ILLINOIS
Ground-Water Quality

Illinois contains abundant water resources. About one-third of the water withdrawn in 1984 for public water-supply systems was from ground-water sources. Public water supplies furnish 88.7 percent (10.2 million) of the State's 11.5 million people (fig. 1) with potable water; ground water supplies about 3.7 million people. An additional 1.3 million people have their own supply of potable water, nearly all of which is ground water (Kirk and others, 1985). Ground-water quality in the principal withdrawal areas (fig. 2) of the State generally does not exceed the drinking-water standards established by the Illinois Pollution Control Board (1984a,b). Ground water in Illinois generally is very hard, and concentrations of iron and manganese commonly exceed the State standard. However, these conditions can be treated and water use is not impaired.

Ground-water quality has been degraded in several areas of the State (fig. 3). The degradation commonly has been associated with urbanization and waste-disposal practices. Although these are not the only sources of contamination in Illinois, they are the ones more readily observed and monitored. Waste disposal is a particularly serious concern, for it may affect all sectors of the State's population and economy. These sources of potential contamination include industrial wastes, municipal landfills, human and animal wastes, oil-field brine and impounded waste.

In 1984, the U.S. Geological Survey and the Illinois Environmental Protection Agency (IEPA), with assistance from the Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS), began a systematic approach to ground-water-quality data collection. The resultant ground-water-quality observation network includes the first statewide sampling for volatile organic compounds (VOC) of all public water-supply wells in Illinois. A smaller subset of wells is being sampled for pesticides. As of July 1986, 1,100 public water-supply wells had been sampled. Before this program, data were collected in response to State regulations requiring compliance with drinking-water standards and the collection did not always consider location or source aquifer. Changes and improvements in analytical procedures and differences in procedures between laboratories complicated data comparisons.

WATER QUALITY IN PRINCIPAL AQUIFERS

There are five principal aquifers in Illinois (fig. 2)—the sand-and-gravel, Pennsylvanian-Mississippian, shallow dolomite, Cambrian-Ordovician, and Mount Simon (U.S. Geological Survey, 1985, p. 199). More than half of the State's ground-water withdrawals are from the sand-and-gravel aquifers. Withdrawals from the combined Cambrian-Ordovician and Mount Simon aquifers account for about 28 percent of the ground-water withdrawal; the shallow dolomite aquifer about 16 percent; and the Pennsylvanian-Mississippian aquifers about 5 percent. In 1984, ground-water withdrawals in Illinois were estimated to be 1,100 Mgal/d (million gallons per day), and the largest percentage (43 percent) was withdrawn for public water supply. About 54 percent of all ground-water withdrawals in the State are for public supply and rural-domestic use (Kirk and others, 1985).

Natural water quality from some zones of some aquifers is undesirable in several parts of the State. The Cambrian-Ordovician and Mount Simon aquifers are not used in the southern two-thirds of the State because concentrations of dissolved solids are larger than 10,000 mg/L (milligrams per liter).

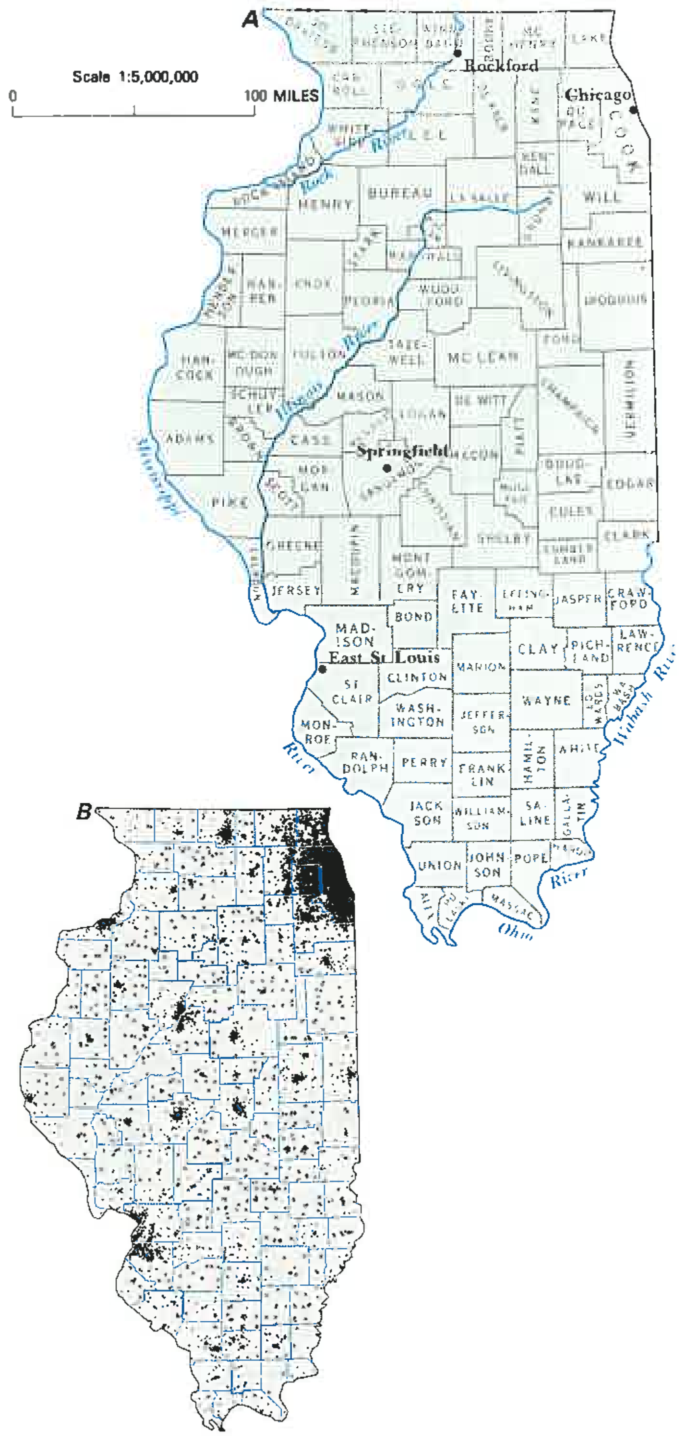

Figure 1. Selected geographic features and 1985 population distribution in Illinois. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files, adjusted to the 1985 U.S. Bureau of the Census data for county populations.)

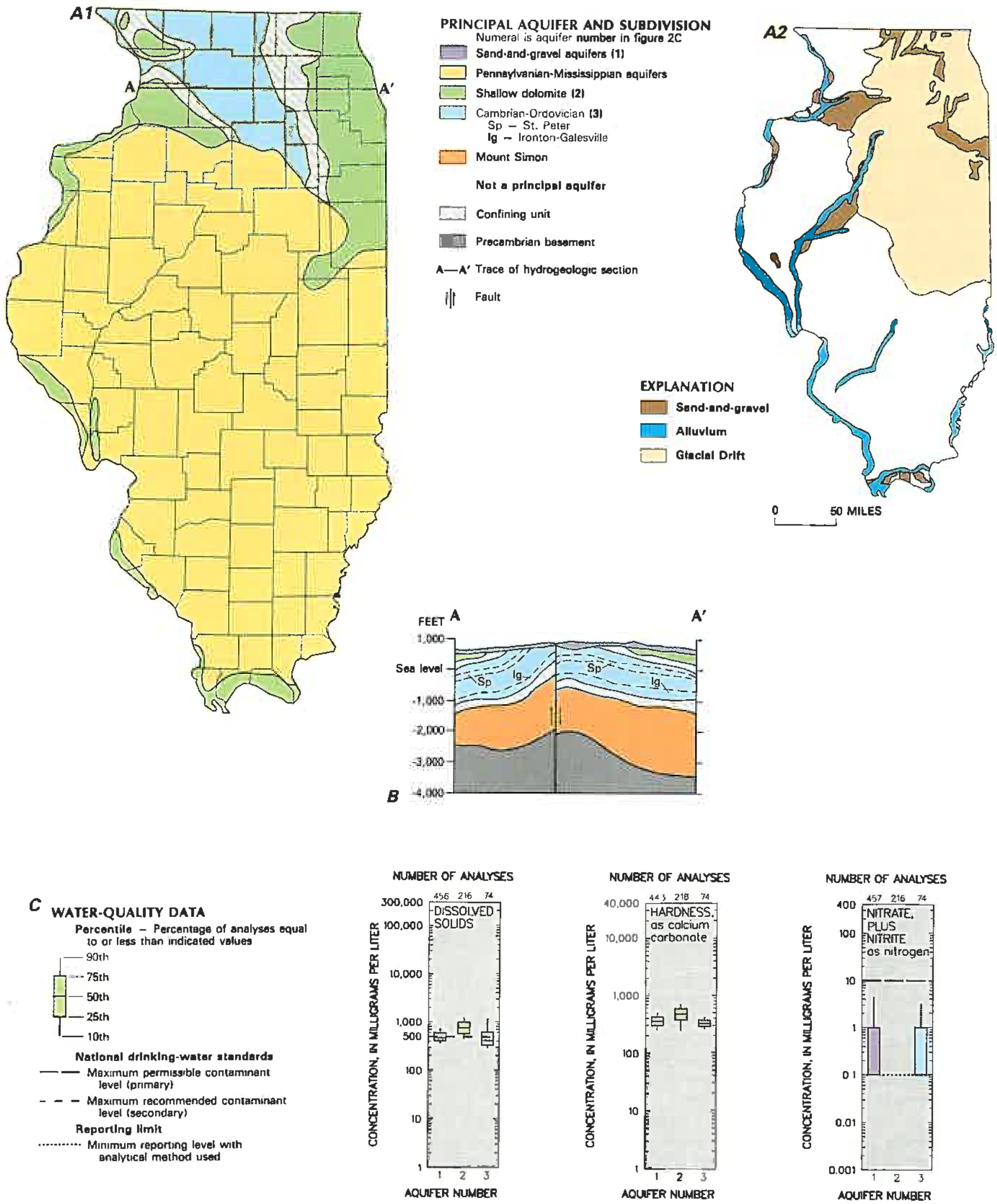

Figure 2. **Principal aquifers and related water-quality data in Illinois.** *A1*, Principal aquifers; *A2*, Surficial deposits. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, as of June 1986. (Sources: *A1*, Willman and others, 1967. *A2*, Willman and others, 1975. *B*, U.S. Geological Survey, 1985. *C*, Analyses compiled from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986a, b.)

Radioactivity from naturally occurring radionuclides such as radium has been observed in the Cambrian-Ordovician and Mount Simon aquifers in parts of northern Illinois (Gilkeson and others, 1983, 1984) and in two smaller areas in the Pennsylvanian-Mississippian aquifer in southern Illinois (Illinois Environmental Protection Agency, 1986) (fig. 3*B*). The ISGS is continuing to study naturally occurring radioactive contaminants in the State.

Recently, attention has focused on arsenic in some drinking-water supplies in the central part of Illinois. Larger than average arsenic concentrations, some exceeding the State standard (0.05 mg/L), have been detected in the sand-and-gravel aquifers. Two public water supplies in Macon County and some private wells in Tazewell County have reported arsenic concentrations that may threaten use of the water. Investigations are currently (1986) underway to define the affected area and determine the source.

Historical ground-water-quality data before 1984 lacked documented quality assurance and have sampling bias. Except for compliance monitoring, ground-water-quality work generally was done in response to "problems"; wells producing "good" water were less likely to be sampled (Frost and others, 1984). Information about private domestic wells was mainly from voluntarily submitted samples, not always identified with regard to location, aquifer, or well sampled. In 1984, the U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency (EPA) initiated a ground-water sampling network that will include all 3,427 public water-supply wells in the State.

BACKGROUND WATER QUALITY

A graphic summary of selected water-quality variables compiled from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) is presented in figure 2*C*. The summary is based on dissolved-solids, hardness (as calcium carbonate), nitrate plus nitrite (as nitrogen), iron, and sulfate analyses of water samples collected from 1984 to 1986 from the principal aquifers in Illinois as part of the ground-water-quality observation network. Percentiles of these variables are compared to national standards that specify the maximum concentration or level of a contaminant in drinking-water supply as established by the U.S. Environmental Protection Agency (1986a, b). The primary maximum contaminant level standards are health related and are legally enforceable. The secondary maximum contaminant level standards apply to esthetic qualities and are recommended guidelines. The primary drinking-water standards include maximum concentrations of 10 mg/L nitrate (as nitrogen), and the secondary drinking-water standards include maximum concentrations of 500 mg/L dissolved solids, 300 μg/L (micrograms per liter) iron, and 250 mg/L sulfate. For nitrate, dissolved solids, and sulfate the State drinking-water standards are the same as the national standards. The State standard for iron is 1,000 μg/L.

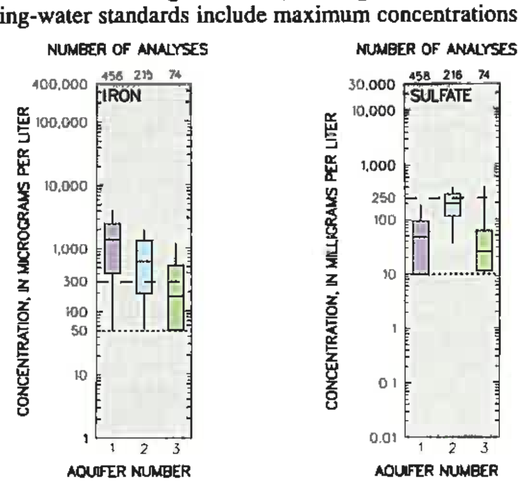

Figure 2. Principal aquifers and related water-quality data in Illinois—Continued.

Sand-and-Gravel Aquifers

Collectively, the sand-and-gravel aquifers in Illinois are the largest source of water for domestic supplies. Although extensively distributed throughout the State, individual aquifers can differ greatly in depth and yield. The largest yields generally are obtained from outwash sand and gravel in major glacial valleys (U.S. Geological Survey, 1985, p. 199–204). Water-quality data (fig. 2*C*) for the sand-and-gravel aquifers are not differentiated by sample depths, aquifer origins, or geographic locations but represent public water-supply wells open to various sand-and-gravel units throughout the State.

Water in these aquifers is of generally good quality for most uses. Dissolved-solids concentrations generally range from about 360 to 750 mg/L, and the median concentration does not exceed the 500-mg/L advisory level set by the State for drinking water (Illinois Pollution Control Board, 1985). In some areas of the State, historical data indicate dissolved-solids concentrations larger than 800 mg/L. Some of the smallest dissolved-solids concentrations are in areas with sandy soils where infiltration of precipitation is rapid (Gibb and O'Hearn, 1980). During the growing season, areas with sandy soils have a large amount of ground water withdrawn for irrigation.

The hardness of waters in the sand-and-gravel aquifers generally is about 250 to 510 mg/L as calcium carbonate. The median concentration of hardness is about 360 mg/L, which generally is considered to be very hard water.

Nitrate plus nitrite concentrations do not exceed the State standard of 10 mg/L throughout the sand-and-gravel aquifers, except for some isolated locations. Of more than 450 samples from public water-supply wells, only 2 samples exceeded the State standard for nitrate. Larger nitrate plus nitrite concentrations may be more common in shallow private wells that have inadequate protection from septic systems, fertilizer usage, or animal wastes. However, this information is not well documented.

Iron concentrations in the sand-and-gravel aquifers are extremely variable. Generally, iron concentrations range from about 50 to 4,100 μg/L. Gibb and O'Hearn (1980) indicate that iron concentrations are smallest in samples from the shallow drift wells in the northern part of the State and along the Illinois River valley, whereas concentrations are larger in southern Illinois. Most iron concentrations in water from the drift exceed the State drinking-water standard of 1,000 μg/L. However, current water-treatment practices make these waters usable for public water supplies. Manganese concentrations throughout the State follow a pattern similar to that for iron.

Sulfate concentrations generally do not exceed the State advisory level of 250 mg/L. The median concentration of sulfate is about 50 mg/L.

Pennsylvanian-Mississippian Aquifers

Four-fifths of the bedrock surface in Illnois is formed by sedimentary rocks of Pennsylvanian and Mississippian age (U.S. Geological Survey, 1985, p. 200). Although fairly extensive in area, this aquifer yields amounts of water that generally are sufficient only for small supplies. Very few data are available on the quality of water from this aquifer.

Dissolved-solids concentrations are extremely variable and range from about 500 to about 3,000 mg/L (Gibb and O'Hearn, 1980), well in excess of the State's advisory level. Some of the variability is attributable to increased mineralization with depth owing to longer residence times of water in the aquifer. Hardness also is extremely variable, ranging from 150 to 400 mg/L in north-central Illinois and from to 150 to 1,000 mg/L in southern Illinois. Hardness generally is similar to that in water from the overlying glacial drift. Iron concentrations generally range from 1,000 to 5,000 μg/L. Sulfate concentrations generally are less than 5 mg/L (Gibb and O'Hearn, 1980).

Shallow Dolomite Aquifer

The shallow dolomite aquifer of northeastern Illinois has been studied extensively. Dissolved-solids concentrations generally exceed the State advisory level, and the most recent analyses indicate a range of about 400 to 1,200 mg/L. Few nitrate plus nitrite concentrations exceed 6 mg/L. Hardness values have a relatively broad range; concentrations range from about 200 to almost 700 mg/L and the median is 470 mg/L. The median iron concentration in this aquifer is about 610 μg/L, although several samples had concentrations that exceeded the State standard. Sulfate concentrations range from about 35 to 380 mg/L (Gibb and O'Hearn, 1980).

Cambrian-Ordovician Aquifer

The Cambrian-Ordovician aquifer provides much of the ground-water supply in the northern one-third of Illinois. The water quality in this aquifer generally is suitable for most uses. Visocky and others (1985) analyzed the Cambrian-Ordovician system in Illinois. Their report presents information on the geology, hydrology, and water quality of this system in northern Illinois.

Water in the unconfined zone of this aquifer has relatively small dissolved-solids concentrations; however, in the confined units, concentration differences may occur either vertically or horizontally. Gibb and O'Hearn (1980) report that dissolved-solids concentrations range from 250 to 400 mg/L and increase downgradient in the aquifer. Analyses of samples collected from 1984 to 1986 indicate dissolved-solids concentrations in the Ironton and Galesville Sandstones of Cambrian age ranging from 290 to 1,180 mg/L.

Hardness generally ranges from 260 to 420 mg/L. Iron concentrations generally are smaller than 500 μg/L and appear to be regionally uniform. Sulfate concentrations generally do not exceed the 250-mg/L State advisory level.

Mount Simon Aquifer

The Mount Simon aquifer is overlain by and hydraulically connected to the lower Eau Claire Sandstone of Cambrian age. The upper part of the Mount Simon aquifer in most of northern Illinois contains water of quality similar to that in overlying units in the Cambrian-Ordovician aquifer. Generally, water-supply wells tapping the Mount Simon aquifer are also open to the overlying aquifers. Wells completed in the Mount Simon aquifer generally penetrate only the upper sections of the aquifer because dissolved-solids concentrations increase with depth.

Effects of Land Use on Water Quality

Contaminants from several sources have affected ground-water quality in Illinois. Sources may include, but are not limited to, industrial wastes, municipal landfills, agricultural chemicals, septic-system effluents, oil and gasoline leaks, animal wastes, acid-mine drainage, oil-field-brine wastes, road salts, hazardous-waste disposal, and waste impoundments. Waste sites are shown in figures 3*A* and 3*C*, and human-induced contamination is shown in figure 3*B*. Figure 4 illustrates how trends in concentrations of dissolved solids have increased in three areas.

Waste Sites

Waste sites shown in figure 3*A* include 14 Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) sites listed on the EPA's National Priority List (NPL) for 1986; 38 Resource Conservation and Recovery Act (RCRA) hazardous-waste disposal facilities; 3 U.S. Department of Defense (DOD) facilities; waste sites listed for cleanup through such programs as the State Remedial Action Priority List (SRAPL) and the Immediate Hazardous Waste Removal Program (IHWRP); and 4 sites at which deep-well injection of hazardous wastes is occurring through the Underground Injection Control (UIC) Program (U.S. Environmental Protection Agency, 1984). Although all these sites are considered to be potential sources of ground-water contamination, not all are known to have current contamination problems.

As of September 1985, 87 hazardous-waste sites at six facilities in Illinois had been identified by the DOD as part of their Installation Restoration Program (IRP) as having potential for contamination (U.S. Department of Defense, 1986). The IRP, established in 1976, parallels the EPA Superfund program under CERCLA. EPA presently ranks these sites under a hazard ranking system and may include them in the NPL. Of the 87 sites in the program, 38 contained contaminants but did not present a hazard to the environment. Six sites at three facilities (fig. 3*A*) were considered to present a hazard significant enough to warrant response action in accordance with CERCLA. The remaining sites were scheduled for confirmation studies to determine if remedial action is required.

Urbanization and Industry

In northeastern Illinois (fig. 3*B*, area A), westward expansion of the Chicago suburbs has increased the demand for ground water. Increased pumpage in this area has lowered the regional water levels in the shallow dolomite and Cambrian-Ordovician aquifers, necessitating the drilling of wells to greater depths to obtain adequate water supplies. Concerns have been raised about the transfer of saline water between aquifers through the deeper wells, especially those open to both the Cambrian-Ordovician and the Mount Simon aquifers.

In north-central Illinois, several problems, including contamination by nitrate and VOC have been identified in the near-surface sand-and-gravel aquifers (fig. 3*B*, area B). Wehrmann (1983) studied an area north of Rockford, Ill., where nitrate concentrations exceeded State standards. The increased nitrate concentrations were associated with septic-tank wastewaters and areas of agricultural fertilizer usage.

VOC have also been detected in some wells in area B throughout Boone and Winnebago Counties. The city of Rockford has had a sampling program for monitoring organic constituents since 1983. Several wells have been closed, owing to contamination by VOC. VOC detected in ground-water samples from Winnebago County include tetrachloroethlyene, tribromomethane (bromoform), trichloromethane (chloroform), dichloroethane, dichlorobromomethane, trichloroethylene, and chlorodibromomethane. The area is densely populated (fig. 1*B*) and extensively industrialized, with accompanying activities that may contribute to ground-water contamination.

The area around East St. Louis, locally known as the American Bottoms (fig. 3*B*, area C), has long been favored for ground-water use. Because of plentiful ground water, the area became urbanized as a result of industry relocation there. Water use increased and water quality of the sand-and-gravel aquifer deteriorated, owing to the effects of urbanization and industrialization (fig. 4). Voelker (1984) reported that iron, sulfate, and dissolved-solids concentrations exceeded State standards in most of the area. Nitrate plus nitrite concentrations have increased in areas where rising water levels have intercepted and damaged sewer lines and septic systems that were installed during periods of lower water levels. Additionally, the vast amount of oil refining in the area has resulted in seepage of some petroleum by-products into

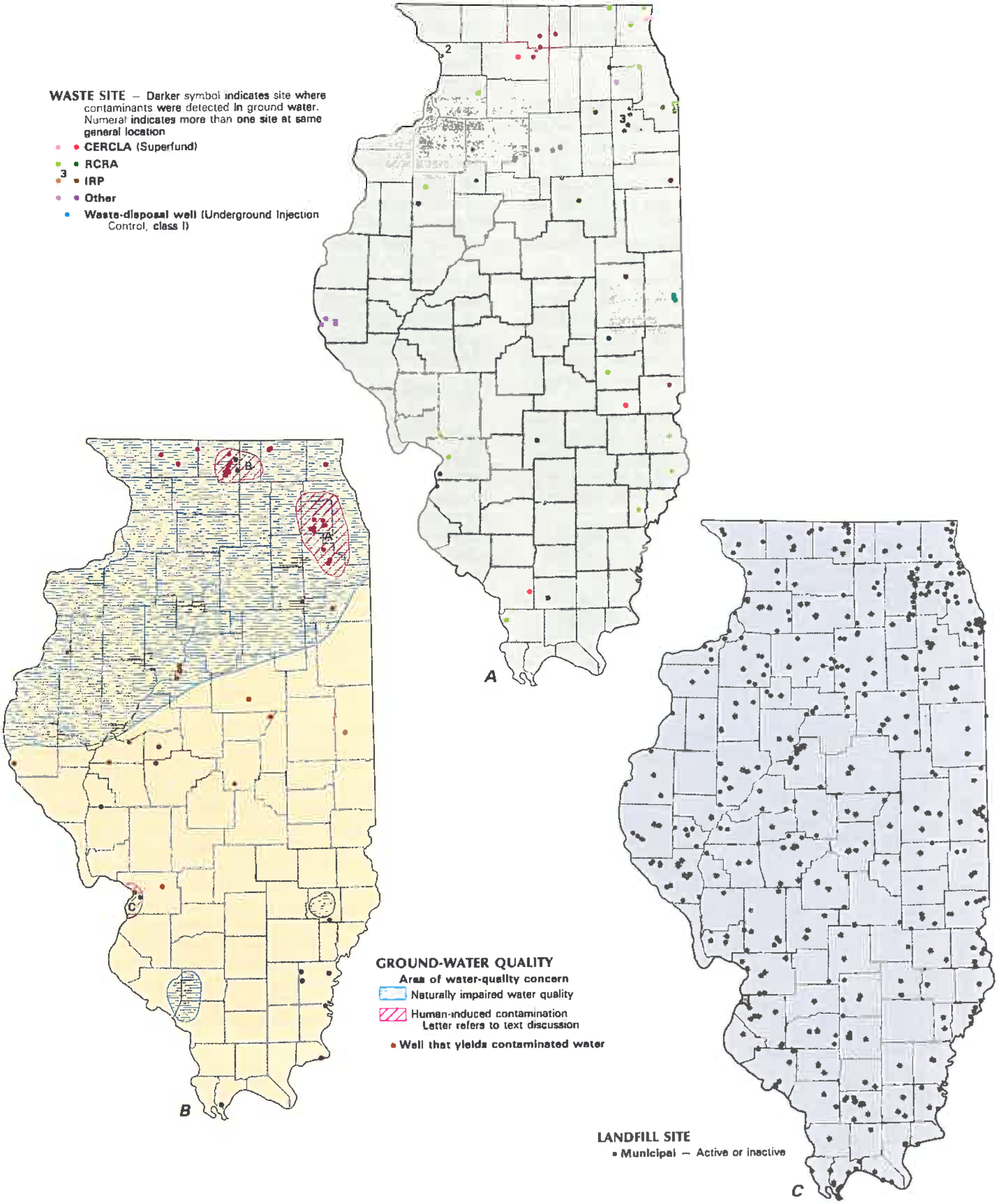

Figure 3. **Selected waste sites and ground-water-quality information in Illinois.** *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of 1986; Department of Defense Installation Restoration Program (IRP) sites, as of 1985; and other selected waste sites, as of 1986. *B*, Areas of naturally impaired water quality, areas of human-induced contamination, and distribution of wells that yield contaminated water, as of 1986. *C*, Municipal landfills, as of 1986. (Sources: *A*, Dixon and others, 1986; D.J. Yeskis, U.S. Environmental Protection Agency, written commun., 1986; U.S. Department of Defense, 1986. *B*, Voelker, 1984; R.P. Clarke, Illinois Environmental Protection Agency, oral commun., 1986. *C*, Dixon and others, 1986.)

the ground water. In an effort to remedy these potentially hazardous conditions, "skimmer" wells have been used in some areas to remove these compounds from the ground-water surface.

Potential for Water-Quality Changes

The effects noted in the preceding section have generally been associated with urbanization and industrialization where the demand for ground water is large. Urbanized areas overlying relatively shallow aquifer systems such as the sand-and-gravel or shallow dolomite aquifers probably present the greatest potential for water-quality degradation. Areas most susceptible to ground-water contamination have been mapped by the Illinois State Geological Survey (Berg and others, 1984) in an attempt to delineate areas of the State where monitoring needs are greatest (Shafer, 1985).

In addition to waste disposal in the densely urbanized and industrialized areas of the State, most towns and cities have disposed of nearly all types of waste materials in municipal landfills (fig. 3*C*). Ground-water contamination has been detected at some sites adjacent to landfills. Some landfills are located in recharge areas and have the potential for contaminating some downgradient parts of underlying aquifers.

Agriculture is of major economic importance within the State and has the potential for affecting water quality over wide geographic areas. Fertilizers, herbicides, and insecticides are stored, transported, and applied over large areas that include recharge areas. In addition to potential contamination by these agricultural chemicals, surficial aquifers of the State also are susceptible to changes caused by irrigation and to contamination by animal wastes and effluent from inadequate septic systems. An estimated 97 percent of rural-domestic water systems are supplied from shallow aquifers.

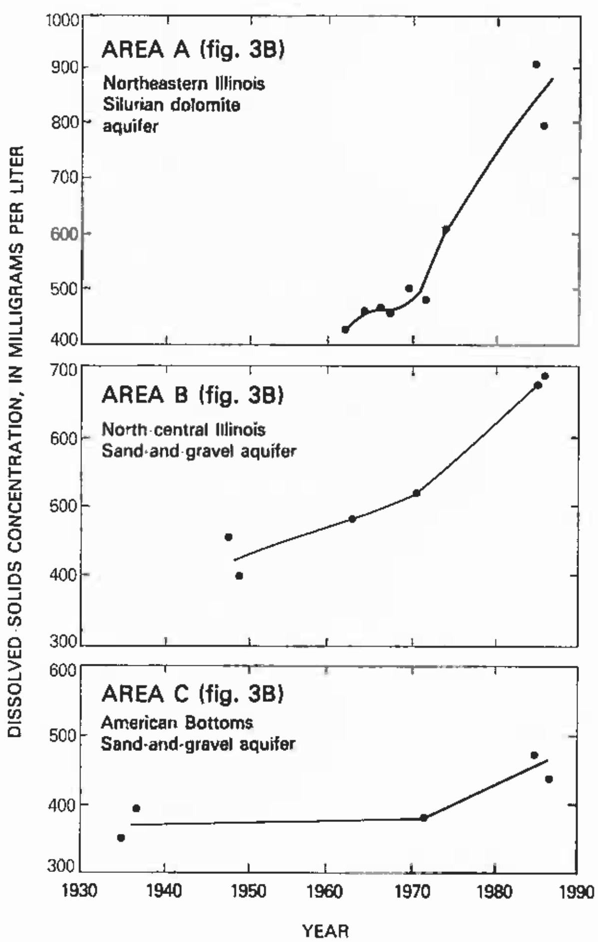

Figure 4. Long-term fluctuations of dissolved solids in ground water from three Illinois areas with known water-quality problems. (Source: S.C. Schock, Illinois State Water Survey, written commun., 1986.)

Illinois also is a major producer of oil, gas, and coal. Thousands of oil and gas wells are located throughout Illinois, with most being in the southern one-third of the State. Brine-waste impoundments have been associated with many of the production wells, and salinity has increased in nearby water-supply wells, but documentation is scarce. These impoundments are now banned in Illinois, and wastes presently are being injected below current and potential water supplies through disposal wells.

Coal production has resulted in surface-mined areas in much of southern, western, and east-central Illinois that may also be a threat to shallow aquifers. Investigations such as that by Borghese and Klinger (1984) have identified some of the effects of mining on ground-water quality, but additional work is needed. Acid-mine drainage also may be a threat to ground-water quality.

GROUND-WATER QUALITY MANAGEMENT

The issue of ground-water protection was brought to the attention of the Illinois State Water Plan Task Force in 1981. The Task Force issued a report (Illinois State Water Plan Task Force, 1984) that recommended a coordinated, multiagency policy and framework for action. The Illinois General Assembly recognized the need for a statewide problem assessment and for an action plan. Public Act 83–1268 was passed to respond to the need for monitoring, assessing, and resolving ground-water problems, and for developing a unified, statewide, ground-water protection plan. The IEPA (1986) proposed a core program to prevent future ground-water contamination and to correct current problems. Additionally, Public Act 83–1268 directed the Illinois Department of Energy and Natural Resources to prepare a study on ground-water quality by July 1985; the IEPA was directed to conduct a statewide monitoring program and develop a ground-water protection plan by January 1986.

The IEPA developed "A Plan for Protecting Illinois Groundwater" in 1986, and submitted it to the Governor, General Assembly, and Pollution Control Board. Governor James R. Thompson established a task force under the guidance of his Subcabinet for Natural Resources. This ground-water task force was scheduled to submit its findings for legislative, budgetary, and regulatory initiatives to the Governor by January 1, 1987.

Part of the IEPA's plan was a 5-year program to address ground-water protection. This time frame was suggested because several important and related programs would be operating concurrently. These programs include (1) the recently reauthorized Federal RCRA program, (2) the Build Illinois program, and (3) the Federal CERCLA (Superfund) program. The time frame is sufficient to anticipate significant progress within existing programs and to establish new programs where necessary.

Within this time, the IEPA recommends the following five-part plan:

1. Clarify goals and objectives for ground-water protection in Illinois including legislative and regulatory actions. This part would focus on application of standards and determination of differential or uniform protection needs.

2. Operate appropriate ground-water monitoring programs including the first statewide sampling of VOC in public water-supply wells and networks for pesticide monitoring.

3. Continue to address suspected and (or) known contamination problems by taking advantage of the "Build Illinois" initiative.

4. Implement technology based on programs for land pollution control that focus on waste decrease and reuse. A special program on leaking underground storage tanks will be initiated.

5. Establish a statewide program for ground-water source protection that requires legislation to do the following:

   - Designate potential ground-water contamination sources;
   - Establish a well-site protection effort including siting prohibitions;
   - Establish a local plan for recharge-area protection;
   - Require new potential-contamination sources to be reported to the IEPA; and
   - Assure continued water supply or replacement thereof if contamination occurs.

The current focus is to finalize the proposed program, thereby providing information and protection in support of current and future ground-water programs. In addition, considerable effort will be made to assure that all Federal Safe Drinking Water Act amendments are incorporated in the new Illinois ground-water-protection programs.

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Natural gas powered centrifugal pump used to irrigate crops in Mason County, Illinois. The County has extensive pumpage for irrigation from the shallow sand and gravel aquifer in the area (Photograph by Walter Lembke, Department of Agricultural Engineering Sciences, University of Illinois.)

Prepared by David C. Voelker, U.S. Geological Survey, "Ground-Water-Quality Management" section by Robert P. Clarke, Illinois Environmental Protection Agency

FOR ADDITIONAL INFORMATION: District Chief, U.S. Geological Survey, 102 E. Main Street, 4th Floor, Urbana, IL 61801