NORTH DAKOTA
GROUND-WATER QUALITY

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U.S. Geological Survey Open-File Report 87-0744

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FOREWORD

This report contains summary information on ground-water quality in one of the 50 States, Puerto Rico, the Virgin Islands, or the Trust Territories of the Pacific Islands, Saipan, Guam, and American Samoa. The material is extracted from the manuscript of the *1986 National Water Summary*, and with the exception of the illustrations, which will be reproduced in multi-color in the *1986 National Water Summary*, the format and content of this report is identical to the State ground-water-quality descriptions to be published in the *1986 National Water Summary*. Release of this information before formal publication in the *1986 National Water Summary* permits the earliest access by the public.

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North Dakota
Ground-Water Quality

Ground water is an important resource in North Dakota. About 62 percent of the population (fig. 1) of the State rely on ground water, and nearly all of the rural population depend on ground water for domestic supply. Ground water provides about sixty percent of the water used for public and private drinking-water systems and nearly fifty percent of the water used for agricultural purposes (Rick Nelson, North Dakota State Department of Health, written commun., 1986.)

Unconsolidated aquifers tend to provide less mineralized water than sedimentary bedrock aquifers; however, water quality from both types of aquifers is marginal for some uses (fig. 2). Excessive dissolved-solids concentrations can limit the usability of water for drinking, irrigation, and manufacturing processes. Although dissolved-solids concentrations generally are less than 1,000 mg/L (milligrams per liter), the median concentrations in some areas exceed 1,000 mg/L. Water in unconsolidated aquifers tends to be hard to very hard. Locally, concentrations of nitrate (as nitrogen) greater than 10 mg/L have been detected. There is no current (1987) evidence to indicate that these nitrate concentrations are due to the use of agricultural chemicals.

North Dakota has 37 documented cases of ground-water quality degradation. Of those cases, about two-thirds are gasoline, diesel-fuel, fuel-oil, or lubricating oil contamination resulting from leakage or spills. Most of the degradation has been corrected by simple means, such as excavating contaminated earth materials. However, at one site about 1 million gallons of diesel fuel is floating on the water surface of an unconsolidated aquifer.

North Dakota has one site that has been evaluated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (fig. 3). The CERCLA site, in the southeastern part of the State, has reported concentrations of arsenic in ground water greater than 50 μg/L (micrograms per liter), the primary drinking-water standard established by the U.S. Environmental Protection Agency (EPA) (1986a). The U.S. Department of Defense (DOD) has identified seven hazardous-waste sites at three facilities as having potential for ground-water contamination.

WATER QUALITY IN PRINCIPAL AQUIFERS

North Dakota has two principal types of aquifers (fig. 2*A*)—unconsolidated (glaciofluvial and glaciolacustrine deposits) and sedimentary bedrock (consolidated sedimentary rocks) (U.S. Geological Survey, 1985, p. 335). The unconsolidated aquifers generally are more productive and yield less mineralized water than bedrock aquifers; however, the bedrock aquifers are more widespread and areally continuous. Most of the unconsolidated aquifers are located in the eastern one-half of the State. Dissolved-solids concentrations of the unconsolidated aquifers commonly are less than 1,000 mg/L. The sedimentary bedrock aquifers provide a source of water in the western one-half of the State. Although these aquifers generally are used as sources for domestic water supply and livestock watering, excessive dissolved-solids concentrations and increased salinity limit their use as a source of water for irrigation.

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 (as nitrogen), sodium, and fluoride analyses of water samples collected from 1946 to 1985 from the principal aquifers in North Dakota. 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 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 nitrate (as nitrogen). The secondary drinking-water standards include maximum concentrations of 500 mg/L dissolved solids and 250 mg/L sulfate.

The graphic summary is limited to six unconsolidated aquifers (fig. 2*C*, areas 1–6), and one sedimentary bedrock aquifer (fig. 2*C*, area 7). The data were interpreted without regard to sample depth. The principal uses of ground water in these areas are: areas 1–4, irrigation; area 5, public supply; area 6, public supply and industrial; and area 7, public supply.

Unconsolidated Aquifers

The degree of mineralization of water in the unconsolidated aquifers depends on the hydraulic properties of and the geochemical processes occurring in the aquifer. In general, the longer the residence time of the water in an aquifer, the greater the degree of mineralization. In many areas of North Dakota, mineralized water in confined bedrock aquifers is under sufficient hydraulic pressure to cause upward flow into unconsolidated aquifers, where it mixes with the less mineralized water.

In unconsolidated aquifers that occupy buried valleys, water at the bottom of the aquifer tends to be more mineralized than water at shallow depths. This is due to both increased residence time of the water in the aquifer and mixing.

The median dissolved-solids concentrations in areas 1 and 2 are less than 500 mg/L; in areas 3, 4, 5 and 6, the median concentrations exceed 500 mg/L. At greater than 500-mg/L concentrations, ground water is marginally acceptable for irrigation.

In general, water in the unconsolidated aquifers is very hard, with median hardness concentrations (as calcium carbonate) ranging from about 300 to 500 mg/L.

Median concentrations of nitrate (as nitrogen) in ground water from areas 1–6 are less than 1 mg/L; much less than the primary drinking-water standard of 10 mg/L. Concentrations of nitrate greater than 10 mg/L have been detected in private wells throughout the State. In most instances, the source of nitrate is not known, but septic-tank drainfields, nitrogen fertilizers, and feedlot operations are suspected.

Median concentrations of sodium in areas 1–6 range from 20 to 570 mg/L. As a component of dissolved solids, increased sodium concentrations decrease the usability of water for irrigation. Concentrations of sodium and potassium in excess of 50 mg/L, in combination with suspended matter, cause foaming, which accelerates scale formation and corrosion in boilers.

Ninetieth-percentile fluoride concentrations in water from unconsolidated aquifers, areas 1–6, are all less than 1 mg/L. Median percentiles for areas 1–6 range from 0.1 to 0.4 mg/L. At optimum concentrations, fluoride has a beneficial effect on the resistance to decay of teeth, but concentrations in excess of optimum can cause mottling of teeth.

Median sulfate concentrations (sulfate percentiles not shown in fig. 2*C*) in areas 3 and 5 exceed the secondary drinking-water standard of 250 mg/L. In areas 1, 2, 4, and 6, median sulfate concentrations range from 58 to 221 mg/L. Sulfate concentrations greater than 500 mg/L may impart a bitter taste to water and can have a laxative effect. Sulfate combines with calcium and magnesium to form scale in heating equipment.

Sedimentary Bedrock Aquifers

FORT UNION AQUIFER SYSTEM

The Fort Union aquifer system is the uppermost bedrock aquifer system. In general, these aquifers differ in horizontal extent and thickness, and therefore, are less reliable sources of water than deeper aquifers. Water in the Fort Union aquifer system is used by farms, ranches, and small communities for most purposes except irrigation (U.S. Geological Survey, 1985, p. 336).

The quality of water in this aquifer system is variable. The water generally is soft (hardness, as calcium carbonate, generally is less than 60 mg/L) and contains large concentrations of sodium and dissolved solids. Locally, water from aquifers near the top of the Fort Union aquifer system may yield hard water with smaller concentrations of sodium and dissolved solids. Naturally occurring selenium, in concentrations ranging from 50 to 600 μg/L, has been detected in water from this aquifer system. The EPA primary drinking-water standard for selenium is 10 μg/L.

Hell Creek-Fox Hills Aquifer System

The Hell Creek–Fox Hills aquifer system (fig. 2*A*, area 7) is a relatively dependable source of water, supplying many farms, ranches, and small cities in central and western North Dakota. Water in this system is generally soft; median hardness (as calcium carbonate) is 10 mg/L (fig. 2*C*, area 7). Because the median dissolved-solids concentration is 1,060 mg/L, the water generally is not used for irrigation. Sodium is the principal dissolved-solids constituent. The median sulfate concentration, 220 mg/L, does not exceed the secondary drinking-water standard of 250 mg/L; however, at least 25 percent of the water from this aquifer system exceeds this standard (not shown in fig. 2*C*). At least 50 percent of the water from this aquifer system exceeds the secondary drinking-water standards of 2 mg/L fluoride, and at least 10 percent exceeds the primary drinking-water standard of 4 mg/L. Data were insufficient to compile a statistical summary for nitrate concentrations.

Great Plains (Dakota) Aquifer System

Although the Great Plains (Dakota) aquifer system underlies most of the State, most of the wells completed in this aquifer system are in the southeastern part of the State. The primary use of the water in this area is for watering livestock. In the western part of the State, the water is moderately saline, with an average dissolved-solids concentration of 7,300 mg/L. Because of the salinity of the water in this area, the only use is in oil-field operations (U.S. Geological Survey, 1985, p. 338).

Madison Group Aquifer

Water in the Madison Group aquifer generally is the most mineralized ground water in the State. Dissolved-solids concentrations generally are greater than 10,000 mg/L. In deeper parts of the aquifer, in western North Dakota, dissolved-solids concentrations are greater than 200,000 mg/L. The Madison Group aquifer is not developed in North Dakota.

EFFECTS OF LAND USE ON WATER QUALITY

Ground-water contamination in North Dakota is relatively minor. North Dakota is primarily an agricultural State and has not experienced the degradation of ground-water quality usually associated with industrial development. Most of the problems with ground-water quality in the State are due to naturally occurring, excessive concentrations of dissolved solids and hardness. Although ground water in North Dakota generally is of marginal quality for many uses, it is used because there are no other available sources of water.

Waste Disposal

As of September 1985, seven hazardous-waste sites at three facilities in North Dakota 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 the CERCLA of 1980. The U.S. Environmental Protection Agency (1986c) presently ranks these sites under a hazard-ranking system and may include them in the National Priorities List (NPL). There are no Resource Conservation and Recovery Act (RCRA) sites, one CERCLA site, and two Underground Injection Control (UIC) Program sites (U.S. Environmental Protection Agency, 1984) in the State (fig. 3*A*).

Landfills are the most commonly used disposal method for nonhazardous waste in North Dakota. Nonhazardous-waste-disposal sites are classified as either sanitary landfills (fig. 3*C*) or special-use disposal sites (identified as "other" in fig. 3*A*). Special-use disposal sites are used for containment of fly-ash residue, flue-gas desulfurization wastes, oil-field drilling muds, industrial wastes, lime sludge, and construction/demolition wastes.

Fly-ash residue and flue-gas desulfurization wastes from lignite-fired electricity generating plants generally contain large concentrations of dissolved solids, arsenic, molybdenum and, selenium. An increase in dissolved-solids concentration in ground-water has been detected at five special-use disposal sites containing these wastes. Water at these sites is being monitored to determine the effect on local ground-water quality and to define a course of remedial action.

Although no sanitary landfills have been identified as sources of contamination of ground water, 24 have been identified as geologically unacceptable by the North Dakota State Department of Health, Division of Hazardous Waste Management and Special Studies (written commun., 1986). Criteria defined as unacceptable includes construction of landfills in very permeable material, or the presence of shallow ground-water levels close to the base of the landfill.

The 37 sites where ground-water contamination has been detected are shown in figure 3*B*. Dissolved-solids concentrations in ground water have increased at seven additional sites. The increases have been attributed to disposal of fly-ash residue and seepage from storage lagoons. Arsenic and saltwater have contaminated ground water at two other sites. Most of the sites where ground water has been contaminated have been identified in the last five years.

Agriculture

North Dakota has about 40 million acres of land that are used for farming and ranching; therefore, the effects of agricultural chemicals on ground-water quality is a major concern. The North Dakota State Department of Health (NDSDH), Division of Water Supply and Pollution Control, recently analyzed 218 samples of water from private and municipal wells for a suite of synthetic organic chemicals. At 14 sites, ground water was found to contain trace concentrations of pesticides, however, none of the concentrations were large enough to pose a health hazard. The most commonly detected chemical was picloram.

Nitrate (as nitrogen) concentrations in excess of 10 mg/L were detected in water from 22 private, irrigation, and observation wells south of the town of Oakes. Nitrate contamination of ground water has been detected at many feedlots, corrals, and farmsteads.

Arsenic was detected in ground water in excess of 50 μg/L in four areas in Ransom, Sargent, and Richland Counties, in the southeastern part of the State (fig. 3*B*). These areas, near the town of Lidgerwood, total about 170 square miles. The sources of arsenic are considered to be from natural leaching from earth materials and from the application of arsenic-laced grasshopper bait used in the area through 1947. The arsenic contamination was examined during a CERCLA ("Superfund") remedial investigation (Roberts and others, 1985).

Hydrocarbon Contamination

Most incidents of ground-water contamination in North Dakota are from hydrocarbon leaks and spills. Gasoline, diesel fuel, fuel oil, or lubricating oil are the most common hydrocarbons detected in contaminated areas. Most spills and leaks are minor and require minimal remedial action. There are, however, five restoration projects to remove hydrocarbons from ground water in North Dakota. The largest of these is at the city of Mandan, where about 1 million gallons of diesel fuel is floating on the surface of the shallow aquifer (North Dakota State Department of Health, written commun., 1986).

Wastewater Impoundments

Wastewater impoundments are the most widely used method for wastewater treatment and storage in North Dakota because of inexpensive operating costs and availability of land. Water from a public-supply well at the city of Wahpeton had an increase in dissolved-solids concentrations due to seepage from a wastewater lagoon, but the ground-water quality was restored by installing and operating two contaminant recovery wells (North Dakota State Department of Health, written commun., 1986). Seepage from a city lagoon at the town of McVille has increased concentrations of dissolved solids, chloride, and ammonium in the underlying shallow aquifer. A ground-water investigation is being conducted at McVille to determine the extent of effects on the ground-water quality of the shallow aquifer. Permitting, monitoring, and research by State agencies at several wastewater-impoundment sites has minimized the effects of seepage from municipal, industrial, agricultural, and mining impoundments on ground-water quality.

POTENTIAL FOR WATER-QUALITY CHANGES

Areas of contaminated ground water in North Dakota are limited in extent and degree of degradation. In large part, this is due to the limited industrialization within the State. Because North Dakota is primarily an agricultural state, the potential effect of agricultural chemicals on ground-water quality is a major concern. Large concentrations of nitrate in ground water in the State may be caused by both natural sources and the use of fertilizers. Other agricultural chemicals have not been determined to have degraded ground-water quality, but further monitoring within the State will better define their effects on ground-water quality.

Oil-and-gas development and mining are other activities that may degrade ground-water quality. Potential effects of oil-and-gas development on ground-water quality come from possible blowouts of wells, leaching and seepage from reserve pits, and contamination from underground injection wells. Evaporation ponds are not used for the disposal of brines associated with oil and gas development in North Dakota. Current mining operations are under evaluation to determine the extent to which they have affected local ground-water quality. Existing mining operations are in sparsely populated areas of the State and changes in ground-water quality that may occur probably will be localized.

Subsurface disposal of domestic waste in septic-tank and other onsite-treatment systems has not been identified as a problem in North Dakota. However, the increased abundance and use of household chemicals may cause degradation of ground water near improperly designed or installed systems.

GROUND-WATER-QUALITY MANAGEMENT

North Dakota ground-water-quality protection programs are primarily source oriented. Their implementation is designed to prevent ground-water contamination by controlling potential sources of contamination. This control is accomplished by maintaining contaminant-source permit programs, defining effluent limitations, setting minimum performance and design standards, and encouraging use of best-management practices. Implementing ground-water protection programs in North Dakota is a task shared by several State agencies with their own legislative authority and rules governing various aspects of ground-water protection and use. These agencies and their respective activities are:

North Dakota State Department of Health (NDSDH)—Overall ground-water protection responsibilities.

North Dakota State Water Commission (NDSWC)—Water allocation and ground-water monitoring and mapping.

North Dakota State Industrial Commission, Oil and Gas Division (OG)—Ground-water protection associated with oil and gas development.

North Dakota Geological Survey (NDGS)—Ground-water protection from mineral and geothermal exploration and development.

North Dakota State Public Service Commission (NDPSC)—Ground-water protection and monitoring associated with coal-mine development and reclamation.

Chapter 61-28 of the North Dakota Century Code establishes the NDSDH as the primary State agency responsible for the protection of water in the State. This chapter directs the NDSDH to develop comprehensive programs for the prevention, control, and decrease of polluted water and establishes the State policy to protect, maintain, and improve the quality of water for continued use as public and private water supplies for domestic, agricultural, industrial, recreational, and other legitimate beneficial uses.

The NDSDH administers most of the Federal water-quality legislation, including the Safe Drinking Water Act (SDWA), RCRA, CERCLA, and the Clean Water Act.

The SDWA includes the Drinking Water Program and the UIC program, for which the State has complete primacy, and the Sole Source Aquifer Program, which is administered on the Federal level by the EPA. The NDSDH, Division of Water Supply and Pollution Control (WSPC) administers the Drinking Water Program. This includes monitoring water quality and inspecting 333 community and 373 noncommunity water-supply systems throughout the State. The UIC program is a multiagency program. The WSPC administers the Federal grant and regulates municipal and industrial injection wells. The OG controls oil- and gas-injection wells, and the NDGS controls solution-mining injection wells. An application for a sole-source designation of the New Rockford unconsolidated aquifer in southwestern Eddy County has been submitted to the EPA. The WSPC and SWC currently are involved in a vulnerability study of the aquifer to assist the EPA in making a decision on the application.

The RCRA program is administered through the NDSDH, Division of Hazardous Waste Management and Special Studies (HWMSS). The RCRA program includes the Hazardous Waste Management Program, the PCB Inspection Program, and the Underground Storage Tank Program. The HWMSS also is responsible for issuing permits for all nonhazardous-solid-waste facilities. There are no permitted hazardous-waste facilities in North Dakota.

The CERCLA is administered by the EPA, through agreements with both the WSPC and HWMSS, to conduct and assist in preliminary site assessments, site inspections, remedial investigations, and feasibility studies. A remedial investigation and feasibility study has been completed on a large site where arsenic-contaminated ground water has been detected near Lidgerwood.

The NDSDH currently has a nondegradation policy and uses an aquifer-classification process based on the UIC program. Aquifers with water having dissolved-solids concentrations less than 10,000 mg/L are identified as Class-I aquifers and are fully protected. Aquifers with water having dissolved-solids concentrations greater than 10,000 mg/L are identified as Class-II aquifers and are given limited protection. In administering the nondegradation policy, the NDSDH has the discretion to consider certain social and economic factors in the decision-making process. Therefore, many ground-water-quality issues are considered on a case-by-case basis.

The NDSDH, NDSWC, NDPSC, and the U.S. Geological Survey all collect and compile ground-water-quality data in North Dakota. Examination of these data has identified sites that may need remedial action and ground-water cleanup. Through monitoring of organic substances in about 200 wells in North Dakota, the NDSDH has detected trace concentrations of several pesticides. The NDSDH plans to concentrate this monitoring program on the most vulnerable areas of the State during the next year.

An initial inventory of ground-water resources of the State has recently been accomplished by a long-standing cooperative program between the NDSWC and the U.S. Geological Survey. During a 25-year period, the geology and ground-water resources of all 53 counties in the State were evaluated. The information resulting from this program is the data base for the State ground-water protection programs.

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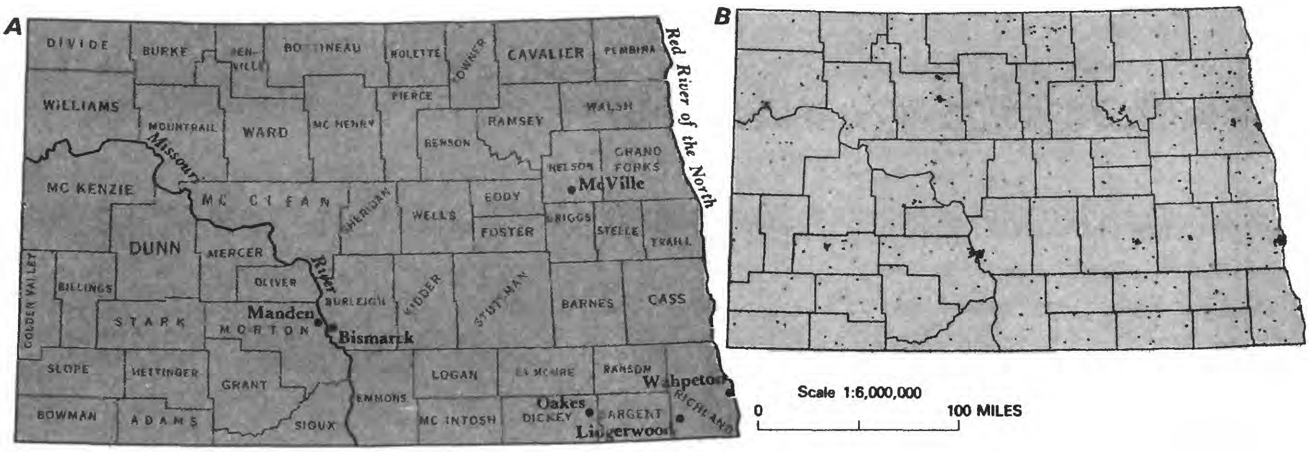

Figure 1. Selected geographic features and 1985 population distribution in North Dakota. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files,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

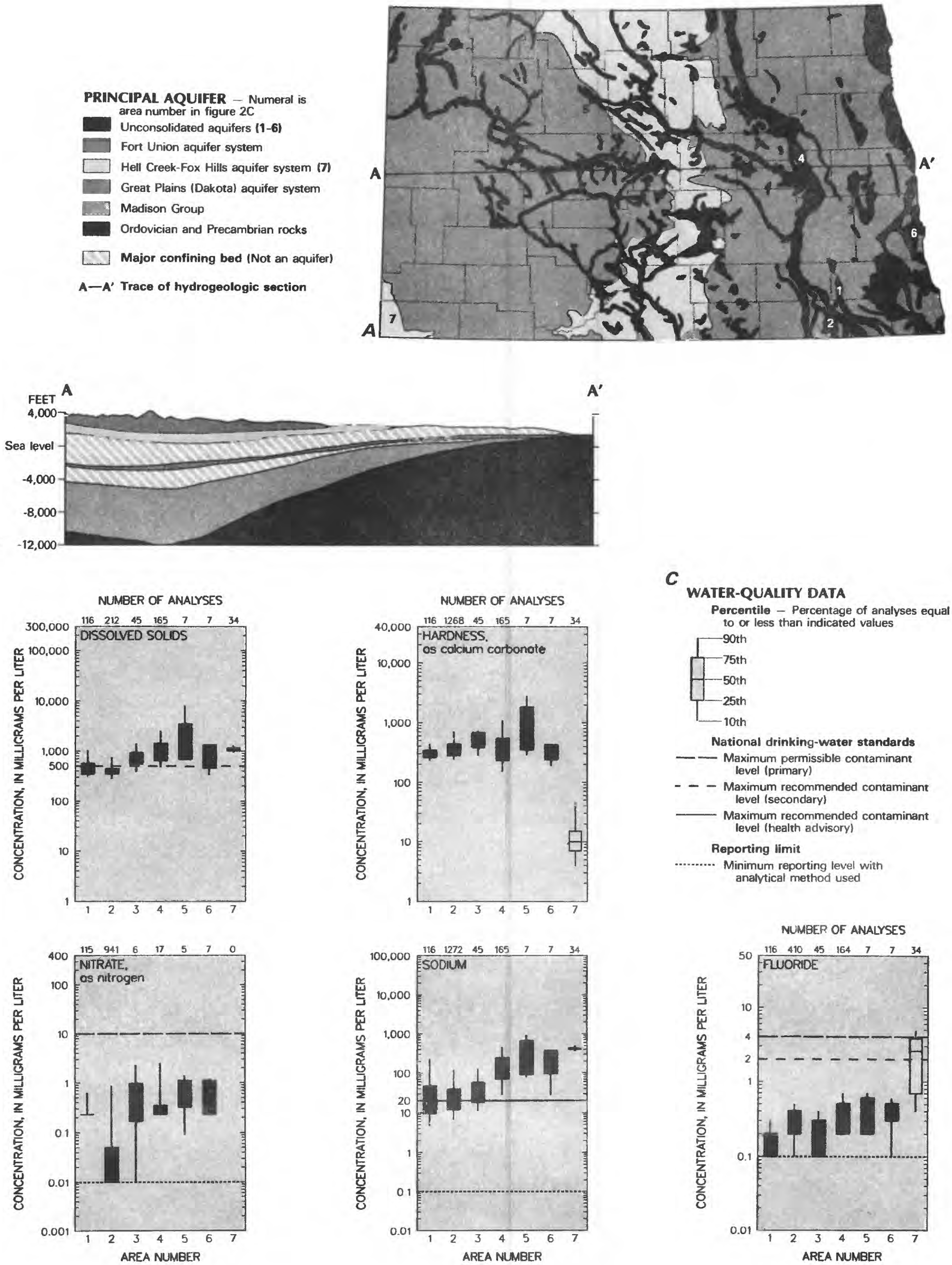

Figure 2. **Principal aquifers and related water-quality data in North Dakota.** *A*, Principal aquifers, *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, 1946-85. (Sources: *A*, North Dakota State Water Commission, 1982, *B*, Paulson, 1983. *C*, Analyses complied from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986a,b.)

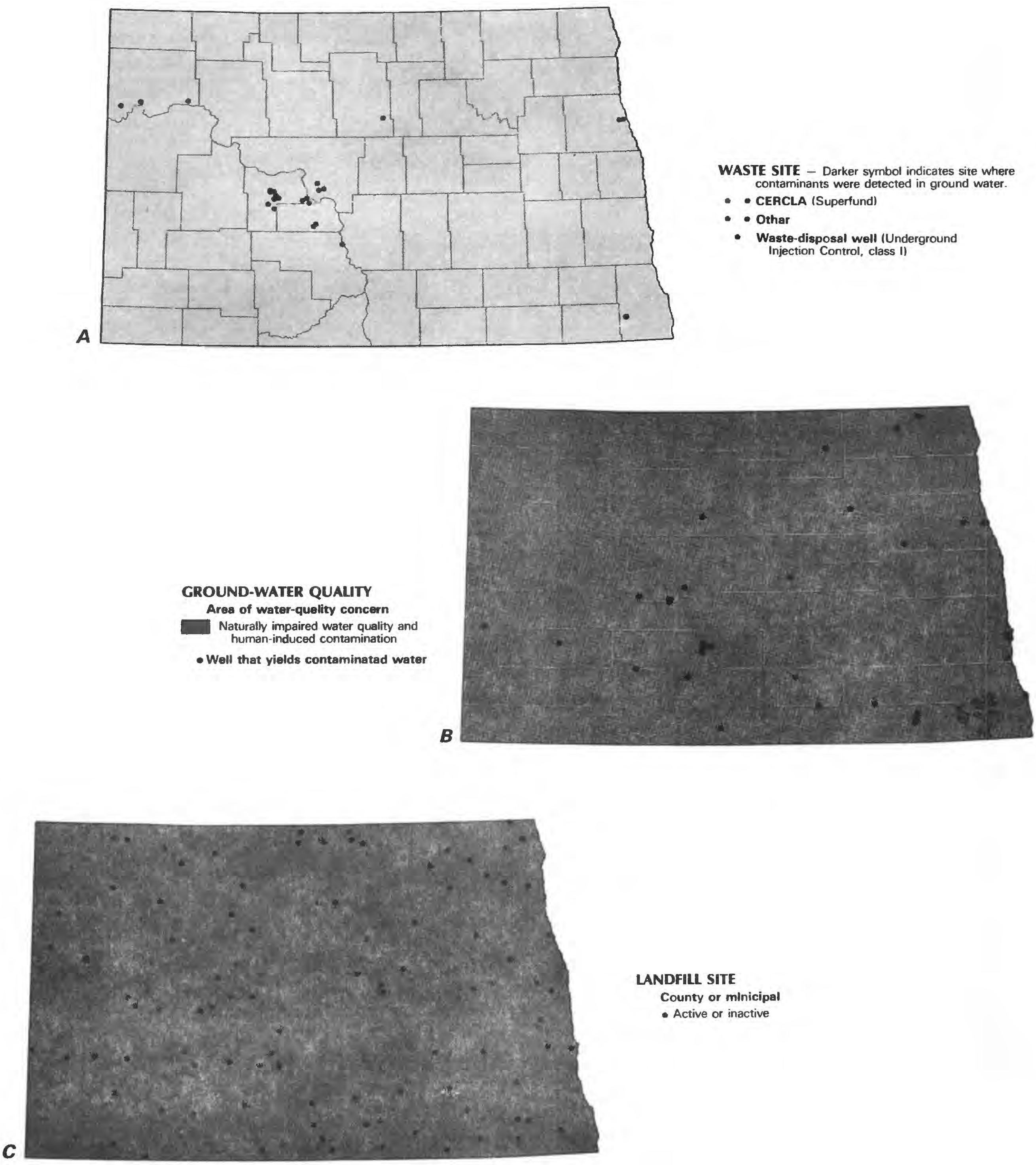

Figure 3. Selected waste sites and ground-water-quality information in North Dakota. *A* Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of 1986; and other selected waste sites, as of 1986. ***B***, Areas of naturally impaired water quality, areas of human-induced contamination, and distribution of wells that yield contaminated water, as of 1986. ***C***, County and municipal landfills, as of 1986. (Sources: *A*, *B*, and *C*, North Dakota State Department of Health, written commun., 1986.