Arkansas
Ground-Water Quality

In Arkansas, ground water is the major source for public-supply and rural self-supplied systems; about 55 percent of the population (fig. 1) depends on ground water (Harold Seifert, Arkansas Department of Health, written commun., 1986). Water quality in the principal aquifers (fig. 2) is acceptable for most uses; however, in many areas of the State the water contains undesirably large concentrations of iron and hardness.

Degradation of water quality in several areas, commonly reflected in increased dissolved-solids or nitrate concentrations, is associated with urbanization, irrigation, and waste disposal (fig. 3). Organic contamination also has been detected in the shallow zones of some aquifers. Possible sources of contamination include underground storage tanks, surface impoundments, saline aquifers, irrigation returns, landfills, and septic tanks.

Twenty-six hazardous-waste sites require monitoring of ground-water quality under the Federal Resource Conservation and Recovery Act (RCRA) of 1976 or are included in the National Priorities List (NPL) of Superfund hazardous-waste sites identified by the U.S. Environmental Protection Agency (1986c) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. As of September 1985, 13 sites at 2 Federal facilities were planned for confirmation studies to determine if remedial action is required.

Monitoring of ground-water quality is increasing. In 1937 the Arkansas Department of Health began a ground-water-quality monitoring program for public water supplies. This program currently (1986) includes 793 wells. Several inorganic constituents are monitored, as mandated by the Safe Drinking Water Act; an increasing number of organic constituents also are monitored. In 1969, the U.S. Geological Survey, in cooperation with the Arkansas Geological Commission, established a water-quality network to monitor constituents in the principal aquifers of the State. Samples taken from this 25-well network are analyzed for inorganic, organic, radiochemical, and bacteriological constituents. These wells are sampled on a 5-year rotational basis. The Arkansas Department of Pollution Control and Ecology (ADPCE) is now (1986) establishing a ground-water-quality network as part of its responsibilities in administering its Ground Water Protection Strategy.

WATER QUALITY IN PRINCIPAL AQUIFERS

Most of the ground-water supplies in the State are obtained from six aquifers or aquifer systems—the alluvial, the Cockfield, the Sparta, the Wilcox, and the Nacatoch aquifers, and the Ozark aquifer system (fig. 2*A*1, 2*B*). These aquifers are regionally significant and, except for rural-domestic supplies, constitute the source of nearly all ground-water withdrawals in the State.

Because wells are drilled primarily where these aquifers are known to contain freshwater, most water-quality data are from these areas. Therefore, the following water-quality summary is based on information principally from areas having water quality that is suitable for most uses.

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, nitrate plus nitrite (as nitrogen), chloride, and iron analyses of water samples collected from 1945 to 1986 from the principal aquifers

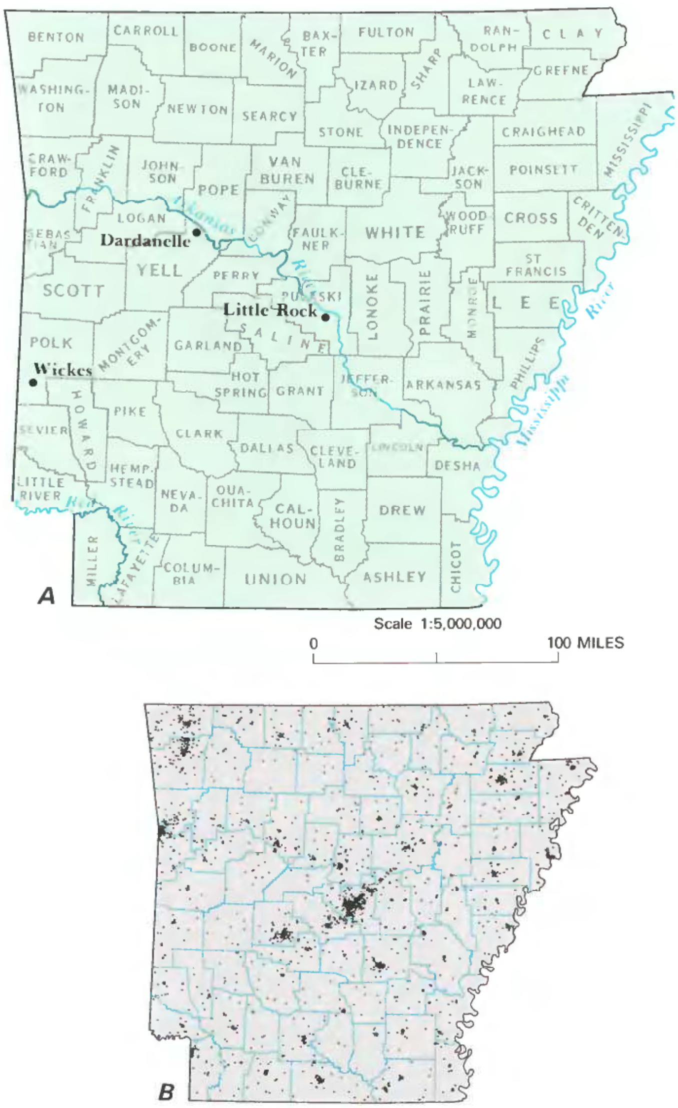

Figure 1. Selected geographic features and 1985 population distribution in Arkansas. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files, adjusted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

in Arkansas. 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 a maximum concentration of 10 mg/L (milligrams per liter) nitrate (as nitrogen), and the secondary drinking-water standards include maximum concentrations of 500 mg/L dissolved solids, 250 mg/L chloride, and 300 μg/L (micrograms per liter) iron.

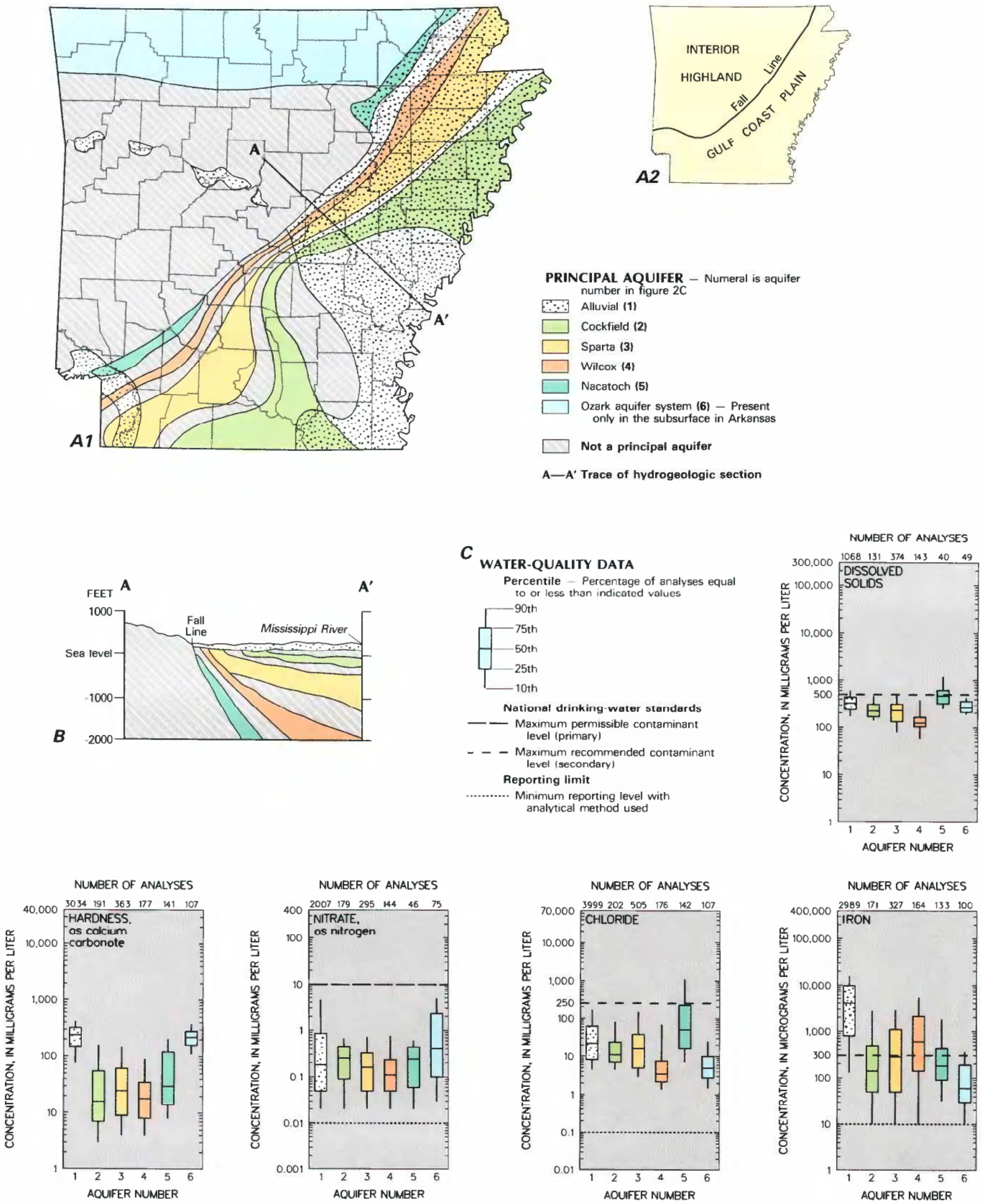

Figure 2. **Principal aquifers and related water-quality data in Arkansas.** *A1*, Principal aquifers; *A2*, Physiographic provinces. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, as of 1945-86. (Sources: *A1*, U.S Geological Survey, 1985; *A2*, Fenneman, 1938; *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.)

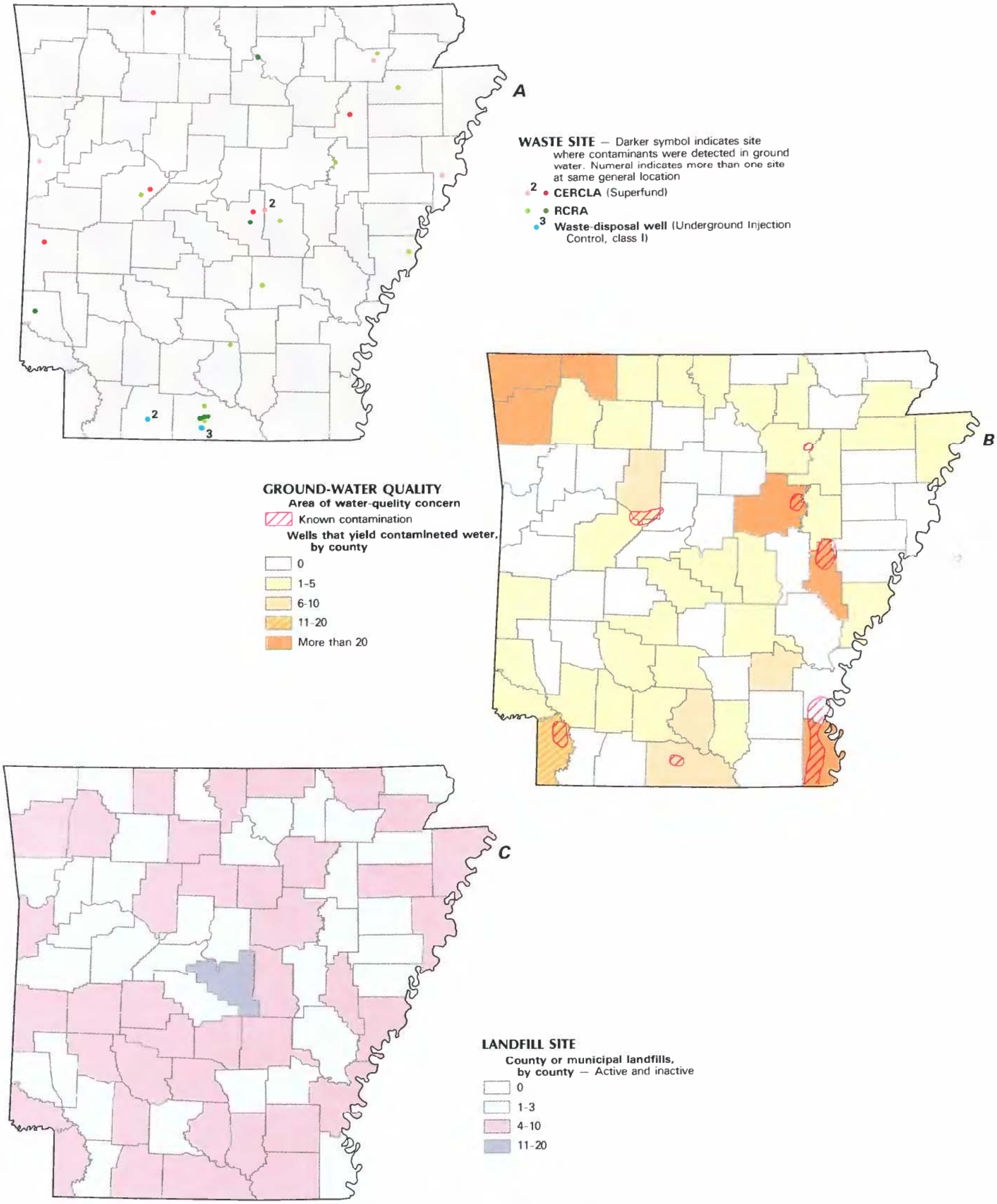

Figure 3. Selected waste sites and ground-water-quality information in Arkansas. *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites; Resource Conservation and Recovery Act (RCRA) sites; and other selected waste sites, as of 1986. *B*, Areas of known contamination and distribution of wells that yield contaminated water, as of 1986. *C*, County and municipal landfills, as of 1986. (Sources: *A*, U.S. Environmental Protection Agency, 1986c; Arkansas Department of Pollution Control and Ecology files. *B*, U.S. Geological Survey files; Arkansas Department of Health files; Cox and others, 1980; MacDonald and others, 1976. *C*, Arkansas Department of Pollution Control and Ecology files; U.S. Geological Survey files.)

Alluvial Aquifer

Alluvium is the principal source of water for irrigation in Arkansas, making it the most intensively used aquifer in the State. Alluvial deposits blanket much of eastern Arkansas, the Red River Valley in southwestern Arkansas, and isolated areas along the Arkansas River in the Interior Highlands (fig. 2*A*1). Generally, water from the alluvial aquifer is of acceptable quality for irrigation and, with treatment, for public supply (fig. 2*C*).

The median dissolved-solids concentration is 330 mg/L, which is much smaller than the limit of 1,000 mg/L commonly used to judge the suitability of water for irrigation—however, concentrations are about 4,000 mg/L in parts of Chicot, Desha, Miller, Monroe, Independence, and White Counties, making water in these areas unsuitable for most purposes.

Hardness and iron concentrations can be undesirably large. With a median hardness concentration of 240 mg/L, much of the water within the alluvium is very hard. This hardness, coupled with median iron concentration of 4,000 μg/L, makes this water undesirable for public supply and rural-domestic use without significant treatment.

The median concentration of nitrate in water from the alluvium is 0.18 mg/L, but the maximum value measured was 67 mg/L, which far exceeds the drinking-water standard. Increased nitrate concentrations in the shallow alluvium usually result from a leaking septic tank or a surface source such as a feedlot which affects the well.

Chloride concentrations generally do not exceed drinking-water standards, except in parts of Chicot, Desha, Miller, Monroe, Independence, and White Counties. Increased chloride concentrations usually are associated with increased sodium.

Cockfield Aquifer

The Cockfield aquifer ranks fifth in total ground-water withdrawals in the State. It is present in much of eastern Arkansas and is a sole source for ground water in some areas. Its principal use is for public and rural-domestic supply, and generally the water is of good quality for these purposes (fig. 2*C*).

The median concentrations of water from the Cockfield aquifer are 220 mg/L dissolved solids, 16 mg/L hardness, 0.25 mg/L nitrate, 11 mg/L chloride, and 140 μg/L iron. Based on these values, the water generally is soft and does not exceed the drinking-water standards. Although most iron concentrations were considerably smaller than the 300-μg/L standard, more than 25 percent of the samples exceed the standard.

Sparta Aquifer

The Sparta aquifer ranks second in total ground-water withdrawals in the State. Located in much of the eastern half of the State, the aquifer is used extensively for industry and public supply and increasingly for irrigation. Generally, water of the Sparta aquifer is of good quality for drinking (fig. 2*C*).

The median concentrations for water from the Sparta aquifer are 226 mg/L dissolved solids, 25 mg/L hardness, 0.16 mg/L nitrate, 16 mg/L chloride, and 280 μg/L iron. Thus, the water is soft and generally does not exceed drinking-water standards. However, exceptions occur in Union County for dissolved solids and chloride. About half of the iron concentrations exceed the drinking-water standards, indicating that some treatment for iron removal might be necessary.

Wilcox Aquifer

The Wilcox aquifer occurs in most of the Gulf Coastal Plain of Arkansas, but is a major source of water only in northeastern Arkansas where it is known as the "1,400-foot sand." The aquifer is used primarily for public and industrial supplies and ranks fourth in total ground-water withdrawals in the State. The Wilcox aquifer has the best water quality of the six principal aquifers in the State (fig. 2*C*).

The median concentrations for dissolved solids, nitrate, and chloride are all considerably smaller than the drinking-water standards. More than 75 percent of the samples contained water that is soft. Only iron concentrations detract from an otherwise excellent water quality. About half of the measured iron concentrations are larger than 600 μg/L.

Nacatoch Aquifer

The Nacatoch aquifer underlies the Gulf Coastal Plain of the State but contains freshwater only in parts of northeastern and southwestern Arkansas (Petersen and others, 1985). It is used primarily for public and industrial supplies and ranks sixth in total ground-water withdrawals in the State. The Nacatoch aquifer has water quality that is marginally acceptable for rural-domestic and public supply (fig. 2*C*).

About half of the measured dissolved-solids concentrations of the Nacatoch aquifer exceed the drinking-water standard. The water ranges from soft to hard. The median concentration of nitrate (0.24 mg/L) indicates no general problem with surface contamination. About 25 percent of the chloride concentrations exceed the standard. Even though most iron concentrations are smaller than 300 μg/L, iron concentrations have exceeded the standard in a significant number of wells.

Ozark Aquifer System

The Ozark aquifer system, located in the Interior Highlands in the northern quarter of the State (fig. 2*A*1), ranks third in total ground-water withdrawals in the State (Holland and Ludwig, 1981). It consists of as many as 24 individual aquifers that may contribute significant amounts of water to a well. The water, which is used for public, industrial, and agricultural supplies, generally is of good quality for drinking (fig. 2*C*).

Less than 10 percent of the dissolved-solids values exceed the drinking-water standard. Hardness values indicate a hard to very hard water requiring treatment to decrease the calcium and (or) magnesium to acceptable levels. Nitrate concentrations, although generally smaller than 10 mg/L, indicate the possibility of surface contamination of some of the aquifers in the Ozark aquifer system. Bacteria concentrations in some areas also indicate contamination (MacDonald and others, 1976; Cox and others, 1980). Chloride and iron concentrations generally do not exceed the drinking-water standards.

EFFECTS OF LAND USE ON WATER QUALITY

Water quality has deteriorated in some areas because of the effects of urban and rural development, ground-water withdrawal, and waste-disposal practices. Investigations by the U.S. Geological Survey in cooperation with the Arkansas Geological Commission and the ADPCE have documented these changes (Morris and Bush, 1986; Fitzpatrick, 1985; Broom and others, 1984).

Urban and Rural Development

The area most affected by urban and rural development (fig. 1*B*) is northern and northwestern Arkansas in the Interior Highlands. The geology of this area is primarily limestone, dolomite, and sandstone with extensive fracture systems and solution channels. These openings allow surface water to rapidly infiltrate to the ground water. Therefore, without protective measures, facilities such as septic tanks, underground storage tanks, sewage lagoons, and chicken houses built in these areas have a significant potential of contaminating nearby ground water. The contamination may be detected as increased nitrate concentrations and unacceptable coliform bacteria concentrations. This type of contamination has been reported in Washington County (MacDonald and others, 1976), in Benton County (Cox and others, 1980), and in Carroll County (Harold Seifert, Arkansas Department of Health, oral commun., 1986) (fig. 3*B*).

In other areas of the State, contamination of public-supply wells by hydrocarbons has been reported. The source of this contamination is suspected to be underground storage tanks (Harold Seifert, Arkansas Department of Health, oral commun., 1986). The towns affected and dates of occurrence were Wickes in Polk County (1977) and Dardanelle in Yell County (1984) (fig. 1*A*).

Ground-Water Withdrawals

Ground-water withdrawals for irrigation, industrial, and public supply use have contributed to the deterioration of ground-water quality in Arkansas (fig. 3*B*), particularly in Chicot, Desha, Lincoln, Monroe, and Union Counties (Morris and Bush, 1986; Fitzpatrick, 1985; Broom and others, 1984). In some areas, withdrawals for irrigation have lowered the water table, allowing saline water from underlying aquifers to replace the freshwater. Consequently, chloride concentrations have increased by 3,700 percent in some areas. Chloride concentrations in water from a well located within the contaminated area of Monroe County (fig. 3*B*) increased from 22 mg/L in 1949 to 830 mg/L in 1975 (fig. 4). Significant, but less dramatic, changes have occurred in the other affected areas.

Waste-Disposal Practices

The RCRA list currently (1986) includes nearly 1,000 sites in the State where hazardous wastes are generated, stored, treated, or disposed. Of these sites, 16 are operated or have been operated as a hazardous-waste landfill, land treatment, or surface-impoundment unit that require ground-water monitoring programs for each hazardous-waste management facility (fig. 3*A*). The ADPCE has determined that shallow ground water has been contaminated at six of these sites. Ground-water-quality monitoring at the six sites has detected concentrations of arsenic, barium, cadmium, chromium, lead, mercury, nitrate, selenium, silver, polychlorinated biphenyls (PCB), pentachlorophenol (PCP), cresote products including chlorinated dibenzo-furan (CDF), ethylene dibromide (EDB), chloride, gasoline, oil, and tribromophenol; extreme values of pH also have been detected. At the other 10 sites either no contamination has been detected or monitoring data have not yet been evaluated (Gary Martin, Arkansas Department of Pollution Control and Ecology, oral commun., 1987). An additional 10 sites have been included in the NPL (U.S. Environmental Protection Agency, 1986c). Ground-water contamination has been detected at five of these CERCLA (Superfund) sites. Contaminants at one or more of these five sites include trichloroethene (TCE), tetrachloroethene (TTCE), benzene, chlorinated dibenzo-dioxin (CDD), (CDF), (PCP), arsenic, chromium, 2,3,7,8-TCDD (dioxin), chlorinated benzene, chlorinated phenol, and the herbicides 2,4-D and 2,4,5-T (Mark Satterwhite, U.S. Environmental Protection Agency, written commun., 1987).

Six Class I injection wells (fig. 3*A*) currently are regulated by the Underground Injection Control (UIC) Program (U.S. Environmental Protection Agency, 1984; David Thomas, Arkansas Department of Pollution Control and Ecology, oral commun., 1986), which is administered jointly by the ADPCE and the Arkansas Oil and Gas Commission. These wells are used for underground disposal of hazardous and nonhazardous waste.

POTENTIAL FOR WATER-QUALITY CHANGES

Ground-water problems could occur almost anywhere in the State. The potential for ground-water contamination by hazardous materials disposed on the land surface generally coincides with the

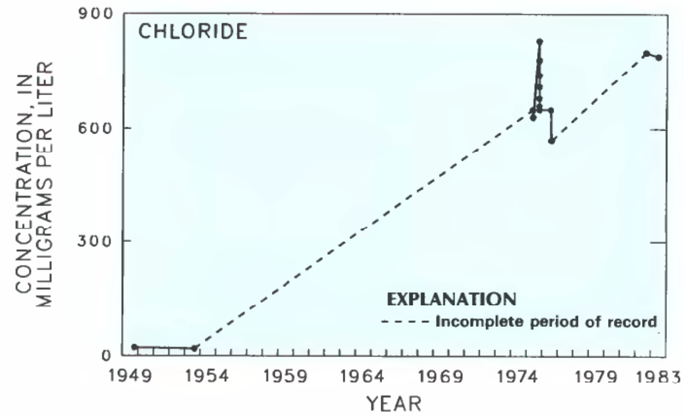

Figure 4. Change in chloride concentration in the alluvial aquifer, Monroe County, Arkansas 1949-83. (Source: U.S. Geological Survey files.)

rates of recharge to aquifers. Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground-water system. A more detailed discussion of aquifer contamination potential, with locations, is given by Bryant and others (1985).

Areas of large potential recharge are characterized by surficial material that readily allows infiltration of water. These include the surface of alluvial deposits, outcrop areas of confined aquifers, upland terrace deposits lacking a clay cap, and areas of extensive fracture systems or solution channels in the Interior Highlands. Areas of moderate recharge have surficial materials that retard the percolation of water or have a ground-water system that is capable of storing only limited amounts of water. Areas of small recharge potential have thick, relatively impermeable clays that lie directly beneath the land surface.

Several categories of waste have the potential to effect future changes in ground-water quality. Whether these wastes actually affect ground-water quality will be determined by the type of waste, the operation of disposal sites, and the location of sites with respect to ground-water recharge areas.

Waste-disposal sites in Arkansas generally can be categorized as petroleum industry, manufacturing and storage, municipal, military installation, and agricultural wastes. Waste at some of these sites has a greater chance of infiltrating a ground-water supply than others. A facility that temporarily stores wastes in containers for subsequent disposal offsite is less likely to affect ground water than one that stores long term in surface impoundments. As of 1979, more than 7,600 such impoundments were located in the State (Chesney, 1979).

Petroleum Industry

Waste sites commonly associated with petroleum industries are landfills, lined and unlined surface impoundments (6,000 according to Chesney, 1979), and land farms where wastes are treated, stored, or disposed. These wastes usually are acidic and contain trace metals, such as chromium and lead, and toxic organic chemicals such as toluene, benzene, and ethyl benzene. Several of these impoundments hold saline wastewater resulting from oil extraction operations. An estimated 20,000 acres of land has been damaged in southern Arkansas by saltwater and petrochemical residues (Arkansas Department of Pollution Control and Ecology, 1984). This water has a large potential for entering the shallow ground-water system. A second possibility for ground-water contamination lies in the abandonment of oil and gas test wells. Improperly plugged wells can leak saline water to the surface and to the overlying freshwater-bearing aquifers through which they were drilled.

Manufacturing and Storage

Products manufactured in Arkansas include fertilizers, herbicides and insecticides, clothing, paper, treated wood, metal-plating products, and many others. The waste associated with the production of these products includes chlorinated solvents, toluene, benzene, methanol, pesticides, arsenic, chromium, lead, pentachlorophenol, ethylene dibromide (EDB), and other metals and toxic organic chemicals.

Municipal

Municipalities are responsible for the treatment of domestic and, in many instances, industrial wastes. Generally, these wastes can reach a ground-water supply in two ways—buried distribution lines may leak directly to an aquifer, or improperly lined treatment lagoons may leak to a ground-water supply. In addition, Arkansas has 303 active and inactive (abandoned) municipal and county landfill sites (fig. 3*C*). Little data have been collected to evaluate their effects on the quality of ground water.

Military

Military installations have a wide variety of waste-disposal areas including surface impoundments, evaporation ponds, chemical-disposal pits, active and inactive landfills, and unlined beds for drying sludge from wastewater treatment. The types of wastes are many and include oils, solvents, paint, photographic chemicals, miscellaneous degreasing agents such as trichloroethylene, warfare agents such as mustard gas, plating wastes, sulfuric acid, and methyl ethyl ketone.

As of September 1985, 13 hazardous-waste sites at 2 facilities in Arkansas had been identified by the U.S. Department of Defense (DOD) as part of their Installation Restoration Program (IRP) as having potential for contamination. The IRP, established in 1976, parallels the Environmental Protection Agency (EPA) Superfund program. EPA presently ranks these sites under a hazard ranking system and may include them in the NPL. These 13 sites were scheduled for confirmation studies to determine if remedial action is required.

Agricultural Practices

The widespread use of insecticides and herbicides essential to crop production has the potential to affect the ground water. Pesticides applied to row crops may percolate to ground water. Irrigation practices may increase the chance of infiltration. Improper storage or disposal of pesticide containers, especially near wells, may result in direct infiltration along the outside of an improperly sealed well casing.

GROUND-WATER-QUALITY MANAGEMENT

The ADPCE has the primary responsibility for ground-water quality protection in the State. This authority was given in the Arkansas Water and Air Pollution Control Act, Act 472 of 1949, as amended. Various acts and (or) agencies have control over various aspects of State ground-water quality.

- The Arkansas Surface Coal Mining and Reclamation Act of 1979, Act 134 of 1979 as amended, administered by the ADPCE.
- The Arkansas Open Cut Land Reclamation Act, Act 336 of 1977 as amended.
- The Arkansas Solid Waste Management Act, Act 237 of 1971; Arkansas Solid Waste Management Code, Act 238 of 1978, administered by the ADPCE.
- The Arkansas Hazardous Waste Management Act, Act 406 of 1979 as amended, administered by the ADPCE.
- The Arkansas Underground Injection Control Program, jointly overseen by ADPCE and the Arkansas Oil and Gas Commission.
- The Rural Abandoned Mine Program administered by the U.S. Soil Conservation Service.
- Act 96 of 1913 established the Arkansas Department of Health, giving that agency the power to develop regulations to control pollution and general sanitation regulations that prohibit the contamination of ground water.
- Act 402 of 1977 gave the Arkansas Department of Health specific authority to develop regulations for septic tanks and their use by both individuals and subdivisions.
- The Hazardous Materials Transportation Act of 1977, Act 421 of 1977, administered by the Arkansas Transportation Commission.
- Railroad Transportation Procedures of Hazardous Materials, Act 651 of 1979.
- ADPCE Regulation No. 1 for the Prevention of Pollution by Saltwater and Other Field Wastes Produced by Wells in New Fields or Pools.
- ADPCE Regulation No. 2, as amended, Arkansas Water Quality Standards Interim Revision.
- Pest Control Law, Act 488 of 1975.
- Pest Control Act and Regulations, Act 410 of 1975.
- Pesticide Use and Application Act and Regulations Act 389 of 1975.

To fulfill its responsibility, the ADPCE currently (1986) is developing and implementing a Ground Water Protection Strategy. A State interagency technical advisory committee, the Ground Water Quality Protection Steering Committee, provides guidance as this strategy is implemented. The Steering Committee has made several recommendations directed toward improving the State's ground-water information base. A series of ground-water monitoring prototypes covering typical geologic and population areas of the State has been completed and plans for implementation have been proposed. Cooperation between the major data-collecting agencies in the State is being encouraged through the Ground Water Quality Protection Steering Committee. This monitoring information, when added to the existing data base, will support the expanded ground-water protection activities of the future.

In addition, the Arkansas Soil and Water Conservation Commission oversees the Arkansas State Water Plan. This plan evaluates water-resource problems and management strategies necessary to protect water for its most beneficial uses.

With regulations in place to protect ground-water quality there is a need to know the existing quality of ground water and to continually monitor this quality to detect any changes. For example, the quantity of trace metals and organic compounds in most of the State's ground water is not well known.

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Measurement of water flowing from an irrigation well in a rice field. The U.S. Geological Survey in cooperation with the Arkansas Geologic Commission collected well yield and water-quality information from the alluvial aquifer near Brinkley, Arkansas. The results of chloride analyses were used to map the extent and magnitude of saltwater intrusion into the alluvial aquifer. (Photo courtesy of the U.S. Department of Agriculture, Soil Conservation Service.)

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