QUALITY OF WATER FROM PUBLIC-SUPPLY WELLS IN PRINCIPAL AQUIFERS OF ILLINOIS, 1984-87

by David C. Voelker

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units, the inch-pound values in this report may be converted by using the following factors:

Multiply inch-pound unit	by	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
mile (mi)	1.609	kilometer (km)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

The quality of water from public-supply wells that tap the principal aquifers in Illinois are summarized for a 4-year period. Water-quality data collected during the study included concentrations of inorganic and volatile organic constituents in 2,756 samples from 2,080 public-supply wells, and soluble organic constituents in samples from 330 of these wells.

Water quality differs among the aquifers as well as within each aquifer. Ground-water quality generally is suitable for most domestic uses; however, concentrations of iron, dissolved solids, and manganese commonly exceed the State's general-use and public- and food-processing water-supply standards. Water from some wells also contains concentrations of barium, chloride, fluoride, and sulfates that exceed those State standards. Most of these conditions are considered to be the result of natural processes.

An analysis of volatile organic compounds indicates that more than 300 of the 2,756 samples collected contained at least one volatile organic compound. The sand and gravel aquifers generally are the most susceptible to human-induced contamination, and 172 of the 1,047 samples from these aquifers indicate the presence of at least one volatile organic compound.

The analysis for soluble organic compounds include more than 30 pesticides, herbicides, and polychlorinated biphenyls (PCB's). Of the 330 wells sampled for these organic compounds, water from only 8 wells had quantifiable concentrations of soluble organic compounds. Five pesticides, including metolachlor, atrazine, alachlor, cyanazine, and metribuzin, were detected in samples from five wells, all of which contained measurable concentrations of atrazine. Water from three wells contained detectable levels of PCB's, but upon resampling, the presence of PCB's in the well water was not confirmed. The presence of these soluble organics appears to be limited to wells located near sources of potential contamination. Soluble organic compounds were detected only in wells open to the sand and gravel aquifers.

INTRODUCTION

Illinois has been considered a water-rich State because of its abundant water resources. As a part of the effort to protect these resources, State and local planning, management, and regulatory agencies need reliable hydrologic information. In the past several years, attention has been focused on the quality of the ground-water resource. State agencies involved in water resources have placed ground-water management as a top priority.

Historical ground-water-quality data in the State has some limitations. The Illinois Department of Public Health has records of chemical analyses of water samples from domestic wells. Most of the samples were submitted voluntarily because of known or suspected problems; information on the well location and source aquifer commonly is absent.

The Illinois Environmental Protection Agency (IEPA) has maintained records of routine sampling of public-supply systems. Routine sampling of public-supply wells by water-system operators has been used to determine treatment necessary for compliance with regulatory requirements.

The Illinois State Water Survey has been maintaining records of chemical analysis of ground water since 1890; about 83 percent of the data has been collected since 1940. These records include analyses from public-supply wells, industrial wells, irrigation wells, and privately owned domestic wells. Most records include data on dissolved solids, hardness, sulfate, nitrate, chloride, and iron, but virtually no data on organic compounds.

Ground-water withdrawals in Illinois reached nearly 1,100 Mgal/d (million gallons per day) in 1984; about 475 Mgal/d were withdrawn for public supplies. Public-water supplies provide 88.7 percent of the State's population with potable water, of which ground water supplies about 3.7 million people. An additional 1.3 million people, primarily those in rural areas, have their own supply of potable water, nearly all of which is from a ground-water source (Kirk and others, 1985, p. 3). Table 1 shows water use in Illinois in 1984.

As part of Illinois' Public Act 83-1268, the IEPA was assigned the task of establishing a statewide ground-water monitoring network (Illinois Environmental Protection Agency, 1986). In 1984, the U.S. Geological Survey, in cooperation with IEPA's Division of Public Water Supplies, developed and instituted such a sampling program. Goals of the program were to sample water from public-supply wells constructed in the major geohydrologic units in the State, describe baseline water-quality conditions in those units, investigate potential trends in ground-water quality, and establish a manageable data base for the periodic assessment of ground-water conditions statewide (Frost and others, 1984).

The monitoring program initially was operated as a pilot study from 1984 to 1985, during which time 106 public-supply wells were sampled quarterly. The statewide distribution of these wells is shown in figure 1. During the pilot study, sampling protocol and data management for the cooperative program were developed and instituted (Cobb and Sinnott, 1987).

During the pilot study, ground-water samples from public-supply wells were analyzed for nutrients, common constituents, metals, phenols, and cyanide. Data on physical properties also were collected at the well sites (Voelker, 1986). The first comprehensive statewide sampling for volatile organic compounds also was accomplished during this period (Cobb and Sinnott, 1987).

After the pilot study was completed in 1985, the program developed into one in which every public-supply well in the State was to be sampled. Wells from which samples indicated the presence of volatile organic compounds were

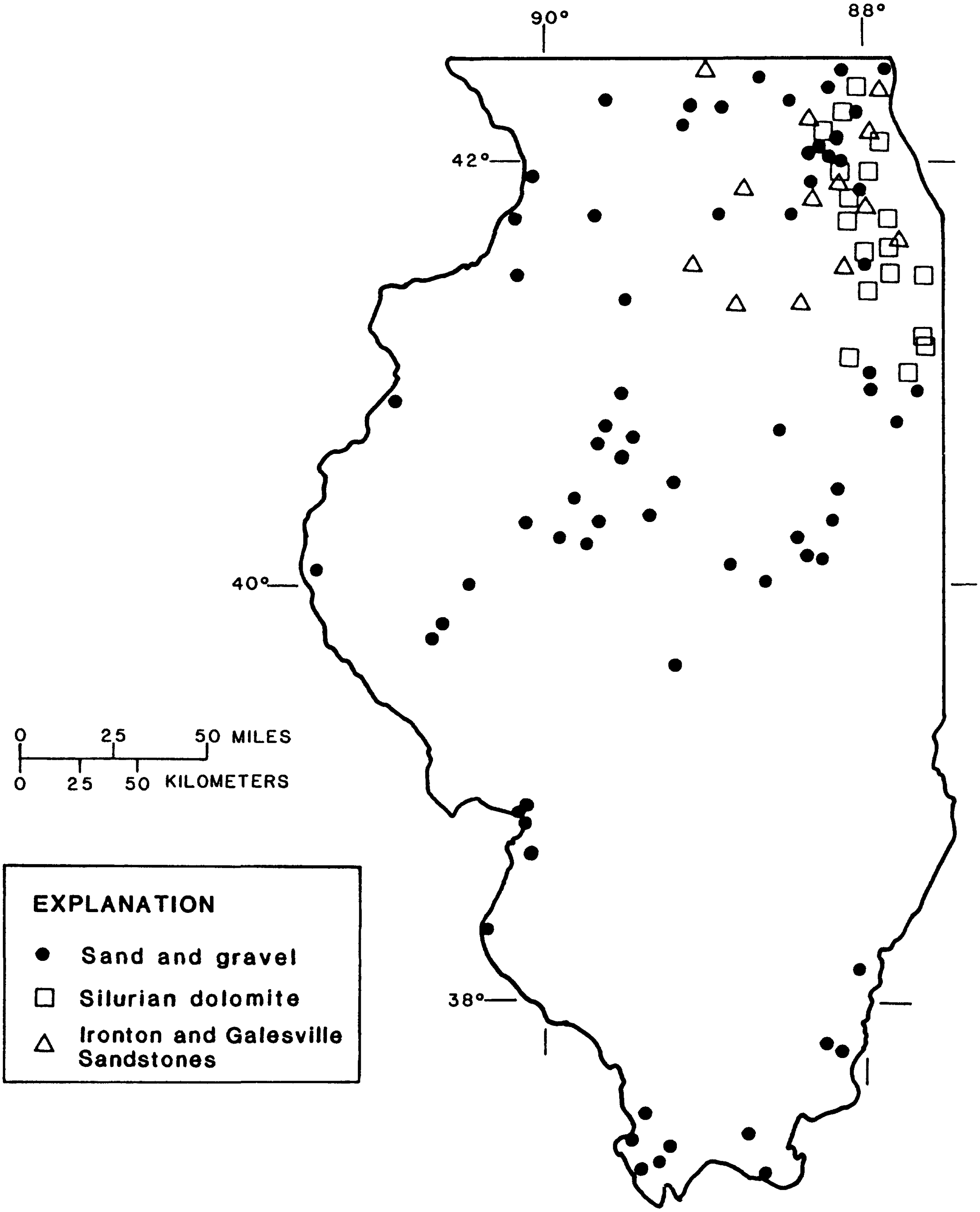

Figure 1.--Distribution of wells sampled in the pilot study.

Table 1.--Water use in Illinois, 1984

[Kirk and others, 1985; Mgal/d, million gallons per day]

Public supplies:		
total withdrawals	1,797.0 Mgal/d	
surface water	1,322.2	74 percent
ground water	474.8	26 percent
Self-supplied industry:		
total withdrawals	34,622.9 Mgal/d	
surface water	34,387.8	99 percent
ground water	235.1	1 percent
Rural (includes domestic, irrigation, farm) use:		
total withdrawals	380.7 Mgal/d	
ground water (estimated)	380.7	100 percent
Fish & wildlife management areas:		
total withdrawals	31.0 Mgal/d	
surface water	22.8	74 percent
ground water	8.2	26 percent
Summary:		
total withdrawals	36,831.7 Mgal/d	
surface water	35,732.8	97 percent
ground water	1,098.8	3 percent

Population:	total	11.5 million
	supplied by:	
	surface water	6.1
	ground water	3.7 (1/3 of the population)
	combined	.4
	unknown	1.3

resampled for data verification. As of July 1, 1987, 2,756 samples were collected from 2,080 public-supply wells in the State. Figure 2 shows the statewide distribution of the wells sampled; the actual number of wells sampled by county is shown in figure 3. Of those 2,080 wells, 330 wells also were sampled for pesticides, herbicides, and PCB's (fig. 4). Data collected during the cooperative ground-water-monitoring program are presented in two reports (Voelker, 1986; Voelker and others, 1988).

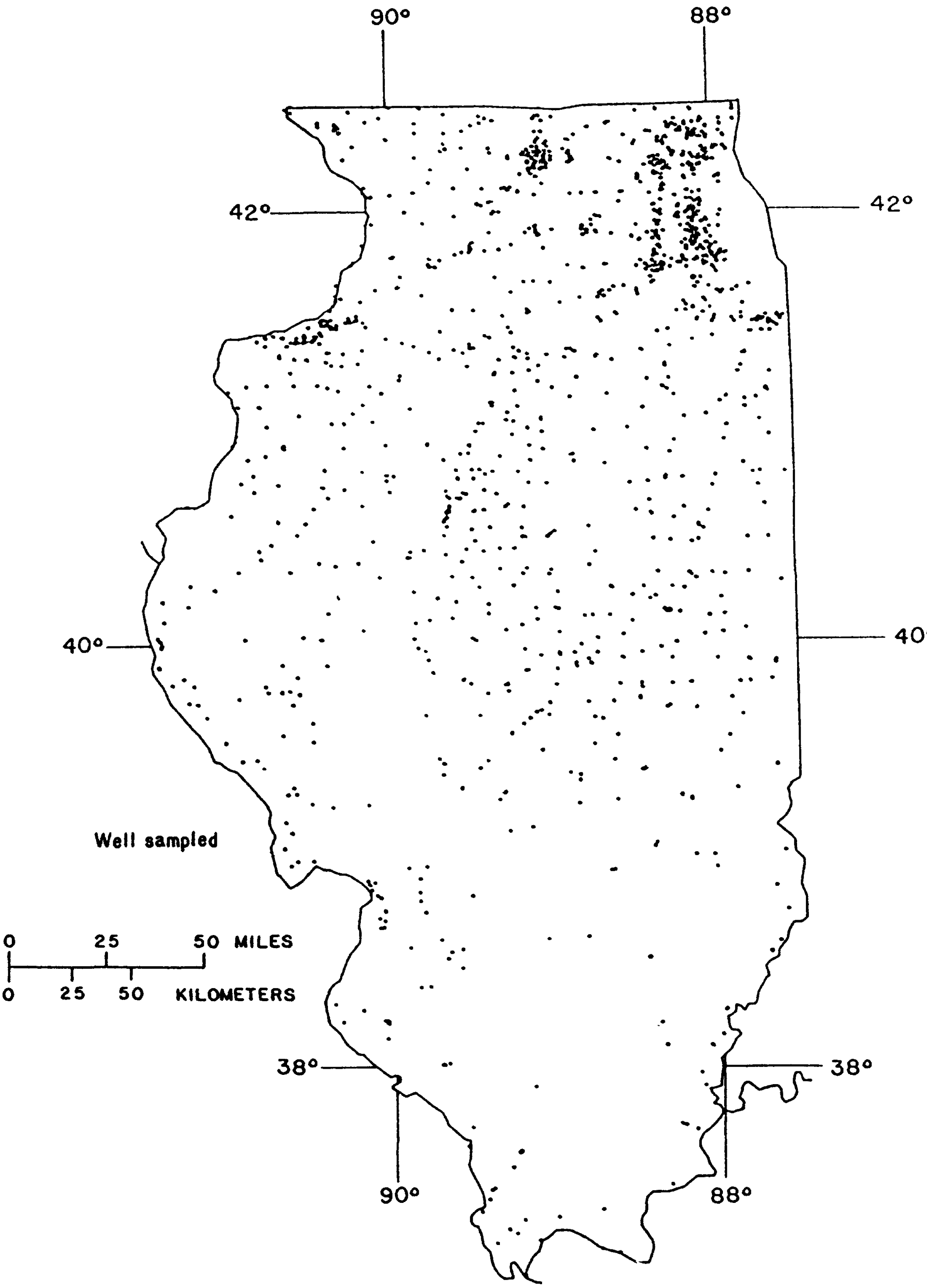

Figure 2.--Distribution of wells sampled during the period 1984-87.

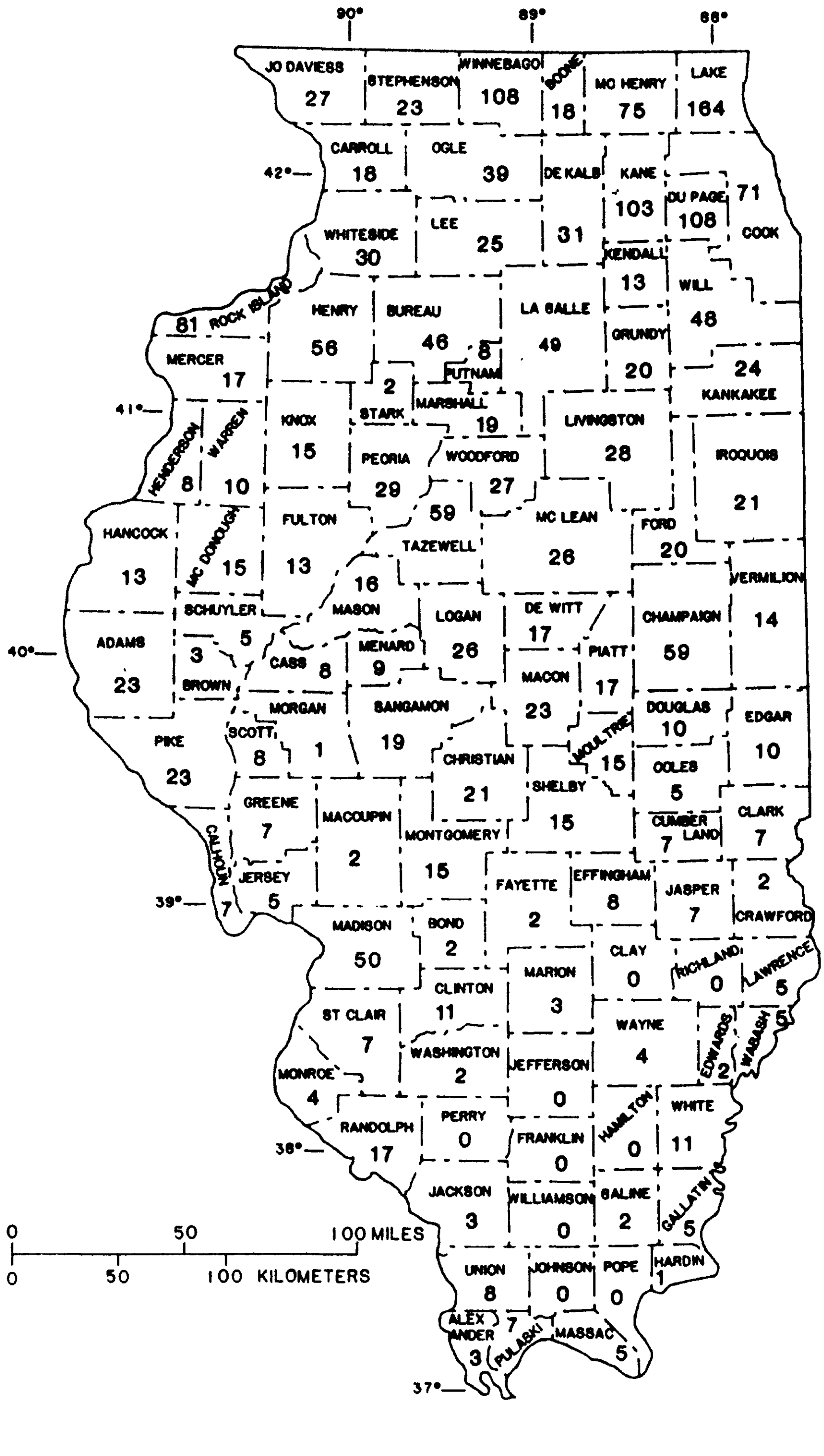

Figure 3.--Total number of wells sampled, by county.

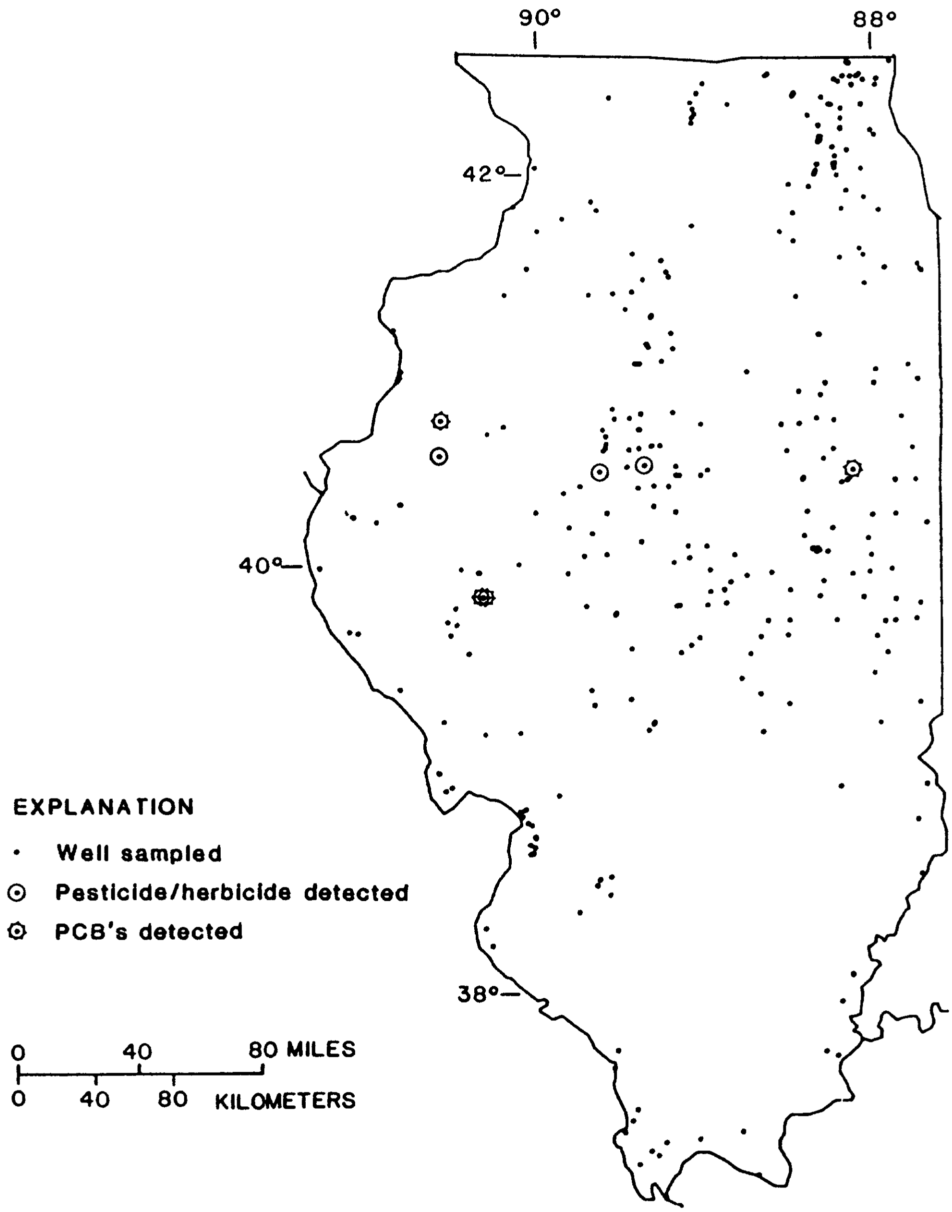

Figure 4.--Distribution of wells sampled for soluble organic compounds.

Purpose and Scope

The purpose of this report is to summarize the water-quality data collected from 2,009 public-supply wells completed in the five principal aquifers in Illinois. Results of statistical analyses of the data collected during the cooperative program between the U.S. Geological Survey and the Illinois Environmental Protection Agency are presented. Data collected from the 71 wells sampled that are constructed with openings at unknown intervals are excluded from this report.

Acknowledgments

The author acknowledges IEPA's Division of Public Water Supplies for their involvement in the ground-water-monitoring program--especially Robert Clarke, Richard Cobb, Wade Boring, Dave McMillan, Fred Martinez, Greg White, and Carol Sinnott. All inorganic chemical analyses were done at the IEPA laboratory in Champaign, Illinois, and the organic analyses were performed at the IEPA laboratory in Springfield, Illinois. A note of thanks also goes to the Illinois State Water Survey and the Illinois State Geological Survey for their assistance in helping initiate the ground-water-monitoring program in Illinois. Special thanks also go to the water-supply owners and operators for their assistance in gaining access to the wells.

CONDITIONS THAT AFFECT GROUND-WATER QUALITY

Ground-water quality can be affected by both natural and human-influenced conditions. Natural conditions include precipitation and the interaction of waters with vegetation, soils, and rocks. Human-influenced conditions include the results of agriculture, industry, mining, urban development, and the use, transport, and disposal of hazardous wastes. The following sections describe these conditions during the study period.

Natural Conditions

Several major rivers border or flow through Illinois. The State has a maximum length of about 380 mi (miles) and a maximum width of about 210 mi; it extends from the Great Lakes to the confluence of the Mississippi and Ohio Rivers. More than three-fourths of Illinois lies within the Central Lowland physiographic province (fig. 5B). Small areas in extreme southern and southwestern Illinois lie within the Ozark Plateaus province, Interior Low Plateaus province, and the Coastal Plains province. Different physiographic and geologic conditions throughout Illinois cause significant differences in ground-water conditions (Willman and others, 1975).

Illinois has a total relief of about 950 ft (feet), ranging from 285 ft above sea level at the confluence of the Mississippi and Ohio Rivers at the southern tip of the State to 1,235 ft above sea level in extreme northwestern Illinois. More than one-half of the State is from 600 to 800 ft above sea level (Willman and others, 1975, p. 19).

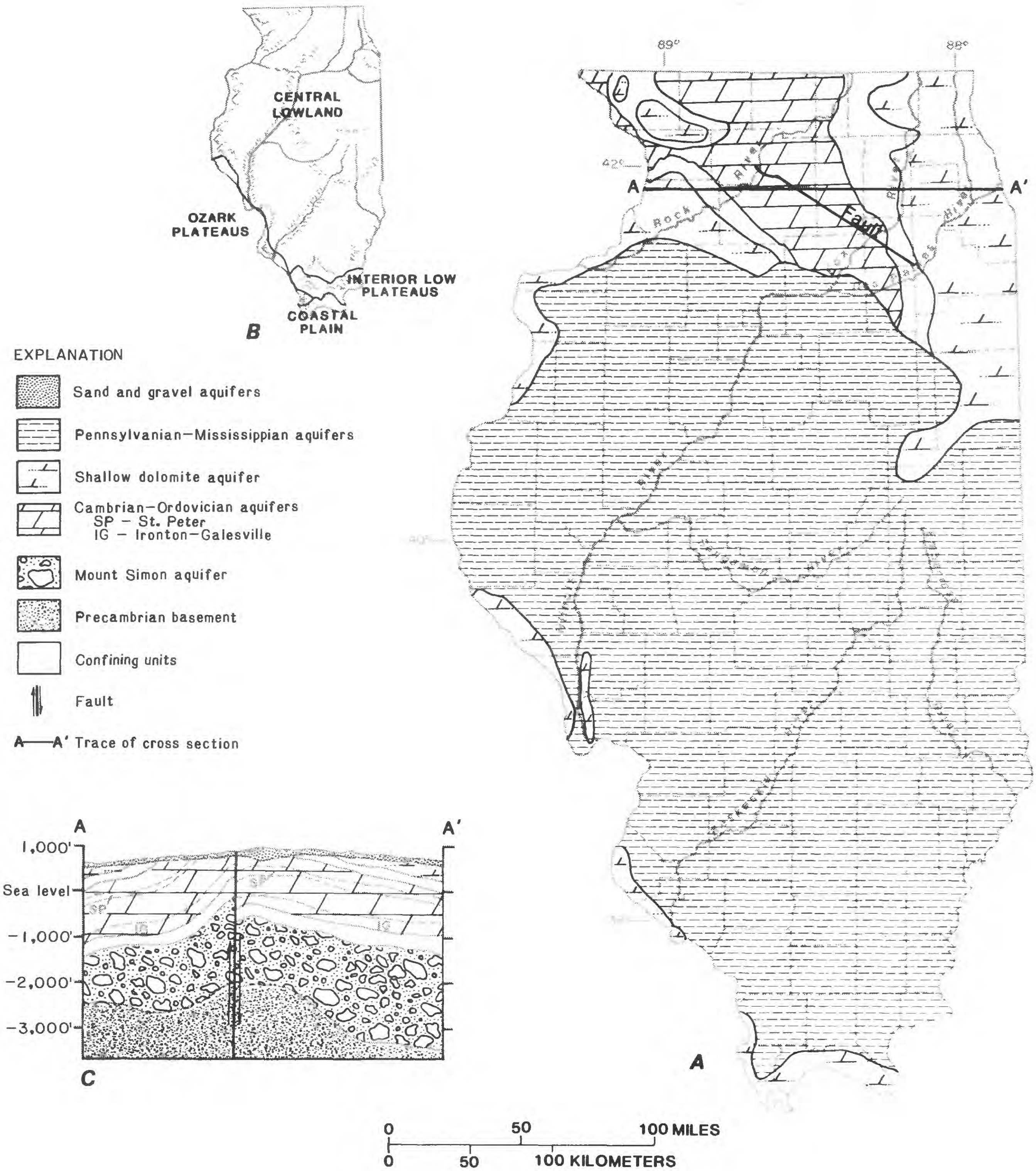

Figure 5.--Principal aquifers in Illinois. A, Geographic distribution. B, Physiographic diagram and divisions. C, Generalized cross section (A-A'). (From Sherrill and others, 1985)

Large areas in western, south-central, and southern Illinois are underlain by relatively thin glacial drift (less than 75 ft thick); in northern and east-central Illinois, the glacial drift is much thicker (greater than 600 ft in some areas). Large deposits of water-yielding sand and gravel are present in the drift (Sherrill and others, 1985).

Average annual rainfall in Illinois ranges from 36 inches in the north to 44 inches in the south. During the 1981-86 period, precipitation was above the 30-year average in Illinois. This has been the longest above-average rainfall period in Illinois in the last 120 years (Stahl and others, 1987).

Human-Influenced Conditions

Because of the variety of land uses in Illinois, there are many potential sources of ground-water contamination in the State. These potential sources include, but are not limited to, waste-disposal sites, surface impoundments for the storage and treatment of liquid wastes, septic systems, buried fuel tanks, agricultural chemicals, pipelines, road salts and deicers, brine disposal from oil and gas production, improperly abandoned wells and borings, induced recharge of contaminants and contaminated waters, increased pumpage resulting in saline water upwelling, land application of wastewaters, unintentional releases of contaminants, and improper or illegal storage and disposal of wastes. These represent a wide variety of point and nonpoint sources of contamination (Shafer, 1985).

PRINCIPAL AQUIFERS IN ILLINOIS

Illinois is underlain by five principal aquifers (fig. 5); these include the sand and gravel, Pennsylvanian-Mississippian, shallow dolomite, Cambrian-Ordovician, and Mount Simon aquifers (Sherrill and others, 1985). The Mount Simon aquifer collectively includes Cambrian sandstone of the lower part of the Eau Claire Sandstone and the underlying Mount Simon Sandstone, which are hydraulically connected. Because most wells are generally constructed only in the upper part of the Mount Simon aquifer where dissolved-solids concentrations are lowest and the same wells also are open to the overlying aquifers, ground-water data from wells open to this formation are combined with the data from wells open to the Cambrian-Ordovician aquifers for the purposes of this report.

More than half (51 percent) of the ground-water withdrawals in the State are from sand and gravel aquifers. Five percent of ground-water withdrawals are from the Pennsylvanian-Mississippian aquifer, 16 percent from the shallow dolomite aquifer, and 28 percent from the combined Cambrian-Ordovician aquifers and Mount Simon aquifer (Kirk and others, 1985).

Sand and Gravel Aquifers

Glacial drift of Quaternary age covers about 80 percent of Illinois and ranges in thickness from about 1 to 600 ft. These glacial deposits are absent only in extreme southern, northwestern, and part of western Illinois. Sand and gravel of Tertiary and Cretaceous age form thick deposits in southern

Illinois. The northern one-third and the extreme southern part of the State have sand and gravel deposits that yield large quantities of water. Elsewhere in the State, ground-water yields are lower, except where preglacial stream channels are filled with sand and gravel deposits (Sherrill and others, 1985).

The sand and gravel aquifers in Illinois are the largest source of domestic water supplies. Well yields from sand and gravel aquifers range from about 10 to 1,000 gal/min (gallons per minute), depending on the thickness, continuity, and permeability of the aquifer. The largest yields are from outwash sands and gravels in major glacial valleys (Sherrill and others, 1985).

Pennsylvanian-Mississippian Aquifer

Sedimentary rocks of Pennsylvanian and Mississippian age comprise the bedrock surface in about four-fifths of Illinois. These rocks form the Pennsylvanian-Mississippian aquifer and include limestones, sandstones, and shales. Although fairly extensive in area, these rocks generally have low porosity and permeability, and yield relatively small amounts of water. Most wells developed in these units supply domestic, farm, or small municipalities at rates of less than 20 gal/min (Sherrill and others, 1985).

Shallow Dolomite Aquifer

The shallow dolomite aquifer includes rocks of Silurian and Late Ordovician age. This aquifer is most productive in northern Illinois, especially where it is unconfined beneath the glacial drift. Yields exceed 1,000 gal/min where the water is present in joints, fissures, and solution channels (Sherrill and others, 1985).

Cambrian-Ordovician Aquifers

The St. Peter Sandstone of Ordovician age and the underlying Ironton and Galesville Sandstones of Cambrian age are the principal aquifer units of the Cambrian-Ordovician aquifers. Regionally, the entire sequence of Cambrian and Ordovician strata seems to function hydraulically as a single unit (Frost and others, 1984). These aquifers provide much of the ground-water supply in the northern third of Illinois (Kirk and others, 1985).

The St. Peter Sandstone is widely used as an aquifer for domestic, municipal, and industrial water supplies. The Ironton and Galesville Sandstones form the most productive aquifer in the Cambrian-Ordovician aquifers, yielding almost half of the production (Sherrill and others, 1985).

Mount Simon Aquifer

The Mount Simon aquifer collectively includes Cambrian sandstone of the lower part of the Eau Claire Sandstone and the underlying Mount Simon Sandstone, which are hydraulically connected (Sherrill and others, 1985, p. 202). Because dissolved-solids concentration in the aquifer generally increases with depth, most wells open to this aquifer penetrate only the upper part. Because of this increase in mineralization with depth, these wells commonly tap the overlying aquifer units as well.

QUALITY OF WATER FROM PUBLIC-SUPPLY WELLS IN THE PRINCIPAL AQUIFERS

Ground-water quality throughout the State generally is suitable for most uses (Illinois Environmental Protection Agency, 1987). The ground-water quality in most areas of the State meets the general-use and public- and food-processing water-supply standards (table 2) established by the Illinois Pollution Control Board (IPCB) (1984a). The water-quality standards set by the IPCB are complex and designed to insure safe and adequate water supplies to all Illinois residents. The standards listed in table 2 are presented without regard to any of the qualifications or exemptions attached to the constituents and are used in this report as a line of reference for data analysis. The public- and food-processing water-supply standards are used in addition to the general-use standards, and, therefore, the more stringent of the two standards were used for this report. Iron, manganese, and total dissolved-solids concentrations most commonly exceed State general-use and public- and food-processing water-supply standards, but these constituents generally can be reduced to acceptable levels.

The collection of ground-water samples for the analysis of volatile organic constituents began in the spring of 1985. Of the 2,065 samples collected for analysis of volatile organics, 305 samples contained at least one such constituent. Detection limits for all volatile organic compounds were set at 1 μg/L (microgram per liter) by the IEPA laboratory doing the sample analyses. Wells that contained water with these organic constituents were resampled for verification of data; where appropriate, long-term monitoring of wells has been scheduled for future analyses. Methylene chloride, chloroform, trichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, dichlorobromomethane, dichloroethylene, and 1,1-dichloroethane were each detected in more than 5 percent of the samples collected. The IPCB has no standards for these compounds.

Samples for analysis of soluble organic constituents, consisting of more than 30 pesticides and herbicides as well as PCB's, also were collected from a group of 330 wells that was considered to be at risk of contamination from such constituents. Of the 347 samples analyzed for these constituents, only 14 samples from 8 wells indicated the presence of these constituents in the ground water. Wells indicating possible contamination are scheduled for resampling to verify results of analyses and to determine whether monitoring at the site will be expanded. Clarke and Sinnott (1988) provided a descriptive analysis of pesticide monitoring in Illinois' community water supplies.

Sand and Gravel Aquifers

Water in these aquifers generally is suitable for most uses (Illinois Environmental Protection Agency, 1987). A summary of the inorganic analyses

Table 2.--General-use and public- and food-processing water-supply standards for Illinois

[Illinois Pollution Control Board, 1984a; dashes indicate no standard designated; public- and food-processing water-supply standards are cumulative with general-use standards; mg/L, milligrams per liter]

Constituent	General-use standards (mg/L)	Public- and food-processing water-supply standards (mg/L)
Arsenic (total)	1.0	0.05
Barium (total	5.0	1.0
Cadmium (total)	.05	.010
Chloride	500	250
Chromium	.05	.05
Copper	.02	--
Cyanide	.025	--
Fluoride	1.4	--
Iron	1.0	--
Lead (total)	.1	.05
Manganese (total)	1.0	.15
Mercury	.0005	--
Nitrate-nitrogen	--	10
Phenols	.1	.001
Selenium (total)	1.0	.01
Silver	.005	--
Sulfates	500	250
Total dissolved solids	1,000	500
Zinc	1.0	--

Table 2.--General-use and public- and food-processing water-supply standards for Illinois--Continued

Constituent	General-use standards (mg/L)	Public- and food-processing water-supply standards (mg/L)
Pesticides		
Chlorinated Hydrocarbon Insecticides		
Aldrin	--	.001
Chlordane	--	.003
DDT	--	.05
Dieldrin	--	.001
Endrin	--	.0002
Heptachlor	--	.0001
Heptachlor Epoxide	--	.0001
Lindane	--	.004
Methoxychlor	--	.1
Toxaphene	--	.005
Organophosphate Insecticides		
Parathion	--	.1
Chlorophenoxy Herbicides		
2,4-Dichlorophenoxyacetic acid (2,4-D)	--	.01
2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP or Silvex)	--	.01

of water from these aquifers is found in table 3. Dissolved-solids concentrations generally ranged from about 330 to 700 mg/L (milligrams per liter), and the median concentration (459 mg/L) did not exceed the 500 mg/L standard set by the State for public- and food-processing water supplies (Illinois Pollution Control Board, 1984a). Concentrations in more than one-third of the samples exceeded the 500 mg/L standard, and several samples had concentrations greater than 1,000 mg/L.

Iron concentrations in the sand and gravel aquifers were much more variable, generally ranging from about 0.5 to 5.0 mg/L. More than one-half of the samples from these aquifers exceeded the State general-use standard of 1.0 mg/L. The median concentration was about 1.7 mg/L. Although many concentrations exceeded 10.0 mg/L, water with elevated concentrations are usable for public-water supply with proper treatment.

Manganese concentrations followed a pattern similar to iron; concentrations generally ranged from 0.05 to 0.5 mg/L. The State public- and food-processing water-supply standard for manganese is 0.15 mg/L, and 28 percent of the samples exceeded this limit. Sulfates, phenols, arsenic, and nitrate concentrations exceeded State public- and food-processing water-supply standards in from 1.4 to 4.2 percent of the samples collected. Copper concentrations exceeded the State's general-use standard of 0.02 mg/L in 5.0 percent of the samples collected.

Volatile organic compounds were measured in 172 of the 1,048 samples collected from 978 public-supply wells open to the sand and gravel aquifers. Samples from 124 public-supply wells contained at least one volatile organic compound. Table 4 summarizes the volatile organic analyses for wells open to the sand and gravel aquifers. The most commonly observed constituents were chloroform, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, tetrachloroethylene, and dichlorobromomethane. Of the 1,048 samples collected from these aquifers, 46 samples contained at least one of these six volatile organic coupounds. Tetrachloroethylene was detected at a maximum concentration of 565 μg/L--a concentration well above that of other volatile constituents detected in these aquifers. Some elevated concentrations of methylene chloride may have resulted from sample contamination in the laboratory (personal communication from Illinois Envirionmental Protection Agency).

Soluble organic compounds were detected in samples from eight wells that were open to the sand and gravel aquifers (table 5). Five of the six compounds detected were pesticides and the sixth was PCB. Samples from three wells contained PCB concentrations of 0.1 to 0.7 μg/L. Resampling of these three wells did not verify the presence of PCB. Pesticides were detected in samples from five wells; atrazine was the only pesticide detected in samples from all five wells. Atrazine concentrations ranged from 0.07 to 4.8 μg/L. Alachlor and cyanazine were detected in samples from three wells, and metolachlor was detected in samples from two wells. Samples collected from one well also contained detectable levels of metribuzin. Detection limits for these pesticides ranged from 0.01 to 0.05 μg/L. The wells from which samples contained trace amounts of pesticides are all located within 50 to 700 ft of site-specific sources of potential contamination, such as agricultural chemical operations (Cobb and Sinnott, 1987; Clarke and Sinnott, 1988).

Table 3.--Summary of inorganic data from wells open to the sand and gravel aquifers

[mg/L, milligrams per liter]

Number of samples collected: 1,444
Number of wells sampled: 991

Constituent	Water-quality standard[1] (mg/L)	Maximum concentration (mg/L)	Number of samples exceeding standards	Percentage of samples exceeding standards
Arsenic	0.05	0.096	30	2.1
Barium	1.0	1.4	10	.7
Cadmium	.010	.017	3	.2
Chloride	250	1,700	12	.8
Chromium	.05	.13	1	.1
Copper	.02	1.7	72	5.0
Cyanide	.025	.05	3	.2
Fluoride	1.4	4.5	7	.5
Iron	1.0	40	767	53
Lead	.05	.26	7	.5
Manganese	.15	2.2	406	28
Mercury	.0005	.069	3	.2
Nitrate	10	88.4	20	1.4
Phenols	.001	.020	54	3.7
Selenium	.01	.025	3	.2
Sulfates	250	1,400	61	4.2
Total dissolved solids	500	3,700	504	35
Zinc	1.0	5.1	6	.4

[1]Public- and food-processing water-supply standards of the Illinois Pollution Control Board (1984a).

Table 4.--Summary of volatile organic data for the sand and gravel aquifers

[μg/L, micrograms per liter]

1,048 samples (978 wells) analyzed for volatile constituents.
172 samples (124 wells) had at least one constituent present.

Constituent	Maximum concentration (μg/L)	Number of samples constituent detected in
Chloroform	130.0	46
Dichlorobromomethane	26.0	22
Dibromochloromethane	18.0	17
Bromoform	10.0	10
Methylene chloride	10.0	40
Dichloroethylene	35.0	11
1,1-Dichloroethane	6.0	18
T-1,2-Dichloroethylene	48.0	15
1,2-Dichloroethane	10.0	11
1,1,1-Trichloroethane	24.0	29
Carbon Tetrachloride	5.2	4
Trichloroethylene	60.0	39
Tetrachloroethylene	565.0	17
Chlorobenzene	27.0	6
Benzene	3.4	5
Toluene	1.0	1
Ethylbenzene	1.0	1

Table 5.--Concentrations of soluble organic compounds observed in public-supply wells open to the sand and gravel aquifers

[Dashes indicate concentrations are below detection limits]

Station number	Date	Time	Metola-chlor	Atra-zine	Ala-chlor	Cyana-zine	Metri-buzin	PCB's
			Concentrations, in micrograms per liter					
395311090224201	05-20-87	1005	--	--	--	--	--	0.3
395311090224202	01-28-87	1425	--	0.53	--	--	--	--
	04-14-87	1140	--	.20	--	0.30	--	--
400300090092801	08-05-86	1020	2.9	1.1	3.5	--	--	--
	10-08-86	1000	6.1	2.5	6.5	--	0.61	--
	10-08-86	1005	7.4	2.5	5.5	--	--	--
	04-14-87	1025	9.6	4.8	8.9	4.5	2.2	--
	06-30-87	1000	11.0	3.1	12.0	2.0	3.7	--
402941089391601	06-10-87	1155	1.20	.80	.54	.38	--	--
403159089221801	10-07-86	1055	--	.23	--	--	--	--
	03-11-87	0930	--	.08	--	--	--	--
	06-30-87	1230	--	.07	--	--	--	--
403329090403802	05-21-87	1020	--	.12	.06	--	--	--
403658088111201	03-27-86	1735	--	--	--	--	--	.1
404353090404101	06-23-87	1000	--	--	--	--	--	.7

Pennsylvanian-Mississippian Aquifer

Because this aquifer yields amounts of water that generally are sufficient only for small supplies, the water-quality data available is limited to 97 samples from 94 wells open to the Pennsylvanian-Mississippian aquifer. The results of these analyses are summarized in tables 6 and 7.

Dissolved-solids concentrations generally ranged from about 330 to 760 mg/L; the median concentration was about 420 mg/L. Although the median concentration was below the State standard for public- and food-processing water supplies, 22 percent of the samples exceeded that standard. Iron concentrations generally ranged from 0.1 to 4.7 mg/L; concentrations in 19 percent of the samples exceeded the State standard for general use. Manganese concentrations exceeded Illinois' public- and food-processing water-supply standards in 9.3 percent of the samples; concentrations generally ranged from 0.01 to 0.4 mg/L. Concentrations of chloride, arsenic, nitrates, and barium also exceeded State standards for public- and food-processing water supplies in from 1.0 to 4.1 percent of the 97 samples collected. Fluoride concentrations exceeded the general-use standards in 6.2 percent of the samples collected.

Volatile organic constituents were least often detected in wells open to the Pennsylvanian-Mississippian aquifer. Only eight samples had detectable concentrations of volatile organics; chloroform was detected in six of the samples (table 7).

Shallow Dolomite Aquifer

Dissolved-solids concentrations in the shallow dolomite aquifer generally exceeded the State public- and food-processing water-supply standard (table 8). Concentrations generally ranged from about 365 to 1,120 mg/L; concentrations in 60 percent of the samples exceeded the 500 mg/L standard. One-fourth of the samples had concentrations of iron and sulfate in excess of the State general-use and public- and food-processing water-supply standards for these constituents. Iron concentrations generally ranged from 0.1 to 1.9 mg/L, and sulfate concentrations generally ranged from 21 to 450 mg/L. Copper, fluoride, chloride, manganese, and phenol concentrations were in excess of their respective State standards in 1.8 to 7.1 percent of the samples collected from this aquifer.

Table 9 summarizes the volatile organic analyses performed on 494 samples from 431 wells open to the shallow dolomite aquifer. Sixty-two samples collected from 55 wells contained detectable levels (greater than 1 μg/L) of at least one volatile organic constituent. Methylene chloride was most often detected, followed by chloroform, tetrachloroethylene, and 1,1,1-trichloroethane.

Cambrian-Ordovician Aquifers and Mount Simon Aquifer

Because all of the public-supply wells in the network that are open to the Mount Simon aquifer also are open to the two Cambrian-Ordovician aquifers, the water quality of these units is considered together. General results of the inorganic analyses are presented in table 10.

Table 6.--Summary of inorganic data from wells open to the Pennsylvanian-Mississippian aquifer

[mg/L, milligrams per liter; <, less than]

Number of samples collected: 97
Number of wells sampled: 94

Constituent	Water-quality standard[1] (mg/L)	Maximum concentration (mg/L)	Number of samples exceeding standards	Percentage of samples exceeding standards
Arsenic	0.05	0.08	3	3.1
Barium	1.0	3.3	1	1.0
Cadmium	.010	.008	0	0
Chloride	250	550	4	4.1
Chromium	.05	.04	0	0
Copper	.02	1.1	11	11
Cyanide	.025	<.01	0	0
Fluoride	1.4	3.1	6	6.2
Iron	1.0	21	18	19
Lead	.05	.015	0	0
Manganese	.15	1.4	9	9.3
Mercury	.0005	.00057	2	2.1
Nitrate	10	13	2	2.1
Phenols	.001	<.005	0	0
Selenium	.01	.009	0	0
Sulfates	250	250	0	0
Total dissolved solids	500	1,760	21	22
Zinc	1.0	.90	0	0

[1]Public- and food-processing water-supply standards of the Illinois Pollution Control Board (1984a).

Table 7.--Summary of volatile organic data from wells open to the Pennsylvanian-Mississippian aquifer

[μg/L, micrograms per liter; dashes indicate constituent not detected in any samples]

91 samples (87 wells) analyzed for volatile constituents.
8 samples (8 wells) had at least one constituent present.

Constituent	Maximum concentration (μg/L)	Number of samples constituent detected in
Chloroform	60.0	6
Dichlorobromomethane	15.0	3
Dibromochloromethane	12.0	2
Bromoform	--	-
Methylene Chloride	1.0	2
Dichloroethylene	--	-
1,1-Dichloroethane	--	-
T-1,2-Dichloroethylene	--	-
1,2-Dichloroethane	1.4	1
1,1,1-Trichloroethane	2.0	1
Carbon Tetrachloride	--	-
Trichloroethylene	--	-
Tetrachloroethylene	--	-
Chlorobenzene	--	-
Benzene	--	-
Toluene	--	-
Ethylbenzene	--	-

Table 8.--Summary of inorganic data from wells open to the shallow dolomite aquifer

[mg/L, milligrams per liter]

Number of samples collected: 607
Number of wells sampled: 498

Constituent	Water-quality standard[1] (mg/L)	Maximum concentration (mg/L)	Number of samples exceeding standards	Percentage of samples exceeding standards
Arsenic	0.05	0.049	0	0
Barium	1.0	2.4	5	.8
Cadmium	.010	.012	2	.3
Chloride	250	1.7	14	2.3
Chromium	.05	.032	0	0
Copper	.02	1.3	43	7.1
Cyanide	.025	.0001	0	0
Fluoride	1.4	4.1	26	4.3
Iron	1.0	45	157	26
Lead	.05	.20	3	.5
Manganese	.15	.82	11	1.8
Mercury	.0005	.00063	2	.3
Nitrate	10	20	1	.2
Phenols	.001	.020	14	2.3
Selenium	.01	.003	0	0
Sulfates	250	1,500	150	25
Total dissolved solids	500	3,370	362	60
Zinc	1.0	4.6	6	1.0

[1]Public- and food-processing water-supply standards of the Illinois Pollution Control Board (1984a).

Table 9.--Summary of volatile organic data from wells open to the shallow dolomite aquifer

[µg/L, micrograms per liter; dashes indicate constituent not detected in any samples]

494 samples (431 wells) analyzed for volatile constituents.
62 samples (55 wells) had at least one constituent present.

Constituent	Maximum concentration (µg/L)	Number of samples constituent detected in
Chloroform	21.0	15
Dichlorobromomethane	22.0	3
Dibromochloromethane	17.0	1
Bromoform	2.8	1
Methylene Chloride	202.0	30
Dichloroethylene	16.0	4
1,1-Dichloroethane	97.0	6
T-1,2-Dichloroethylene	2.0	3
1,2-Dichloroethane	4.0	1
1,1,1-Trichloroethane	6.0	12
Carbon Tetrachloride	--	0
Trichloroethylene	105.0	7
Tetrachloroethylene	21.0	10
Chlorobenzene	13.0	2
Benzene	29.0	3
Toluene	11.0	2
Ethylbenzene	--	0

Table 10.--Summary of inorganic data from wells open to the Cambrian-Ordovician aquifers and Mount Simon aquifer

[mg/L, milligrams per liter]

Number of samples collected: 521
Number of wells sampled: 426

Constituent	Water-quality standard[1] (mg/L)	Maximum concentration (mg/L)	Number of samples exceeding standards	Percentage of samples exceeding standards
Arsenic	0.05	0.024	0	0
Barium	1.0	23	47	9.0
Cadmium	.010	.013	3	.6
Chloride	250	890	39	7.5
Chromium	.05	.011	0	0
Copper	.02	.11	15	2.9
Cyanide	.025	.00002	0	0
Fluoride	1.4	6.4	56	11
Iron	1.0	23	2	.4
Lead	.05	.047	0	0
Manganese	.15	1.2	5	1.0
Mercury	.0005	.0016	2	.4
Nitrate	10	14	2	.4
Phenols	.001	.02	27	5.2
Selenium	.01	.003	0	0
Sulfates	250	1,200	45	8.6
Total dissolved solids	500	3,040	138	26
Zinc	1.0	.54	0	0

[1]Public- and food-processing water-supply standards of the Illinois Pollution Control Board (1984a).

Dissolved-solids concentrations in these aquifers generally ranged from about 300 to 1,100 mg/L; concentrations in about one-fourth of the samples exceeded the State's public- and food-processing water-supply standard of 500 mg/L. Fluoride concentrations exceeded the general-use standards for Illinois in 11 percent of the samples; concentrations generally ranged from 0.1 to 1.6 mg/L. Sulfate concentrations generally ranged from 13 to 300 mg/L, and concentrations in almost 9 percent of the samples exceeded the public- and food-processing water-supply standards. Barium concentrations exceeded the State's public- and food-processing water-supply standards in 9 percent of the samples; concentrations commonly ranged to 1.0 mg/L, which is the State standard for public- and food-processing water supplies. Chloride concentrations exceeded Illinois' public- and food-processing water-supply standards in about 7.5 percent of the samples from this aquifer; phenol concentrations exceeded those standards in 5.2 percent of the samples.

Sixty-three samples collected from 57 wells open to these aquifers indicated the presence of at least one volatile organic constituent (table 11). The most often detected constituents included methylene chloride and trichloroethylene. A trichloroethylene concentration was 952 µg/L in one sample, and a tetrachloroethylene concentration was 385 µg/L in one sample. These are among the highest concentrations of any volatile organic compound detected in public-supply wells in the State.

SUMMARY

Ground water is the source of water supply to about 5 million people in Illinois. Most of this is provided by public-supply systems that withdrew almost 475 Mgal/d from the five principal aquifers in the State in 1984. Past monitoring of Illinois' ground-water quality focused on known or suspected problems with domestic wells or for determining treatment necessary for compliance with regulatory requirements in public-supply systems.

The quality of Illinois ground water can be affected by many factors, including both natural and human-induced conditions. These conditions include precipitation; interaction of water with vegetation, soils, and rocks; and human activities, such as agriculture, industry, mining, and waste management.

The five principal aquifers in Illinois are the sand and gravel, Pennsylvanian-Mississippian, shallow dolomite, Cambrian-Ordovician, and the Mount Simon aquifers. The sand and gravel aquifers are the source for more than half of the State's ground-water supply, followed by the combined Cambrian-Ordovician aquifers and Mount Simon aquifer, the shallow dolomite aquifer, and the Pennsylvanian-Mississippian aquifer.

Based on the sampling of 2,080 public-supply wells over a 4-year period, the water quality of these aquifers generally is good and suitable for most uses. However, ground water typically contains elevated concentrations of iron, manganese, and dissolved solids; deeper aquifers also contain elevated concentrations of barium and sulfate. For the most part, these conditions do not limit water use.

Table 11.--Summary of volatile organic data from wells open to the Cambrian-Ordovician aquifers and Mount Simon aquifer

[μg/L, micrograms per liter; dashes indicate constituent not detected in any samples]

433 samples (408 wells) analyzed for volatile constituents.
63 samples (57 wells) had at least one constituent present.

Constituent	Maximum concentration (μg/L)	Number of samples constituent detected in
Chloroform	2.0	6
Dichlorobromomethane	1.8	1
Dibromochloromethane	2.0	2
Bromoform	--	0
Methylene Chloride	5.0	25
Dichloroethylene	42.0	7
1,1-Dichloroethane	2.0	4
T-1,2-Dichloroethylene	54.0	11
1,2-Dichloroethane	1.1	1
1,1,1-Trichloroethane	11.0	10
Carbon Tetrachloride	--	0
Trichloroethylene	952.0	19
Tetrachloroethylene	385.0	12
Chlorobenzene	1.0	1
Benzene	--	0
Toluene	2.0	2
Ethylbenzene	--	0

Overall water quality in the principal aquifers of the State generally is suitable for public supply, with the exception, perhaps, of the Mount Simon aquifer, where the increase in mineralization with depth makes it unsuitable as an independent water-supply source. To reduce mineralization in the public-supply system, water from this aquifer usually is blended with water from other aquifers.

The sand and gravel aquifers are the aquifers of greatest use in Illinois, providing 51 percent of the ground water used in public-supply systems. Nearly all ground water withdrawn for rural use is obtained from these aquifers. Most of the water contains elevated concentrations of iron, and one-third or more of the public-supply wells sampled contained concentrations of dissolved solids and manganese well above the State general-use and public- and food-processing water-supply standards. Volatile organic compounds were detected in 172 samples from 124 wells open to the sand and gravel aquifers--the only aquifers in which soluble organic compounds were detected.

Water from the Pennsylvanian-Mississippian aquifer contained concentrations of inorganic constituents similar to those in the sand and gravel aquifers, but with a much lower incidence of contamination by volatile organics. Dissolved-solids and iron concentrations exceeded the State standards for general-use and public- and food-processing water supplies in about 20 percent of the samples, and manganese concentrations exceeded the State standards for public- and food-processing water supplies in 9 percent of the samples. Only 8 of 91 samples collected from wells open to the Pennsylvanian-Mississippian aquifer contained volatile organic compounds.

Only 1.8 percent of the samples from the shallow dolomite aquifer, which is highly utilized in northeastern Illinois, contained manganese concentrations that exceeded the State public- and food-processing water-supply standards. In one-fourth of the samples from this aquifer, iron and sulfate concentrations exceeded the State general-use and public- and food-processing water-supply standards. Sixty-two samples from 55 wells open to this aquifer contained detectable levels of volatile organic compounds.

The combined Cambrian-Ordovician aquifers and Mount Simon aquifer also are highly utilized in the northern one-third of Illinois. Because of increased mineralization with depth, public-supply wells open to the Mount Simon aquifer also are open to the overlying Cambrian-Ordovician aquifers. Dissolved-solids concentrations exceeded Illinois' public- and food-processing water-supply standards in one-fourth of the samples; barium concentrations exceeded those standards in 9 percent of the samples from these aquifers. Volatile organic compounds were detected in 63 samples from 57 wells open to these aquifers. Concentrations of tri- and tetra-chloroethelene were among the highest ever detected for a volatile organic compound.

Current data indicate that organic contamination from human-induced conditions is not a widespread problem in Illinois, although it can be implicated in ground-water contamination in some areas. Elevated concentrations of iron, manganese, dissolved solids, and, to a lesser extent, sulfate, barium, chloride, and fluoride, which are present in many aquifers in the State, appear to be of natural origin. Concentrations of these constituents can be reduced or removed by water treatment and the water utilized as a source for water supply.

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