUIRES TESTING, SCREENS AND DEVELOPMENT	THICK SAND AND GRAVEL DEPOSITS SOURCE OF LARGE SUPPLIES IN MAJOR STREAM VALLEYS; THIN UPLAND SAND AND GRAVEL DEPOSITS LOCALLY SUITABLE FOR SMALL SUPPLIES
PENNSYLVANIAN		MC LEANSBORO GROUP		0-1000	SHALE, SANDSTONE, LIMESTONE AND COAL	MAY REQUIRE CASING	WATER-YIELDING CHARACTER VARIABLE; LOCALLY SHALLOW SANDSTONE AND CREVICED LIMESTONE YIELD SMALL SUPPLIES; WATER QUALITY USUALLY BECOMES POORER WITH INCREASING DEPTH
		KEWANEE GROUP		0-300			
		MC CORMICK GROUP		0-1100			
MISSISSIPPIAN	CHESTERIAN	KINKAID DEGONIA CLORE PALESTINE MENARD WALTERSBURG VIENNA TAR SPRINGS GLEN DEAN HARDINSBURG GOLCONDA CYPRESS RIDENHOWER BETHEL DOWNEYS BLUFF YANKEETOWN		0-1300	LIMESTONE, SANDSTONE AND SHALE	SHALES MAY REQUIRE CASING	SOME SANDSTONES ARE IMPORTANT SOURCES OF GROUND WATER IN MADISON, ST. CLAIR AND MONROE COUNTIES; LIMESTONE MAY YIELD DOMESTIC SUPPLIES; TOO DEEP IN EASTERN AND CENTRAL PART OF AREA TO YIELD POTABLE WATER
	VALMEYERAN	RENAULT AUX VASES STE. GENEVIEVE ST. LOUIS SALEM HARRODSBURG BORDEN		600-1500	SANDSTONE LIMESTONE AND DOLOMITE SILTSTONE	CREVICES AND SOLUTION CHANNELS MAY CAUSE DRILLING DIFFICULTIES	DEPENDABLE AQUIFER FOR SMALL TO MEDIUM SUPPLIES IN MADISON, ST. CLAIR AND MONROE COUNTIES; ST. LOUIS LIMESTONE PARTICULARLY FAVORABLE
	KINDER-HOOKIAN			0-250	LIMESTONE SHALE		NOT WATER-YIELDING
DEVONIAN				0-200	LIMESTONE, DOLOMITE		MAY YIELD GROUND WATER FROM JOINTS AND CHANNELS; TOO DEEP TO YIELD POTABLE WATER
SILURIAN				0-1000	LIMESTONE		

AFTER SELKREGG (1957)

Table 7. Generalized Column of Rocks in Southern' Illinois

SYSTEM	SERIES	GROUP OR FORMATION	LOG	THICKNESS IN FEET	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-200	UNCONSOLIDATED GLACIAL DEPOSITS, LOESS AND ALLUVIUM	NORMALLY REQUIRES WELL SCREENS AND CAREFUL DEVELOPMENT	WATER-YIELDING CHARACTERISTICS VARIABLE; THICK DEPOSITS OF SAND AND GRAVEL IN MAJOR STREAM VALLEYS PRESENT POSSIBILITIES FOR MUNICIPAL AND INDUSTRIAL SUPPLIES
TERTIARY		LAFAYETTE WILCOX PORTERS CREEK CLAYTON		0-495	GRAVEL SAND AND CLAY CLAY AND SANDY CLAY	NORMALLY REQUIRES WELL SCREENS AND CAREFUL DEVELOPMENT	WATER-YIELDING CHARACTERISTICS VARIABLE; THICK DEPOSITS OF SAND PRESENT EXCELLENT POSSIBILITIES FOR DOMESTIC AND FARM SUPPLIES AND LOCALLY POSSIBILITIES FOR MUNICIPAL AND INDUSTRIAL SUPPLIES
CRETACEOUS	GULFIAN	MC NAIRY		0-500	SAND, SILT AND CLAY	NORMALLY REQUIRES WELL SCREENS AND CAREFUL DEVELOPMENT	
PENNSYLVANIAN		MC LEANSBORO GROUP		0-1000	SHALE, SANDSTONE, LIMESTONE AND COAL	MAY REQUIRE CASING OF CAVING SHALES AND HEAVY UNDERLAYS	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
		KEWANEE GROUP		0-500			
		MC CORMICK GROUP		0-1200			
MISSISSIPPIAN	CHESTERIAN	GROVE CHURCH KINKAID DEGONIA CLORE PALESTINE MENARD WALTERSBURG VIENNA TAR SPRINGS GLEN DEAN HARDINSBURG GOLCONDA CYPRESS RIDENHOWER BETHEL DOWNEYS BLUFF YANKEETOWN		0-1400	LIMESTONE, SANDSTONE AND SHALE	CAVING SHALE REQUIRES CASING OR LINERS	YIELDS WATER FROM SANDSTONE AND LIMESTONE STRATA; WIDESPREAD AND USED CHIEFLY FOR FARM AND DOMESTIC SUPPLIES; WATER QUALITY VARIABLE
	VALMEYERAN	RENAULT AUX VASES STE. GENEVIEVE ST. LOUIS SALEM HARRODSBURG BORDEN-FORT PAYNE		0-450	SANDSTONE LIMESTONE, PARTLY CHERTY AND CREVICED SILTSTONE, SHALE, LIMESTONE AND CHERT	SOME TROUBLE KEEPING A STRAIGHT HOLE IN FAULTED AREAS	WATER-YIELDING CHARACTERISTICS OF SANDSTONE VARIABLE; LOCALLY MUNICIPAL AND INDUSTRIAL SUPPLIES ARE OBTAINED; WATER QUALITY VARIABLE WIDESPREAD AND DEPENDABLE AQUIFER FOR DOMESTIC AND FARM SUPPLIES; LOCALLY A SOURCE OF WATER FOR MUNICIPAL AND INDUSTRIAL SUPPLIES
	KINDER-HOOKIAN	CHOUTEAU NEW ALBANY GROUP		0-400	LIMESTONE SHALE	CAVING SHALE REQUIRES CASING OR LINERS	SMALL SUPPLIES LOCALLY AVAILABLE FROM THIN LIMESTONE STRATA
DEVONIAN	UPPER			0-1400	SHALE	LOCALLY TROUBLE IS ENCOUNTERED WITH CROOKED HOLES; CHERT MAY CAUSE DRILLING DIFFICULTIES	WIDESPREAD AND DEPENDABLE AQUIFER FOR DOMESTIC AND FARM SUPPLIES; LOCALLY A SOURCE OF WATER FOR MUNICIPAL AND INDUSTRIAL SUPPLIES
	MIDDLE	DUTCH CREEK			LIMESTONE, SANDSTONE AND CHERT		
	LOWER	CLEAR CREEK BAILEY					
SILURIAN	NIAGARAN			0-400	LIMESTONE AND DOLOMITE		DEPENDABLE AQUIFER FOR DOMESTIC AND FARM SUPPLIES IN LOCAL AREA FROM CREVICED LIMESTONE AND DOLOMITE
	ALEXANDRIAN						

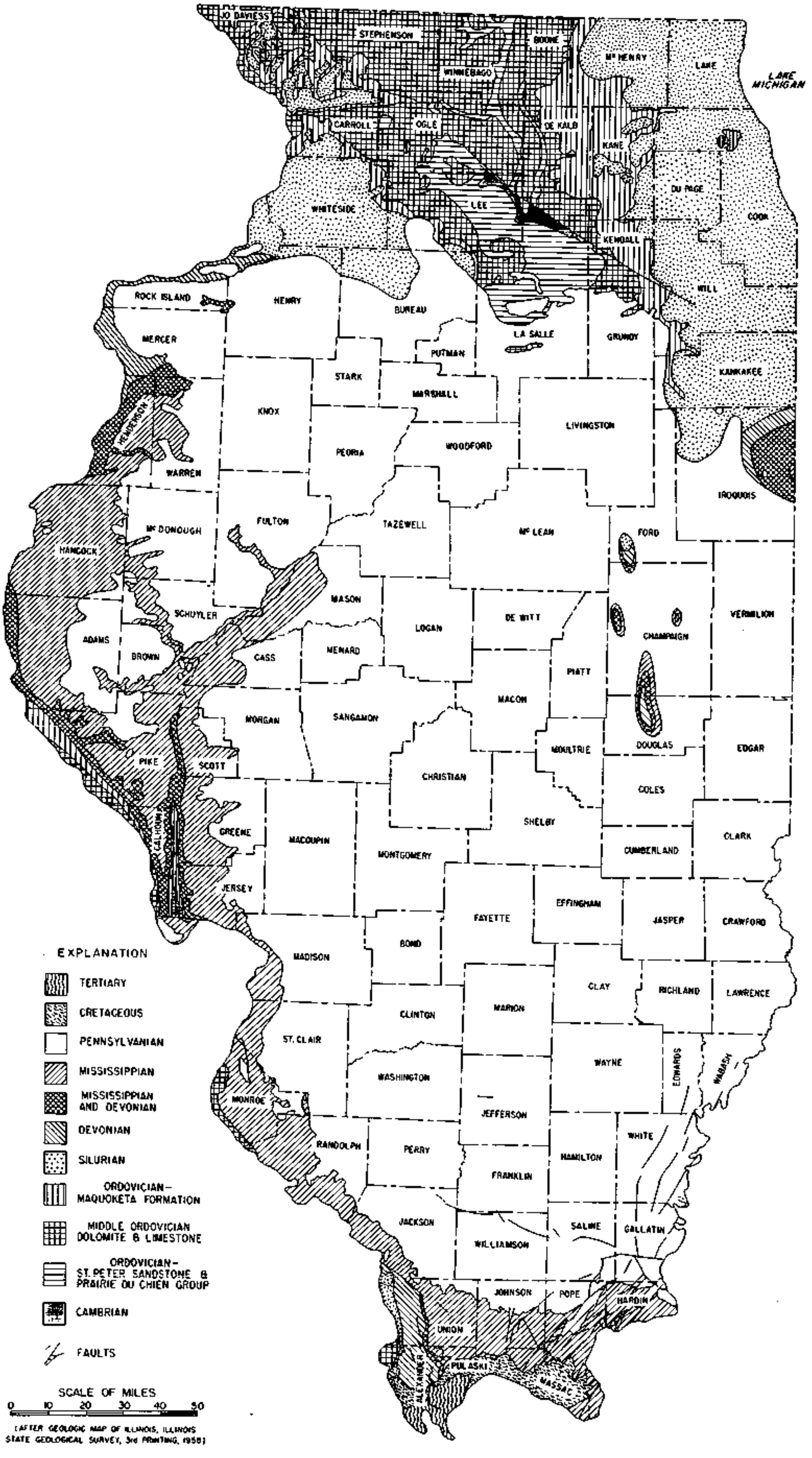
AFTER PRYOR (1956a)



AFTER ILLINOIS STATE GEOLOGICAL SURVEY
GEOLOGIC MAP OF ILLINOIS, 1961

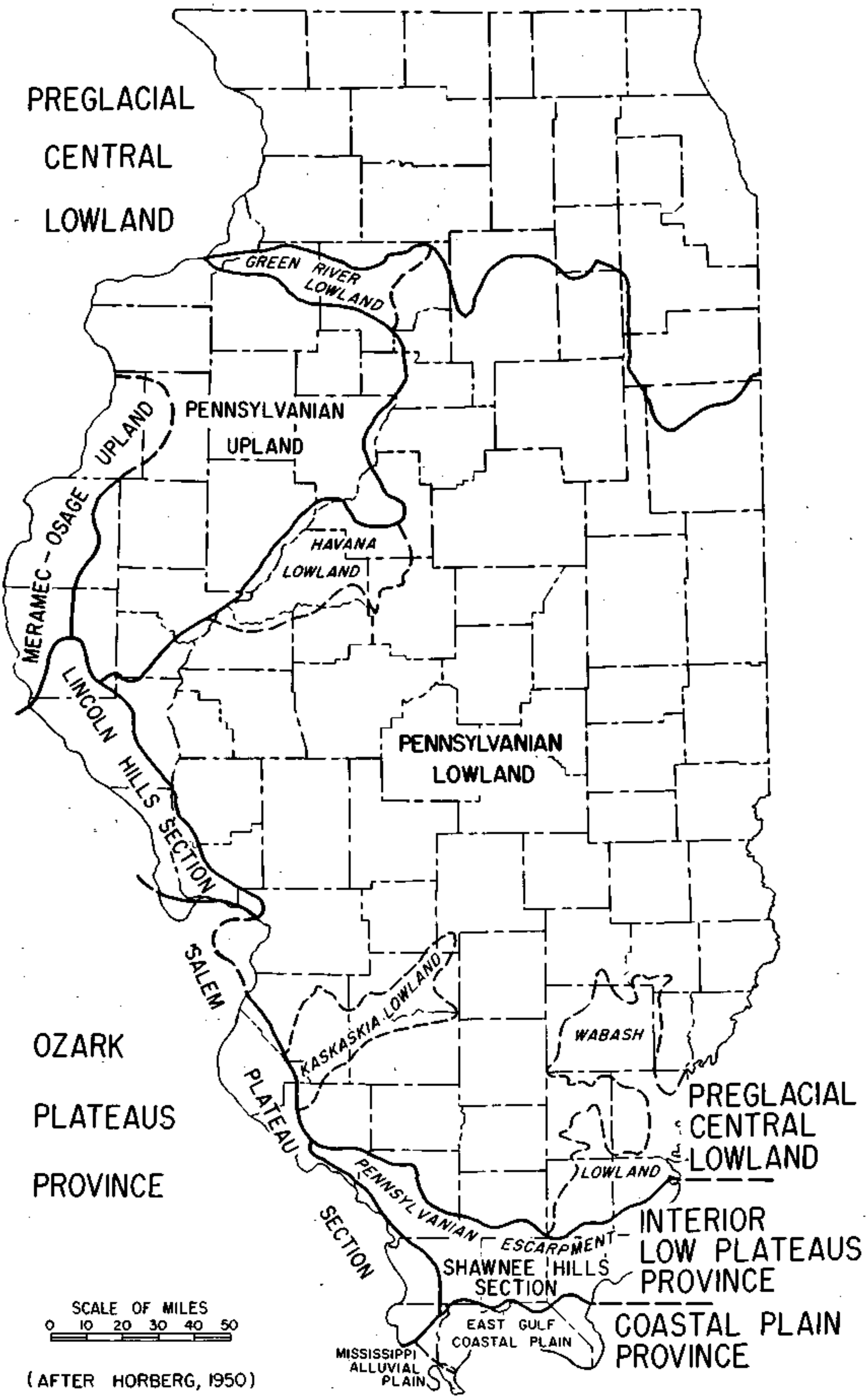
Figure 1. Cross sections of structure and stratigraphy of bedrock in Illinois

Figure 2. Locations of geologic cross sections and geographic districts



(AFTER GEOLOGIC MAP OF ILLINOIS, ILLINOIS STATE GEOLOGICAL SURVEY, 3rd PRINTING, 1958)

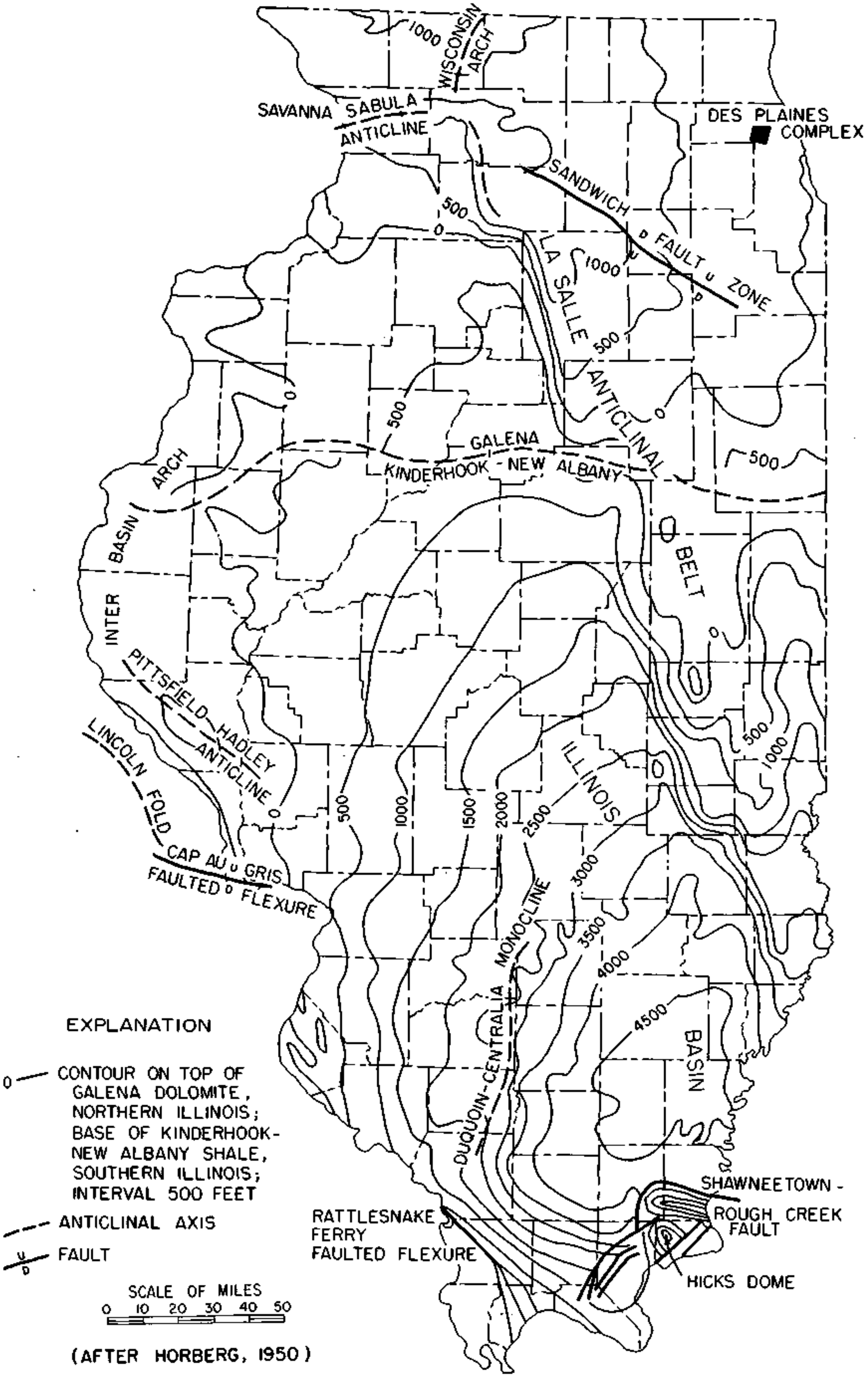
Figure 3. Areal geology of bedrock surface in Illinois, generalized



(AFTER HORBERG, 1950)

Figure 4. Preglacial physiographic divisions of bedrock surface formed by Pennsylvanian and Mississippian rocks

Figure 5. Bedrock topography of Illinois, generalized



(AFTER HORBERG, 1950)

Figure 6. Major bedrock surface in Illinois

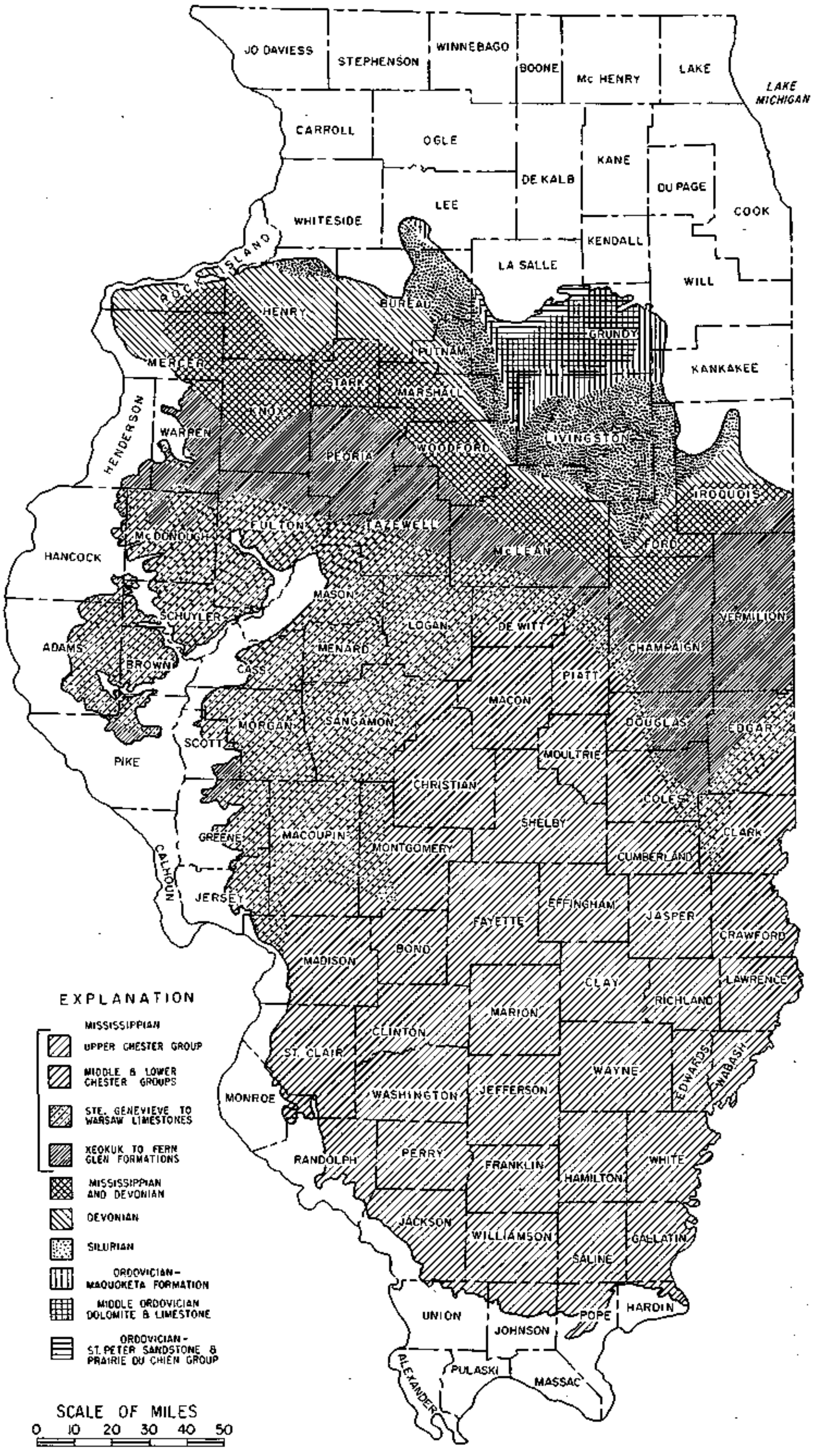


Figure 7. Sub-Pennsylvania geologic map of Illinois

Greene Counties; and in areas along the Illinois River Valley from Mason to Jersey County. As shown in figure 7 it is directly overlain by rocks of Pennsylvanian age in a wide strip through central Illinois. In western Illinois the formation attains thicknesses up to 300 feet and is generally well creviced. Domestic, farm, and small municipal supplies are developed from the Keokuk-Burlington Formation in western Illinois.

The Warsaw shale yields very little water to wells, generally requires casing, and is not considered an important aquifer. The Ste. Genevieve-St. Louis-Salem-Warsaw Formations are the uppermost bedrock formations in parts of Hancock and Adams Counties and along the Illinois River Valley south of Mason County. As shown in figure 7 they directly underlie Pennsylvanian rocks in parts of western, east-central, and south-central Illinois. In western and east-central Illinois the Warsaw shale has a maximum thickness of about 130 feet. The Ste. Genevieve-St. Louis-Salem Formations range in thickness from 0 to 325 feet in western Illinois. They are too thin to be considered as an important aquifer west of the Illinois River Valley.

The Valmeyeran Series forms the bedrock surface along the Mississippi River in Madison, St. Clair, Monroe, and Randolph Counties in western Illinois and in parts of Union, Jackson, Pulaski, Massac, Pope, and Hardin Counties in southern Illinois. In places in the Shawneetown-Rough Creek fault zone in Pope, Hardin, Massac, and Pulaski Counties in southern Illinois, the Valmeyeran limestones are extensively faulted and creviced and are good sources of ground water for municipal and domestic water supplies.

The Chesterian Series is absent in the northern half of the state. It forms the bedrock surface in small parts of the western part of south-central Illinois and the southern part of southern Illinois. In a large part of southern Illinois the Chesterian Series is overlain by rocks of Pennsylvanian age (figure 7). The Chesterian Series is composed of sandstone, limestone, and shale formations and has a maximum thickness of 1400 feet in southern Illinois. In areas where the Chesterian Series is the uppermost bedrock, the thickness of the series varies because the bedrock surface has been eroded. In areas where the series is overlain by Pennsylvanian rocks it has a fairly uniform thickness. Domestic, farm, and small municipal water supplies are developed from sandstone and limestone formations in the Chesterian Series where it forms the bedrock surface and where the Pennsylvanian rocks overlying it are thin. Several miles east and north of the Pennsylvanian border, water in the Chesterian Series becomes highly mineralized. The Aux Vases sandstone at the base of the Chesterian Series is an important source of ground water for municipal, domestic, and farm water supplies in parts of Madison, St. Clair, and Monroe Counties.

CONSTRUCTION FEATURES OF WELLS

Wells in the Pennsylvanian and Mississippian rocks are usually drilled by the cable tool method. They range in depth from 25 to 550 feet in the Pennsylvanian rocks and from 70 to 1030 feet in the Mississippian rocks. The average depth of wells in the Pennsylvanian rocks is about 170 feet and in the Mississippian rocks, about 250 feet.

Very few wells are uncased in both the Pennsylvanian and the Mississippian rocks. Several wells penetrate both rocks but are uncased only in the Mississippian rocks. In western and southern Illinois several formations of Mississippian age may contribute to the yields of wells. Wells may be grouped into the following categories according to the rocks uncased in wells: 1) Pennsylvanian, 2) Mississippian, and 3) Pennsylvanian and Mississippian. The distribution of wells in the three categories is given in table 8.

Wells in the Pennsylvanian rocks are usually uncased in sandstone and limestone beds; however, shale beds in the rocks generally require casing. In central Illinois water from the Mississippian rocks is considered too highly mineralized to be acceptable for domestic, livestock, or municipal use. In western Illinois most wells are uncased in the entire thickness of the Keokuk-Burlington Formation of Mississippian age. The Warsaw Formation, which consists largely of shale with thin beds of limestone, usually requires casing in most wells. In south-central and southern Illinois wells are uncased in either the Pennsylvanian or Mississippian rocks; casing is often required in shale beds of both rocks.

The diameters of some wells are smaller at the bottom than at the top. Well bore diameters ranging from 6 to 12 inches at the top and finished 6 to 8 inches at the bottom are common. Generalized graphic logs of wells in the Pennsylvanian and Mississippian rocks are given in figures 8, 9, and 10.

Table 8. Distribution of Wells

Area	*Percentage of wells uncased in aquifers*		
	Pennsylvanian	Mississippian	Pennsylvanian and Mississippian
Northeastern Illinois	100		
Northwestern Illinois	100		
Western Illinois	8	87	5
East-Central Illinois	100		
South-Central Illinois	88	12	
Southern Illinois	65	33	2

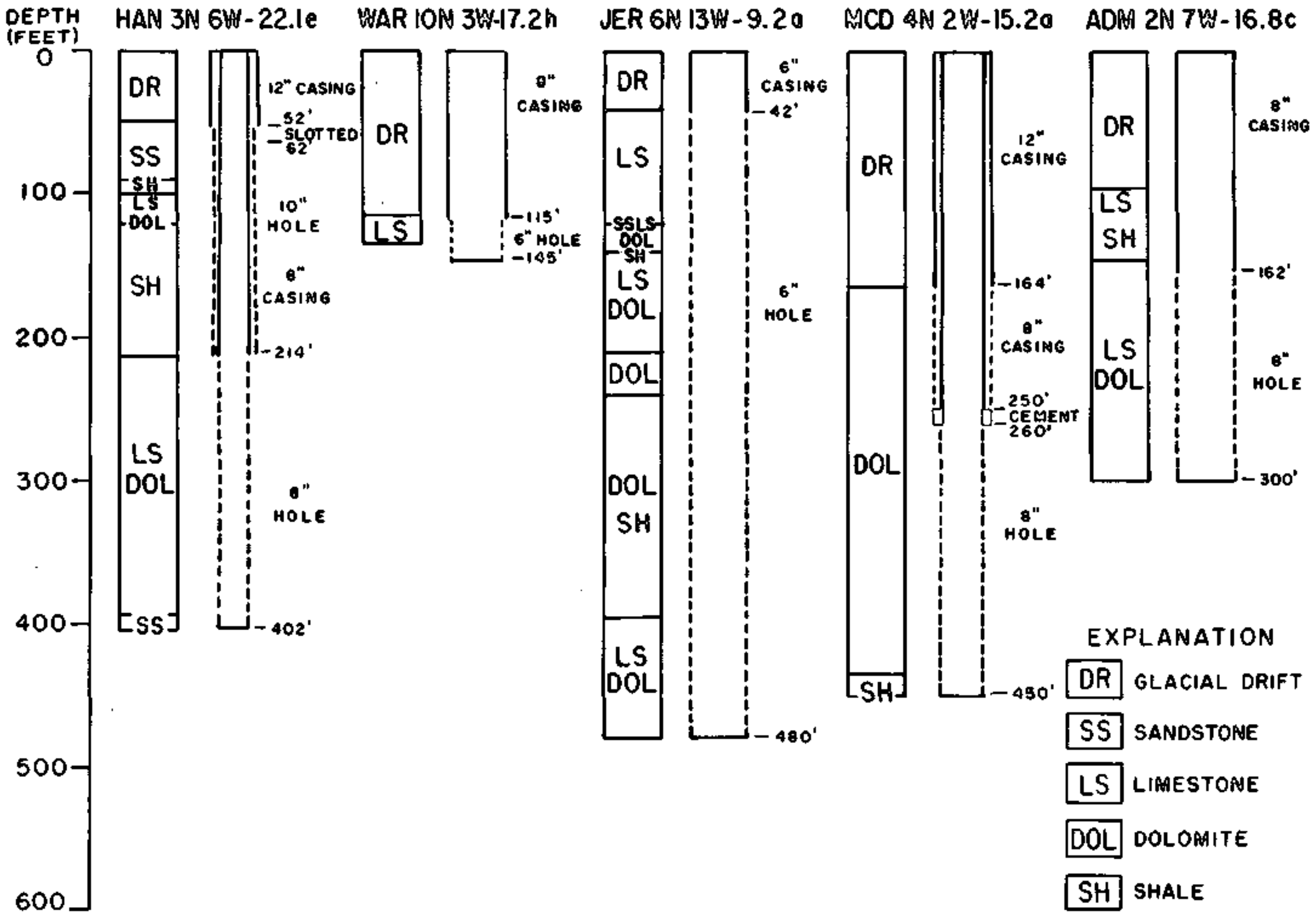


Figure 8. Construction features of selected wells in western Illinois

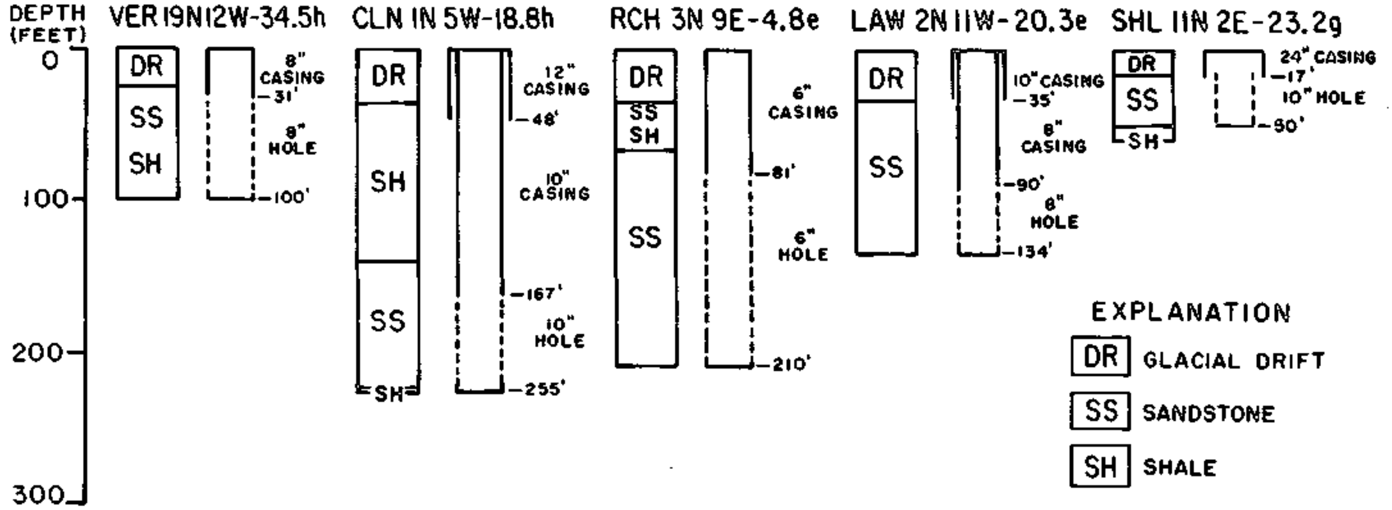


Figure 9. Construction features of selected wells in central Illinois

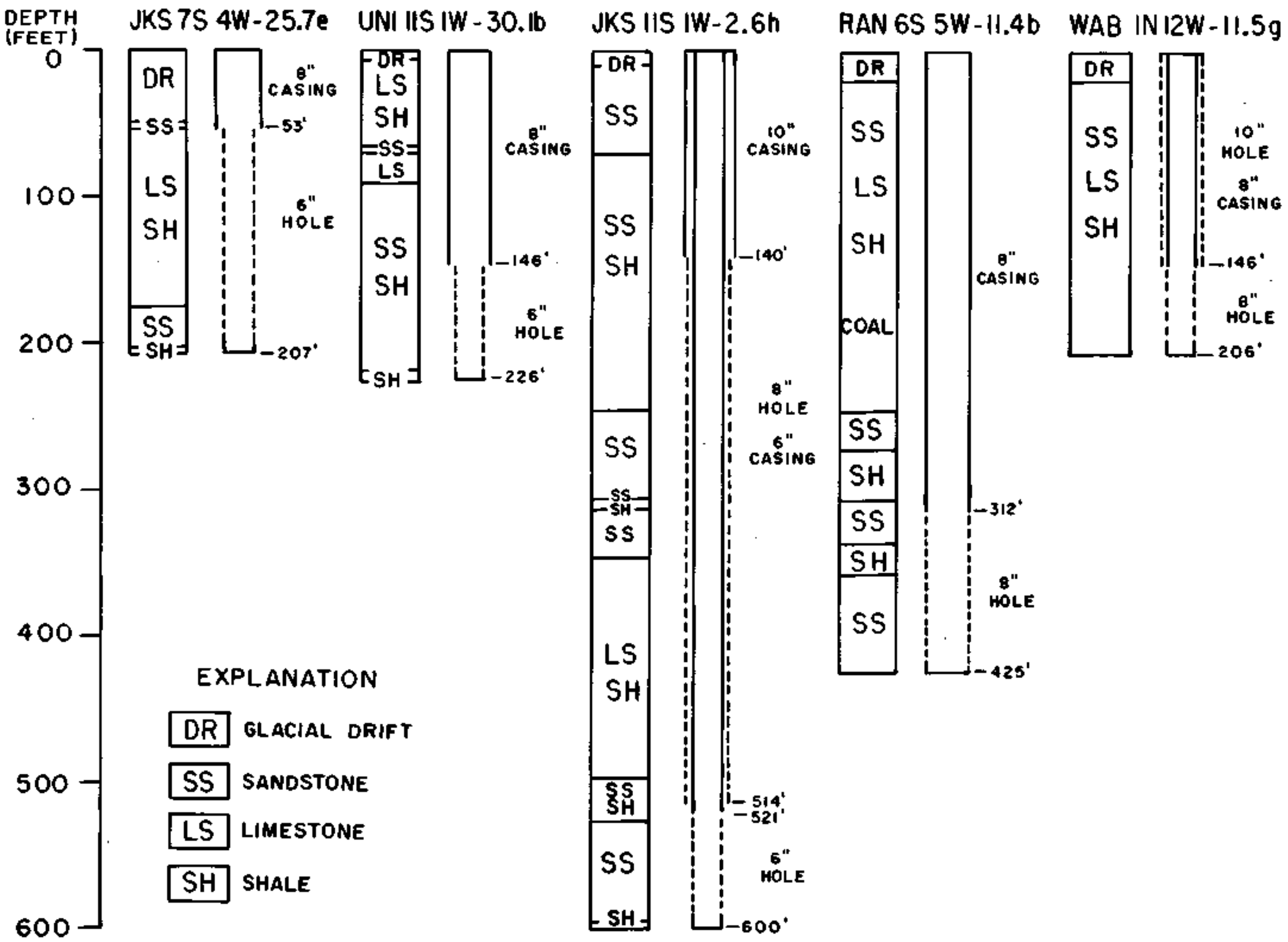


Figure 10. Construction features of selected wells in southern Illinois

GROUND-WATER WITHDRAWALS

Total pumpage from wells in the Pennsylvanian and Mississippian rocks was estimated to be about 46.6 mgd in 1960.

Pumpage use data are classified in this report according to four main categories: 1) public, including municipal and institutional; 2) industrial; 3) domestic, including rural farm (nonirrigation) and rural nonfarm; and 4) livestock. Most water-supply systems furnish water for several types of use. For example, a public supply commonly includes water used for drinking and other domestic uses, manufacturing processes, and lawn sprinkling. Industrial supplies may also be used in part for drinking and other domestic uses. No attempt has been made to determine the final use of water within the public and domestic categories; for example, any water pumped by a municipality is called a public supply, regardless of the use of the water.

Of the 1960 total pumpage, withdrawals (table 9) for public water-supply systems amounted to 5 percent, or 2.3 mgd; industrial pumpage was about 1 percent, or 0.5 mgd; domestic pumpage was about 35 percent, or 16.3 mgd; and pumpage for livestock use was 59 percent, or 27.5 mgd.

The reliability of pumpage estimates varies greatly. Municipal pumpage in most cities and villages is metered. Many small villages and industries, however, do

Table 9. Total Estimated Withdrawal from Pennsylvanian and Mississippian Rocks in Illinois, 1960

	Pumpage *(gpd)*
Public	
Municipal	2,136,000
Institutional	164,000
Industrial	500,000
Domestic	16,300,000
Livestock	27,500,000
Total	46,600,000

Table 10. Municipal Pumpage from Pennsylvanian and Mississippian Rocks in Illinois, 1955 and 1960

Municipality	Population		Date system installed	Aquifer *	Estimated pumpage (gpd)		County
	1950	1960			1955	1960	
Albers		566	1957	P		12,000	Clinton
Allendale	442	465	1949	P	20,000	25,000	Wabash
Anna	4,380	4,280	1912	M	335,000	500,000	Union
Ava	734	665	1938	P	21,000	25,000	Jackson
Baylis		284	1959	P		20,000	Pike
Bellmont		320	1956	P		12,000	Wabash
Camargo		276	1956	P		10,000	Douglas
Campbell Hill	336	263	1949	P	6,000	10,000	Jackson
Catlin	953	1,263	1935	P	28,000	48,000	Vermilion
Cisne	628	615	1950	P	12,000	30,000	Wayne
Claremont		223	1955	P		5,000	Richland
Cobden	1,104	918	1935	M	32,000	35,000	Union
Creal Springs	864	784	1952	P	20,000	27,000	Williamson
Cutler	520	445	1941	P	20,000	18,000	Perry
Dongola	704	757	1936	M	60,000	50,000	Union
Enfield	906	791	1950	P	20,000	42,000	White
Equality	830	665	1951	P	23,000	14,000	Gallatin
Fairmount	618	725	1950	P	25,000	60,000	Vermilion
Golden	512	491	1949	M	10,000	15,000	Adams
Hecker		313	1955	M		20,000	Monroe
Industry	496	514	1952	M	10,000	19,000	McDonough
Jonesboro	1,607	1,636	1924	M	72,000	85,000	Union
Joy	505	503	1923	M	21,000	25,000	Mercer
Kirkwood	747	771	1894	M	13,000	23,000	Warren
Loraine		303	1900	M		7,000	Adams
Mendon	625	784	1950	M	13,000	33,000	Adams
Millstadt	1,566	1,830	1932	M	65,000	100,000	St. Clair
Modesto	232	228	1954	P	5,000	5,000	Macoupin
Muddy		95	1960	P		5,000	Saline
New Baden	1,428	1,464	1911	P	51,000	70,000	Clinton
Noble	776	761	1949	P	34,000	25,000	Richland
Omaha	394	312	1946	P	4,000	10,000	Gallatin
Payson	490	502	1910	M	20,000	25,000	Adams
Percy	933	810	1935	P	25,000	60,000	Randolph
Red Bud	1,519	1,942	1915	M	150,000	120,000	Randolph
Roodhouse	2,368	2,352	1928	P	130,000	175,000	Greene
St. Francisville	1,117	1,040	1928	P	60,000	55,000	Lawrence
St. Jacob	478	529	1949	M	20,000	25,000	Madison
Smithton	515	629	1950	M	30,000	16,000	St. Clair
Steeleville	1,353	1,569	1935	P	35,000	75,000	Randolph
Stonefort		349	1958	P		5,000	Saline
Stronghurst	741	815	1915	M	50,000	50,000	Henderson
Tower Hill	784	700	1952	P	30,000	14,000	Shelby
Trenton	1,432	1,866	1909	P	50,000	60,000	Clinton
Westfield	661	636	1913	P	23,000	15,000	Clark
Willisville	635	532	1940	P	30,000	38,000	Perry
Windsor	569	658	1924	M	8,000	18,000	Mercer
Total	35,502	39,239			1,581,000	2,136,000	

** P—Pennsylvanian rocks; M—Mississippian rocks*

not meter their pumpage, and pumpage estimates are made on the basis of the number of wells, their reported yields, and the number of hours wells are in production per day. Pumpage from wells for domestic and livestock use was estimated from detailed water-use surveys (Csallany, 1965). Domestic pumpage, including rural farm and rural nonfarm uses, was estimated by considering rural population as reported for 1960 by the U. S. Bureau of the Census and per capita use. Pumpage for livestock was estimated from established average daily water use for farm animals and farm animal population given in the Illinois Agricultural Statistics, 1960, Annual Summary.

Public Supplies

Public supplies include both municipal and institutional uses. Pumpage during 1955 and 1960 from municipal wells in the Pennsylvanian and Mississippian rocks is given in table 10; total municipal pumpage was 1.58 mgd in 1955 and 2.14 mgd in 1960. In 1955 about 42 percent or 0.67 mgd of the total pumpage was from wells in the Pennsylvanian rocks, and about 58 percent or 0.91 mgd was from wells in the Mississippian rocks. During 1960, 45 percent or 0.97 mgd was from wells in the Pennsylvanian rocks and 55 percent or 1.17 mgd from wells in the Mississippian rocks. There were 22

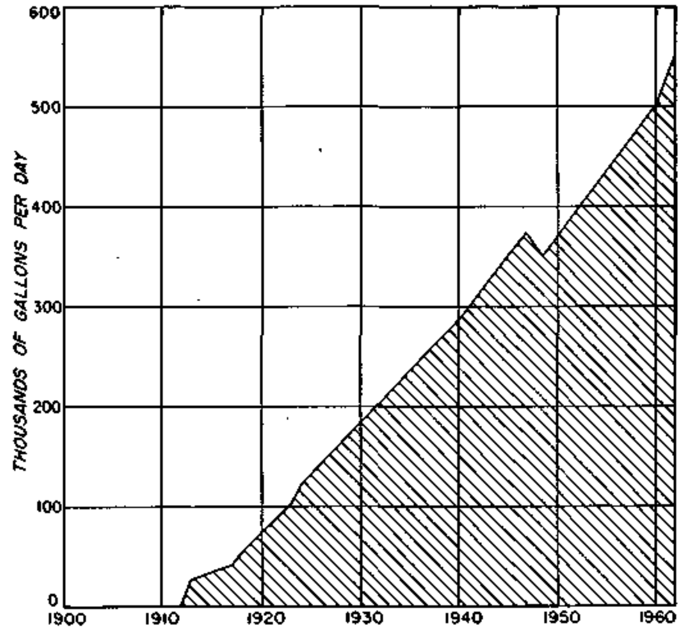


Figure 11. Estimated pumpage at Anna, 1912-1962

municipalities supplied by wells in the Pennsylvanian rocks in 1955 and 29 in 1960. Sixteen municipalities were supplied by wells in the Mississippian rocks in 1955 and 18 in 1960. The following municipalities have installed or were in 1962 considering installing water systems involving wells in the Pennsylvanian and Mississippian rocks: Alma, Calhoun, Iuka, Milton, Parkersburg, Plainville, and Ruma. There were in 1962 ten state institutions and six unincorporated towns supplied by wells in the Pennsylvanian and Mississippian rocks.

A large part of the municipal pumpage from wells in the Mississippian rocks is concentrated in two relatively small areas: 1) Union County in southern Illinois (the cities of Anna and Jonesboro and the villages of Cobden and Dongola); and 2) St. Clair, Monroe, and Randolph Counties south of East St. Louis (the city of Red Bud and the villages of Hecker, Millstadt, and Smithton).

Municipal pumpage from wells in the Mississippian rocks is greatest at Anna, where the first municipal wells were constructed in 1912. In 1913 about 25,000 gallons per day (gpd) was pumped to satisfy commercial and domestic water needs of the city. As shown in figure 11, pumpage has increased at a fairly uniform rate since 1912 as the city has grown in population from about 2900 in 1913 to 4280 in 1960. In 1960 approximately 500,000 gpd was required to fulfill pumpage demands. Total per capita consumption increased from about 8.6 gpd per person in 1913 to 117 gpd per person in 1960. Pumpage has increased at a fairly uniform rate from 3700 gpd per year between 1912 and 1917 to 10,700 gpd per year between 1917 and 1962.

Prior to 1936 water was pumped from wells about 650 feet in depth which penetrated the upper part of the Keokuk-Burlington Formation. After 1936 several wells were drilled to depths of 1000 feet which penetrated most of the Keokuk-Burlington Formation.

Total pumpage for municipal supplies in Anna, Jonesboro, Cobden, and Dongola was 670,000 gpd in 1960, or 31.4 percent of the total municipal pumpage from wells in the Mississippian and Pennsylvanian rocks; total population of these municipalities was 7591 in 1960, or 19.5 percent of the total population of municipalities listed in table 10. Total pumpage for municipal supplies at Red Bud, Hecker, Millstadt, and Smithton was 256,000 gpd in 1960, or 12 percent of the total pumpage in table 10; the population of these municipalities in 1960 was 3714, or 9.5 percent of the total population in table 10.

A large part of the municipal pumpage from wells in the Pennsylvanian rocks is concentrated near the intersection of Randolph, Perry, and Jackson Counties in southern Illinois (villages of Steeleville, Percy, Cutler, Willisville, and Campbell Hill, and the city of Ava). Total pumpage for municipal supplies in these municipalities was 226,000 gpd in 1960, or 10.7 percent of the total pumpage in table 10; the population of these municipalities was 4284 in 1960, or 10.9 percent of the total population in table 10.

Municipal pumpage from wells at Steeleville is shown in figure 12. Since the first municipal well was constructed in 1928, pumpage has increased at an average rate of 1500 gpd per year to 85,000 gpd in 1962. The annual increase in pumpage between 1948 and 1962 was 4000 gpd per year. The depths of wells penetrating the Pennsylvanian rock in Steeleville range from 250 to 350 feet.

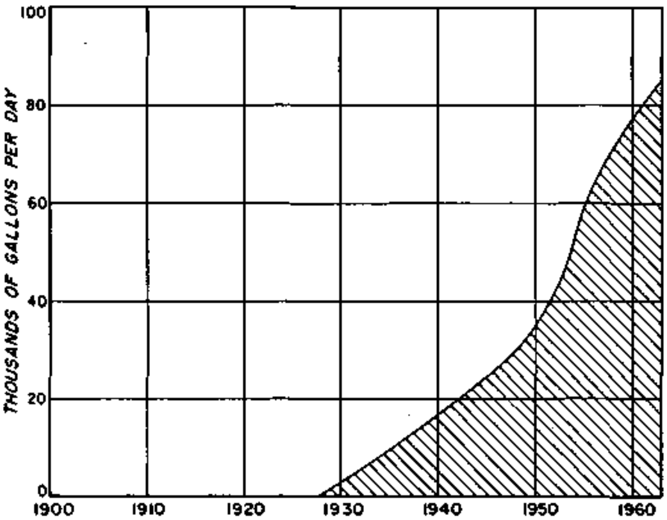


Figure 12. Estimated pumpage at Steeleville, 1928-1963

HYDRAULIC PROPERTIES

The water-yielding properties of limestone and sandstone formations of Pennsylvanian and Mississippian age influence the productivity of wells. As the size and/or number of openings in limestone formations increase, yields of wells increase. The water-yielding properties of sandstones are dependent upon grain-size and degree of sorting and cementation. The hydraulic properties of these aquifers are commonly expressed mathematically by the coefficients of transmissibility, *T,* or permeability, *P,* and storage, *S.* The hydraulic property of a confining bed (deposits overlying aquifers and retarding vertical movement of water into aquifers) influencing the productivity of a well is the coefficient of vertical permeability, *P'.*

The *coefficient of transmissibility* is defined as the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide and extending the full saturated thickness of the aquifer under a hydraulic gradient of 100 percent (1 foot per foot) and at the prevailing temperature of the ground water. The *coefficient of permeability* is defined as the rate of flow of water in gallons per day, through a cross-sectional area of 1 square foot of the aquifer under a hydraulic gradient of 1 foot per foot at the prevailing temperature of the ground water. Their relation is $P = T/m$ or $T = Pm$ where m is the saturated thickness of the aquifer.

The storage properties of an aquifer are expressed by the *coefficient of storage,* which is defined as the volume of water in cubic feet released from or taken into storage per square foot of surface area of the aquifer per foot change in the component of head normal to that surface. The *coefficient of vertical permeability* of a confining bed is defined as the rate of flow of water in gallons per day through a horizontal cross-sectional area of 1 square foot of the confining bed under a hydraulic gradient of 1 foot per foot at the prevailing temperature of the ground water. The leakage coefficient is *(P'/m')* where *m'* is the saturated thickness of the confining bed through which leakage occurs in feet.

The Pennsylvanian and Mississippian aquifers are commonly overlain by deposits of glacial drift that contain a high percentage of silt and clay and have a low permeability. Walton (1960) found from aquifer-test data that the coefficient of vertical permeability of glacial drift varies from 0.08 to 1.6 gpd/sq ft. The Pennsylvanian and Mississippian aquifers may be recharged in some cases by vertical leakage through shale beds. Walton (1960) estimated that the coefficient of vertical permeability of the Maquoketa Formation in northeastern Illinois, which consists largely of beds of dolomitic shale, was low, about 0.00005 gpd/sq ft.

Aquifer Tests

The hydraulic properties of aquifers and confining beds may be determined by means of aquifer tests, wherein the effect of pumping a well at a known constant rate is measured in the pumped well and in observation wells penetrating the aquifer. Graphs of drawdown versus time after pumping started, and/or of drawdown versus distance from the pumped well, are used to solve formulas which express the relation between the hydraulic properties of an aquifer and its confining bed, if present, and the lowering of water levels in the vicinity of a pumped well.

The data collected during aquifer tests can often be analyzed by means of the leaky artesian formula (Hantush and Jacob, 1955); however, leakage was not measurable during the aquifer tests made with wells in Pennsylvanian and Mississippian rocks. The modified nonleaky artesian formula (Cooper and Jacob, 1946) given below was used to analyze aquifer-test data for these rocks:

$$T = 264Q/\Delta s \tag{1}$$

$$S = Tt_o/4790r^2 \tag{2}$$

where:

T = coefficient of transmissibility, in gpd/ft
S = coefficient of storage, fraction
Q = discharge, in gpm
Δs = drawdown difference per log cycle, in ft
r = distance from pumped well to observation well, in ft
t_o = intersection of straight-line slope with zero-drawdown axis, in min

Values of drawdown during the pumping periods are plotted against the logarithms of time after pumping started on semilogarithmic paper. The time-drawdown field data graph will yield a straight-line graph. The slope of the straight line is used to determine the coefficient of transmissibility. The straight line is extrapolated to its intersection with the zero-drawdown axis. The zero-drawdown intercept and the computed value of *T* are used to calculate the coefficient of storage.

A controlled aquifer test was made using wells in Pennsylvanian rocks November 3 and 4, 1949, at Allendale in cooperation with village officials, the consulting engineer (Paul J. Kleiser and Associates), and the driller (E. L. Potts and Son). The test site was located in Wabash County in an area about 2100 feet north and 2400 feet west of the southeast corner of section 11, TIN, R12W. The effects of pumping village well 3-49 was measured in village well 2-49 which is located 1000 feet southwest of the pumped well. Pumping was started at 10:54 a.m. on November 3 and continued for about 20 hours at an average rate of 10.5 gpm. Pumping was stopped at 6:45 a.m. November 4, and water levels were allowed to recover for about 4 hours. Water levels were measured with a recording gage on well 2-49 and with an airline and pressure gage on well 3-49.

Well 2-49 is 206 feet deep and is cased with 8-inch casing to a depth of 146 feet; the open hole below 146 feet is 8 inches in diameter. Well 3-49 is 170 feet deep and is cased with 8-inch casing to a depth of 116 feet, below which the open hole is 8 inches in diameter. Drillers logs of these two wells are given in table 11.

Table 11. Drillers Log of Wells in Allendale

Formation	From (ft)	To (ft)
Well 2-49		
Clay and soil	0	20
Sandstone, brown, broken	20	27
Sandstone, gray, broken	27	33
Slate, gray	33	41
Coal and shale, black	41	43
Slate, gray	43	50
Slate, light and soft	50	56
Limestone, broken	56	59
Slate, light	59	65
Limestone, broken	65	68
Slate, gray	68	77
Slate, dark	77	110
Slate, gray	110	121
Slate, gray, soft	121	126
Slate, light	126	143
Sandstone, broken	143	148
Sandstone, water	148	205
Limestone	205	206
Well 3-49		
Clay and soil	0	15
Shale and sandstone	15	19
Slate, gray	19	39
Slate, dark	39	60
Limestone	60	62
Slate, gray	62	88
Slate, light, muddy	88	96
Slate, gray	96	110
Sandstone, broken	110	116
Sandstone, hard	116	124
Sandstone, water	124	168
Slate, gray	168	170

Values of drawdown in well 3-49 were plotted on semilogarithmic paper against values of time after pumping started, as shown in figure 13. A straight line was drawn through the points. The slope of the straight line per log cycle and the pumping rate were substituted into equation 1, and the coefficient of transmissibility was computed to be 578 gpd/ft. The coefficient of storage was computed from equation 2 to be 0.0000295.

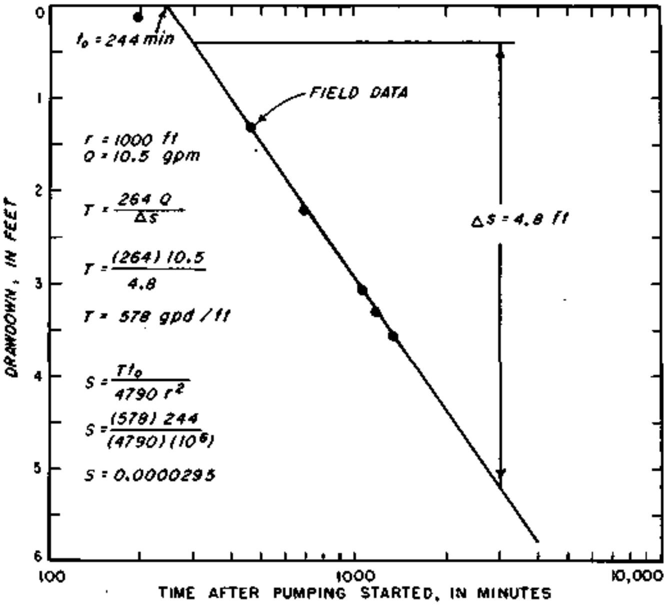


Figure 13. Time-drawdown data for observation well 2-49 in Allendale aquifer test

The coefficient of transmissibility of Pennsylvanian and Mississippian rocks was determined at eight additional sites by analyses of data for production wells. Aquifer tests involving only the pumped well were made at Albers, Farina, Catlin, Bowen, Muddy, and Anna. The coefficient of storage cannot be determined with any degree of accuracy from data for the pumped well because the effective radius of the pumped well is seldom known and drawdowns in the pumped well are often affected by well losses which cannot be determined precisely. The results of the aquifer tests made with only pumped wells are summarized in table 12.

Table 12. Results of Aquifer Tests Made with Only Pumped Wells

Location	Aquifer *	Coefficient of transmissibility (gpd/ft)	Aquifer thickness (ft)	Coefficient of permeability (gpd/sq ft)
Albers, Clinton County	P	225	88	3
	P	350	41	9
Anna, Union County	M	494		
Bowen, Hancock County	M	270	30	9
Catlin, Vermilion County	P	153	57	3
	P	565	50	11
Farina, Fayette County	P	840	142	6
Muddy, Saline County	P	122	68	12

* *P—Pennsylvanian; M—Mississippian*

The drillers logs of wells were studied to determine the accumulated thickness of limestone and sandstone beds encountered by the production wells. The computed coefficients of transmissibility were divided by the accumulated thickness of limestone and sandstone beds to determine the coefficients of permeability listed in table 12. The average permeability of the limestone and sandstone beds within Pennsylvanian and Mississippian rocks ranges from 3 to 12 gpd/sq ft. Coefficients of transmissibility range from 122 to 840 gpd/ft.

Specific-Capacity Data

The yield of a well may be expressed in terms of its specific capacity, which is commonly defined as the yield of the well in gallons per minute per foot of drawdown (gpm/ft) for a stated pumping period and rate. The specific capacity is influenced by the hydraulic properties of the aquifer and confining bed, thickness of the confining bed, radius of the well, and pumping period.

When leakage through a confining bed is not measurable, the theoretical specific capacity, Q/s, of a well discharging at a constant rate in a homogeneous, isotropic, artesian aquifer infinite in areal extent, is from the nonequilibrium formula (Theis, 1935) given by the following equation:

$$Q/s = T/[264 \log (Tt/1.87 \ r_w^2 S) - 65.5] \qquad (3)$$

where:

Q = discharge of pumped well, in gpm
s = drawdown, in ft
T = coefficient of transmissibility, in gpd/ft
S = coefficient of storage, fraction
r_w = nominal radius of well, in ft
t = time after pumping started, in days

Equation 3 was derived by assuming that 1) the well completely penetrates the aquifer, 2) well loss is negligible, and 3) the effective radius of the well has not been affected by the drilling and development of the well and is equal to the nominal radius of the well.

From equation 3 the theoretical specific capacity of a well depends in part upon the radius of the well and the pumping period. The relationships between theoretical specific capacity and the radius of a well and the pumping period are shown in figure 14. Diagram A indicates that a 24-inch diameter well has a specific capacity about 12 percent larger than that of an 8-inch diameter well. It is evident that large increases in the radius of a well are accompanied by comparatively small increases in specific capacity. Diagram B shows that the specific capacity decreases with the length of the pumping period as the cone of depression deepens and expands.

In addition to the drawdown in equation 3 there is generally a head loss or drawdown (well loss) in the pumped well due to the turbulent flow of water as it enters the well itself and flows upward through the well bore. Well loss can often be determined from the results of "step-drawdown tests." During a step-drawdown test the well is operated during three successive periods of the same duration at constant fractions of full capacity. Well loss is approximately equal to the product of the square of the discharge and a well-loss constant (Walton, 1962). The yields of wells in Pennsylvanian and Mississippian rocks are generally so low that well loss could not be accurately determined from test data.

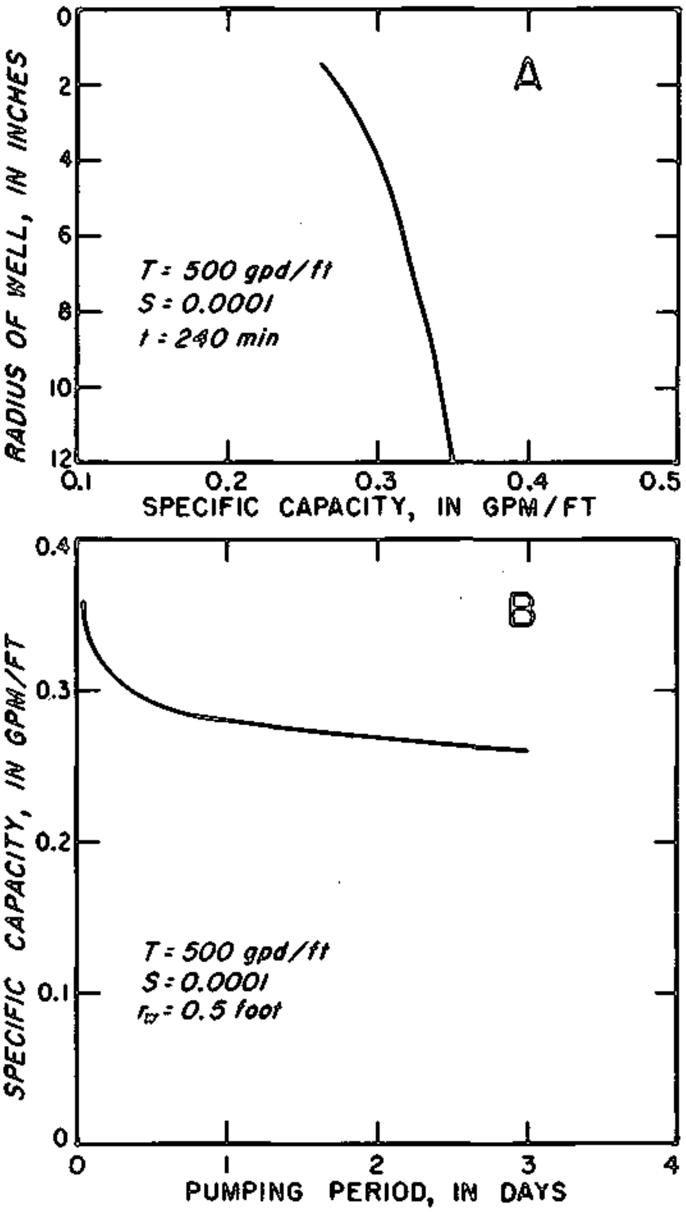


Figure 14. Theoretical relation between specific capacity and the radius of a well (A) and the pumping period (B)

During the period 1920 to 1963, 249 well-production tests were made by the State Water Survey, consulting engineers, well drillers, and municipal officials on 200 wells in Pennsylvanian and Mississippian rocks in Illinois. Of the 249 tests, 157 tests were made on wells in the Pennsylvanian rocks and 92 tests were made on wells in the Mississippian rocks. The well-production tests consisted of pumping a well at a constant rate and measuring drawdown in the pumped well. Drawdowns were commonly measured with an airline, electric dropline, or steel tape. The discharge rates were usually measured by an orifice bucket or an orifice tube.

The results of the tests are summarized in tables A, B, and C presented in the appendix. Each test is identified by the well number of the pumped well. The lengths of

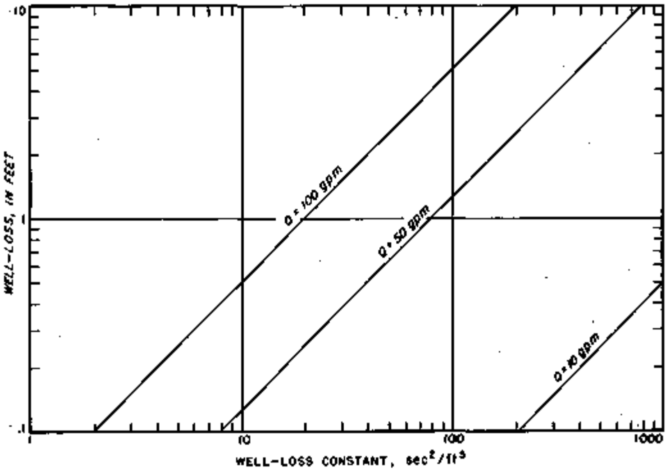


Figure 15. Drawdown due to well lots for pumping rates of 10, 50, and 100 gpm

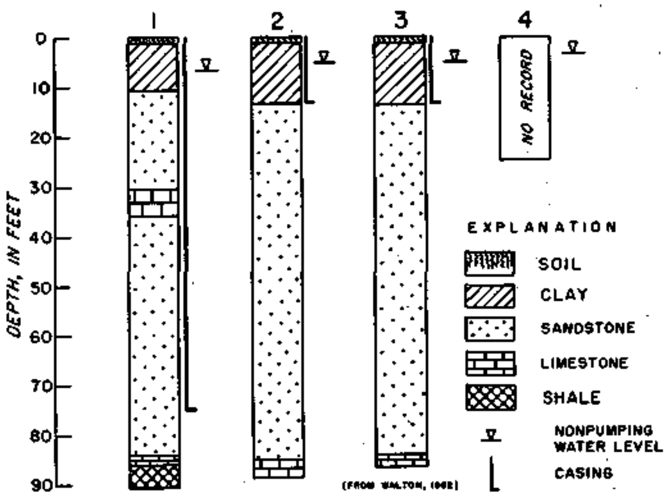


Figure 16. Generalized graphic logs of wells used in test at Iuka

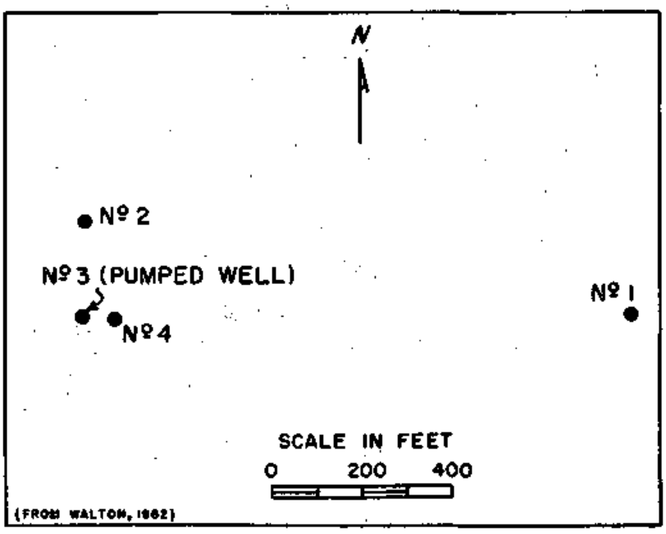


Figure 17. Location of wells used in test at Iuka

tests range from less than 1 hour to 75 hours and average about 6 hours. Pumping rates range from 2 to 440 gpm and average about 35 gpm. Diameters of wells range from 3 to 24 inches and average about 8 inches.

As shown in figure 15, except for pumping rates exceeding 50 gpm, well loss is negligible when the well-loss constant is less than 20 $\sec^2/ft^5$. On the basis of data given by Walton and Csallany (1962), it is probable that well-loss constants for most wells in Pennsylvanian and Mississippian rocks are less than 20 $\sec^2/ft^5$. Therefore, well loss is negligible in most cases.

Although drawdown due to well loss in most cases may be small, Walton (1962) found that well loss can greatly increase when water levels are lowered below the top of Pennsylvanian rocks. A step-drawdown test was made by the State Water Survey in cooperation with Marbry and Johnson, Inc., consulting engineers, and E. C. Baker & Sons, well contractor, on a well in Pennsylvanian rocks owned by the village of Iuka. The well is located about 600 feet west and 1300 feet south of the northeast corner of section 18, T2N, R4E, in Marion County.

The log and construction features of the pumped well and three observation wells are shown in figure 16; the locations of the wells are shown in figure 17. Two major water-yielding zones are encountered in wells 1, 2, and 3 between the depths of 20 and 31 feet and 40 and 85 feet. Well 3 was pumped on May 29, 1961, at three rates, 5.4, 9.3, and 12.7 gpm. Drawdowns were measured in the pumped well and in the three observation wells.

Drawdowns in wells 2, 3, and 4 were plotted against time on semilogarithmic paper. The time-drawdown graph for well 3 is given in figure 18, and the time-drawdown graphs for wells 2 and 4 are given in figure 19. There was no significant drawdown in well 1.

During the first step with a pumping rate of 5.4 gpm the pumping level in well 3 remained above the top of

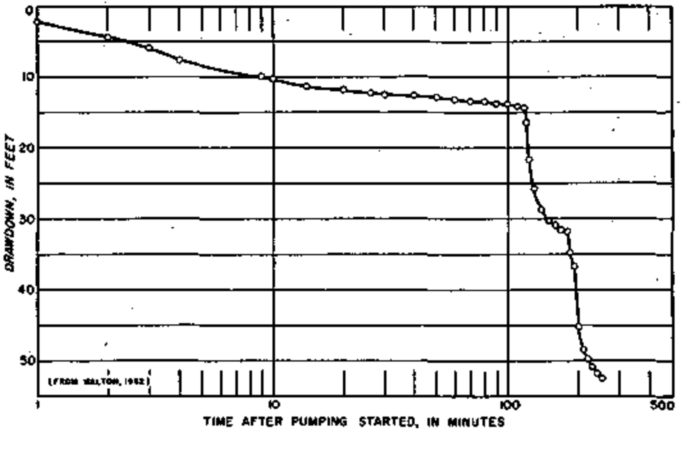


Figure 18. Time-drawdown graph for well 3 at Iuka

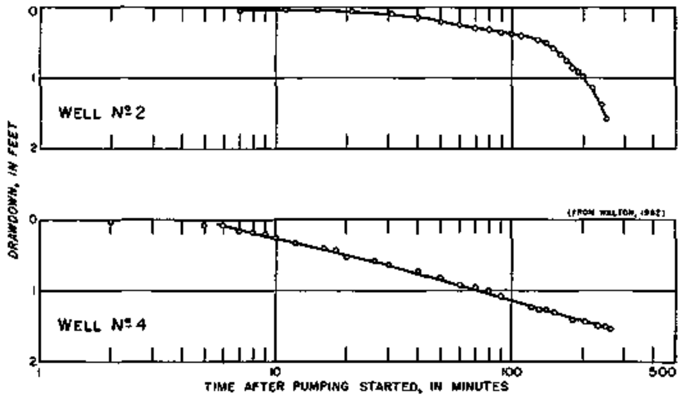


Figure 19. Time-drawdown graphs for wells 2 and 4 at Iuka

the upper water-yielding zone. The specific capacity of the well for a pumping rate of 5.4 gpm and a pumping period of 1 hour is 0.35 gpm/ft. Water levels in the shallow observation well (well 4) that penetrates only the upper water-yielding zone, and in the deep observation well (well 2) that penetrates both the upper and lower water-yielding zones, were similarly affected during the first step.

The pumping level in well 3 declined below the upper water-bearing zone during the second step with a pumping rate of 9.3 gpm. The specific capacity of the well for a pumping rate of 9.3 gpm and a pumping period of 1 hour is 0.28 gpm/ft and is much less than the specific capacity for a pumping rate of 5.4 gpm. Water levels in the shallow observation well were not affected by the increase in pumping rate, whereas the time-rate of drawdown in the deep observation well increased about in proportion to the pumping rate. When the pumping level declined below the upper water-yielding zone, there was free flow from the upper water-yielding openings. Thus the maximum contribution from the upper zone was attained during the second step. As shown by the time-drawdown graph for well 4, discharge from the upper zone was not appreciably increased, indicating that most of the increase in discharge during step 2 was obtained from the lower zone.

The pumping level in well 3 declined below the top of the lower zone during the third step with a pumping rate of 12.7 gpm. The specific capacity of the well for a pumping rate of 12.7 gpm and a pumping period of 1 hour is 0.17 gpm/ft and is less than the specific capacity for pumping rates of 5.4 and 9.3 gpm. Water levels in the shallow observation well were not affected by the increase in pumping rate, whereas the time-rate of drawdown in the deep observation well increased about in proportion to the pumping rate. The specific capacity during the third step is less than the specific capacity during the second step because there was free flow from some of the openings in the lower zone and the openings in the basal part of the lower zone were called upon for much of the increase in pumpage.

Prom this discussion it is obvious that erroneously optimistic predicted yields of the production well under higher rates of pumping would occur if the specific capacities for steps 1 or 2 were used in computations.

YIELDS OF PENNSYLVANIAN AND MISSISSIPPIAN ROCKS

Specific capacities of wells in Pennsylvanian rocks were tabulated in order of magnitude, and frequencies were computed by the Kimball (1946) method. Values of specific capacities were then plotted against percent of wells on logarithmic probability paper as shown in figure 20. The specific capacities of wells in Pennsylvanian rocks generally range between 0.1 and 1.0 gpm/ft; the median specific capacity is 0.32 gpm/ft. Specific capacities of wells at selected sites are shown in figure 21. The range of specific capacities varies little from place to place throughout the state.

Wells in the Mississippian rocks were segregated into four categories: 1) wells in western Illinois uncased in the Keokuk-Burlington Formation; 2) wells in southern Illinois uncased in the Keokuk-Burlington Formation; 3) wells in western Illinois uncased in the Ste. Genevieve-St. Louis-Salem-Warsaw Formations; and 4) wells uncased in the Chesterian Series in western south-central and southern Illinois. A few wells in the second category were also uncased in the Ste. Genevieve-St. Louis-Salem-Warsaw Formations, but they were thin in these cases and did not contribute significantly to yields of the wells. The specific-capacity frequency graphs for the four categories are shown in figure 22.

The productivity of the Keokuk-Burlington Formation is greater than that of both the Ste. Genevieve-

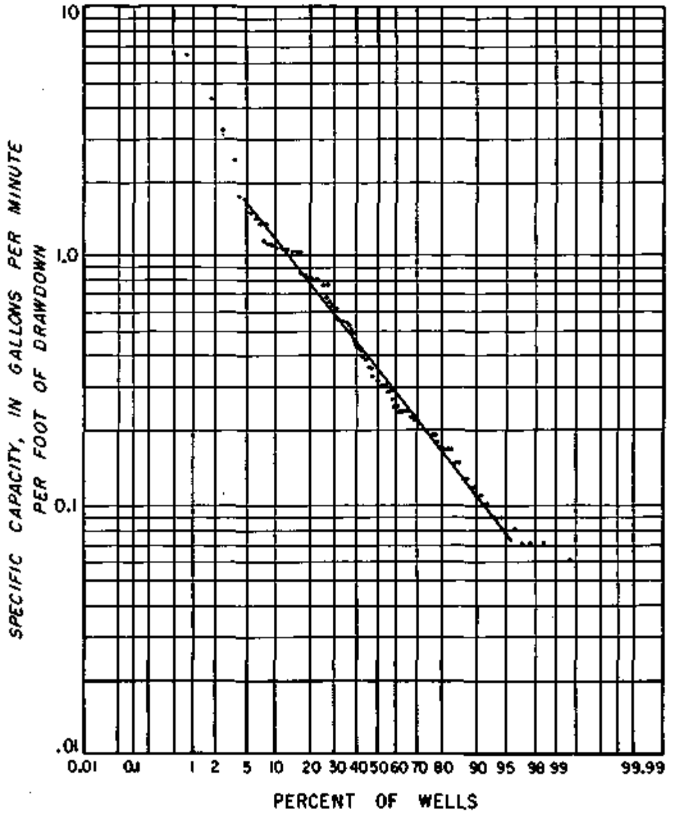


Figure 20. Specific-capacity frequency graph for wells penetrating Pennsylvanian rocks

St. Louis-Salem-Warsaw Formations and the Chesterian Series. The productivity of the Chesterian Series is much less than that of the Keokuk-Burlington Formation but much greater than that of the Ste. Genevieve-St. Louis-Salem-Warsaw Formations.

Specific capacities of wells penetrating Pennsylvanian and Mississippian rocks were divided by total depths of penetration to obtain specific capacities per foot of penetration. Wells were segregated into the four categories previously described. Frequency graphs of specific capacity per foot of penetration for wells in western and southern Illinois uncased in the Keokuk-Burlington Formation are shown in figure 23. The graphs indicate that the Keokuk-Burlington Formation is more productive in western Illinois than it is in southern Illinois.

Specific capacities of wells in Mississippian rocks generally range between 0.03 and 6 gpm/ft; the median specific capacity is 0.62 gpm/ft. Specific capacities of wells at selected sites are shown in figure 24.

A comparison of the specific-capacity frequency graphs of Pennsylvanian and Mississippian rocks (see figures 20 and 22) indicates that the productivity of wells in the Keokuk-Burlington Formation in western and southern Illinois is greater than the productivity of wells in the Pennsylvanian rocks. The yields of wells in the Chesterian Series are about the same as the yields of wells in the Pennsylvanian rocks. The Ste. Genevieve-St. Louis-Salem-Warsaw Formations yield less water to wells than do Pennsylvanian rocks.

Graphs of specific capacity per foot of penetration for wells in Silurian and Ordovician rocks (Csallany and Walton, 1963), as well as in Pennsylvanian and Mississippian rocks, are shown in figure 25. The productivity of Pennsylvanian and Mississippian rocks is much less than the productivity of Silurian and Ordovician rocks in areas where these rocks directly underlie the glacial drift. In areas where Silurian and Ordovician rocks are overlain by bedrock, their productivity is about the same as that of the Keokuk-Burlington limestone in western Illinois. The Maquoketa Formation in northern Illinois has about the same productivity as the Keokuk-Burlington limestone in western Illinois.

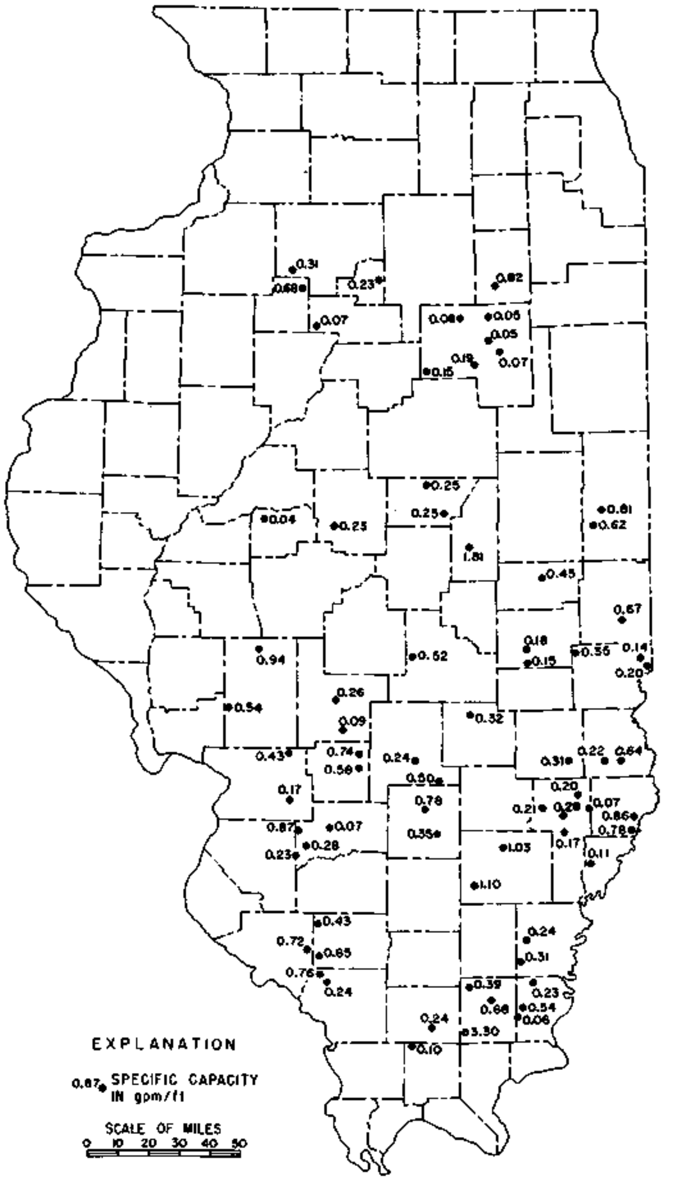


Figure 21. Specific capacities of selected wells in Pennsylvanian rocks

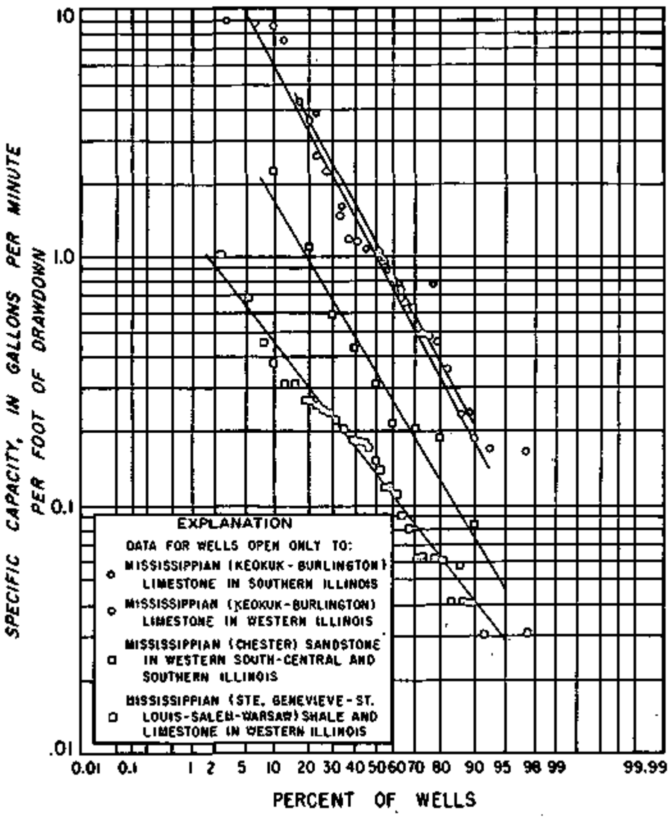


Figure 22. Specific-capacity frequency graphs for wells in Mississippian rocks

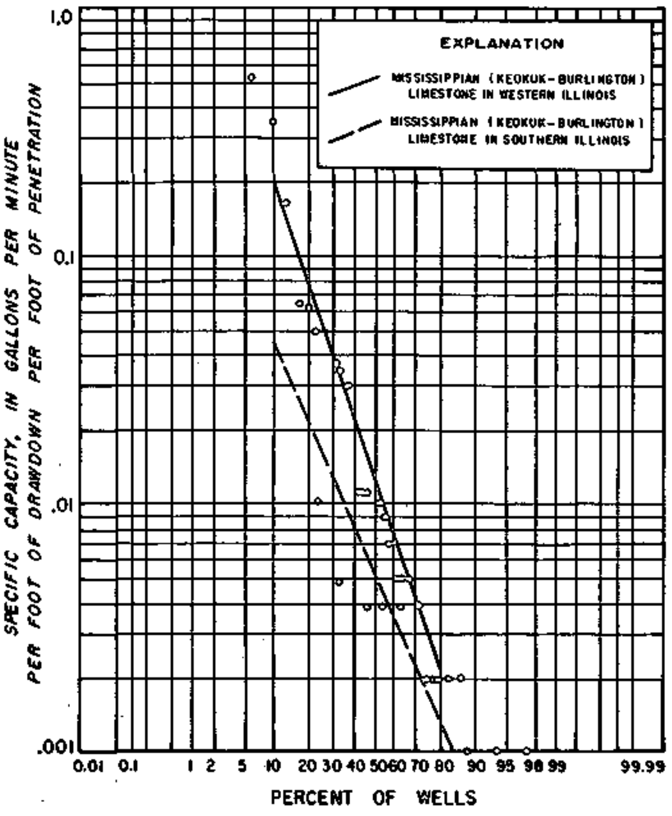


Figure 23. Specific-capacity frequency graphs for wells in Keokuk-Burlington limestone

SHOOTING WELLS TO INCREASE YIELDS

Explosives have been used to develop newly constructed wells or to rehabilitate old wells in Pennsylvanian and Mississippian rocks in Illinois. Wells are commonly shot with nitroglycerine (liquid or solidified) opposite several areas in the well bore. Shots of approximately 20 to 100 pounds or quarts of nitroglycerine are usually exploded opposite the most permeable zones of a formation. Shots are commonly spaced vertically 10 feet apart. The explosives loosen small quantities of rock that have to be bailed out of the well.

Unfortunately, very few well-production tests on newly constructed or old wells were made before and after shooting. The available data suggest that shooting newly constructed wells will generally not increase the yields of the wells substantially. However, data indicate a large increase in the yields of old wells as the result of shooting. For example, the yield of well 3 at Red Bud in Mississippian rocks was increased 70 percent by the use of explosives in 1957. The well was originally drilled in 1944. Specific capacities of the well before and after shooting were 0.50 and 0.85 gpm/ft, respectively. The yield of well 1, at Percy in Pennsylvanian rocks was increased 400 percent by the use of explosives. The well was originally drilled in 1934 and was shot in 1955. Specific capacities of the well before and after shooting were 0.28 and 1.40 gpm/ft, respectively.

Careful study of the effects of shooting suggests that in most cases the yields of wells in Pennsylvanian and Mississippian rocks are increased because 1) the hole is enlarged and 2) fine materials and incrusting deposits on the face of the well bore and extending a short distance into the formation are removed. Enlarging the hole diameter by shooting will increase the yield of the well by only a few percent on the average. The yield

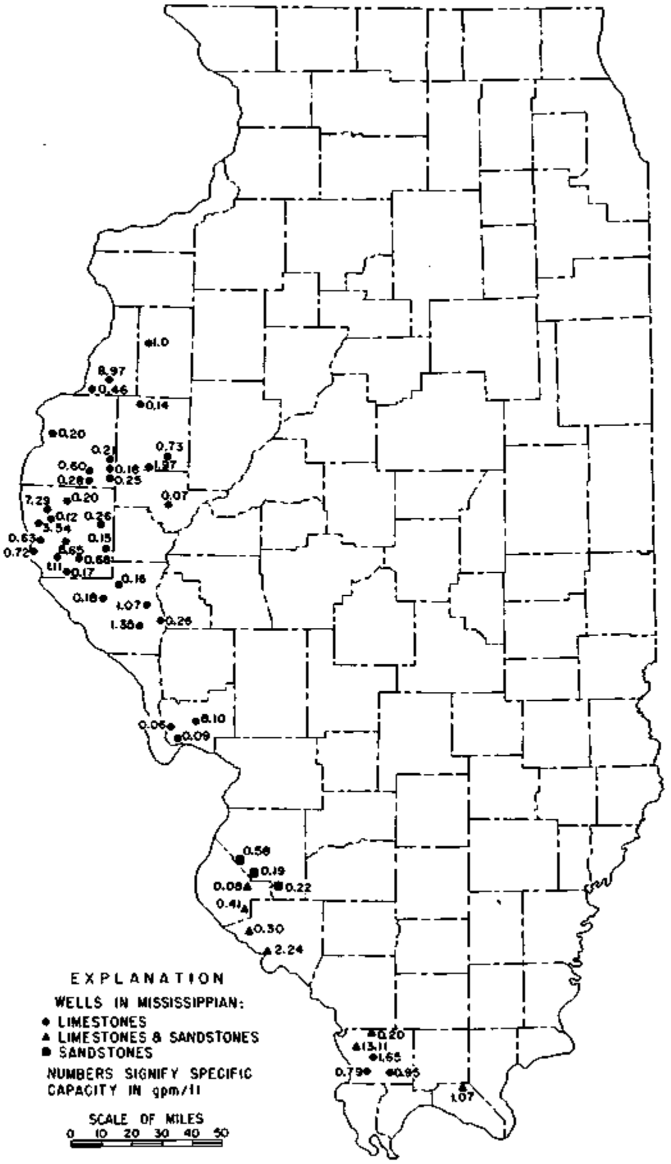


Figure 24. Specific capacities of selected wells in Mississippian rocks

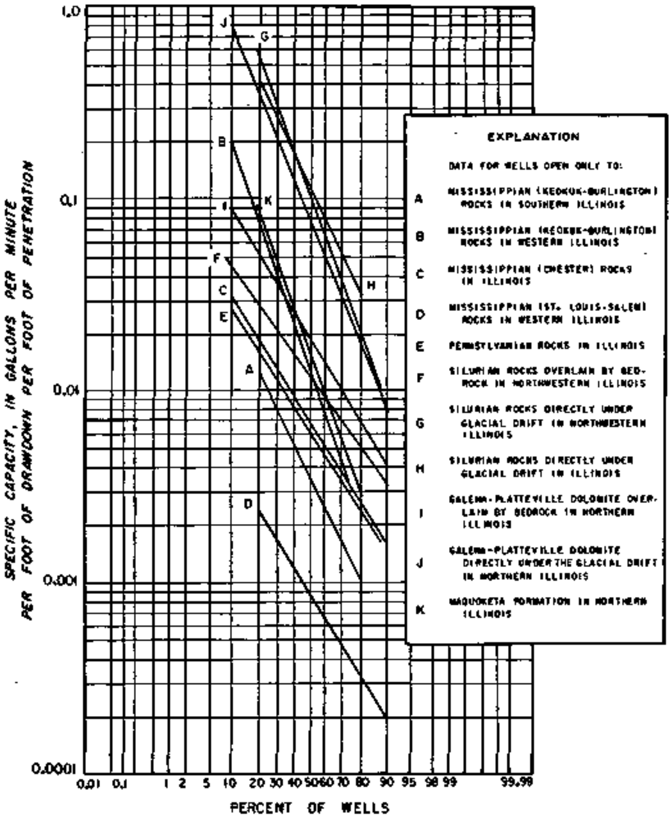


Figure 25. Specific-capacity frequency graphs for Pennsylvania!!, Mississippian, Silurian, and Ordovician rocks in Illinois

of a newly completed well can sometimes be increased substantially by removing fine materials which have migrated into the formation during construction. Under heavy pumping conditions, the yields of wells often decrease as a result of well deterioration; the well face and well wall become partially clogged, commonly with calcium carbonate. The yields of clogged wells can often be restored to the original values through shooting.

AVAILABILITY OF GROUND WATER IN PENNSYLVANIAN AND MISSISSIPPIAN ROCKS

From reports of the State Geological Survey listed in the references, detailed information has been abstracted on the availability of ground water from wells in Pennsylvanian and Mississipian rocks in Illinois. These discussions, given by counties in alphabetical order, supplement the information that has been presented on yields of wells.

Adams County. The Keokuk-Burlington limestone, present beneath the entire upland in the county, is the main source of private water supplies. Water is generally obtained from wells penetrating the limestone for 120 to 140 feet and ranging in depth from 200 to 350 feet. At some places the upper and weathered part of the formation, composed of well-creviced rock and pockets of loose chert, is a source of water. The limestone is suitable mainly for small private ground-water supplies and commonly yields water more or less charged with hydrogen sulfide. Payson and Loraine obtain water from the Keokuk-Burlington limestone with wells ranging from 300 to 330 feet deep.

Alexander County. In the uplands in the northern part of the county, where the unconsolidated material is thin, the Mississippian limestone, dolomite, and chert 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 ground water for municipal and industrial supplies.

Bond County. Water for farm and domestic supplies is obtained from shallow Pennsylvanian sandstones at depths ranging from 100 to 300 feet in the northeast part of the county and at depths ranging from 60 to 130 feet below land surface in the area of Beaver Creek in the southern part of the county.

Brown County. The Keokuk-Burlington limestone is the primary source of ground water for domestic supplies. In most of the county it is within 250 feet of land surface but is overlain by Pennsylvanian rocks, or Kinderhookian shale, or both. Drilling into the limestone about 130 feet is usually necessary to penetrate the most favorable water-yielding zones, although at a few locations where the limestone is highly fractured in its upper few feet good wells result with only shallow penetration.

Bureau County. Much of Bureau County is covered by Pennsylvanian formations. These formations are chiefly tight shales and are water-yielding only where more permeable sandstone beds are present. The formations are underlain by Silurian dolomite in the northern and eastern parts of the county, by Devonian limestone in the southwest, and by Mississippian shale in the extreme south. Of these, only the Silurian dolomite is a dependable source of ground water.

Calhoun County. Wells on the uplands obtain water from the Keokuk-Burlington limestone in the northern quarter of the county, and in the St. Louis limestone south of the flexure. The limestones and dolomites are not extensively creviced and consequently yield water supplies suitable only for small domestic wells. Springs are abundant in the limestone uplands and have been extensively used as sources of private, school, and community water supply.

Cass County. In the northern part of Cass County the drift has been intensively dissected by tributaries of the Sangamon River, and most drilled wells go into the Pennsylvanian or Keokuk-Burlington bedrock. South and east of Chandlerville many wells obtain water from just below the No. 2 coal at depths less than 100 feet. The Pennsylvanian rocks thicken eastward, extending to a depth of about 400 feet along the east county line. Mississippian limestones underlie the drift in the western part of the county but are seldom penetrated for water supplies because of the availability of water in the shallower sand and gravel deposits.

. *Champaign County.* The bedrock may contain water-yielding formations, but because ground-water supplies are usually available from the unconsolidated material, water wells rarely penetrate the bedrock.

Christian County. Throughout the county the Pennsylvanian bedrock below the drift is composed principally of shale. Locally, sandstone lenses are present and may yield small water supplies. However, drilling into the bedrock should be considered only when a suitable ground-water source cannot be found in the glacial drift; and because of the poor quality of the water present in deeper bedrock formations, drilling should not extend below an approximate depth of 200 to 250 feet below land surface.

Clark County. Ground water generally is available from sandstone strata in the upper part of the Pennsylvanian system in the western two-thirds of the county. In this area domestic supplies are usually obtained from the sandstone and, in some places, from limestone strata in the upper 200 feet of the bedrock. In the eastern part of the county, sandstone is not reported except for a small area east and south of Weaver in the northeastern corner. Between Melrose and West Union in the southeastern part of the county, thin limestones are the source of ground water for domestic and farm supplies.

Clay County. In the northern, eastern, and southern parts of the county ground-water supplies for farm and domestic use can be obtained from Pennsylvanian sandstones at depths generally less than 200 feet. In most of the central and east-central parts of the county, sandstones are generally missing. However, in a limited area east of Louisville a few wells obtain small supplies from thin Pennsylvanian limestones at shallow depths.

Clinton County. Pennsylvanian sandstones, coals, or fractured shales and limestones are a local source of water for small farm supplies throughout the county. Water-yielding sandstones are present at depths ranging from 50 to 200 feet in much of the county.

Coles County. The Pennsylvanian sandstones, coals, or fractured shale and limestone are local sources of ground water for small farm supplies throughout the county. Because of the poor quality of the water in deeper bedrock formations, drilling generally should not extend below a depth of approximately 300 feet.

Crawford County. Water-yielding Pennsylvanian sandstones are present throughout most of the county, with the exception of small areas in the north and southeast. Many domestic and farm wells obtain water from these sandstones at various depths down to 175 feet.

Cumberland County. Water-yielding Pennsylvanian sandstones occur throughout most of the county with the exception of small areas in the northwestern and southwestern parts of the county. The sandstones generally occur at depths of less than 150 feet.

DeWitt County. The Pennsylvanian bedrock underlying the drift is not generally used as a source of ground water in the county because the glacial drift contains more favorable aquifers. Nevertheless, small supplies of ground water may be obtained from the upper 50 to 100 feet of the Pennsylvanian formations, but they should be tested only after all attempts to develop a well in the drift have failed.

Douglas County. Pennsylvanian bedrock, consisting principally of shale, underlies the drift in most of the county and locally may yield small ground-water supplies from thin beds of sandstone or creviced limestone or from fractures in the shale. Along the LaSalle anticlinal belt, bedrock of the Mississippian and Devonian systems directly underlies the drift. In this area ground water is obtained from the Devonian and underlying Silurian dolomites where drift supplies are not available. Where Mississippian shales underlie the drift, drilling must continue through the shale into the dolomite.

Edgar County. Ground water is obtained from shallow Pennsylvanian sandstone, creviced limestone, and shale in most of the county. Drilling should be extended into the upper 100 to 150 feet of Pennsylvanian bedrock if water is not obtained from shallow unconsolidated deposits.

Edwards County. 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.

Effingham County. Ground water is obtained from shallow Pennsylvanian sandstones throughout most of the county with the exception of local areas south and east of Effingham, in the northeastern part of the county, and in the southeast corner. Most of the sandstones yielding fresh water occur at depths of less than 150 feet. However, in a small area in the south-central part of the county they may occur at depths ranging from 150 to 300 feet.

Fayette County. Domestic and farm supplies of ground water are generally available from shallow Pennsylvanian sandstones throughout most of the county with a few local exceptions. Throughout most of the area these sandstones are present in the upper 50 to 150 feet, although a few occur as deep as 200 feet.

Ford County. Pennsylvanian bedrock underlies the drift in most of the county. Small ground-water supplies may be obtained locally from shallow Pennsylvanian formations.

Franklin County. 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.

Fulton County. Most domestic wells are drilled into Pennsylvanian sandstones that occur a few feet below coal beds, at depths ranging from 50 to more than 300 feet, or into the Keokuk-Burlington limestone, which is encountered at depths ranging from 250 to about 500 feet. The Keokuk-Burlington limestone is sufficiently creviced to yield water for domestic supplies at most, but not all, localities.

Gallatin County. 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.

Greene County. The principal source of private and municipal supplies of ground water in the county is the creviced Keokuk-Burlington limestone. Municipal supplies at Carrollton have been obtained for many years from springs that issue from fissures in the. limestone that crops out along a small tributary of Apple Creek. Roodhouse obtained water from similar springs along a tributary of Sandy Creek, but later drilled 150-foot wells into the Keokuk-Burlington limestone near the springs and secured yields of more than 400 gpm (Illinois State Water Survey Bulletin 40). Water is also obtained from Pennsylvanian rocks and the Salem limestone in the eastern half of the county. East of Roodhouse many domestic wells are finished in fractured shales or sandstones above or a few feet below coal beds, at a depth less than 100 feet. In wells where suitable water supplies are not obtained in the Pennsylvanian rocks in this area, drilling is extended into the underlying Salem or Keokuk-Burlington limestones.

Grundy County. South of the Illinois River, the relatively tight Pennsylvanian rocks underlie the glacial drift. The principal water-yielding formations for domestic wells around Verona, Carton Hill, Braceville, Gardner, and South Wilmington are tight sandstones less than 150 feet from land surface.

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

Hancock County. The Keokuk-Burlington limestone is within 200 feet of the surface in most of the county and is the main source of ground-water supplies in the bedrock. At some locations water is obtained from a weathered creviced zone at the top of the limestone, but more commonly penetration of more than 100 feet is necessary to obtain adequate water for domestic or farm supplies. Water-yielding zones are rarely encountered in the Salem and Warsaw Formations which overlie the Keokuk-Burlington. Pennsylvanian rocks are generally absent, although along the east edge of the county and in isolated outliers to the west, thin Pennsylvanian rocks may occur beneath the drift and include sandstones that yield ground water. At Bowen a 42-foot Pennsylvanian sandstone is encountered at a depth of 48 feet.

Hardin County. 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 (Valmeyeran) limestones, especially the St. Louis limestone. Where the Valmeyeran limestones are overlain by thin Chesterian rocks, it is common practice to penetrate the Chesterian rocks and drill into the Valmeyeran limestones.

Henderson County. At most localities it is" possible to obtain ground water from the bedrock formations. In the northern township of the county, the Keokuk-Burlington limestone is less than 350 feet from the surface in the upland south of T11N.

Henry County. In most of the county the Devonian and Silurian rocks are overlain by Pennsylvanian rocks. Sandstone, fractured shale, and coal in the Pennsylvanian rocks yield sufficient water for domestic use at some localities.

Iroquois County. Few wells have been drilled below the Kinderhookian shale in the eastern part of the county.

Jackson County. Ground water from bedrock aquifers can be obtained with little difficulty throughout most of the county. The bedrock is Pennsylvanian in the northeast, where the sandstone aquifers are present, and Mississippian (Valmeyeran) in the southwest, where creviced limestones are present. Chesterian rocks are favorable for ground-water 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.

Jasper County. Sandstone aquifers in the Pennsylvanian system are water-yielding in the eastern and northwestern parts of the county. East of Newton these sandstones are at depths of 100 to 300 feet below land surface, and in the northwestern part of the county wells obtain water in the upper 100 to 150 feet of bedrock.

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

Jersey County. Many farm wells in the eastern half of Jersey County obtain small supplies of water from fractures in Pennsylvanian shales within a depth of 180 feet. In wells drilled into underlying Mississippian limestones, the Pennsylvanian rocks are commonly cased off to prevent caving of the shales. The Keokuk-Burlington limestone is the source of private ground-water supplies in much of the county, with wells varying in depth from less than 50 feet in some of the hollows east of the confluence of the Illinois and Mississippi Rivers to more than 350 feet on the upland east of Jerseyville. At shallower depths in the eastern two-thirds of the county the St. Louis-Salem limestone is sufficiently thick and creviced at some places to yield water for farm wells.

Johnson County. Ground water is obtainable from sandstones in Pennsylvanian bedrock at depths below 100 feet. Chesterian 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 Valmeyeran limestones.

Kankakee County. Conditions are least favorable for good wells near the western edge of the county, as at Reddick, where water-bearing sands may be difficult to find and where most of the 100 feet or more of shale directly below the glacial drift is not water-yielding.

Knox County. Bedrock sources of ground water include sandstone and fractured shale in the Pennsylvanian system, and underlying limestone and dolomite formations. The Keokuk-Burlington limestone, present south of Galesburg and Knoxville, is a dependable aquifer for farm supplies, with wells penetrating from 30 to 70 feet into the limestone.

LaSalle County. In southern LaSalle County, Pennsylvanian rocks overlap older rocks of several ages. Where ground water 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 ground-water sources. They are cased off in wells drilled to deeper formations.

Lawrence County. Pennsylvanian sandstones are water-yielding throughout most of Lawrence County, with the exception of a small area in the north-central part. Most domestic and farm wells outside the areas of the Wabash and Embarras Rivers obtain water from sandstones at depths of 100 to 300 feet below the surface.

Lee County. The majority of ground-water supplies in northern Lee County are obtained from bedrock. In a portion of southern Lee County, the glacial deposits are underlain by tight Pennsylvanian formations. In this area, particular attention should be directed toward development of sand and gravel aquifers.

Livingston County. Throughout the county, domestic and farm supplies are obtained from shallow Pennsylvanian formations. Drilling into the Pennsylvanian is recommended only when a suitable ground-water supply is not obtained from the drift. Water in the Pennsylvanian bedrock is sometimes of poor quality, as in the area around Odell where drillers report the water to be slightly salty.

Logan County. Domestic and farm supplies are obtained locally in the central and southern part of the county from the Pennsylvanian bedrock. Wells should not be drilled deeper than 150 to 200 feet into the bedrock.

Macon County. The Pennsylvanian bedrock below the glacial drift is composed principally of shale with thin beds of limestone, sandstone, and coal. Because of the widespread availability of ground water from sand and gravel, wells drilled into the bedrock are uncommon in most of the county. In the southern part of the county, in T15N and T14N, if water is not obtained from shallow drift deposits, wells should be drilled to the upper 50 to 100 feet of bedrock where small supplies may be obtained from water-yielding sandstone or creviced limestone or shale. Deeper drilling is not recommended because the water in deeper bedrock formations is highly mineralized.

Macoupin County. In the northern part of the county, water for farm and domestic supplies is obtained from shallow Pennsylvanian sandstones at depths ranging from 70 to 200 feet below land surface. Because of the unfavorable ground water possibilities in the drift, it is recommended that wells be drilled into the upper 50 to 150 feet of bedrock throughout the county. Domestic and farm supplies may be obtained locally from thin sandstone beds or from fractured shales, coals, and limestone beds.

Madison County. The bedrock, although in part capable of producing large quantities of ground water, is of negligible importance in the Mississippi Valley flat because of the excellent possibilities in the shallower sand and gravel deposits. On the upland, however, in many areas the bedrock is the only ground-water source. Thin sandstone beds, present in the Pennsylvanian system in general, are suitable only for domestic supplies. The Mississippian limestones and sandstones are favorable sources of ground water where they are encountered at shallow depths. The St. Louis limestone is a favorable source of water for farm and domestic supplies west of Godfrey, where it is encountered immediately below the drift, and in the area between Godfrey and Fosterburg, where it is encountered at depths ranging from 125 to 175 feet below land surface. Pennsylvanian and Chesterian sandstones are potential sources of ground water, and wells are finished at depths ranging from 100 to 400 feet below land surface. In the southeastern part of the county, wells are finished in Pennsylvanian sandstones at depths ranging from 100 to 250 feet below land surface.

Marion County. In limited areas Pennsylvanian sandstones are a source of ground water, particularly southeast of Salem. Where the sandstone occurs, farm and domestic supplies may be obtained from the upper 150 feet of the bedrock or, locally, in the upper 200 feet.

Marshall County. The Pennsylvanian formations underlying the drift in the eastern and western parts of the county are not considered a dependable source of ground water. Small ground-water supplies are available from a few wells in the Pennsylvanian rocks, but drilling into these formations should be considered only as a last resort.

Mason County. Mississippian and Pennsylvanian bedrock formations underlie the glacial drift; but because ground water is available in shallow unconsolidated material, only a few water wells have been attempted in the bedrock.

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

McDonough County. The top of the water-yielding Keokuk-Burlington limestone is reached within 175 feet of the surface in the western part of McDonough County and within 250 feet in the eastern part. Drillers report the Keokuk-Burlington strata to be a dependable source of water for domestic supplies at most localities, with depth of penetration into the limestone ranging from 75 to 150 feet. Pennsylvanian and "Warsaw shales overlie the Keokuk-Burlington limestone. Sandstone or coal beds in the Pennsylvanian rocks yield ground water locally for small to moderate supplies. Many wells in the vicinity of Colchester, including the city wells, obtain water from old mine workings in the No. 2 coal at a depth of about 80 feet.

McLean County. The Pennsylvanian bedrock directly underlies the glacial drift throughout the county. Although little information is available on the distribution of water-yielding beds within the upper part of the Pennsylvanian rocks, a few wells obtain small supplies of ground water from these formations. When all attempts to develop drift wells have failed, the upper 100 feet of the Pennsylvanian bedrock should be tested for the presence of water-yielding sandstone, creviced limestone, or fractured shale beds. Below 100 feet in the bedrock, the formations are generally tight and the water is highly mineralized.

Menard County. Pennsylvanian bedrock underlying the drift throughout the county is locally a source of ground water for domestic and farm supplies.

Mercer County. Most farm wells are in the Pennsylvanian sandstones, coal, or fractured shale, Devonian limestone, or Silurian dolomite. Common procedure in constructing farm wells in Mercer and adjoining counties is to drill and drive 6-inch casing into the top of the Devonian or Silurian to shut off water from the glacial drift and the Pennsylvanian formations, then reduce to 5-inch and drill open hole to total depth.

Monroe County. Wells drilled into the bedrock obtain water from limestones and sandstones of the Mississippian system. The St. Louis limestone, which forms the sinkhole topography north and south of Renault and west, southwest, and northwest of Waterloo, is the source of water for a large number of domestic and farm supplies throughout the county. This formation is encountered immediately below the surface or below a thin cover of glacial drift in T2N, T3N, and T4N, R10W, and dips eastward to depths ranging from 300 to 500 feet below land surface in T3S, R8W. Because of the danger of pollution- in wells that penetrate shallow cavernous limestone, wells in the St. Louis formation must be constructed with special attention to sanitary practices. The Keokuk-Burlington limestone, which is encountered at depths ranging from 200 to 500 feet below land surface in the central and the western parts of the county, is a possible source of ground water for farm and domestic supplies, although it is less creviced than the shallower St. Louis limestone. In the eastern part of the county, the Aux Vases sandstone is a favorable source of ground water for domestic and possibly larger supplies. This formation is encountered immediately below the drift, that is, at depths ranging from 15 to 30 feet below land surface, in the southern part of T3S, R9W, and in the north part of T4S, R9W. In T3S, R8W, the Aux Vases is present at depths ranging from 260 to 300 feet below land surface. Although the St. Louis limestone, the Keokuk-Burlington limestone, and the Aux Vases sandstone are the best aquifers in the bedrock of Monroe County, other Mississippian limestone and sandstone formations may be a source of water for farm and domestic supplies.

Montgomery County. Pennsylvanian sandstones are the source of ground water for domestic and farm supply in the central and south-central parts of the county where they are present at depths ranging from 100 to 180 feet below land surface. In the northwestern part of the county water-yielding sandstone is present at depths ranging from 70 to 120 feet below land surface. Well records show that west of Litchfield sandstone is present at a very shallow depth, from 20 to 40 feet below land surface.

Morgan County. Pennsylvanian rocks, which underlie the drift in the uplands, range in thickness from 25 to 50 feet near the river bluffs to more than 400 feet in the southeastern part of the county. At some locations private wells are finished in sandstone or fractured coal, shale, or limestone in the Pennsylvanian rocks within 200 or 300 feet of land surface. The Salem limestone underlies the Pennsylvanian rocks and in many places is penetrated for domestic ground-water supplies. Water-bearing crevices in the Salem are not abundant, so that yields are generally low. Depth to the Salem ranges from 175 to about 550 feet from northwest to southeast. The Keokuk-Burlington limestone is usually more than 200 feet below the top of the Salem and is rarely reached in domestic wells. Drilling for water in the bedrock is somewhat restricted by the presence of gas in the lower Pennsylvanian and Salem recks in T15N, R9W. The water associated with the gas in these areas is usually not potable.

Moultrie County. Pennsylvanian sandstones, coal, or fractured shales and limestone are a local source of water for small farm supplies. Because of the poor quality of water in deeper bedrock formations, drilling should not extend below a depth of approximately 300 feet.

Peoria County. Bedrock conditions are not favorable for drilled wells for domestic ground-water supplies. Some water is obtained from sandstones, coal, and fractured shale in the Pennsylvanian rocks in wells as much as 350 feet deep, but drilling into the Keokuk-Burlington and Devonian-Silurian is not recommended because of the poor quality of the water. State Water Survey records show the water of the Keokuk-Burlington to be more highly mineralized (8000 ppm) than that from any other formation in the area.

Perry County. In northern and eastern Perry County, ground water is obtained from shallow Pennsylvanian sandstones 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.

Piatt County. Because of the availability of water from sand and gravel above the bedrock, wells are rarely drilled into shallow Pennsylvanian bedrock formations. It is possible that locally small farm supplies may be obtained in the upper 250 to 300 feet of bedrock.

Pike County. The Keokuk-Burlington limestone is the primary source of ground water for private supplies in Pike County. Drillers report that water is obtained in the upper 60 feet of the formation where crevicing is most extensive. At some locations, particularly east of Pittsfield, the upper 25 to 30 feet of the formation is composed of broken, rubbly rock which yields water readily. The formation is less favorable for obtaining water west of the anticlinal belt running northwestward through Pittsfield, including the area of the old Pittsfield gas field.

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

Pulaski County. Underlying the unconsolidated deposits, the well-creviced Valmeyeran limestones are water-yielding and good sources of ground water for municipal and industrial supplies.

Putnam County. Pennsylvanian sandstones or fractured limestones are local sources of water for small farm supplies throughout the county.

Randolph County. Drilled wells in the upper bedrock obtain ground water from lower Pennsylvanian sandstones in the northeastern half of Randolph County. The depth to these thick sandstones varies from less than 100 feet along the western border of Pennsylvanian outcrop to over 600 feet east of Sparta and Percy. Chesterian 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 Chesterian beds where they underlie the glacial deposits.

Richland County. Pennsylvanian sandstones are present throughout most of Richland County except in the northwest corner. They yield fresh water at various depths, from just beneath the drift (30 to 60 feet) to a maximum depth of 400 feet at a few localities in the east-central part of the county. Supplies for domestic and farm use generally can be obtained from these sandstones.

Bock Island County. Many domestic wells in this county obtain water from sandstone, coal, or fractured shale in the Pennsylvanian rocks, although in wells penetrating the Silurian strata the Pennsylvanian and underlying Kinderhookian shales are cased off.

St. Clair County. Where the drift is thin and underlain by Pennsylvanian rocks, domestic and farm supplies are obtained from shallow sandstones and creviced limestones. Wells in the Pennsylvanian formations range in depth from 80 to 200 feet below land surface. The Chesterian sandstones are potential sources of ground water either where they are present immediately below the drift or where they are overlain by Pennsylvanian beds. Wells are finished in these sandstones at depths from 50 to 500 feet below land surface. Industries located in Belleville obtain water supplies from wells drilled into Mississippian sandstones at depths from 400 to 600 feet below land surface, and the former municipal supply of Belleville was obtained from wells drilled 500 to 600 feet into Chesterian formations. In the western part of the county the Valmeyeran formations are a source of ground water for private and larger supplies. The St. Louis limestone, which forms the sinkhole topography south of Stolle, is a potential water source in St. Louis and in the region between Prairie Du Pont Creek and the Mississippi River. Because of the danger of pollution in wells that penetrate shallow cavernous limestone, wells in the St. Louis formation must be constructed with special attention to sanitary practices.

Saline County. 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.

Sangamon County. The Pennsylvanian bedrock below the glacial drift is composed of shale with beds of limestone, sandstone, and coal. Throughout the county small ground-water supplies have been obtained from permeable sandstone, creviced limestone, or fractured shale in the upper 150 feet of bedrock. Drilling should not extend below this depth because mineralized water is usually encountered in the deeper bedrock formations.

Schuyler County. In Schuyler County the Keokuk-Burlington limestone, which is encountered at depths ranging from 50 feet along the La Moine River to more than 350 feet on the uplands just east of Rushville, is the main source of domestic ground-water supplies. It is commonly 200 feet thick, although drilling usually penetrates only the upper two-thirds of the limestone which is the part reported to be the best creviced. At some locations water is obtained from limestone and chert rubble at the top of the formation. On the uplands the Keokuk-Burlington is overlain by Warsaw shale, thin Salem limestone, Pennsylvanian rocks, and glacial drift. At a few locations drilled wells obtain water from the Salem limestone or Pennsylvanian fractured shales, limestone, or coals; but these rocks are generally less likely sources of ground water than the Keokuk-Burlington.

Scott County. Most drilled wells in Scott County are completed in Mississippi limestone bedrock at depths less than 300 feet. The Keokuk-Burlington limestone occurs at shallow depths in the west part of Scott County and east of Winchester. In the northeast and southeast townships where thin Pennsylvanian rocks overlie Mississippian rocks, it is customary to finish wells in the Keokuk-Burlington and case off the overlying shales and drift. At some locations in these townships water is obtained from coal beds, sandstones, or fractured limestones or shales in the Pennsylvanian rocks.

Shelby County. In the central part of the county east of Shelbyville, ground water is obtained from shallow Pennsylvanian sandstones at depths down to 150 feet. In the general area between Mode and Stewardson in the southern part of the county, water has been obtained from sandstones as deep as 200 feet below the surface. Lack of information in much of Shelby County prohibits precise determination of the depths from which fresh water may be obtained from these sandstones. Pennsylvanian sandstones appear to be absent in the western part and a portion of the eastern part of Shelby County.

Stark County. Because the Keokuk-Burlington limestone is absent in Stark County, shallow bedrock sources of ground water include only sandstone, coal, and fractured shale in the Pennsylvanian system and the Devonian-Silurian rocks. The Pennsylvanian rocks range from 300 to 500 feet thick in the county, and the most favorable sources of ground water are in the upper 200 feet.

Tazewell County. The Pennsylvanian bedrock below the drift is a source of water for farm and domestic supplies east of Pekin where the drift is thin. In the rest of the county, because ground water is widely available from the unconsolidated material, only a few wells have been attempted in the bedrock.

Union County. The sandstones and limestones of the Chesterian Series, which form a series of southeast-trending ridges in the northeastern part of Union County, are water-yielding. Most domestic wells are finished in the Chesterian at depths below 100 feet. Little difficulty is encountered in obtaining domestic water supplies from the well-creviced and fractured Valmeyeran in the southwestern part of Union County.

Vermilion County. South of Danville the probabilities of aquifers above the bedrock are poor. Here, some wells that have penetrated the upper part of the Pennsylvanian bedrock obtain small supplies of ground water from shale and thin sandstone or limestone beds. The quality of the water obtained from the bedrock formations below depths ranging from 150 to 300 feet may be unsatisfactory.

Wabash County. 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.

Warren County. Where suitable sand and gravel are absent, wells may be continued into the bedrock and obtain water from sandstones in the Pennsylvanian system, from the Keokuk-Burlington limestone, or from the Silurian dolomite. Where the Keokuk-Burlington is absent in the northern townships of the county, deeper wells obtain water from the Silurian dolomite. In the southwestern quarter of the county the Silurian is absent, so most bedrock wells do not go deeper than the Keokuk-Burlington strata.

Washington County. 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. Domestic supplies are obtainable in most of the county from sandstone aquifers in the upper 250 feet of the bedrock.

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

Will County. South of Braidwood, in extreme southwestern Will County, sandstone beds of the Pennsylvanian system lie beneath 10 to 50 feet of glacial drift. These sandstones yield water to a number of farm and domestic wells, but they are not considered suitable for high-capacity wells.

Williamson County. 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 to 800 feet.

Woodford County. Ground-water supplies for farm and domestic use are generally available from sand or gravel layers within the drift, and therefore relatively few wells are finished in the Pennsylvanian formations. In the eastern two-thirds of the county, if water is not obtained from the unconsolidated material, the upper part of the Pennsylvanian bedrock should be tested.

CONCLUSIONS

Statistical analysis of specific-capacity data for wells in Pennsylvanian and Mississippian rocks shed much light on the productivities of these rocks. The differences in productivity of individual formations uncased in wells become apparent after studying specific-capacity frequency graphs for these formations.

Because the productivity of the Pennsylvanian and Mississippian rocks is inconsistent, it is impossible to predict with a high degree of accuracy the specific capacity of a well before drilling at any location. Probable ranges of specific capacities of wells in undeveloped areas can be estimated from the specific-capacity frequency graphs and information on the availability of ground water in individual counties.

It is possible to drill what is essentially a dry hole at any location. On the basis of existing data, the chances of obtaining a well in Pennsylvanian rocks with a yield exceeding 15 gpm are poor in most areas. The chances of obtaining a well in Mississippian rocks with a yield exceeding 30 gpm are poor in most areas.

REFERENCES

Atlas of Illinois resources, section 1: water resources and climate. 1958. Illinois Department of Registration and Education, Division of Industrial Planning and Development, Springfield.

Bell, A. H. 1943. Subsurface structure of the base of Kinderhook-New Albany shale in central and southern Illinois. Illinois Geological Survey Report of Investigation 92.

Bergstrom, R. E. 1956. Ground-water geology in western Illinois, north part. Illinois Geological Survey Circular 222.

Bergstrom, R. E., J. W. Foster, L. F. Selkregg, and W. A. Pryor. 1955. Ground-water possibilities in northeastern Illinois. Illinois Geological Survey Circular 198.

Bergstrom, R. E., and T. R. Walker. 1956. Ground-water geology of the East St. Louis area, Illinois. Illinois Geological Survey Report of Investigation 191.

Bergstrom, R. E., and A. J. Zeizel. 1957. Ground-water geology in western Illinois, south part. Illinois Geological Survey Circular 232.

Cooper, H. H., and C. E. Jacob. 1946. A generalized graphical method for evaluating formation constants and summarizing well-field history. Transactions American Geophysical Union v. 27(4).

Csallany, S. C. 1965. Relationship between water use and population in the Embarras River Basin, Illinois. Journal of American Water Works Association v. 57(3).

Csallany, S. C, and W. C. Walton. 1963. Yields of shallow dolomite wells in northern Illinois. Illinois State Water Survey Report of Investigation 46.

Foster, J. W. 1956. Ground-water geology of Lee and Whiteside Counties, Illinois. Illinois Geological Survey Report of Investigation 194.

Foster, J. W. 1954. Water wells for farm supply in central and eastern Illinois. Illinois Geological Survey Circular 192.

Hackett, J. E., and R. E. Bergstrom. 1956. Ground water in northwestern Illinois. Illinois Geological Survey Circular 207.

Hantush, M. S., and C. E. Jacob. 1955. Non-steady radial flow in an infinite leaky aquifer. Transactions American Geophysical Union v. 36(1).

Horberg, Leland. 1950. Bedrock topography of Illinois. Illinois Geological Survey Bulletin 73.

Illinois State Water Survey. 1957. Potential water resources of southern Illinois. Report of Investigation 31.

Kimball, B. F. 1946. Assignment of frequencies to a completely ordered set of sample data. Transactions American Geophysical Union v. 27(6).

Pryor, W. A. 1956a. Ground-water geology in southern Illinois. Illinois Geological Survey Circular 212.

Pryor, W. A. 1956b. Ground-water geology of White County, Illinois. Illinois Geological Survey Report of Investigation 196.

Selkregg, L. F., and J. P. Kempton. 1958. Ground-water geology in east-central Illinois. Illinois Geological Survey Circular 248.

Selkregg, L. F. 1957. Ground-water geology in south-central Illinois. Illinois Geological Survey Circular 225.

Smith, H. F. 1950. Ground-water resources in Champaign County. Illinois State Water Survey Report of Investigation 6.

Suter, Max, R. E. Bergstrom, H. F. Smith, G. H. Emrich, W. C. Walton, and T. E. Larson. 1959. Preliminary report on ground-water resources of the Chicago region, Illinois. Illinois State Water Survey and Geological Survey Cooperative Ground-Water Report 1.

Theis, C. V. 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage. Transactions American Geophysical Union 16th Annual Meeting, part 2.

Walton, W. C. 1960. Leaky artesian aquifer conditions in Illinois. Illinois State Water Survey Report of Investigation 39.

Walton, W. C. 1962. Selected analytical methods for well and aquifer evaluation. Illinois State Water Survey Bulletin 49.

Walton, W. C, and Sandor Csallany. 1962. Yields of deep sandstone wells in northern Illinois. Illinois State Water Survey Report of Investigation 43.

Walton, W. C, and J. C. Neill. 1963. Statistical analysis of specific capacity data for a dolomite aquifer. Journal Geophysical Research v. 68(8).

Zeizel, A. J., W. C. Walton, T. A. Prickett, and R. T. Sasman. 1963. Ground-water resources of DuPage County, Illinois. Illinois State Water Survey and Geological Survey Cooperative Ground-Water Report 2.

APPENDIX A
SPECIFIC-CAPACITY DATA FOR WELLS IN PENNSYLVANIAN ROCKS

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (yr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft^2)	Remarks
BND													
5N2W-8.1h	La Moss	120	8	37	1947	1947	3	4	2.5	4.3	0.58	0.013	
6N2W-36	L. J. Franklin	75	7	5	1949	1949	.3	7	32	43	0.74	0.148	
BUR													
15N6E-10.2a	Village of Neponset	181	-	133	1945	1946	-	18	11.5	32	0.36	0.003	School Well
15N6E-10.5b	Village of Neponset	250	14	120	-	1955	3.5	44.4	15.8	64.6	0.25	0.002	Village Well No. 2
CLK													
9N11W-7.5d	M. Prust	55	6	-	1931	1934	1.5	15	5.5	40	0.14	-	
9N11W-30.7d	C. Chambers	100	6	-	1926	1934	.3	90	5	10	0.50	-	
12N14W-29.8c	Village of Westfield	155	-	115	1919	1939	1.8	60	19	55	0.35	0.003	Village Well No. 1
12N14W-30.1c	Village of Westfield	150	10	54	1940	1940	6	72	18	66	0.27	0.005	Village Well No. 3, shot
CLN													
1N4W-4.4b	Village of Germantown	223	8	134	1955	1955	.3	33	5	70	0.07	0.001	Village Well No. 1
1N5W-11.1c	Village of Albers	145	8	43	1955	1956	3	37.1	20	82.9	0.24	0.006	Village Well "Hempen"
1N5W-12.8c	Village of Albers	149	8	47	1955	1956	10	35.8	26.5	92	0.31	0.007	Johnson Well
1N5W-12.8d	Village of Albers	185	7	90	1956	1956	4	37	26	89	0.29	0.003	Village Well No. 2
1N5W-18.8h	Village of New Baden	255	12	88	1947	1947	4	147	10	103	0.10	0.001	Village Well No. 3, shot
1N5W-18.8h	Village of New Baden	255	12	88	1947	1948	1	175	17	75	0.23	0.003	Village Well No. 3
2N5W-20.5e	City of Trenton	245	10	115	1945	1945	10	160	52	60	0.87	0.008	City Well No. 2
COL													
11N8E-3.1b	Village of Lerna	182	5	71	1955	1955	.3	58.8	7	34.2	0.20	0.003	Village Well No. 4
12N8E-3.2a	Village of Lerna	146	8	41	-	1956	.5	54.2	8	68.3	0.12	0.029	Village Well No. 6
11N8E-3.3b1	Village of Lerna	151	8	51	1955	1955	3	50.6	10.4	66.2	0.16	0.003	Village Well No. 2, shot
11N8E-3.3b2	Village of Lerna	159	-	59	1955	1955	.5	57	6	47	0.13	0.002	Village Well No. 3
12N8E-16	Coles County Airport	115	6	17	1962	1962	4.3	27.6	5.5	48.1	0.11	0.007	Well No. 1-62
12N8E-16	Coles County Airport	108	6	9	1962	1962	4.3	30	7	29.1	0.24	0.027	Well No. 2-62
CRF													
6N12W-25.1h	Village of Flat Rock	83	12	55	1954	1954	18	15.5	25	39	0.64	0.012	
6N13W-27.8a	The Ohio Oil Co.	390	8	60	1948	1948	.5	147	50	223	0.22	0.004	
DWT													
19N4E-19.1f	C. H. Moore Estate	321	4	-	1916	1934	-	90	5	20	0.25	-	
21N3E-25	F. Lackner	195	4	1	1945	1945	1	50	5	20	0.25	0.250	
DGL													
16N9E-34.3c	Village of Camargo	165	10	5	1956	1956	6	20	37	81.5	0.45	0.090	Village Well No. 1
EDG													
13N12W-2.1h	Ill. Cereal Mills, Inc.	180	10	40	1954	1954	23	68.5	50.0	58.5	0.86	0.021	
13N12W-12.8d	City of Paris	160	20	35	1954	1954	2.5	29.2	25	50.8	0.49	0.014	Test Well 1-54
EFF													
8N5E-15.4g	W. O. Best	201	6	28	1960	1960	5.5	38.5	18.6	57.9	0.32	0.011	Well No. 1
FAY													
5N4E-32.4d	Village of Farina	280	8	198	1948	1948	.3	13	24	39	0.62	0.003	Test Well No. 1-48
5N4E-32.4f	Village of Farina	135	12	93	1948	1948	5	22.5	20	89	0.22	0.002	Village Well "Boston" No. 2
5N4E-32.4f	Village of Farina	135	12	93	1948	1948	-	17.7	18	95.3	0.19	0.002	Village Well "Boston" No. 1
5N4E-32.5d	Village of Farina	455	10	255	-	1948	12	10.5	20	83	0.24	0.001	Village Well "Wade" No. 1
5N4E-32.1g	Village of Farina	170	10	142	1948	1948	5.2	13	25.5	22	1.15	0.007	Village Well "Allen"
5N4E-32.2g	Village of Farina	125	8	92	1949	1949	6.5	13	9.9	47.7	0.21	0.002	Village Well "Curry" No. 1
5N4E-33.7d	Village of Farina	146	8	76	1959	1959	3	32	17	68	0.25	0.003	Village Well No. 6
5N4E-33.8c	Village of Farina	133	5	84	1958	1958	5	23	34.5	65	0.53	0.006	Village Well No. 5
7N3E-32.5b	Jarvis Bros. and Marcell Inc.	425	13	368	-	1955	.8	63.7	12	51	0.24	0.001	Well S. W. 2
GAL													
7S8E-27.1f	Village of Omaha	130	6	20	1946	1946	-	5	18	54	0.33	0.016	
9S8E-16.2g1	Village of Equality	160	6	44	1950	1950	7.5	21.3	42	52.7	0.80	0.018	Test Well 1-50
9S8E-16.2g2	Village of Equality	160	8	53	1950	1950	9	18.9	29.3	105.9	0.28	0.005	Test Well 2-50
9S8E-17.4f	Village of Gallatin	200	8	160	1947	1947	-	27.7	7	122	0.06	0.001	Highschool Well
GRY													
31N8E-4.1a	Village of Gardner	173	6	111	1939	1939	5	1.4	32	39	0.82	0.007	Village Well "East"
31N8E-4.1a	Village of Gardner	173	6	111	1939	1939	22	15	57	101	0.56	0.005	Village Well "East"
31N8E-4.4b	Village of Gardner	161	10	96	1944	1944	24	26	160	38	4.21	0.044	Village Well "Park" shot
HAN													
3N6W-22.2d	Village of Bowen	57	6	13	1948	1948	20	22.4	2	27.6	0.07	0.005	Village Well No. 4
3N6W-22.1e2	Village of Bowen	75	6	25	1948	1948	3	23.3	6.2	22.2	0.28	0.011	Village Well No. 5
3N6W-22.1e3	Village of Bowen	65	6	30	1948	1948	9	24.3	1.8	21.9	0.08	0.003	Village Well No. 6

APPENDIX A (Continued)

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (yr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft^2)	Remarks
JKS													
7S4W-9.5b	Village of Campbell Hill	320	8	70	1942	1942	16	71.5	26	-	-	-	
7S4W-9.5b	Village of Campbell Hill	442	7	198	1946	1946	1	100	54	71	0.76	0.004	
7S4W-9.5b	Village of Campbell Hill	442	7	198	1946	1946	48	72	54	102	0.53	0.003	
7S4W-25.7e1	City of Ava	207	8	155	1940	1941	24	132	25	-	-	-	City Well No. 1
7S4W-25.7e2	City of Ava	214	8	159	1942	1942	1	65	6	90	0.07	0.001	City Well No. 2
7S4W-25.7e2	City of Ava	308	8	253	1947	1947	-	80	37	90	0.41	0.002	City Well No. 2
JAS													
6N14W-19.8a	Village of St. Marie	114	10	90	1953	1953	11	8	4.8	15.3	0.31	0.003	Village Well No. 2-53
JHN													
11S2E-21	Ferne Cliffe State Park	205	6	-	-	1955	.5	52	12.5	120	0.10	-	
LAW													
2N11W-20.2d	City of St. Francisville	136	10	101	1951	1951	1.3	33	50	91	0.55	0.005	City Well No. 3
2N11W-20.3e	City of St. Francisville	134	8	54	1928	1928	-	18	125	110	1.14	0.021	City Well No. 1
2N11W-20.3e	City of St. Francisville	134	8	54	1928	1952	-	35	50	89	0.56	0.010	City Well No. 1
2N11W-21.6f	City of St. Francisville	160	6	100	-	1961	2	61.3	26	13.3	1.16	0.012	City Well No. 4
3N11W-6	Avalon Theatre	205	8	101	1947	1947	11	55	60	70	0.86	0.009	
3N13W-4.5c	City of Sumner	221	8	174	1951	1951	3.8	17.6	9.8	150.4	0.07	0.001	City Well No. 1
LIV													
27N3E-20.1a	M. C. Ohl	252	4	-	1947	1947	-	41	10	69	0.15	-	
27N3E-31.4h	H. Greenwald	266	4	-	1947	1947	-	33	10	67	0.15	-	
28N5E-8.1h	D. Balback	121	-	-	1951	1951	-	8	10	52	0.19	-	
29N6E-16	T. Curtis	280	3	-	1932	1934	.5	100	4	80	0.05	-	
29N6E-25	J. Wolf Estate	235	3	75	1929	1934	-	80	4	80	0.05	0.001	
29N7E-33	J. Dornbierer	216	3	66	1896	1934	2	88	4	60	0.07	0.001	
30N6E-1	State Reformatory for Women	210	6	66	1935	1935	.2	32	12.3	154	0.08	0.001	
30N6E-1.d	State Reformatory for Women	210	6	66	-	1935	4.5	-	8	154	0.05	0.001	Well No. 1
30N6E-26	C. Hubert Estate	140	4	-	1917	1934	.5	40	4	90	0.04	-	
30N6E-30	F. J. Noonan	198	18	93	1922	1934	4	24	6	52	0.12	0.002	
30N6E-34	J. Dornbierer	235	4	75	1918	1934	-	40	6	80	0.08	0.001	
LOG													
19N3W-20	H. Laver	95	4	2	1939	1939	-	18	5	22	0.23	0.115	
MCP													
9N9W-30.8d	Village of Medora	55	8	28	1953	1953	-	19.4	18	28.1	0.64	0.023	Village Well No. 2
12N8W-22.8f	Village of Modesto	131	6	48	1954	1957	1.5	36.6	15	14.2	1.05	0.022	Village Well No. 1
12N8W-22.4g	Village of Modesto	107	6	49	1955	1957	7	14.9	30	38.7	0.78	0.016	Village Well No. 2
12N8W-22.4g	Village of Modesto	107	6	49	1955	1955	3.3	14.6	31.5	38.5	0.82	0.017	Village Well No. 2 (new)
MAD													
3N6W-9.2d	Village of St. Jacob	201	8	56	1948	1949	2.5	33	22.5	127	0.18	0.003	Village Well No. 1
3N6W-9.2g	Village of St. Jacob	182	8	89	1956	1956	10	46.2	20	117	0.17	0.002	Village Well No. 4
3N6W-16.3g	Village of St. Jacob	198	7	63	1954	1954	9	57.8	9.9	66.3	0.15	0.002	Village Well No. 3
6N6W-26.4d	Village of Livingston	100	8	35	1950	1950	4	2.6	7.4	17.2	0.43	0.012	Village Well No. 1
MRN													
2N4E-17.7f	Village of Iuka	85	5	10	1961	1961	1.5	10.4	5.3	49.8	0.11	0.010	Test Hole No. 1
2N4E-18.1d	Iuka School	110	-	-	-	1955	1	13.5	12	69	0.17	-	
2N4E-18.1d1	Village of Iuka	84	6	71	1961	1961	4.5	5.6	15.3	30.6	0.50	0.007	Test Hole No. 4
2N4E-18.1d2	Village of Iuka	78	6	22	1961	1961	4.5	4.5	15	32.9	0.46	0.021	Test Hole No. 4A
2N4E-18.1d	Village of Iuka	79	8	30	1962	1962	2.5	7.3	31	4.9	6.34	0.212	Village Well No. 5
2N4E-18.1g1	Village of Iuka	88	5	48	1961	1961	1.5	8	5.4	28.5	0.19	0.004	Test Hole No. 13
2N4E-18.1g2	Village of Iuka	87	6	74	1961	1961	2	5.6	5.4	14.1	0.38	0.005	Test Hole No. 3
3N3E-6.6a	Village of Alma	85	6	42	1962	1962	5	2.5	19.8	30.2	0.66	0.016	Test Hole No. 11
3N3E-6.4c	Village of Alma	33	6	5	1961	1961	4.5	4.5	15	14.1	1.06	0.212	Test Well No. 4
3N3E-7.5g	Village of Alma	50	6	31	1961	1961	5	7.1	12	15	0.80	0.026	Test Well No. 4
3N3E-19.5a	Village of Alma	101	6	65	1961	1961	3	10	10.2	16.9	0.60	0.009	Test Well No. 10
MRS													
12N8E-22.8b	A. C. Weber, Sparland	120	-	3	1940	1940	2	18	6	92	0.07	0.002	
MSN													
19N7W-21.4e	E. L. Dawson	234	-	-	1941	1941	4.3	100	3.5	100	0.04	-	
MTG													
8N3W-35.2f	Coffeen School	370	7	247	1955	1955	2.5	125	15	160	0.09	0.001	Well No. 3
9N3W-22	Village of Irving	180	-	93	-	1960	.3	41.5	27.2	103.7	0.26	0.003	
MOU													
13N5E-12.1c	City of Sullivan	280	12	97	1916	1916	9.5	93	-	-	-	-	City Well "Kersey" No. 1

APPENDIX A (Concluded)

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (yr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft2)	Remarks
PRY													
6S4W-5.4d	Village of Cutler	550	6	55	1940	1940	-	93	33	77	0.43	0.008	
6S4W-30.8g	Village of Willisville	555	8	277	1955	1955	-	160	90	80	1.11	0.004	Village Well No. 2
6S4W-30.8h	Village of Willisville	550	8	467	1940	1940	-	130	40	212	0.19	0.001	Village Well No. 1
PIA													
17N5E-18.5a	Village of Bement	275	12	64	1917	1917	-	26	70	38.7	1.81	0.028	
PUT													
32N1W-2.2a	John Whitaker	105	4	3	1951	1957	.3	46.7	11	43.3	0.25	0.083	
32N2W-34	Albert Paulsens	95	4	50	1954	1954	-	45	5	25	0.20	0.004	
RAN													
6S5W-11.4b	Village of Percy	423	8	121	1934	1935	-	58	107	133	0.81	0.007	Village Well No. 1
6S5W-11.4b	Village of Percy	423	8	122	1934	1940	-	80	82	99	0.83	0.007	Village Well No. 1
6S5W-11.4b	Village of Percy	423	8	121	1934	1946	-	90	35	130	0.27	0.002	Village Well No. 1
6S5W-11.4b	Village of Percy	427	8	115	1934	1946	40	100	100	160	0.63	0.004	Village Well No. 1
6S5W-11.4b	Village of Percy	427	8	135	1934	1955	1.8	100	36	128	0.28	0.002	Village Well No. 1
6S5W-11.4b	Village of Percy	427	8	115	1934	1955	5	99	147	105	1.40	0.012	Village Well No. 1 "shot"
6S5W-11.4b	Village of Percy	427	8	115	1934	1957	2.5	97	115	71	1.69	0.014	Village Well No. 1
6S5W-16.4f	Village of Steeleville	319	8	79	1945	1959	.5	54.5	153	138	1.11	0.014	Village Well No. 2
6S5W-16.4f	Village of Steeleville	319	8	79	1945	1945	-	69	93	83	1.12	0.014	Village Well No. 2
6S5W-16.7e	Village of Steeleville	285	8	105	1935	1935	-	59	95	66	1.44	0.014	Village Well No. 1
RCH													
2N10E-24.8c1	Village of Parkersburg	312	7	96	1956	1956	3	60	20	116	0.17	0.002	Village Well No. 1
2N10E-24.8c2	Village of Parkersburg	296	7	89	1956	1956	3	58.4	15.4	91.5	0.17	0.002	Village Well No. 2
3N9E-4.7f	Village of Noble	230	8	154	1960	1960	4	87.6	15	73.6	0.20	0.001	Village Well No. 4
3N9E-4.8e	Village of Noble	210	6	129	1946	1947	-	30	19	59	0.32	0.002	Village Well No. 2
3N9E-16.7h	Village of Noble	245	10	155	1941	1941	-	18	14	115	0.12	0.001	Test Well No. 1
3N10E-36.4c	Village of Calhoun	330	7	122	1962	1962	3.5	103.8	15	66.4	0.23	0.002	Village Well No. 2
3N10E-36.5c	Village of Calhoun	310	6	87	1962	1962	2.5	116.5	29	156.2	0.19	0.002	Village Well No. 1
4N14W-4.2a	Village of Claremont	351	6	321	1954	1954	5	61	20	102	0.20	0.001	Village Well No. 1
SAL													
8S5E-11.2e	Village of Galatia	150	6	90	1954	1954	.3	9.1	24.5	63.1	0.39	0.004	New Well 1-54
9S6E-2.5c	Village of Muddy	100	7	68	1958	1958	7	13.5	40	58.9	0.68	0.010	Village Well No. 1
10S5E-30.5b	Stonefort American Legion	90	7	48	1950	1958	3.3	0.7	50	12	4.16	0.087	Well No. 1
10S5E-30.7b	Stonefort American Legion	90	7	48	1950	1958	2.5	7.9	26	10.6	2.45	0.051	Well No. 2
SHL													
11N2E-23.2g1	Village of Tower Hill	50	24	27	1950	1950	14	7.3	50	15	3.34	0.124	Village Well No. 1
11N2E-23.2g1	Village of Tower Hill	50	24	27	1950	1950	75	7.4	30	9.5	3.16	0.117	Village Well No. 1
11N2E-23.2g2	Village of Tower Hill	77	6	38	1954	1954	8	22	12	23	0.52	0.014	Village Well No. 2
11N2E-23.2h	Village of Tower Hill	59	8	29	1950	1950	6	9.2	10	27.5	0.36	0.012	Village Well "8 inch" shot
STK													
14N7E-14.8h	Albert Hall	23	4	3	1941	1941	6	7	10	9	1.11	0.048	
14N7E-17.7c	Minnie Cohrs	70	4	20	1941	1941	8	15	5	20	0.25	0.013	
VER													
18N13W-4.3a	Village of Fairmount	56	10	10	1950	1950	12	8.8	34	27.9	0.12	0.012	Village Well No. 1
18N13W-9.3h	Village of Fairmount	72	10	26	1950	1950	24	8	35	31	1.13	0.044	Village Well No. 2
19N12W-34.4e	Village of Catlin	90	8	57	1934	1934	4.5	11	14	70	0.20	0.004	Village Well No. 1
19N12W-34.2d	Village of Catlin	92	8	57	1943	1943	4	7.5	20	14.5	1.38	0.024	Village Well No. 5
19N12W-34.6d	Village of Catlin	91	8	61	1936	1936	24	16	12	22	0.55	0.009	Village Well No. 4
19N12W-34.5g	Village of Catlin	100	8	70	1934	1934	1	15	7	80	0.09	0.001	Village Well No. 3
23N12W-11.3e	City of Hoopeston	360	8	-	1886	1919	.3	-	100	65	1.54	-	
WAB													
1N12W-11.2a	Village of Allendale	200	8	50	1949	1949	4.5	96	12	61	0.20	0.004	Village Well No. 1
1N12W-11.4c	Village of Allendale	206	8	60	1949	1949	24	92	14.5	94	0.15	0.003	Village Well No. 2
1N12W-11.1d	Village of Allendale	170	5	40	1950	1950	4.5	67	10.2	34	0.30	0.008	Village Well No. 5
1N12W-11.2d	Village of Allendale	170	4	37	1950	1950	3	61.5	12.5	60.5	0.21	0.006	Village Well No. 4
1N12W-11.4d	Village of Allendale	170	8	54	1949	1949	19.8	57	10.4	78	0.13	0.002	Village Well No. 3
1S13W-31	Village of Bellmont	346	8	76	1954	1954	27	64	29	255	0.11	0.001	Village Well No. 1
WAR													
10N13W-17.3h	Village of Kirkwood	145	8	30	1931	1931	24	30	50	50	1.00	0.033	Village Well No. 3
WAY													
1N7E-21	Village of Cisne	225	8	179	1948	1948	16.5	9.4	64.3	62.2	1.03	0.058	Village Well No. 1
2S5E-13.4b	Village of Wayne City	113	7	74	-	1953	7	21	32	29.2	1.10	0.015	Village Well No. 3
WHT													
5S8E-8.1b	Village of Enfield	420	6	135	1947	1949	3	93	23.6	100	0.24	0.002	Village Well No. 1
5S8E-8.1b1	Village of Enfield	395	6	110	1949	1949	36	96	27	112	0.24	0.002	Village Well No. 2
5S8E-8.1b2	Village of Enfield	395	7	115	1949	1950	5.5	100	30.6	65	0.47	0.004	Village Well No. 2
6S8E-21.4e	Village of Norris City	182	12	140	1936	1936	.5	36.5	25.5	83.5	0.31	0.002	Test Well No. 1
WLM													
10S3E-26.1e	City of Creal Springs	300	7	255	1952	1952	10	14	18	59.8	0.30	0.001	City Well No. 1
10S3E-26.1e	City of Creal Springs	538	7	493	1952	1952	39	14	40	223	0.18	0.001	City Well No. 1
10S3E-26.1c	City of Creal Springs	402	7	386	1953	1953	18	23	25.7	79.5	0.32	0.001	City Well No. 3
10S3E-26.2e	City of Creal Springs	551	7	435	1952	1953	15.5	68	32	193	0.17	0.002	City Well No. 2

APPENDIX B
SPECIFIC-CAPACITY DATA FOR WELLS IN MISSISSIPPIAN ROCKS

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (yr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft^2)	Remarks
ADM													
1N5W-6.4h1	Village of Golden	80	10	35	1949	1949	1	14.2	16.4	65.3	0.25	0.007	Well No. 3-49
1N5W-6.4h2	Village of Golden	78	8	37	1949	1950	3.3	8.8	6.4	16.7	0.38	0.010	Well No. 4-49
1N5W-6.4h2	Village of Golden	78	8	37	1949	1949	2	16.2	16.2	62.0	0.26	0.007	Well No. 4-49
1N6W-34	C.C.C. Camp Point	478	8	244	1935	1935	.5	121	7.7	49	0.16	0.001	
1S7W-6	G. Remrick	220	6	123	1948	1948	1	100	13	50	0.30	0.002	
1S7W-7	H. L. Meyers	236	6	121	1940	1940	3	90	10	60	0.17	0.001	
1S7W-32.8g	Lake Shore Hills Subdivision	102	8	8	1958	1959	1	60.7	25	2.9	8.65	1.079	Well No. 1
1S7W-34.5a	Quincy Municipal Airport	335	6	171	1954	1954	4	104	8	126	0.06	0.001	
1N8W-6.4b	Mendon Comm. School Dist. No. 4	275	6	188	1960	1960	4.5	72.9	8	141.5	0.06	0.001	Well No. 1
1N8W-11.2b	Village of Mendon	275	8	183	1951	1951	2.5	36.4	12.7	107	0.12	0.001	Village Well No. 3-A
1N8W-11.2b	Village of Mendon	225	8	144	1951	1951	26.5	36.4	6.5	54.8	0.12	0.002	Village Well No. 4-A
1N8W-18.5b	Chester Tripp, Ursa	176	6	117	1960	1962	.5	8.3	38	10.7	3.54	0.030	
1N8W-18.5b	Village of Mendon	176	6	117	1962	1962	2.5	14	189	26	7.29	0.062	Test Well No. 1
1S8W-3	Stone	114	6	39	1948	1948	1	60	20	8	2.50	0.064	
1S8W-16	W. G. E. M. Radio	267	6	171	1947	1947	1.5	100	12	10	1.20	0.007	
1S8W-21	J. Kruttenden	206	6	104	1947	1947	1.3	100	12	60	0.20	0.002	
1S8W-28	W. G. E. M. T. V.	217	6	85	1953	1953	1.5	120	25	27	0.93	0.011	
1S8W-32	J. G. Pettle	261	6	191	1948	1948	1.5	60	12	140	0.09	0.001	
1S8W-32.5e	Southern Ill. Division of Highways	297	6	157	1958	1958	5.5	111	4	132	0.03	0.001	Well No. 1
1S8W-33	S. V. Brooks	300	6	214	1947	1947	1.3	70	12	130	0.09	0.001	
2S5W-24	Siloam Springs State Park	335	6	196	1958	1958	.5	104.7	9	59.2	0.15	0.001	Well No. 2
2N6W-21	H. J. Golden	135	6	-	1943	1943	1	35	13	35	0.37	-	
2S6W-20.1c	Linnemeyer, Liberty	295	6	144	1960	1962	3.5	110	17	25.1	0.68	0.005	
2N7W-16.7c	Village of Loraine	300	8	137	1956	1956	7	93	22	98	0.22	0.002	Village Well No. 2
2N7W-16.8c	Village of Loraine	300	8	138	1956	1956	5.8	98	21	126	0.17	0.001	Village Well No. 1
2S8W-5	G. Wagner	124	6	11	1947	1947	1.3	50	15	50	0.30	0.027	
2S8W-5	A. Doerle	132	6	10	1948	1948	.5	45	18	40	0.45	0.045	
2S8W-7.1a	Quincy Golf Course	250	6	207	1946	1946	12	90	25	52	0.48	0.002	Well No. 1
2S8W-7.4b	Quincy Golf Course	260	6	190	1946	1946	8	90	25	57	0.44	0.002	Well No. 2
2S8W-19.8e	Sheridan Swim Club	122	6	64	-	1962	2.3	52.1	24	33.4	0.72	0.011	Well No. 1
2S8W-20	H. Bockhold Estate	91	6	68	1940	1940	2	50	12	20	0.60	0.009	
3S7W-8.8b	Village of Payson	330	5	230	1910	1940	7	75	74	68	1.09	0.005	
3S7W-8.8b	Village of Payson	330	5	230	1910	1940	7	75	74	67	1.11	0.005	
3S7W-26	Village of Plainville	188	8	109	1962	1962	7	57	15	91	0.17	0.002	Village Well No. 2
BRW													
	Producers' Creamery	500	8	-	1936	1937	.3	200	40	220	0.18	-	
1S2W-15	D. O. Thomas	284	5	84	1914	1934	1.5	84	4	116	0.03	0.001	
1S2W-22	L. C. Parker	318	6	253	1941	1941	8	68	3.5	30	0.12	0.001	
2S4W-18	State of Illinois	363	6	300	1948	1948	-	108	10	155	0.06	0.001	
FUL													
5N1E-32.8a	Village of Table Grove	551	16	355	1952	1952	.5	157	84	115	0.73	0.002	
HAN													
3N5W-3	C. Bruner	290	6	158	1945	1945	1.5	83	3.3	92	0.04	0.001	
3N5W-15.1f	Howard Winters	370	7	158	1944	1957	.5	20.5	20.5	90.5	0.23	0.001	
3N6W-22.1e1	Village of Bowen	402	8	188	1946	1947	6.5	24	16	19	0.84	0.004	Village Well No. 2
3N6W-22.2f	Village of Bowen	155	12	101	1946	1946	41.5	20	5.4	19.6	0.28	0.003	
3N6W-23.8c	Village of Bowen	407	8	186	1946	1947	-	25.8	18.6	50	0.37	0.002	Village Well No. 3
3N8W-9.1a	F. Schmidt	278	6	163	1940	1940	2	80	7	40	0.18	0.001	
3N8W-2g	Village of Tioga City	371	5	119	1954	1958	8	200	6	171	0.04	0.001	
3N8W-33	G. T. Hutchinson	243	6	57	1941	1942	.5	85	10	16	0.63	0.011	
4N5W-11	E. E. Dunham	152	7	62	1945	1945	.8	31.5	28	13	2.16	0.035	
4N5W-36.5e	Village of Plymouth	270	10	230	1938	1938	8	126.7	23.5	111.3	0.21	0.001	Village Well No. 1
4N5W-36.5e	Village of Plymouth	315	10	275	1938	1938	1.8	120	18	150	0.12	0.001	Village Well No. 1
4N5W-36.6e	Village of Plymouth	265	10	224	1938	1938	24	113	19	96	0.20	0.001	Village Well No. 2
4N6W-17.1a	Mendon Community School 330	280	6	145	1961	1961	4	70.7	6	140.7	0.04	0.001	Well No. 1
4N8W-6	H. Hofendick	216	6	161	1940	1940	.5	95	6.5	55	0.12	0.001	
4N9W-16	B. T. Lehr	111	6	203	1952	1952	.3	16	5	84	0.06	0.001	
5N8W-23	C. G. Baxter	240	6	226	1941	1941	.3	18	20	102	0.20	0.001	
HAR													
12S9E-13.7e	Village of Cave-in-Rock	220	8	139	1961	1961	5.5	74.6	102	1.2	89.00	-	Village Well No. 1
HND													
8N6W-35	R. E. Ailes	235	6	92	1945	1945	.5	93	9	19.7	0.46	0.005	
9N4W-30.8b	Village of Stronghurst	69	12	24	1938	1938	21	26	61	6.8	8.97	0.373	
9N4W-30.9b	Village of Stronghurst	69	12	24	1938	1938	23	24.6	62	11.5	5.39	0.224	
9N4W-30.8b	Village of Stronghurst	69	10	24	1938	1939	24	25	51	12.5	4.08	0.170	
9N4W-30.8b	Village of Stronghurst	69	10	24	1938	1939	24	25	42	16	2.62	0.109	

APPENDIX B (Concluded)

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (hr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft^2)	Remarks
JKS													
11S1W-2.6h1	Giant City State Park	600	6	79	1940	1940	.5	66	21.5	100	0.22	0.003	Well No. 4
11S1W-2.6h1	Giant City State Park	600	6	79	1940	1940	-	170	50	230	0.22	0.003	Well No. 4, shot
11S1W-2.6h1	Giant City State Park	600	6	79	1940	1953	24.5	161	64	252.3	0.25	0.003	Well No. 4, shot
11S1W-2.6h2	Giant City State Park	600	6	78	1938	1959	5	161	25	198.5	0.13	0.002	Well No. 5
JER													
6N13W-9.2a	Pere Marquette State Park	480	6	438	1933	1933	-	33	13	145	0.09	0.001	Well No. 1
6N13W-13.7g	State of Illinois	203	8	25	1961	1961	6	13.6	11	169.9	0.06	0.002	Well No. 1
7N12W-7.2b	City of Jerseyville	72	8	15	1955	1955	-	11.1	175	21.6	8.10	0.540	Test Well No. 8
MCD													
4N2W-15.2a	Village of Industry	450	8	190	1951	1951	24	103	55	28	1.97	0.010	Village Well No. 1
7N3W-33.7e	Community Unit School Dist. No. 175	245	6	100	1958	1959	6	82.7	10	62.4	0.14	0.002	Well No. 1
7N3W-33.7e	Community Unit School Dist. No. 175	245	6	100	1958	1958	4	77	14.3	105.4	0.14	0.001	Well No. 1
MNR													
3S8W-4.5g	Village of Hecker	304	10	237	1955	1955	7	50	8.3	148	0.06	0.001	Village Well No. 2
3S8W-4.7g	Village of Hecker	314	10	247	1954	1955	5	46	15	171	0.09	0.001	Village Well No. 1
PRY													
6S4W-30.8h	Village of Willisville	550	8	467	1940	1940	-	130	40	212	0.19	0.001	Village Well No. 1
PKE													
4S4W-7.4b	Village of Baylis	453	8	190	1958	1958	2	213	25	106	0.24	0.001	Village Well No. 2
4S4W-7.5e	Village of Baylis	429	8	157	1957	1957	3.5	203	15	193	0.08	0.001	Village Well No. 1
4S6W-26.6h	City of Barry	325	6	171	1954	1954	4	54	16	88	0.18	0.001	City Well No. 4
5S3W-7.3c	City of Pittsfield	160	8	29	1954	1954	.5	60	30	20.5	1.46	0.050	Test Well No. 3
5S3W-7.4d	Hillebrener Farm	190	6	30	1954	1954	5.8	48	50	46.8	1.07	0.036	Well No. 1
5S3W-7.6f	City of Pittsfield	82	8	24	1954	1954	2	77	50	42	1.19	0.050	Test Well No. 2
6S2W-5.3b	Village of Milton	118	6	13	-	1956	1.5	16.8	20	78.2	0.26	0.020	Village Well No. 2
PPE													
13S5E-16.6c	Dixon Springs State Park	104	6	94	1948	1956	2	25.5	24.2	22.6	1.07	0.011	Well No. 1
13S5E-16.6c	Dixon Springs State Park	104	6	94	1948	1953	2.5	25	25.3	21.3	1.19	0.013	Well No. 1
RAN													
4S8W-5	City of Red Bud	289	10	47	1951	1951	10	58	39	154	0.25	0.005	City Well No. 4
4S8W-5.1e1	City of Red Bud	276	6	16	1919	1934	1	38	30	55.5	0.54	0.034	City Well No. 1
4S8W-5.1e2	City of Red Bud	283	10	58	1934	1934	-	52	48	134.5	0.36	0.006	City Well No. 2
4S8W-5.1f	City of Red Bud	293	10	7	1944	1944	24	40	50	100	0.50	0.072	City Well No. 3
4S8W-5.1f	City of Red Bud	293	10	7	1944	1957	9	89	118	139	0.85	0.121	City Well No. 3, shot
4S8W-32.3a	Village of Ruma	285	6	-	-	1961	2	46.5	6.5	24.6	0.27	-	
5S8W-4.7h	Village of Ruma	315	7	77	1962	1962	4	46.1	40	123.3	0.32	0.004	Village Well No. 1
6S7W-31.3g	Fort Kaskaskia State Park	104	8	12	1959	1960	5	54.8	16.5	7.2	2.29	0.191	Well No. 1
RIS													
16N1W-11	Nightingale	322	6	144	1932	1932	4.8	199	10	20	0.50	0.003	
16N4W-7	Illinois City School	164	5	29	1939	1939	-	48	9	30	0.30	0.010	
SCH													
1N2W-7.1h	Rushville, R.F.D. No. 5	216	6	70	1921	1934	2	120	8	70	0.11	0.002	
1N2W-16.3f	Rushville, R.F.D. No. 1	285	6	115	1933	1934	2	85	3.4	115	0.03	0.001	
3N4W-9	P. Elsbury	313	6	153	1945	1945	4	54	4	91	0.04	0.001	
3N4W-21	L. L. Harison	375	6	295	1945	1945	-	126	4	124	0.03	0.001	
STC													
1S8W-28.2a	Village of Smithton	193	8	50	1955	1955	4	21	30	142	0.21	0.004	Village Well No. 3
1S8W-33.3f1	Village of Smithton	256	8	94	1950	1950	6	53	14	115	0.09	0.001	Village Well No. 1, shot
1S8W-33.3f2	Village of Smithton	200	8	50	1950	1950	23	22	19	122	0.16	0.003	Village Well No. 2
1S9W-10.8a	Village of Millstadt	310	10	58	1946	1946	5.3	202	41	71	0.58	0.010	Village Well No. 3, shot
3S6W-7.8f	Village of Lenzburg	300	12	200	1948	1948	-	14.5	1.5	65.5	0.02	0.001	Test Well 1-48
3S7W-12.1e	W. D. Gass, Lenzburg	119	8	35	1948	1948	1	54.5	10	45	0.22	0.006	
UNI													
11S1W-30.1b	Village of Cobden	226	8	80	1934	1934	3.5	83.3	190	14.5	13.11	0.165	
12S1W-17.5e	Anna State Hospital	460	20	450	1911	1941	-	65	47	50	0.94	0.002	
12S1W-17.5e	Anna State Hospital	480	20	450	1911	1941	8.5	65	289	273	1.09	0.002	
12S1W-20.5d	City of Anna	650	12	550	1896	1924	-	77	440	17	25.90	0.047	City Well No. 1
12S1W-20.5d	City of Anna	650	12	550	1896	1912	-	68	290	12	24.15	0.044	City Well No. 1
12S1W-20.5d	City of Anna	650	12	550	1896	1936	-	158	-	10.4	-	-	City Well No. 1
12S1W-20.6d	City of Anna	650	10	394	1929	1929	-	110	300	80	3.75	0.010	City Well No. 2
12S1W-20.2e	City of Anna	1031	16	931	1935	1935	-	85	310	200	1.55	0.002	City Well No. 1-A
12S1W-20.2e	City of Anna	1031	16	931	1935	1936	8	85	204	208	0.98	0.001	City Well No. 1-A
12S1W-20.2e	City of Anna	1031	16	931	1935	1936	-	71	325	297	1.09	0.001	City Well No. 1-A
12S1W-20.4f	City of Anna	1038	16	938	1936	1936	-	58	80	350	0.23	0.001	City Well No. 2-A
12S1W-30.8f	City of Jonesboro	302	10	224	1937	1937	5	7.5	40	50.8	0.79	0.004	Village Well No. 2
13S1W-25.3h1	Village of Dongola	300	6	196	1935	1935	-	26	47	53	0.89	0.005	Test Hole
13S1W-25.3h2	Village of Dongola	300	18	199	1935	1935	2.7	7	100	134	0.75	0.004	Village Well No. 1
13S1W-25.3h2	Village of Dongola	300	18	199	1935	1935	8	26	110	109.5	1.00	0.005	Village Well No. 1
13S1W-25.3h2	Village of Dongola	300	18	199	1935	1935	25	132.5	64	75	0.85	0.004	Village Well No. 1

APPENDIX C

SPECIFIC-CAPACITY DATA FOR WELLS IN PENNSYLVANIAN AND MISSISSIPPIAN ROCKS

Well Number	Owner	Depth (ft)	Diameter (in.)	Penetration (ft)	Date Drilled (yr)	Date of Test (hr)	Length of Test (hr)	Non-pumping Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Capacity per foot of penetration (gpm/ft2)	Remarks
FUL													
5N1E-32.8a	Village of Table Grove	551	16	355	1952	1952	.5	157	84	115	0.73	0.002	
HAN													
3N6W-22.2f	Village of Bowen	155	12	101	1946	1948	41.5	20	5.4	19.6	0.28	0.003	
4N5W-36.5e	Village of Plymouth	315	10	275	1938	1938	1.8	120	18	150	0.12	0.001	Village Well No. 1
4N5W-36.6e	Village of Plymouth	265	10	224	1938	1938	24	113	19	96	0.20	0.001	Village Well No. 2
PRY													
6S4W-30.8h	Village of Williaville	550	8	467	1940	1940		130	40	212	0.19	0.001	Village Well No. 1