Illinois State Water Survey
HYDROLOGY DIVISION

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HYDROLOGY AND WATER QUALITY OF SHALLOW GROUND-WATER RESOURCES IN KANE COUNTY, ILLINOIS

by Adrian P. Visocky
Office of Ground-Water Resources Evaluation and Management

Prepared for Kane County, Illinois

Champaign, Illinois

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Illinois Department of Energy and Natural Resources

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HYDROLOGY AND WATER QUALITY OF SHALLOW GROUND-WATER RESOURCES IN KANE COUNTY, ILLINOIS

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INTRODUCTION

Public and industrial water supplies in Kane County have historically relied heavily on aquifers within the Cambrian and Ordovician bedrock (often referred to as "deep sandstone aquifers"). Because of high concentrations of naturally occurring radium, (Ra), barium, and chlorides, in combination with declining water levels in the deep sandstone aquifers (Gilkeson et al., 1983, Visocky et al., 1985, and Sasman et al., 1982), alternative water sources in Kane County had to be evaluated. Other possible sources of water include: 1) sand-and-gravel aquifers in the glacial drift, 2) aquifers in the shallow fractured dolomite bedrock, and 3) surface water. In recent years Elgin has turned to the Fox River for about half of its water demands. The emphasis of this study was on shallow ground-water alternatives, particularly within the glacial drift.

Although sand-and-gravel aquifers in the glacial drift have been used locally in Kane County for long periods of time, an accurate countywide perspective of the distribution of these aquifers and their potential to serve as major water sources have been needed. The purpose of this study was to map the shallow ground-water resources of Kane County and assess their availability and chemistry on a regional basis. The project involved cooperative efforts among Kane County, the Illinois State Geological Survey (ISGS), and the Illinois State Water Survey (ISWS). The ISGS was charged with geological mapping of the shallow aquifers, and the ISWS studied the hydraulic properties of the aquifers, their potential yield, and their water chemistry.

A description of the regional geohydrology of Kane County, along with the results of extensive aquifer mapping with geophysical surveys and test borehole drilling, has been summarized by the ISGS in a separate report (Curry and Seaber, 1990). Their information included significant quantities of data gathered during the state's concerted effort to locate the proposed Superconducting Super Collider (SSC) in the Kane County area.

The ISWS effort involved the compilation, review, and evaluation of existing aquifer test data (stored in the Aquifer Properties Database) and water chemical analyses (using the Water Quality Database). Several aquifer tests were also conducted as part of ongoing local studies to develop shallow ground-water resources. Thus far, ten such tests have been completed, and as many as four more remain to be scheduled.

Acknowledgements

This project would not have been possible without the support of R.N. Young of the Kane County Environmental Department, as well as numerous individuals representing municipalities in Kane County. Partial funding for the study was provided by Kane County; the cities of Aurora, Batavia, Carpentersville, Elgin, Geneva, North Aurora, and St. Charles; and the villages of East Dundee, Elburn, Hampshire, Montgomery, South Elgin, Sugar Grove, and West Dundee. Additional detailed studies are continuing on local levels under separate contracts for Aurora, Batavia, Geneva, and St. Charles.

This report was written under the general supervision of Ellis W. Sanderson, Head of the former ISWS Ground-Water Section, who also made a technical review of the final draft. Our deep appreciation is extended to the following present and former Water Survey staff members who assisted in the data collection during the aquifer tests and/or contributed well-construction designs to the project: W.H. Baker, C.R. Benson, K.J. Hlinka, P.C. Jahn, D.J. Kelly (who also developed the Microcomputer-based Data Acquisition System), R.C. Kohlhase, R.S. Ludwigs, J.S. Nealon, R.T. Sasman, M.K. Schulmeister, and M.E. Sievers.

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HYDROLOGY

Hydraulic Properties

The principal hydraulic properties that influence well yields and water-level response to pumpage in the glacial sand-and-gravel deposits of Kane County are transmissivity and storage coefficient. Locally, the leakage coefficient also plays an important role in influencing water levels.

The capacity of an aquifer to transmit ground water is expressed as transmissivity, which is defined as "the rate of flow of water through a unit width of the aquifer under a unit hydraulic gradient." Associated with transmissivity is the hydraulic conductivity, which is defined as "the rate of flow of water through a unit cross-sectional area of the aquifer under a unit hydraulic gradient." The hydraulic conductivity is derived by dividing the transmissivity by the total saturated thickness of the aquifer. Since this results in an average value for the hydraulic conductivity over the entire thickness of the aquifer, however, care must be taken in placing too great an emphasis on this value, particularly where homogeneity may be inconsistent, either vertically or areally.

The storage properties of an aquifer are expressed by the storage coefficient, which is defined as "the volume of water released from or taken into storage per unit of surface area of the aquifer per unit change in head normal to that surface." For confined (artesian) conditions, in which water levels rise above the top of the aquifer in wells penetrating the aquifer, water released from or taken into storage is derived solely from the compressibility properties of the aquifer and the water. Such coefficients are usually very small (0.00001 to 0.001). On the other hand, where unconfined (water-table) conditions prevail, in which water levels in wells represent the top of the saturated thickness of the aquifer, water released from or taken into storage is derived almost entirely from gravity drainage or the refilling of the zone through which the water-table change occurs. A small portion of the water volume change comes from the compressibility of the aquifer and the water, as in the artesian case, but this volume is proportionately nearly insignificant. Typical values for water-table storage coefficients in unconsolidated material range from 0.01 to 0.3.

The rate of vertical leakage of ground water through a confining bed in response to a given vertical head gradient depends on the vertical hydraulic conductivity of the confining bed. In cases where the confining bed is not well defined or is unknown, Hantush (1956) suggested the use of the term "leakage coefficient," which is the ratio of the vertical hydraulic conductivity of the confining bed to its thickness. It is defined as "the quantity of water that crosses a unit area of the interface between an aquifer and its confining bed, divided by the head loss across the confining bed."

Aquifer Tests

The hydraulic properties of aquifers and confining beds may be determined by means of aquifer tests, in which the effect of pumping a well at a known constant rate is measured, both in the pumped well and in observation wells penetrating the aquifer. Graphs of drawdown versus time or drawdown versus distance from the pumped well are used to solve formulas that express the relationship between the hydraulic properties of an aquifer and its confining bed, if present, and the lowering of water levels (drawdown) in the vicinity of a pumping well. Graphic analysis might utilize the leaky artesian formula (Hantush and Jacob, 1955), the nonequilibrium formula (Theis, 1935), or the modified nonequilibrium formula (Cooper and Jacob, 1946). Type-curve and straight-line methods for graphic analysis were described by Walton (1962). Test data collected under water-table conditions may be analyzed with a method devised by Boulton (1963) and described by Prickett (1965) or with a method presented by Neuman (1975). Where geohydrologic boundaries are known to exist, their effect on drawdown can be determined by means of image-well theory, as described by Ferris (1959).

Specific-Capacity Analyses

In many cases, especially in reconnaissance ground-water investigations where no observation wells are available and little information is known, the hydraulic properties of an aquifer must be estimated based on drillers' logs, water levels, and specific-capacity data. The specific capacity cannot be used to determine aquifer properties with the same degree of accuracy as can aquifer test data because the specific capacity varies with the radius of the well and with the pumping period. Perhaps even more importantly, the specific capacity can be significantly affected by partial penetration, well loss, aquifer dewatering, leakage, and geohydrologic boundaries. In most cases these factors cause the actual transmissivity to be greater than that estimated from specific-capacity data. Leaky artesian conditions usually cause lower actual transmissivities than those calculated from specific capacities. For this reason, specific-capacity data must occasionally be adjusted to account for one or more of these factors. After necessary adjustments are made, specific-capacity data can be analyzed by the application of the modified nonequilibrium formula as given by Walton (1962).

Summary of Properties

Records of 42 individual tests on wells finished in sand-and-gravel aquifers in Kane County were located in the Water Survey files and are summarized in table 1. In addition to these records, data from 10 aquifer tests conducted by the Water Survey during this study are also included in table 1. The tests are described in more detail below. Only 17 of the tests in table 1 made use of observation wells, and only 14 of these produced data of sufficient quality to allow the determination of a storage coefficient. In all other tests the storage coefficient has been labeled as either "artesian" or "water table," based upon drillers' logs and water-level information developed during the test.

Well tests shown in table 1 ranged in duration from 20 minutes (0.3 hours) to 28 days (665 hours), while discharge rates ranged from 33.5 gallons per minute (gpm) to 3,150 gpm. Specific capacities varied over a wide range, just as did hydraulic properties. Specific capacities ranged from 0.76 gpm per foot (gpm/ft) at Maple Park Well No. 3 to 423 gpm/ft at St. Charles Well No. 11 and averaged 64.0 gpm/ft. The median specific capacity was only 24.2 gpm/ft. Transmissivities ranged from 1,150 gallons per day per foot (gpd/ft) at Elburn to 690,000 gpd/ft at Carpentersville, with an average of 106,785 gpd/ft and a median value of 35,000 gpd/ft. The largest variation (over four orders of magnitude) occurred in hydraulic conductivities, where values ranged from 17 gpd per square foot (gpd/sq ft) at Maple Park Well No. 3 to 13,000 gpd/sq ft at Carpentersville Well No. 5, with an average of 2,226 gpd/sq ft and a median value of 1,068 gpd/sq ft. The areas with the highest pump discharge rates and the highest values of transmissivity and hydraulic conductivity occur along the Fox River and within major buried bedrock valleys. Not surprisingly, these areas correspond to the major bedrock thicknesses and the coarsest deposits of sand and gravel.

Slightly more than half (27) of the tests occurred under artesian conditions, and 25 tests were conducted under water-table conditions. Data collected during the aquifer tests conducted by the Water Survey at Aurora TW 3-71, Aurora TH 10-84, Aurora Well No. 101, Aurora Well No. 107, Aurora Well No. 119, "Batavia Well No. 6," and Geneva Well No. 8 indicated that leaky artesian conditions were present during these tests.

Controlled Aquifer Tests

A major effort of the study involved gathering detailed information about the hydraulic properties of the major sand-and-gravel aquifers within the glacial drift. This was accomplished by conducting controlled aquifer tests (tests conducted for extended periods and utilizing several observation wells) at the sites of test wells or production wells constructed by various municipalities as part of their water supply development and planning. To date, ten such tests have been conducted (see figure 1). A test at an eleventh site, Aurora Well No. 107 at Aurora University, was curtailed after nearly 52 hours and will be rescheduled. Following is a detailed description of the tests on Wells No. 10 and 11 at Montgomery, along with summary descriptions of the other eight completed tests.

Montgomery **Wells** No. 10 **and** 11. The details and analysis of the controlled aquifer tests conducted by the Water Survey as part of this study can be illustrated by the tests of Montgomery Wells No. 10 and 11 (Visocky, 1987a and b). Well No. 10 is 82 feet deep and is located along State Route 25, just south of Ashland Avenue. Figure 2 shows the location of Well No. 10 and the observation wells used during the test. Well

Table 1. Summary of Aquifer Tests and Aquifer Hydraulic Properties in Kane County

Well	Owner	Depth (ft)	Date of test	Length of test (hrs)	Pumping rate (gpm)	Nonpumping water level (ft)	Specific capacity (gpm/ft)	Transmissivity (gpd/ft)	Hydraulic conductivity (gpd/sq ft)	Storage coefficient	Analysis*	Land elevation (msl)
38N7E-21.4e	Sugar Grove #1	104	04/48	4.7	106	49.6	18.3	20,000	370	Water Table	S	727
-21.5e	Sugar Grove #2	107	06/61	5.6	517	48.5	79.5	105,000	1,580	Water Table	S	727
-21.5e	Sugar Grove #3	110	02/61	12.0	220	48.5	44.0	60,000	976	Water Table	S	727
-24.6h	Aurora #101	116	12/70	24.0	810	2.0	13.0	25,450	592	Artesian	T	672
-24.6h	Aurora #101	116	10/87	359	651	4.5	12.8	19,100	424	0.00080	T	672
-31.1a	Aurora TW3-71	130	02/71	24.0	503	22.1	24.8	98,000	1,660	0.00076	T	690
-33.7d	State Water Survey TW1	77	10/70	20.5	421	8.0	33.7	90,000	1,730	0.00053	T	665
38N8E-18.8b	Aurora TH10-84	125	12/86	24.0	1026	5.3	28.9	52,170	510	0.00035	T	675
-19.5e	Aurora #119	130	04/89	99.9	650	14.0	17.5	14,000	405	0.00036	T	685
-20.6a	Aurora #107	135	08/88	52	708	49.0	23.6	58,000	1,288	0.00015	T	690
-31.7a	Blackberry Hts Sbd. #2	46	07/60	8.0	230	15.0	19.2	23,000	742	Water Table	S	665
-33.4h	Montgomery #10	82	12/86-01/87	665	608	20.47	21.9	29,420	680	0.1	T	637
-33.5h	Montgomery #11	59	09/87	191	393	3.7	15.7	28,086	395	0.026	T	621
-34.8g	Aurora #116	61	04/88	168	399	17.2	20.4	23,710	525	0.097	T	655
39N6E-25.4g	Elmhurst Chicago Stone	125	05/71	4.0	1250	38.0	96.2	220,000	4,680	Artesian	S	790
39N7E- 5.8f	Elburn #2	153	03/37	9.0	75	85.0	1.2	1,150	68	Water Table	S	850
-20.4d	Blackberry Ctr TW-1	110	08/74	120	1300	9.0	67.6	59,600	1,360	0.0009	T	750
-21.7a	Pan Amer. Seed Co #1	66	07/85	6.0	253	19.5	143			Artesian		760
39N8E- 5.8a	Geneva #8	150	06/86	72	1513	46.8	66.3	262,000	2,749	0.00034	T	765
- 6.3a	Geneva #9	153	06-07/90	168	2199	13.6	205.5	323,800	2,634	0.02	T	731
-18.5g	Batavia #6	157	12/88	99.9	1000	10.5	52.4	73,000	1,780	0.0009	T	720
40N6E-12.1e	Polioka Farm	238	1961		50	93.0	5.0	14,000	467	Artesian	S	930
-30.7a	Maple Park #3	182	05/71	7.0	80	17.8	0.76	1,187	17	Artesian	T	862
-31.7h	Maple Park #2	134	10/46	3.5	132	19.0	1.55	2,800	34	Artesian	S	865
40N7E-16.3c	Ferson Creek #3	175	10/78	4.3	254	23.0	8.47	17,000	-	Artesian?	S	840
-16.4c	Ferson Creek #2	186	02/75	24	285	69.0	2.91	6,200	-	Artesian?	S	850
40N8E-11.2f	Valley View #1	128	08/74	8.0	244	95.0	17.4	21,000	636	Water Table	S	784
-11.7b	St. Charles Skyline #1	131	08/58	8.0	250	100.5	27.8	35,000	1,060	Water Table	S	787
-11.7b	St. Charles Skyline #2	135	06/69	8.0	346	102	21.6	26,000	788	Water Table	S	787
-12.1e	Polioka Farm	238	/61	-	50	93.0	5.0,	9,000	-	Artesian?	S	930
-15.2a	St. Charles #9	86	12/79	24.0	1585	19.5	186	435,900	6,554	Water Table	T	705
-15.2c	St. Charles #11	130	11/88	72.0	1609	19.83	423	544,000	4,880	0.3	T	706
-28.8a	St. Charles #7	173	11/63	2.0	1005	59.0	251.3	350,000	4,730	Water Table	S	765
41N6E- 9.1g	Burlington #1	108	07/41	3.0	41	33.0	8.2	16,000	640	Artesian?	S	925

Table 1. Concluded

Well	Owner	Depth (ft)	Date of test	Length of test (hrs)	Pumping rate (gpm)	Nonpumping water level (ft)	Specific capacity (gpm/ft)	Transmissivity (gpd/ft)	Hydraulic conductivity (gpd/sq ft)	Storage coefficient	Analysis*	Land elevation (msl)
41N8E-11.7g	Elgin Slade Ave.	52.9	05/70	-	289	9.7	11.4	12,000	-	Water Table?	S	725
-14.3f	Elgin North State St.	43	/34	0.3	84	25.0	60.0	55,000	3,667	Water Table	S	730
-14.3g	W.R. Meadows, Inc. #3	30	08/63	3.3	80	12.8	17.1	18,500	1,076	Water Table	S	710
-14.7d	Elgin Crighton Ave.	48.6	06/48	12.0	200	14.0	20.0	25,000	860	Water Table?	S	795
-26.2e	Kerber Packing	68	06/59	8.1	1284	8.0	80.25	110,000	1,780	Water Table	S	705
-34.1h	South Elgin #4	109	10/83	5.6	517	66.0	79.5	105,000	2,442	Water Tabte	S	762
-35.3a	South Elgin #2	117	04/52	3.1	257	28.8	8.4	16,500	750	Artesian	S	705
-35.3a	South Elgin #6	111	08/87	23.0	521	35.0	31.6	69,000		Artesian	S	730
-35.3c	South Elgin #3	112	04/62	4.6	402	37.0	7.1	14,000	875	Artesian	S	735
42N8E-14.2f	Meadowdale Sbd. #4	177	02/57	8.0	1100	69.0	100	250,000	10,000	Artesian	S	860
-14.2g	Carpentersville #6	179	04/73	4.0	3150	104	242	580,000	8,900	Artesian	S	880
-14.2h	Carpentersville #5	183	01/73	4.0	3016	112.5	287	690,000	13,000	Artesian	S	875
-15.1f	Meadowdale Sbd. #3	72	10/55	8.0	1223	18.0	58.2	150,000	3,750	Artesian	S	790
-16	Meadowdale Raceway	54.5	07/58	4.0	33.5	39.0	13.4	14,500	935	Water Table	S	890
-22.2b	West Dundee #2	87	02/69	20.0	495	51.0	49.5	72,000	2,000	Water Table	S	760
-23.6e	East Dundee #3	128	04/69	8.0	1033	59.2	31.7	70,000	2,190	Artesian	S	830
-23.7d	East Dundee #2	68.8	12/58	6.0	759	37.0	84.3	115,000	4,600	Water Table	S	785
-28.6f	Sleepy Hollow #1	34	10/59	0.3	280	0.2	20.9	16,000	615	Water Table	S	747

* S = Specific capacity analysis
T = Time-drawdown analysis

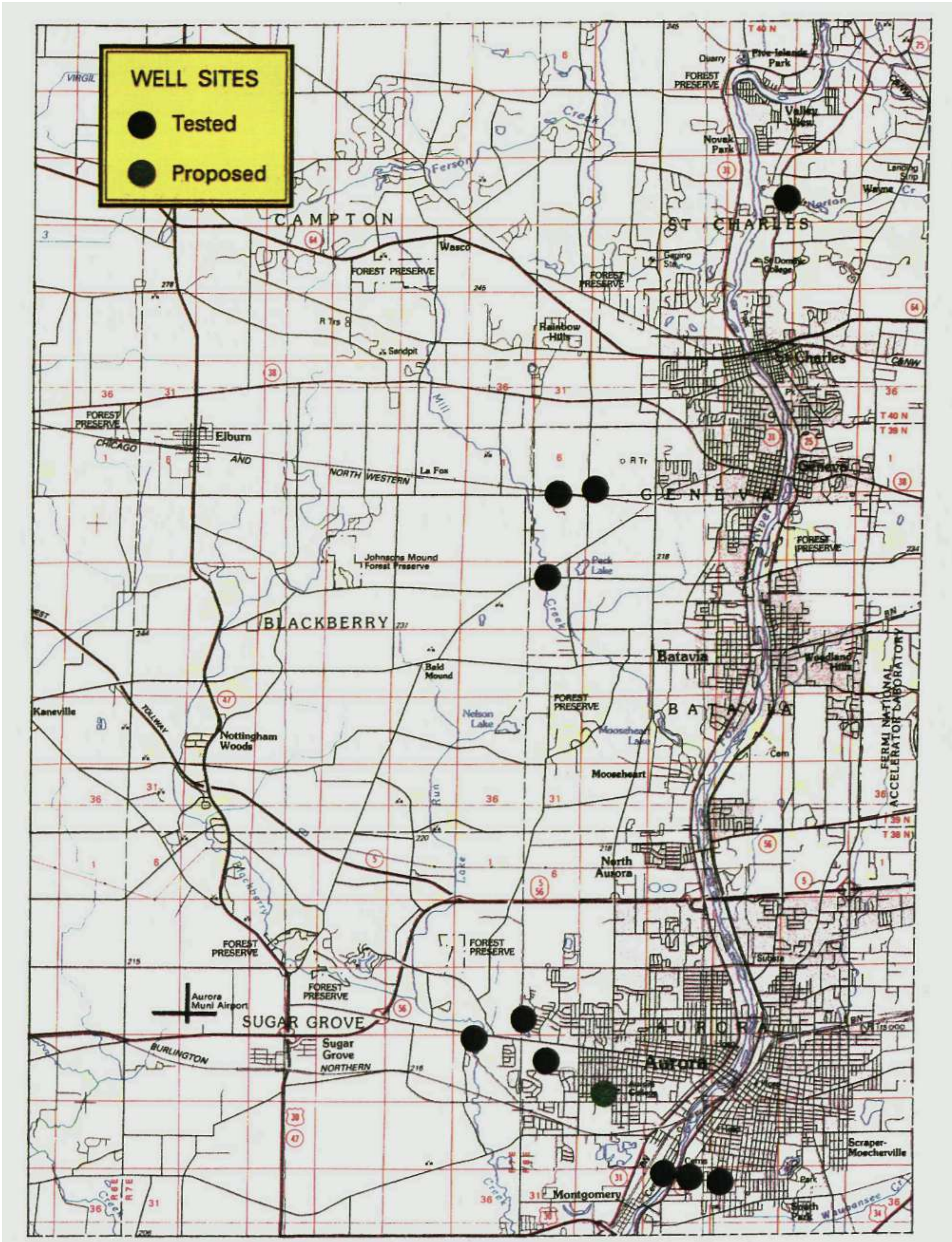


Figure 1. Locations of detailed aquifer tests

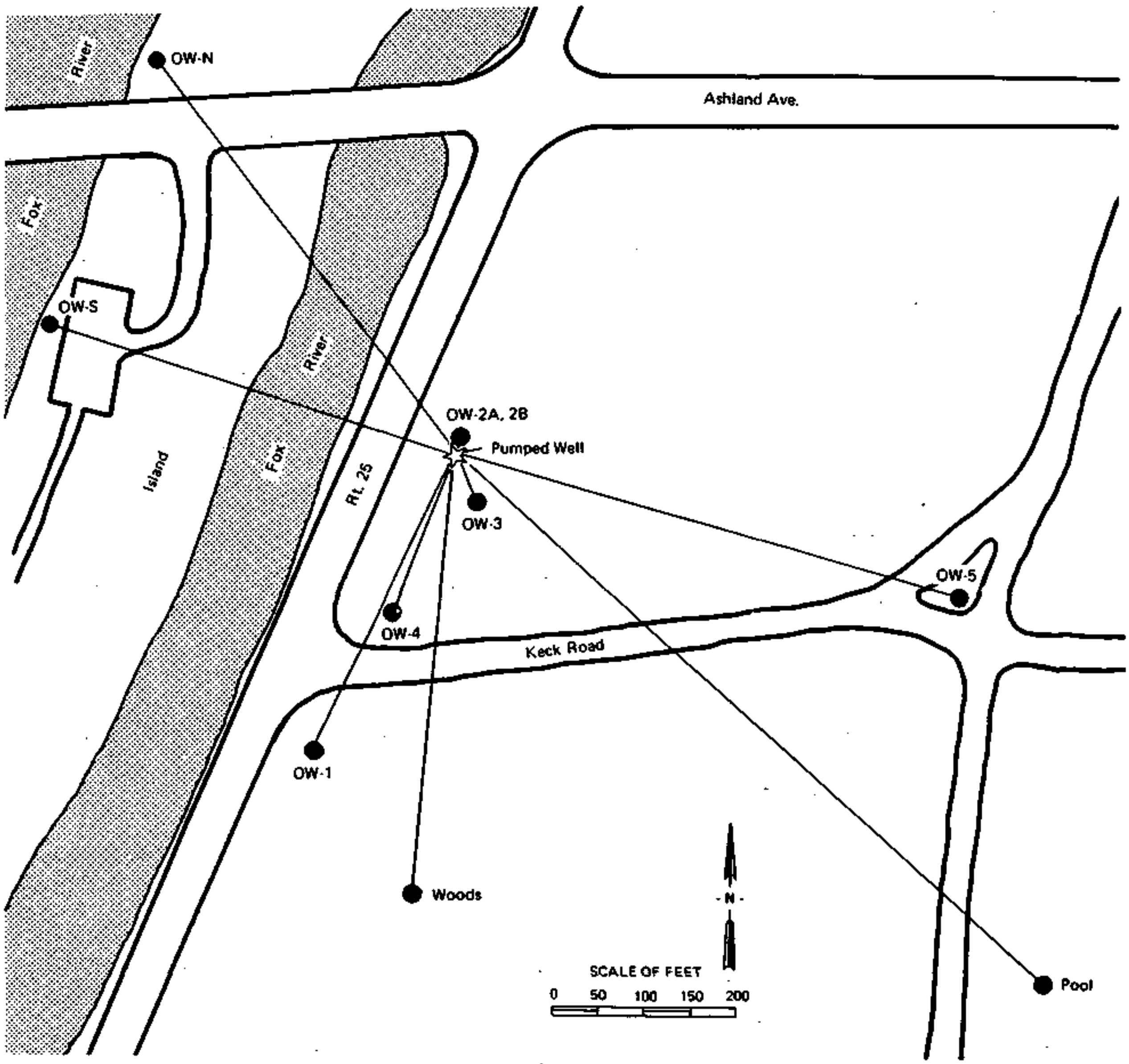


Figure 2. Location of wells for Montgomery Well No. 10 test

No. 11 is 59 feet deep and is located 700 feet west of River Street, across the Fox River from Well No. 10.

Both wells are finished in glacial sand-and-gravel deposits. Due to the anticipated complex hydrogeologic conditions at the site of Well No. 10, a test of much greater duration than normal was deemed necessary. In order to ensure uninterrupted testing, electric power was run to the site, and a turbine pump with an electric motor was employed. On December 5, 1986, the pump was turned on, and pumping continued at an average rate of 608 gpm for 28 days, until January 5, 1987. During this time water levels were monitored in the pumped well and in eight observation wells located between 13 and 570 feet away (figure 2).

This test featured one of the earliest uses of computer-driven monitoring equipment developed at the Water Survey, including pressure transmitters and data-storage devices. This equipment monitored the pumped well and five of the eight observation wells. Another of the observation wells, located on an island in the Fox River, was equipped with a conventional water-level recorder with a float and battery-driven pen. Water levels were also periodically monitored in a second well on the island and in two wells finished in the shallow dolomite located south and southeast of the pumped well.

The specific capacity of Well No. 10 at the end of the 28-day pumping period was 21.9 gpm/ft. Based on the initial analysis of data from this test, the long-term safe yield of the well was estimated to be about 525 gpm or 0.76 million gallons per day (mgd).

Well No. 11 was pumped from September 1 to 9, 1987, at an average discharge rate of 393 gpm. During this test water levels were monitored in nine observation wells, including Well No. 10, which is located east of the Fox River. Well locations are shown in figure 3. In addition to determining the long-term yield of Well No. 11, the test was intended to estimate the amount of interference between Wells No. 10 and 11, should they be operated concurrently.

The specific capacity of Well No. 11 at the end of the eight-day pumping period was 15.7 gpm/ft. Because the specific capacity and available drawdown at the well were less ideal than at Well No. 10, the test data from that well were reexamined for the purpose of estimating the total ground-water resource under a dual-operating condition. Based on the analysis of all these data, it was determined that the resource could be developed most efficiently by operating Well No. 10 at approximately 470 gpm and Well No. 11 at about 250 gpm. The total resource was estimated at 1.0 to 1.3 mgd. Subsequent testing of both wells for several months by the village of Montgomery validated these estimates.

Aurora Test Well TH 10-84. A 24-hour aquifer test was conducted on December 19-20, 1985, on test well TH 10-84. which is 125 feet deep and located on Orchard Road north of Galena Boulevard (Visocky, 1986a). Four observation wells, located from 74 to 610 feet away, were monitored. The specific capacity of the well

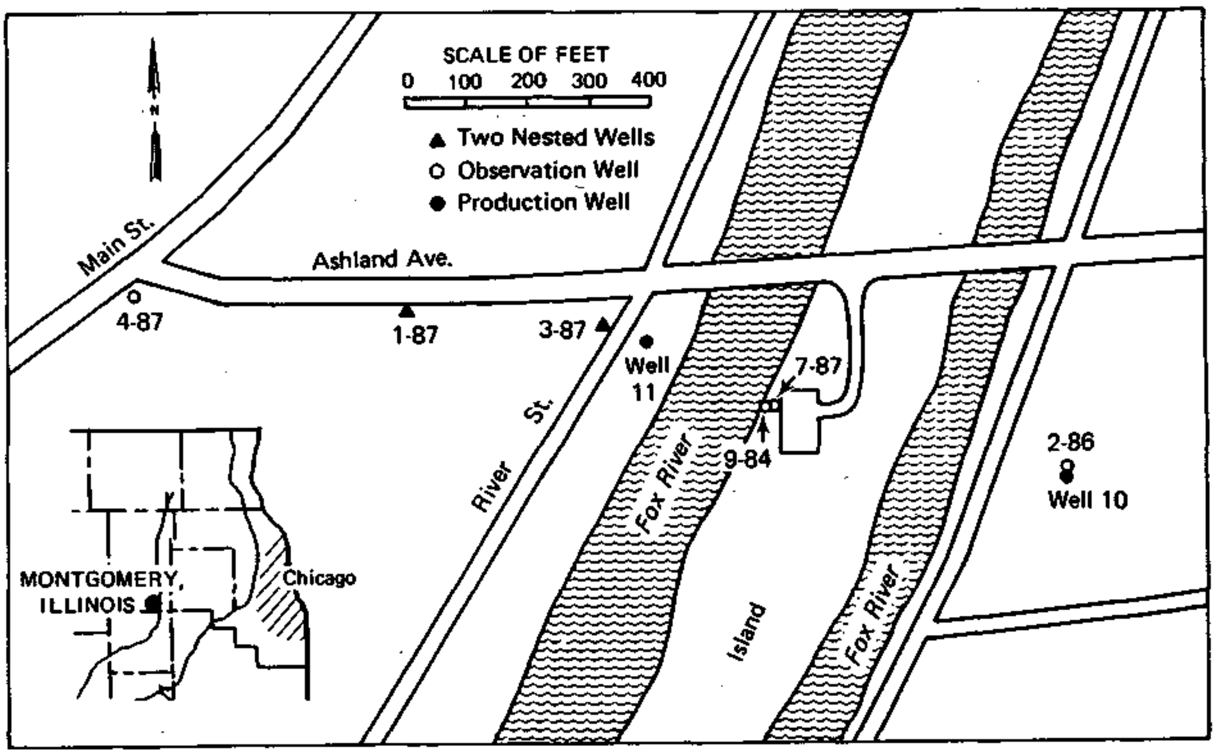


Figure 3. Location of wells for Montgomery Well No. 11 test

after 24 hours of pumping at an average rate of 1,026 gpm was 28.9 gpm/ft. Based on the results of this test and on data collected subsequently at Aurora Well No. 101, it was concluded that a properly designed production well constructed at the site of TH 10-84 could sustain a long-term pumping rate of about 1.5 mgd.

Aurora Well No. **101.** A 15-day aquifer test was conducted from October 7 to 22, 1987, on Aurora Well No. 101 (Visocky, 1987c). The well was drilled in December 1970 to a depth of 116 feet and is located in Pioneer Park along Galena Boulevard. An earlier attempt to conduct such a test (October 1986) was terminated after only 200 minutes because of electrical problems with the pump. During the 15-day test, water levels were monitored in the pumped well and in two observation wells 54 and 100 feet away. Additional monitoring was conducted at one of the four observation wells used during the test on Aurora Test Well TH 10-84 (Well TH 1-85). This observation well was located approximately 3,700 feet northeast of the pumped well. Well No. 101 was operated at an average rate of 651 gpm, and the specific capacity was 12.8 gpm/ft at the conclusion of the test.

Upon completion in 1970, Well No. 101 was tested for 24 hours, and the data analysis suggested that the well was capable of sustaining a withdrawal rate of about 700 gpm (1 mgd). The results of the 1987 test corroborated this estimate.

Aurora Well No. 116. A seven-day aquifer test was conducted from April 21 to 28, 1988, on Aurora Well No. 116, which is 61 feet deep and located just east of the pumphouse of Aurora's deep bedrock Well No. 16 in the southeast part of the city (Visocky, 1988b). During the test, water levels were monitored in the pumped well and in three nearby observation wells located 60, 190, and 400 feet away. With the permission of the village of Montgomery, water levels were also monitored in Well TH 5-86, an observation well located 58 feet southeast of Montgomery Well No. 10 and approximately 3,200 feet west-northwest of Well No. 116. The Montgomery Well TH 5-86 was monitored to assess interference between the two wells, should Aurora decide to put Well No. 116 on-line. Pumpage was maintained at an average rate of 399 gpm during the test, and the specific capacity after seven days was 20.4 gpm/ft.

Based on the results of the test data analysis, it was concluded that the sustained yield of Well No. 116 was limited to between 0.4 and 0.5 mgd. An estimated 2 feet of interference could be observed at Well No. 116 from Montgomery Wells No. 10 and 11.

Aurora Well No. 119. A seven-day aquifer test was conducted from April 12 to 19, 1989, on Aurora Well No. 119, located north of Washington Junior High School on the west edge of the city (Visocky, 1989). During the test, water levels were monitored in the pumped well and in three nearby observation wells located at distances of 125, 250, and 500 feet. At the beginning of the test the pumping rate was adjusted to 700 gpm, but as pumping levels in the production well dropped, the pumping rate gradually declined to about 650 gpm and then stabilized. The specific capacity after seven days was about 17.5 gpm/ft, which was between the values observed at Orchard Road (Aurora Test Well TH 10-84) and Pioneer Park (Aurora Well No. 101), roughly one-half mile to the northwest and one mile to the west, respectively. The long-term sustained yield of Well No. 119 was estimated to be about 1 mgd.

Aurora Well No. 107. A scheduled seven-day aquifer test was begun on July 18, 1988, at Aurora Well No. 107, which is 135 feet deep and located at Aurora University (ISWS files). Observation wells for the test were located **144,** 252, 550, and 800 feet from the pumped well. The well was turned on and pumped at an average rate of 708 gpm for a little more than two days (3,100 minutes). The pumpage was stopped because of complaints of severe interference with nearby domestic wells (in a portion of the city not supplied by city water). Rescheduling of this test has been postponed until an agreement can be completed between the city and the affected well owners.

"Batavia Well No. 6." A seven-day aquifer test was conducted from December 2 to 9, 1988, on a 157-foot-deep well located west of town near the intersection of Kaneville Road and Fabyan Parkway (Visocky, 1988a). At the time of the test the well was designated "Well No. 6" by the city of Batavia. Subsequently, however, the property was acquired by private interests. A supply of 1,500 gpm was desired from this location. Observation wells for the test were located at distances of 100, 200, and 500 feet from the pumped well. The well was pumped at an average rate of 1,000 gpm for just under seven days (9,857 minutes), and the specific capacity at the end of pumping was 52.4 gpm/ft. Based on the test data analysis, it was concluded that the desired production rate of 1,500 gpm was feasible.

Geneva Well No. 8. A three-day aquifer test was conducted from June 24 to 27, 1986, on the city of Geneva's Well No. 8, which is 150 feet deep and located west of the city at the corner of Keslinger and Peck Roads (Visocky, 1986b). Observation wells were located at distances of 10, 100, 199, 377, and 791 feet from the pumped well. The average discharge rate during the test was 1,513 gpm, and the final specific capacity was 66.3 gpm/ft.

Two interesting phenomena were observed during the test and/or the data analysis phase. During the test, water levels rose quickly by 0.1 to 0.2 foot in the observation wells whenever a freight train passed on the nearby railroad tracks. This proved to be a useful observation: the aquifer response to this loading indicated a confined aquifer and answered a question about its operative condition. Although the data analysis suggested either a water-table or leaky artesian system, the loading confirmed that it was artesian. In another curious result of the test, the data indicated no aquifer boundaries, even though the cone of depression had apparently grown well beyond the aquifer boundaries that were defined by geophysical field interpretations. It was concluded that the bedrock valley walls (the physical boundaries of the aquifer) were composed of highly fractured bedrock that contributed significant flow toward the pumped well.

While the test data indicated that the sustained yield at the site was about 1,500 gpm, the uncertainty about the distances to the boundaries prevented speculation on the extent of the resource beyond this amount.

Geneva Well No. 9. A seven-day aquifer test was conducted from June 26 to July 3, 1990, on the city of Geneva Well No. 9, which is located along Keslinger Road about 2,000 feet west of Geneva Well No. 8 (Visocky, 1990). The well was finished at a depth of 153 feet, and the average discharge during the test was 2,199 gpm. Observation wells were located 211 feet and 1,462 feet to the west and 638 feet south of the production well. The specific capacity at the end of seven days was 205.5 gpm/ft, one of the highest observed in the study.

Unlike the test at Well No. 8, the aquifer here responded to pumpage under water-table conditions. But like the test at Well No. 8, no evidence of hydrogeologic boundaries was observed. Based on the data analysis, the well was expected to yield the design rate of 2,200 gpm.

St. Charles Well No. 11. A three-day aquifer test was conducted from November 28 to December 1, 1988, on the city of St. Charles Well No. 11, which is 130 feet deep and located just east of State Route 29 on the north edge of town (Visocky, 1988c). Two observation wells, located 115 feet and 225 feet from the pumped well, were monitored during the test, along with the pumped well. Well No. 11 was pumped at an average rate of 1,609 gpm, and the specific capacity at the conclusion of the test was 423 gpm/ft. This is a very high value, but it is consistent with the nature of the aquifer materials encountered at the site. The aquifer at this site is at least 100 feet thick, very permeable, and operates under water-table conditions, making it one of the most productive in Kane County. The city plans to operate the well intermittently at a rate of 1,600 gpm. Based on the results of the test, this production rate can be attained easily.

Potential Yield

The potential yield is defined as "the maximum amount of ground water that can be developed from a reasonable number of wells and well fields without creating critical water levels or exceeding recharge." Schicht et al. (1976) estimated the potential yields of the sand and gravel and the shallow dolomite in northeastern Illinois from Water Survey maps showing recharge rates (figures 4-7) and from data on the yields of existing wells. In most cases the potential yield of an area was simply the product of the area multiplied by the recharge rate. In some cases, however, the potential yield was limited by the probable yields of wells.

In order to determine the total potential yield of sand-and-gravel and shallow dolomite aquifers in each county, Schicht et al. segregated the glacial drift (sand and gravel) aquifers into two categories: complementary and supplementary. The distinction was based upon whether or not pumping from the glacial drift aquifers would reduce recharge to the shallow dolomite aquifers and thus affect potential yields. For the purposes of their study, they assumed full development of the shallow dolomite aquifers and supplemental development of the glacial drift aquifers. In so doing they acknowledged that in many areas the opposite situation may be advantageous: that is,

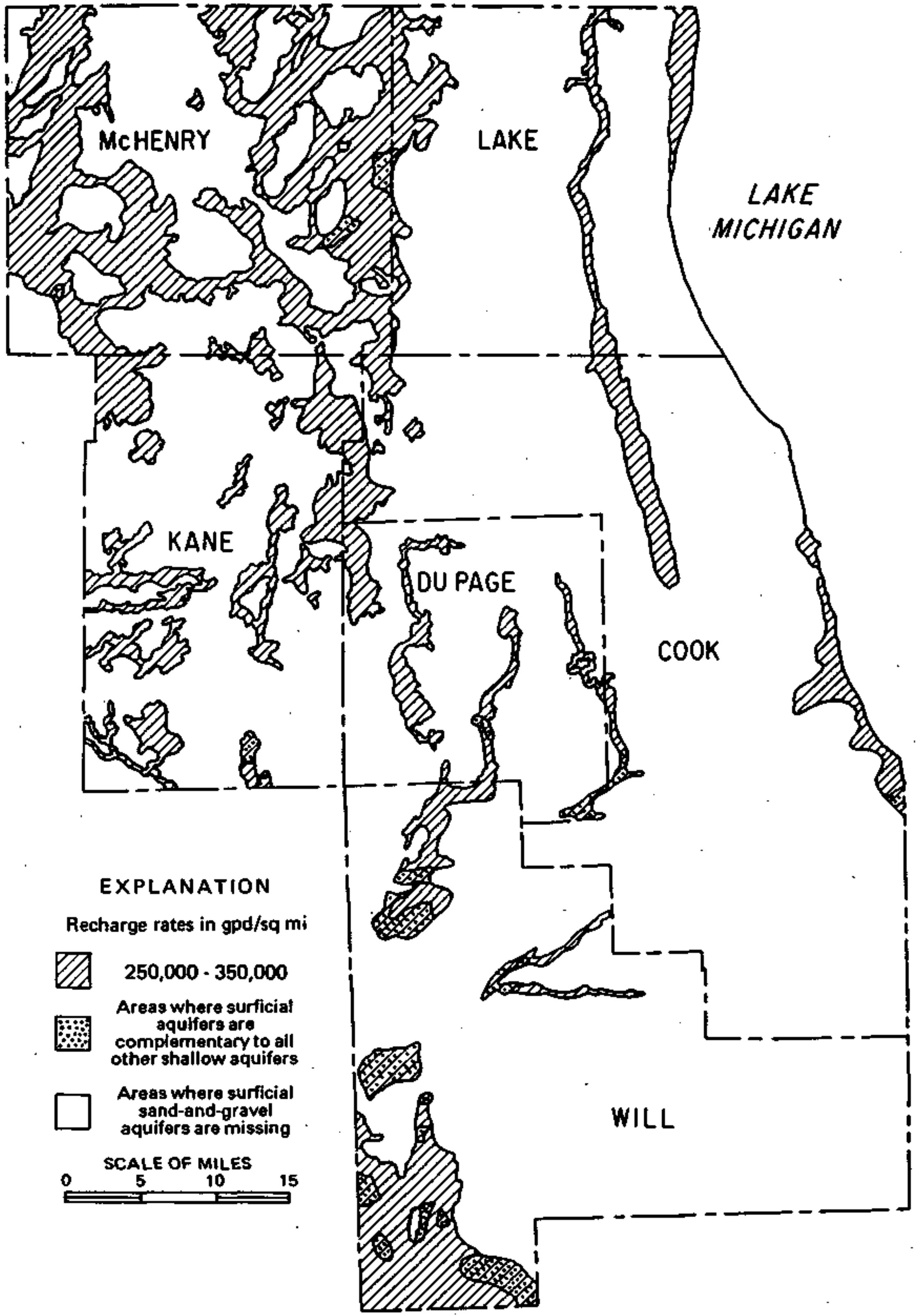


Figure 4. Recharge rates for surficial sand-and-gravel aquifers (from Schicht et al., 1976)

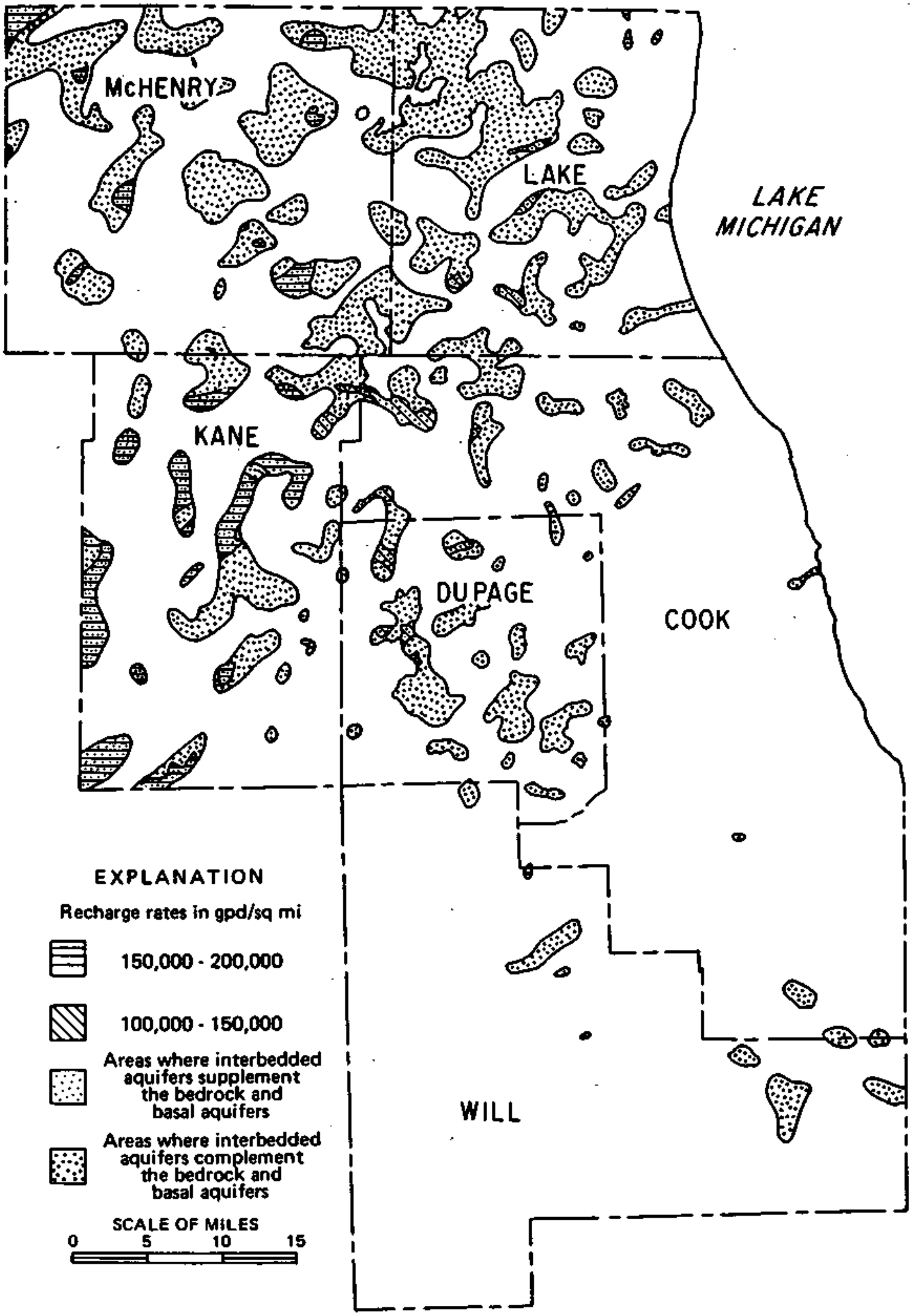


Figure 5. Recharge rates for interbedded sand-and-gravel aquifers (from Schicht et al., 1976)

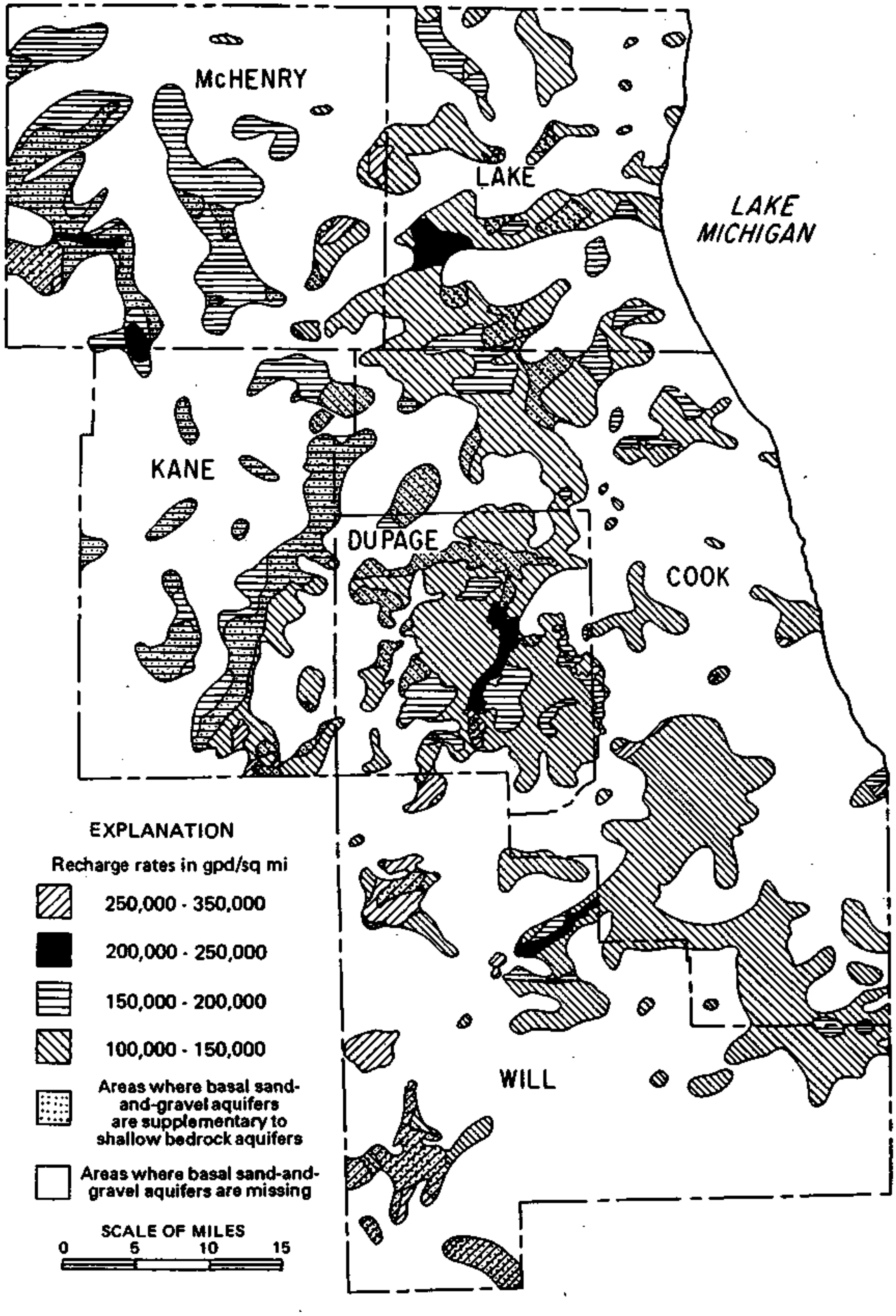


Figure 6. Recharge rates for basal sand-and-gravel aquifers (from Schicht et al., 1976)

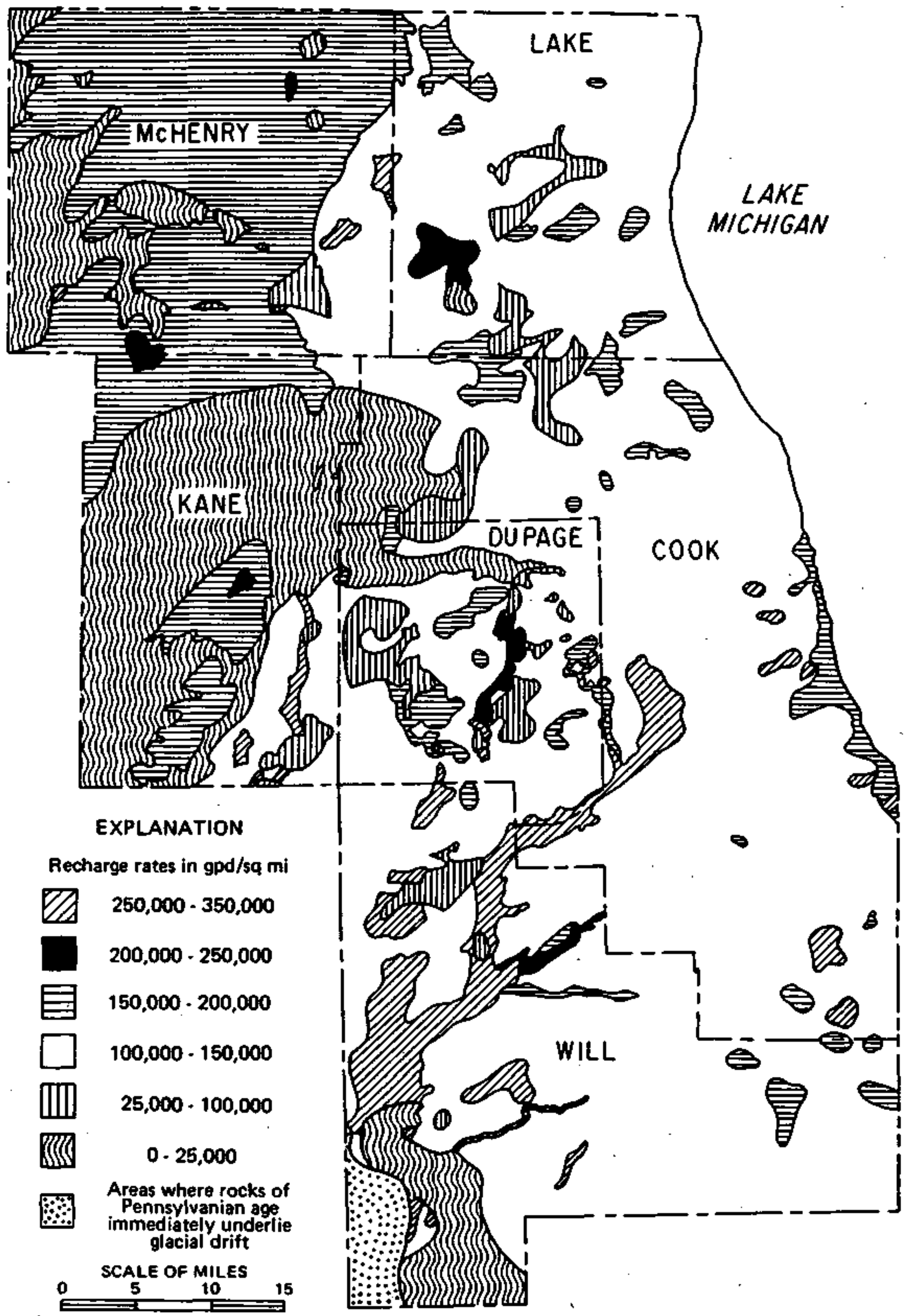


Figure 7. Recharge rates for shallow bedrock aquifers (from Schicht et al., 1976)

full development of glacial drift aquifers and supplemental development of shallow dolomite aquifers. Based on their assumptions, Schicht et al. estimated the potential yield of shallow aquifers in Kane County to be about 57 mgd, including 21 mgd from the glacial drift and 36 mgd from the shallow dolomite.

In the present study, however, the primary emphasis is on the sand-and-gravel aquifers within the glacial drift. Therefore, in a preliminary determination of aquifer yield, prior to the availability of final aquifer distribution maps from the ISGS, the recharge maps shown in figures 4-7 were analyzed. The preliminary determination assumed full development of the glacial drift aquifers and supplemental development of the shallow dolomite aquifers. It was assumed that the basal sand-and-gravel aquifers within the glacial drift would be the primary aquifers for development, followed by the interbedded and surficial sands and gravels. The three sand-and-gravel recharge maps (figures 4-6) were superimposed on one another, and the areas identified as basal aquifers were evaluated for potential yield by multiplying their area by the appropriate recharge rate. These areas were then deleted from the map, and the areas identified as interbedded aquifers elsewhere in the county were then evaluated. In the same manner, these were deleted from the map, and the surficial aquifers in remaining portions of the county were evaluated. Finally, the remainder of the county still not accounted for by glacial drift aquifers was assigned to the shallow bedrock and evaluated for potential yield.

Table 2 shows the results of the preliminary potential yield evaluation based on figures 4-7, assuming primary development within the glacial drift. The analysis for potential yield within the shallow bedrock does not account for those areas with recharge values of 0 to 25,000 gpd/sq mi (figure 7), since large-scale development of water resources in these areas would be impractical.

Table 2. Estimated Potential Yield
of Shallow Aquifers in Kane County

Aquifers	Yield (mgd)
Surficial sand and gravel	16
Interbedded sand and gravel	13
Basal sand and gravel	23
Shallow bedrock	12
TOTAL	64

The results of this analysis are significantly different from those of Schicht et al. (1976). In their analysis, total yield from sand-and-gravel aquifers was only 21 mgd, whereas an analysis that assumes primary development of these aquifers (instead of the shallow bedrock) concludes that 23 mgd could be developed from basal sand-and-gravel aquifers alone, and as much as 52 mgd might be developed from all of the sand-and-gravel deposits within the county.

Revised Estimate of Yield

Studies by the Illinois State Geological Survey (McFadden et al., 1988, and Curry and Seaber, 1990) of the major sand-and-gravel aquifers within the glacial drift have revised the delineation of these units. McFadden et al. delineated the major units into the "lower sand-and-gravel aquifer" and the "upper sand-and-gravel aquifer." The lower aquifer roughly corresponded to the basal sand-and-gravel deposits, and the upper aquifer more or less combined the surficial and interbedded sand-and-gravel aquifers described by Schicht et al. (1976). Figures 8 and 9 show McFadden's lower and upper sand-and-gravel aquifers, respectively. In the most recent work by Curry and Seaber (1990) the major aquifers are delineated as "hydrostratigraphic units"; and in a completely new system of nomenclature, proper names are given to the units. Figure 10 shows the sand-and-gravel aquifers mapped by Curry and Seaber. One of the differences between the aquifer isopach maps constructed by McFadden et al. and those by Curry and Seaber is that McFadden's contour interval allows somewhat thinner deposits to be shown. For example, McFadden's isopach contours show thicknesses of less than 50 feet, whereas those by Curry and Seaber do not. This distinction becomes apparent in the areal extent of the various aquifers that can be presented in the two sets of maps. Since the maps by McFadden et al. show thinner portions of the aquifers (especially the major sand-and-gravel units associated with the bedrock valleys and the Fox River), their apparent areal extent is substantially larger than on the maps by Curry and Seaber. This has important significance for the estimates of potential aquifer yield, as described below.

For the purpose of making a revised estimate of potential aquifer yield, both sets of maps (McFadden et al. and Curry and Seaber) were employed. The maps of McFadden et al. (figures 8 and 9) were superimposed on one another, and the areas identified as the "lower sand-and-gravel aquifer" were measured and multiplied by the appropriate recharge rate (corresponding to the rates presented by Schicht et al., which were used in the preliminary estimate). These areas were then deleted from the map, and those areas elsewhere in the county identified as the "upper sand-and-gravel aquifer" were then measured. Areas for which McFadden et al. noted "unreliable data and thick drift with few aquifers" were not included in the measurement. The areas in all the other categories were then multiplied by appropriate recharge rates, as above.

Finally, the bedrock isopach map of McFadden et al. was superimposed over the drift maps. Those areas with thick drift and few aquifers over thick Silurian dolomite bedrock deposits were outlined. In these areas the shallow bedrock aquifer was assumed to be better suited for ground-water development, so they were measured and multiplied by the appropriate bedrock aquifer recharge rates. Areas where the shallow dolomite seems preferable to other aquifers are generally located in the eastern and southern portions of the county.

Measurements were also made of the areal extent of the various hydrostratigraphic units on the Curry and Seaber map (figure 10), and the results were multiplied by the appropriate recharge rates. The differences between the two sets of maps were reconciled as described below.

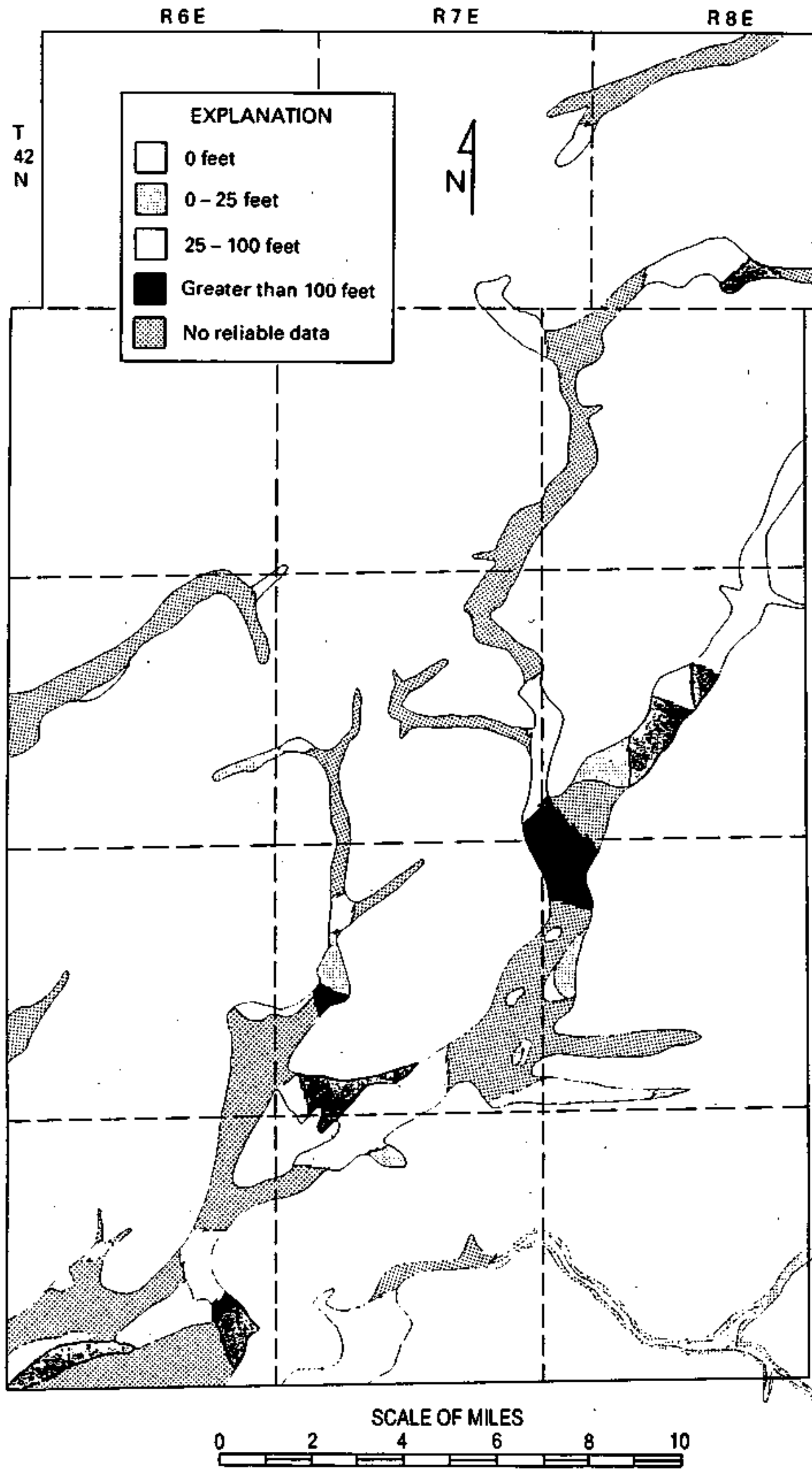


Figure 8. "Lower sand-and-gravel aquifer" in Kane County (after McFadden et al., 1988)

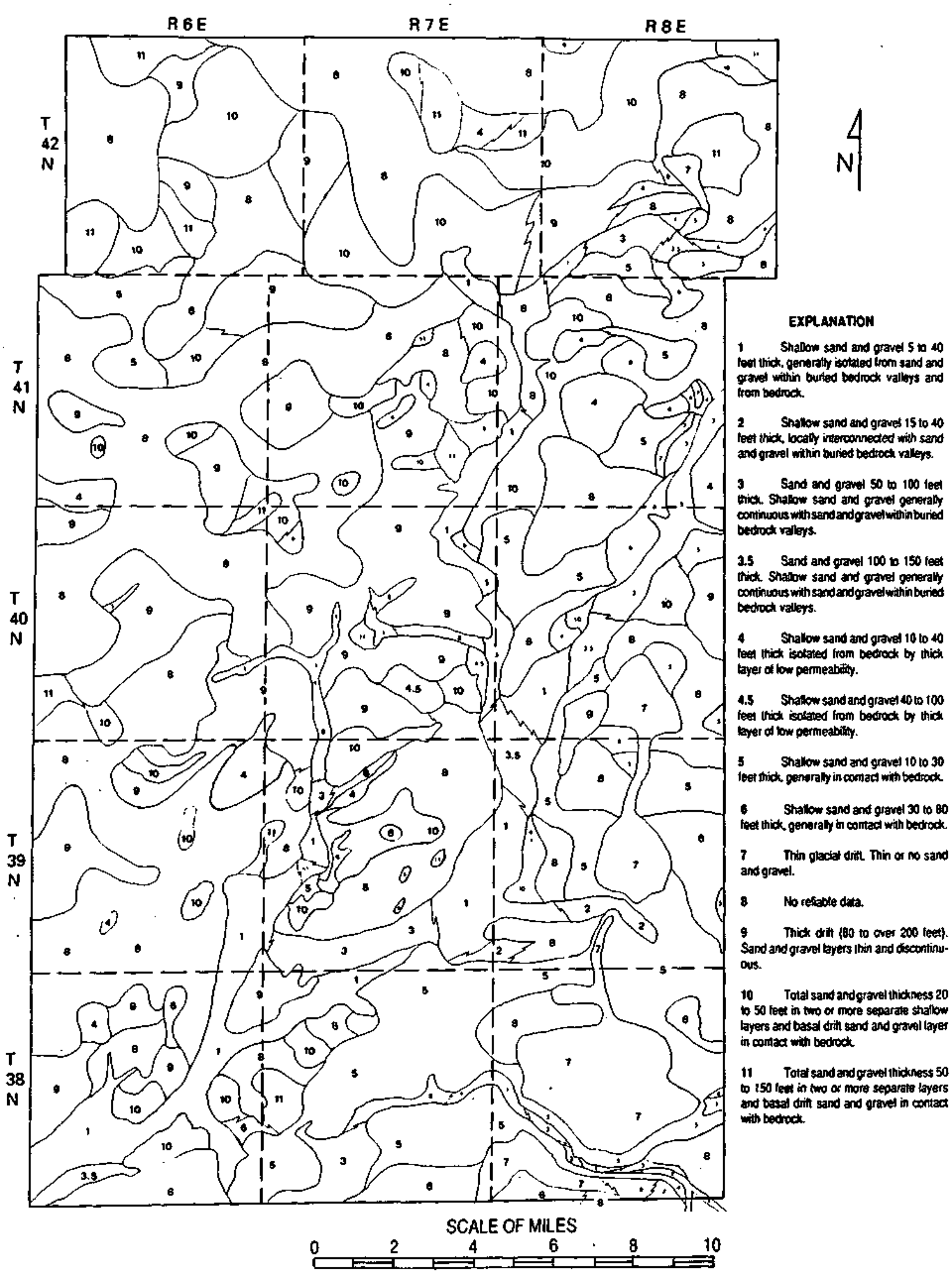


Figure 9. "Upper sand-and-gravel aquifer" in Kane County
(after McFadden et al., 1988)

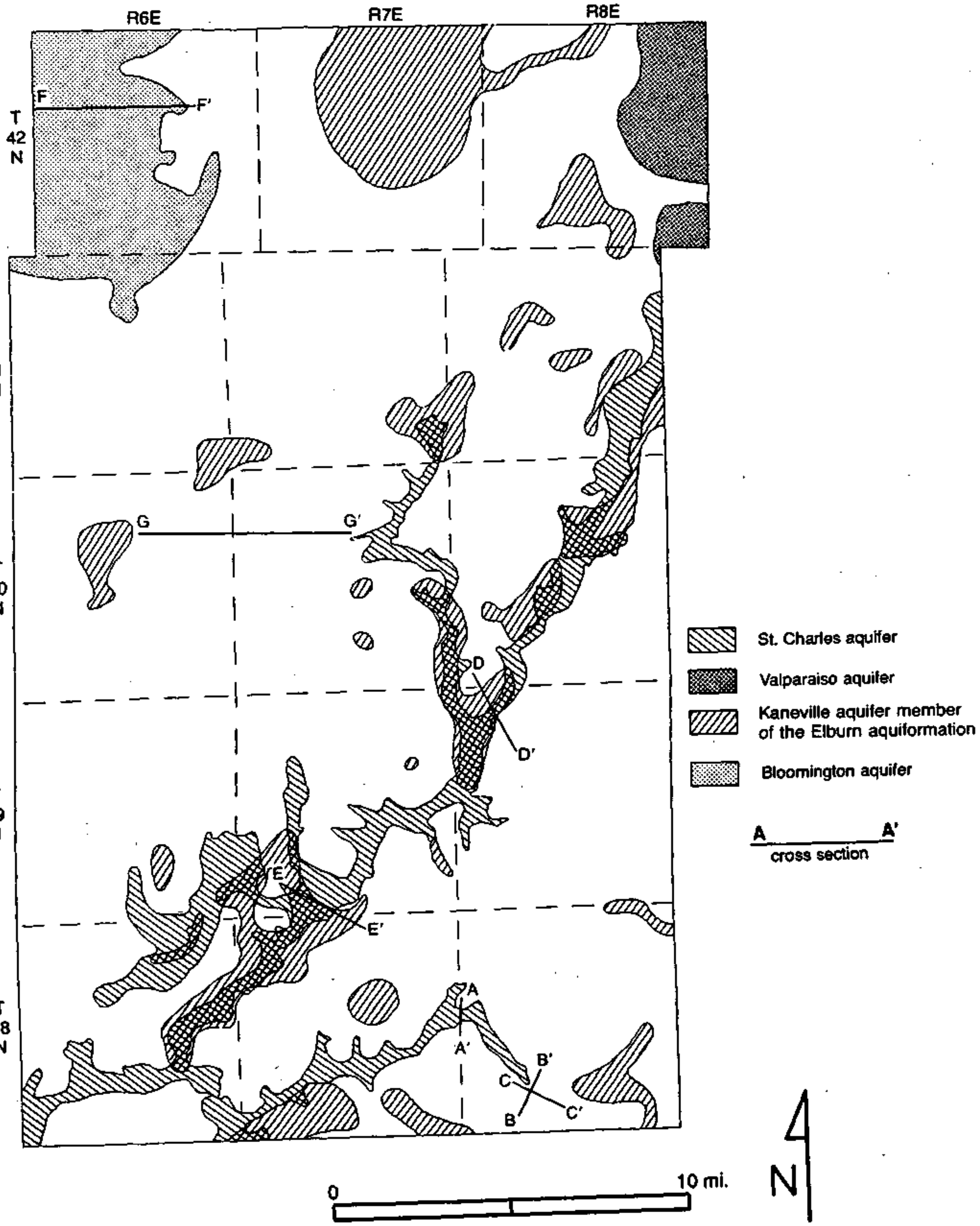


Figure 10. The shallow aquifers of Kane County
(from Curry and Seaber, 1990)

The results of this revised potential yield determination are summarized in table 3. The aquifers delineated by Curry and Seaber are treated as "primary" aquifers for water supplies, and those presented by McFadden et al. that extend beyond the "primary" aquifers are listed together as "supplemental" aquifers. The numbers have been rounded off to the nearest whole number, to avoid implying a degree of accuracy that is not justified.

Table 3. Revised Estimated Potential Yield
of Shallow Aquifers in Kane County

"Primary" aquifers	Yield (mgd)
Bloomington aquifer	5
Valparaiso aquifer	3
Kaneville aquifer	13
St. Charles aquifer	7
"Secondary" aquifers	
Lower and upper sand-and-gravel aquifers	29
Shallow bedrock aquifers	6
TOTAL	63

Many of the sand-and-gravel deposits lie outside of the Fox River Valley and therefore outside the major population centers. Nevertheless, the major deposits, the Kaneville and St. Charles aquifers (associated with the St. Charles Valley, which was originally known as the "Newark Buried Bedrock Valley"), are within economically feasible reach of the cities. Roughly 45 percent of the estimated potential yield of the "primary" Kaneville aquifer and about 55 percent of the potential yield of the St. Charles aquifer originates from areas that lie in proximity to the Fox Valley communities. If the same rough percentages are applied to the "secondary" aquifers, about 34 mgd could be developed from shallow aquifers (including the shallow dolomite) within convenient reach of the Fox Valley communities. Additional supplies could be obtained by developing well fields away from the valley and piping ground water back to the various communities.

This examination of the potential for ground-water development within the glacial drift and shallow bedrock aquifers suggests that substantial quantities of water can be secured for municipal supplies. Although this study has produced a more precise definition of aquifers than has been available heretofore, the potential yields represent estimates for general planning purposes only. Detailed field investigations will be necessary to evaluate the available ground-water resources at any given location.

WATER QUALITY

Introduction

This section summarizes water quality for the three major aquifer systems in Kane County: sand-and-gravel deposits within the glacial drift, shallow bedrock units (the Silurian dolomite aquifer and the Maquoketa confining unit), and deep bedrock units (the Galena-Platteville unit through the Ironton-Galesville aquifer). The summary, however, does not include water quality analyses for the Elmhurst/Mt. Simon aquifer, where mineralization is frequently much greater than in the aquifers above it.

Tables 4-6 show water chemistry analyses for selected wells from sand and gravel, shallow bedrock, and deep bedrock aquifers in the county. Since this report emphasizes the sand-and-gravel aquifers, more water analyses have been compiled for sand-and-gravel wells (30) than for either the shallow bedrock wells (13) or the deep bedrock wells (12). Coverage of the bedrock aquifers is intended primarily for comparison of the three principal aquifer systems. Data are derived from Woller and Sanderson (1978).

While the overall quality of water from the three aquifer systems in the county is generally good, each of these sources is characterized by certain chemical parameters. For example, concentrations of radium and barium commonly exceed drinking water standards. Both of these naturally occurring constituents are found in ground water from the deep sandstones of northern Illinois (Gilkeson et al., 1983), although they tend to occur in lower concentrations in shallower aquifers. The shallow aquifers (sand and gravel and shallow bedrock), on the other hand, tend to have higher levels of dissolved iron than the deep bedrock.. In fact, the shallower aquifers across the county show an apparent tendency toward higher concentrations of dissolved chemical constituents, such as chlorides, hardness, sulfates, and total dissolved minerals, according to the selected chemical analysis records that were examined.

Water Chemistry

Water samples can be compared in a variety of ways. The most useful procedure is to categorize the samples by type according to their major cationic and anionic constituents. The relative concentrations of these constituents can then be analyzed either graphically or numerically to determine similarities or differences between the various waters.

One graphic approach considers the values of the major anions and cations as percentages of total milliequivalents per liter. By combining sodium and potassium and considering the three major cationic and the three major anionic species, the composition of water can be represented conveniently by a trilinear plot (Hem, 1985). The simplest of these plots consists of two equilateral triangles, one for anions and one for cations. Each vertex represents 100 percent of a particular ion or combination of ions. The

Table 4. Water Quality Summary from Selected Sand-and-Gravel Wells in Kane County
(concentrations in milligrams per liter)

Well	Owner	Depth (ft)	Date	Alkalinity	Calcium	Chloride	Hardness	Iron	Magnesium	Potassium	Sodium	Sulfate	Total dissolved minerals
38N7E-21.5e	Sugar Grove #2	107	02/17/76	346	113	87	S28	0.00	60	3.0	30	120	642
-24.6h	Aurora #101	116	10/22/87	341	65.2	8.1	314	0.62	36.8	-	6.9	9.9	363
38N8E-18.8b	Aurora TW10-84	125	12/20/85	280	85.8	20	389	2.22	42.6	-	6.4	-	445
-31.7a	Montgomery #7	46	08/16/76	336	105	35	470	0.00	45	5.6	14	96	526
-33.4h	Montgomery #10	82	01/05/87	345	122	77	525	2.51	53.6	2.4	33.2	99	592
-33.5h	Montgomery #11	59	09/09/87	348	101	101	508	<0.09	58.4	2.8	32.8	92.2	612
39N7E- 5.8f	Elburn #2	153	07/12/78	306	44	1.4	198	1.80	24.0	1.8	52	14	328
39N8E- 5.8a	Geneva #8	150	06/27/86	292	87	14	402	2.93	45	-	4.8	97est	461
40N6E-30.7a	Maple Park #3	182	03/25/80	285	46	1.0	217	0.70	29.0	3.1	24	10	294
-31.7h	Maple Park #2	134	05/25/82	344	71	2.7	305	2.30	38.6	1.7	13	10	385
40N7E-16.3c	Ferson Creek #3	175	11/03/82	380	84	6.8	368	1.80	43.0	1.6	17	29	429
-16.4c	Ferson Creek #2	186	05/12/75	348	60	3	271	1.30	29	1.7	32	4	398
40N8E-11.2f	Valley View #1	131	02/22/78	316	80	6.0	375	1.50	42.0	1.2	6.0	65	426
-11.4c	St. Charles Skyline #1	131	11/02/82	336	86	7.5	428	1.70	47.0	1.7	5.0	82	443
-11.7b	St. Charles Skyline #2	135	11/02/82	356	89	6.4	453	1.60	47.7	1.9	5.0	82	486
-15.2a	St. Charles #9	86	08/24/82	293	84	30.0	360	0.005	40.0	2.8	15.0	57	428
-28.8a	St. Charles #7	173	03/31/75	292	84	14	398	2.10	45	1.1	6	99	404
41N6E- 9.1g	Burlington #1	108	08/06/47	-	-	-	338	3.10	-	-	-	-	385
41N8E-14.3f	Elgin N. State St.	43	12/11/73	344	102	75	452	0.00	48	3.9	37	98	606
-26.2e	South Elgin #5	68	12/01/82	342	108	70	456	0.70	51.6	3.3	33	109	603
-34.1h	South Elgin #4	109	06/14/77	314	85	12	419	0.00	42	1.3	6	79	418
42N8E-14.2g	Carpentersville #6	179	03/09/77	332	85	15	430	1.40	48	1.6	4	67	461
-14.2h	Carpentersville #5	183	09/13/83	302	92	54	417	1.80	51.0	1.7	5.0	72	460
-14.7g	Lake Marian #3	75	03/18/80	331	93	13	389	1.70	46.0	1.4	4.0	60	454
-15.1f	Carpentersville #3	72	09/13/83	340	99	32	455	1.90	51	2.1	11	82	508
-22.2b	West Dundee #2	87	02/03/72	304	94	25	416	0.00	46	3.4	15	102	486
-23.6d	East Dundee Spring	-	12/18/74	267	78	48	351	0.00	38	2.2	25	58	430
-23.6e	East Dundee #3	128	04/06/82	336	84	36	379	0.30	43.5	2.3	16	47	473
-28.6f	Sleepy Hollow #1	34	04/25/77	380	116	82	510	2.30	50	1.6	31	65	561
-28.6f	Sleepy Hollow #2	44	10/20/80	410	130	100	503	2.50	56	2.2	43	85	671

Table 5. Water Quality Summary from Selected Shallow Bedrock Wells in Kane County
(concentrations in milligrams per liter)

Well	Owner	Depth (ft)	Aquifer	Date	Alkalinity	Calcium	Chloride	Hardness	Iron	Magnesium	Potassium	Sodium	Sulfate	Total dissolved minerals
38N6E-26.2h	Moecherville Sbd. #3	196	Silurian	04/21/76	325	66	2.9	337	1.10	42	2.5	27	69	463
38N7E-10.2b	Prestbury Sbd. #1	200	Maquoketa	05/18/76	362	110	11	476	2.20	49	1.3	7.8	120	558
38N8E-24.4e	Ogden Gardens Sbd. #3	185	Silurian	02/24/76	272	55	2	270	0.90	32	2.5	28	58	340
-25.8g	Wermes Sbd. #2	253	Silurian	08/07/74	320	30	4	141	0.40	16	6.3	126	108	540
-31.7a	Montgomery #6	160	Sil/Maq	12/23/75	324	94	29	428	7.30	47	2.2	24	110	484
-34.8g	Bangs-Union-Parker #1	173	Maquoketa	03/02/76	344	55	15	279	1.25	34	6	89	130	550
-35.2g	Park View Wtr Corp. #1	250	Sil/Maq	03/76	332	73	3	350	1.40	41	1.5	12	49	390
-35.6b	Montgomery #5	186	Sil/Maq	01/21/72	304	96	16	452	0.00	50	1.2	10	131	557
-35.7d	Marviray Manor Sbd. #1	300	Sil/Maq	03/09/76	350	91	15	442	0.70	52	5.0	34	152	590
40N8E- 9.1c	River Grange Lakes #1	180	Sil/Maq	03/76	332	71	3	359	1.35	44	1.5	12	34	380
-15.4a	Highland Sbd. #1	152	Maquoketa	03/23/76	266	48	10	222	0.00	25	2.0	64	60	420
41N8E-28.1a	Elgin Lakes Sbd. #1	300	Sil/Maq	02/12/76	346	89	15	409	0.85	45	1	8	80	470
42N8E-11.6d	Lake Marian Sbd. #2	251	Maquoketa	07/15/77	328	73	5	357	1.40	42	1.9	4	48	400

Table 6. Water Quality Summary from Selected Deep Bedrock Wells in Kane County
(concentrations in milligrams per liter)

Well	Owner	Depth (ft)	Aquifer*	Date	Alkalinity	Calcium	Chloride	Hardness	Iron	Magnesium	Potassium	Sodium	Sulfate	Total dissolved minerals
38N8E- 4.8d	North Aurora #4	1325	CO(-GP)	02/18/76	286	55	5.8	232	0.2	23	13	30	30	348
- 8.3e	Aurora #25	1460	CO(-GP)	06/14/77	280	58	10	248	0.1	25	14.4	34	49	376
-34.6b	Montgomery #8	1378	CO(-GP)	07/15/75	278	60.8	10	244	Tr.	22.5	15.2	32	40.9	353
39N8E- 9.8h	Geneva #6	1350	IG	01/18/72	284	59	3.8	256	0.0	26	10.4	13	9	304
-11.7e	Illinois Youth Center -Geneva #4	2001	CO(-GP)/EMS	02/28/72	248	53	10	220	0.1	20.5	12	28	21	376
-23.8f	Batavia #4	1357	CO	07/17/75	284	59.6	6	254	0.1	25.7	14.8	32.3	38.9	352
40N7E-16.6e	Ferson Cr. Sbd. #1	1409	CO	04/05/74	300	49.6	2	212	Tr.	21.4	10.5	41	5.1	325
40N8E-27.5a	St. Charles #3	1191	CO(-GP)	04/25/77	297	61	11	259	0.2	24	12.1	22	7	344
-31.7f	Illinois Youth Center -St. Charles #5	1292	CO(-GP)	02/16/72	288	61	4	252	0.0	25	9	18	8	320
41N6E- 9.1g	Burlington #2	1105	GP/A	02/17/76	312	64	1.5	283	0.2	30	6.6	9	0.0	304
41N8E-16.4d	Elgin #3A	1378	CO	11/15/76	296	64	40	262	0.0	25	9.9	37	0.0	353
42N8E-27.1e	West Dundee #1	1239	CO(-GP)	02/17/76	291	59	2.3	242	0.1	23	9.6	18	2	329

*CO = Aquifers of the Cambrian and Ordovician systems
(-GP) = Not open to Galena-Platteville unit
GP/StP = Galena-Platteville unit/Ancell aquifer
IG = Ironton-Galesville aquifer
EMS = Elmhurst-Mt. Simon aquifer

composition of a particular water sample with respect to its major cations, for example, is indicated by a point plotted in that triangle at the coordinates that correspond to the relative percentages of the three cations. The coordinates at each point add up to 100 percent. A similar relationship exists in the anion triangle.

An extension of the trilinear plotting technique, which was introduced by Hill (1940) and Piper (1944), allows one to combine the anion and cation triangles. Although the procedures were developed independently, both place the two triangles at the bottom of a graph so that their bases align. A diamond-shaped field occupies the upper central portion of the graph. Points in the lower triangles are then projected into the central field along lines parallel to the outside edges of the central field. The intersection of these projections represents the composition of a particular water with respect to both its anions and cations. Figure 11 illustrates this graphic approach with two hypothetical waters, A and B. Type A water projects onto the central field as a calcium-magnesium (Ca/Mg) bicarbonate, whereas type B falls into the sodium chloride (NaCl) quadrant.

In addition to graphic methods, the expression of the ratio of individual ions to one another or to a group can also illustrate the similarities or differences among waters. For most comparisons of this type, concentration values are usually normalized by converting to milliequivalents per liter.

Analyses

Figure 12 shows the results of trilinear graphic analysis (Piper) of the selected water quality data from the same sand and gravel, shallow bedrock, and deep bedrock aquifers that are summarized in tables 4-6. The plots are shown as contours surrounding the clusters of data points. In the central diamond-shaped field most of the data fell in the calcium-magnesium bicarbonate quadrant. Data from the deep bedrock wells clustered more closely together and did not exhibit as large a plotting spread as did the data from sand-and-gravel or shallow bedrock wells.

The clustering of data in the anion triangle shows that in nearly all cases, alkalinity (bicarbonate ions) dominated the anionic makeup of the water. Absolute concentrations of this anion, however, were noticeably different among the aquifers. For example, in the deep bedrock water samples, alkalinity accounted for 81 to 99 percent of the total anions (92 percent average). Average concentrations of alkalinity in the sand-and-gravel and shallow bedrock water samples, by contrast, were 77 and 76 percent, respectively. Among water samples from sand-and-gravel aquifers, alkalinity was greater than 90 percent of the anionic totals in the Elburn, Ferson Creek, and Maple Park areas, but as little as 59 percent near the Fox River.

The most obvious feature of the cation field is the manner in which each data cluster forms a line from the sodium apex toward the calcium-magnesium baseline. If one constructs such a line for each cluster, a fairly close data fit results, suggesting that a stable calcium-to-magnesium ratio exists within each of the three groups of waters.

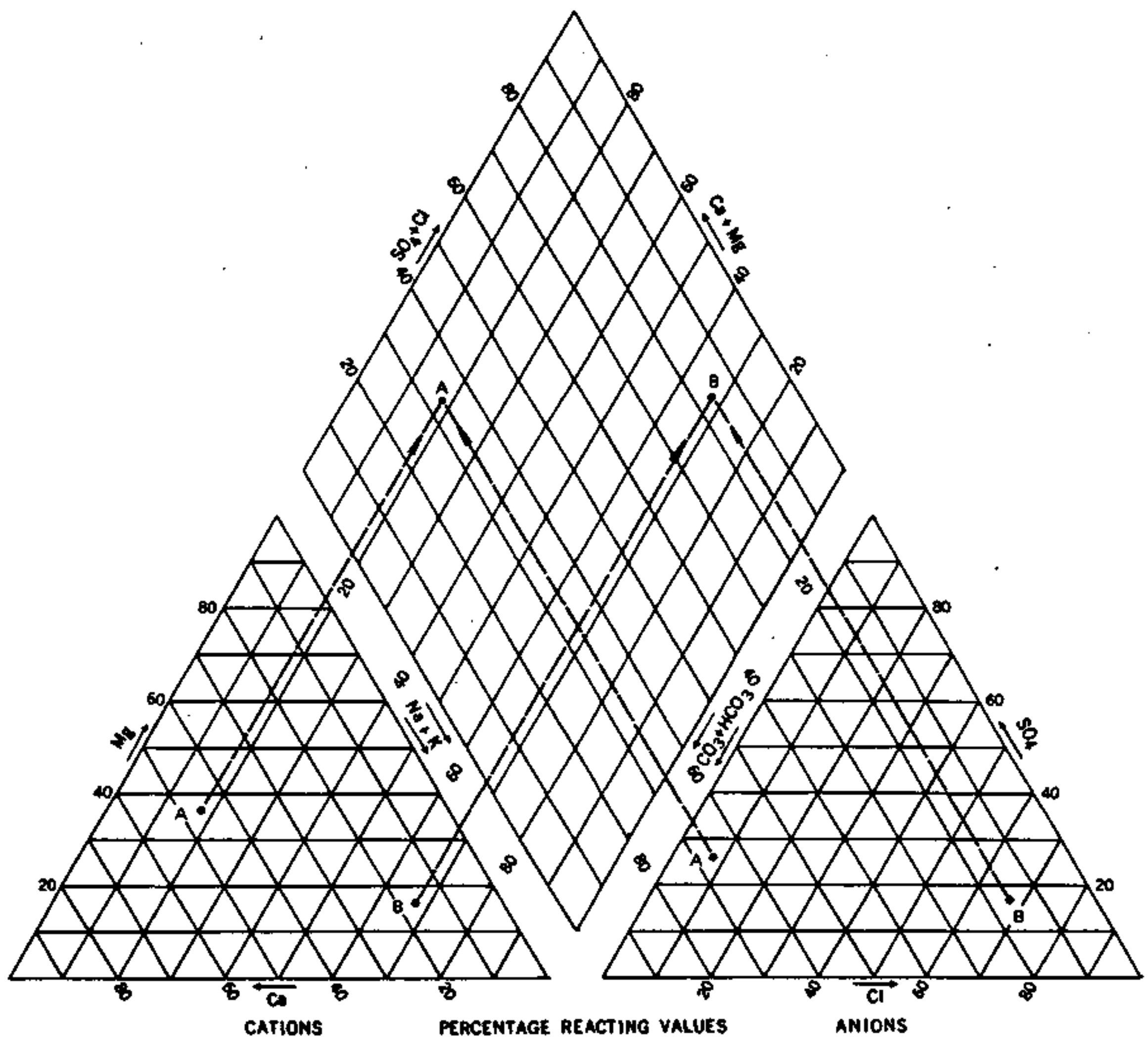


Figure 11. Trilinear plot for two hypothetical waters, A and B

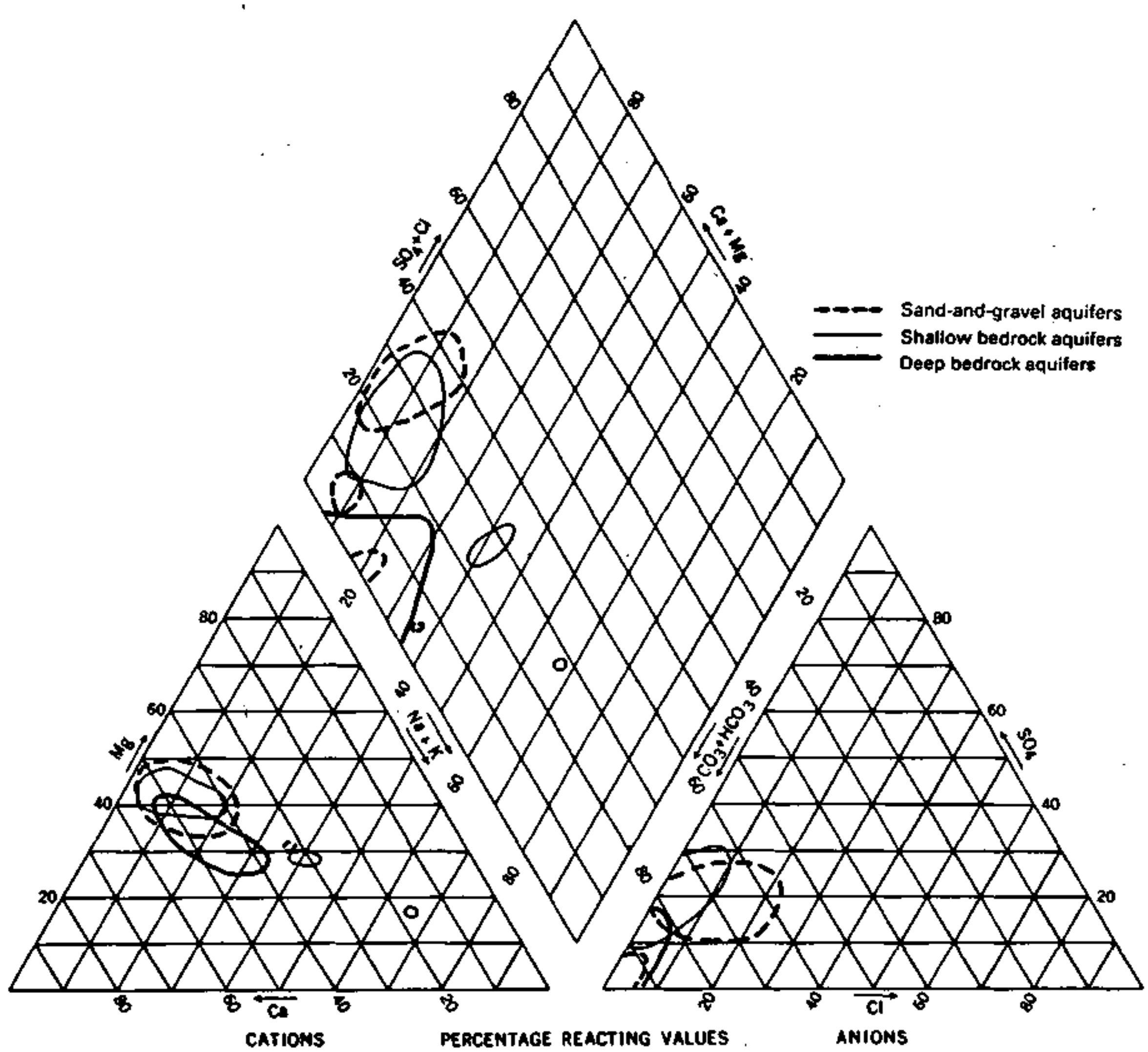


Figure 12. Trilinear diagram of water analyses in Kane County

The intersection of each line with the calcium-magnesium baseline is a convenient way to calculate calcium-magnesium ratios for comparison purposes. Average Ca/Mg ratios of 1.14, 1.12, and 1.46 were derived in this manner for the sand and gravel, shallow bedrock, and deep bedrock, respectively. Average Ca/Mg ratios derived from numerical calculations for the individual water samples were 1.18, 1.11, and 1.47, respectively, indicating a close agreement between the graphic and numerical methods. The Ca/Mg ratio was higher for deep bedrock water samples than for those from shallower aquifers and was, therefore, a useful indicator for comparison purposes.

We have described how alkalinity concentrations served both as indicators of anionic water and as numerical indices for comparison among various waters. But significant differences among the concentrations and ionic proportions of other chemical parameters Were also observed. For example, iron concentrations in both the sand and gravel and shallow bedrock were significantly higher than in the deep bedrock, averaging 1.3 milligrams per liter (mg/L) and 1.4 mg/L, respectively, compared to only 0.1 mg/L in the deep aquifers. Concentrations of sulfate and total dissolved minerals were also higher in the more shallow aquifers. Sulfates averaged 68 and 88 mg/L, respectively, in the sand-and-gravel and shallow bedrock waters, compared to only 17.6 mg/L in the deep bedrock. Total dissolved minerals averaged 473 and 472 mg/L, respectively, in these aquifers, but only 340 mg/L in the deep bedrock.

Hardness exhibited decreasing concentrations with increasing depth, in the three aquifer data sets. Hardness averaged 401 mg/L as calcium carbonate in the sand-and-gravel waters, 348 mg/L in the shallow bedrock, and 247 mg/L in the deep bedrock.

Average chloride concentrations were at least four times higher in the water samples from sand-and-gravel aquifers than from other sources. Chlorides averaged nearly 40 mg/L in the sand-and-gravel water samples, but only 10 mg/L in the shallow bedrock samples and only 8.9 mg/L in the deep bedrock.

Radium and Barium

A study by Gilkeson et al. (1983) examined the relatively high concentrations of radium and barium in ground water from the deep bedrock aquifers in northern Illinois. Their study concluded that these constituents are naturally present in the major sandstone aquifers of the deep bedrock and that the combined concentrations of 226 Ra and 228 Ra found in the majority of analyses exceeded the public drinking water standards set by the Environmental Protection Agency (USEPA, 1975). They also found dissolved barium concentrations in excess of 5.0 mg/L in a large portion of northeastern Kane, southeastern McHenry, southwestern Lake, and northwestern Cook Counties.

Water analyses from selected municipal wells are reported in Water Survey Bulletin 60-22 (Woller and Sanderson, 1978). They include 51 analyses for barium and/or gross alpha and gross beta particle activity. Drinking water standards for barium are 1.0 mg/L, and for alpha and beta activity they are 15 and 50 picocuries per liter (pC/L), respectively. Table 7 summarizes the concentrations for these constituents reported in Bulletin 60-22. In general, alpha and beta activity fall within the EPA limits. Only three wells met or exceeded the limits for alpha activity, and none exceeded the limits for beta activity. Barium concentrations were also relatively low in the sampled wells; only eight were at or above the EPA limits. None of the wells with radioactivity or barium levels in excess of EPA limits were finished in sand-and-gravel aquifers. One of the eight wells with elevated levels of barium was open to both the shallow and deep bedrock aquifers.

Table 7. Summary of Well Concentrations of Gross Alpha Activity, Gross Beta Activity, and Barium

City/subdivision	Well #	Date sampled	Alpha (pC/L)	Deviation	Beta (pC/L)	Deviation	Barium <pC/L)	Formation
Aurora	11	03/01/72	--	----	--	----	<0.1	deep BR
Aurora	12A	01/19/72	6	3	27	4	0.2	deep BR
Aurora	16	01/22/74	7.7	2.8	26.8	3.2	0.0	deep BR
Aurora	25	06/14/77	--	----	--	----	0.1	deep BR
Bangs-Union- Parker Subd.	1	03/02/76	0.4	1.5	8.7	2.4	0.0	shallow BR
Batavia	3	07/17/75	--	----	--	----	<0.1	deep BR
Batavia	4	07/17/75	--	----	--	----	<0.1	deep BR
Burlington	2	02/17/76	14.5	3.0	17.7	2.2	2.3	deep BR
Carpentersville	6	03/09/77	--	----	--	----	0.2	S & G
East Dundee	--	12/18/74	1.2	1.6	2.5	1.8	0.0	(spring)
East Dundee	3	12/18/74	1.0	1.7	0.9	1.7	0.2	S & G
Elburn	1	09/13/71	11	2	33	4	1.0	shallow & deep BR
Elburn	2	09/13/71	1	1	0	2	0.0	S & G
Elgin	2	07/13/71	--	----	--	----	3.1	deep BR
Elgin	3	07/13/71	--	----	--	----	7.4	deep BR
Elgin	3A	11/15/76	--	----	--	----	10.1	deep BR
Elgin	State	12/11/73	0.5	1.6	4.6	2.5	0.0	S & G
Rollins Sewer & Water Co.	1	02/12/76	0.0	1.1	2.6	1.8	0.0	shallow BR
Elgin Mental Health Center	1	03/01/76	0.2	1.8	4.9	2.3	0.0	deep BR
Elgin Mental Health Center	2	03/01/76	11.3	2.4	16.2	1.9	0.2	deep BR
Ferson Creek Subd.	1	04/05/74	--	----	--	----	<7.8	deep BR
Ferson Creek Subd.	2	05/12/75	2.0	1.3	3.2	1.7	0.2	S & G
Geneva	5	01/18/72	6	2	14	2	0.0	deep BR
Geneva	6	01/18/72	6	2	17	3	0.5	deep BR
Hampshire	5	03/04/72	1	1	3	1	0.1	shallow & deep BR
Highland Subd.	1	03/23/76	2.3	1.6	2.2	1.6	0.0	shallow BR
Illinois Youth Center (G.)	4	02/28/72	2	1	12	2	0.0	deep BR
Illinois Youth Center (St.C.)	5	02/16/72	6	2	7	2	0.2	deep BR
Lake Marian in the Woods Subd.	2	07/15/77	--	--	----	----	0.0	shallow BR
Maple Park	3	07/12/72	0.0	1.4	0.3	0.8	0.1	S & G
Marviray Manor Subd.	1	03/09/76	5.1	2.7	8.0	2.4	0.0	shallow BR
Moecherville Subd.	3	04/21/76	1.6	1.3	3.4	1.5	0.1	shallow BR
Montgomery	2	11/29/73	3.6	2.5	11.2	3.0	0.0	deep BR
Montgomery	5	01/21/72	0	1	1	1	0.0	shallow BR
Montgomery	6	12/23/75	3.1	3.5	4.8	2.0	0.1	shallow BR
Montgomery	7	08/16/76	--	--	----	----	0.3	S & G
Montgomery	8	07/15/75	--	--	----	----	<0.1	deep BR
North Aurora	4	02/18/76	25.2	3.9	30.3	2.8	0.1	deep BR
Ogden Gardens Subd.	3	02/24/76	1.3	1.2	3.8	1.4	0.0	shallow BR
Park View Water	1	03/76	0.0	0.0	3.4	1.6	0.2	shallow BR
Prestbury Subd.	1	05/18/76	--	--	----	----	0.1	shallow BR
River Grange Lakes Subd.	1	03/76	1.8	1.5	5.0	1.6	0.0	shallow BR
South Elgin	4	06/14/77	--	--	----	----	0.1	S & G
St. Charles	3	04/25/77	--	--	----	----	1.8	deep BR
St. Charles	6	10/09/75	--	--	----	----	<0.7	deep BR
St. Charles	7	03/31/75	0.5	1.4	3.3	2.0	0.2	S & G
Skyline Sewer & Water Co.	2	02/19/76	0.6	1.2	4.5	1.7	0.1	S & G
Sugar Grove	2	02/17/76	4.1	2.6	5.3	2.6	0.1	S & G
Wermes Subd.	2	08/07/74	1.9	1.8	8.6	2.9	0.1	shallow BR
West Dundee	1	02/17/76	15.6	3.2	25.9	2.5	6.5	deep BR
West Dundee	2	02/03/72	0	1	1	1	0.0	S & G

SUMMARY AND CONCLUSIONS

This study was initiated in response to overpumping and water quality problems in the deep sandstone aquifers of Kane County. Because of these problems alternative ground-water resources are currently being developed or planned in the shallow bedrock and glacial drift in the county. This report has utilized records from the Aquifer Properties Database and the Water Quality Database of the Illinois State Water Survey, along with information collected by the Water Survey during controlled aquifer testing to summarize the hydraulic properties of the shallow aquifers in Kane County, their potential yield, and their water chemistry.

1. The shallow dolomite bedrock can supply sufficient quantities of water for local public supply. The highest yields are generally restricted to the eastern part of the county where the dolomite units are thickest. Yields are highly variable because porosity and permeability are dependent on fracture development. In addition, the shallow dolomite aquifer is hydraulically connected to the overlying sand-and-gravel aquifers in the glacial drift on a regional scale. If preference is given to development of the sand-and-gravel aquifers in these areas, it is estimated that the potential yield of the shallow dolomite aquifer in Kane County is about 6 mgd.

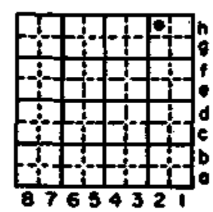
2. Extensive sand-and-gravel aquifers are present in the glacial drift of Kane County. They have been mapped and reported by the Illinois State Geological Survey. Yields of individual wells in the deposits associated with the Fox River Valley and the St. Charles bedrock valley may exceed 1,600 gpm. The estimated potential yield of these major deposits is about 34 mgd, and the total potential yield of all sand-and-gravel deposits within the county is about 57 mgd.

3. Many water quality parameters of both the sand-and-gravel aquifers and the shallow bedrock aquifers tend to exhibit a greater range of concentration and higher average concentrations than do those of the deep bedrock aquifers. Nevertheless, water quality within these more shallow aquifers is generally good. Average concentrations of chlorides, hardness, iron, sulfate, and total dissolved minerals are usually higher in the more shallow aquifers than in the deep bedrdock. Chlorides range from 13 percent higher to a factor of 4 times higher; hardness ranges from 40 to 60 percent higher; iron is higher by a factor of 10; sulfate is from 4 to 5 times higher; and total dissolved minerals are about 40 percent higher. On the other hand, problems associated with high levels of radium and barium are generally associated with the deep bedrock aquifers only. Concentrations of these constituents in the shallow aquifers are well within the EPA drinking water standards.

APPENDIX: 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 coordinates within the section. Sections are divided into rows of 1/8-mile squares. Each 1/8-mile square contains 10 acres and corresponds to a quarter of a quarter of a quarter section. A normal section of one square mile contains eight rows of 1/8-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 below.

The number of the well shown in
Sec. 25 at the right is as follows:
KNE 38N8E-25.2h



In this report, which covers only Kane County, the three-letter county abbreviation is not used in tables that include well numbers.

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