NEBRASKA GROUND-WATER QUALITY

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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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Ground water is the major source of drinking water for about 82 percent of the population in Nebraska (fig. 1), but this use accounts for only about 4 percent of the total water use in the State. Irrigation is the principal use of ground water, accounting for 94 percent of the total ground water used in the State (U.S. Geological Survey, 1985, p. 291); many water-quality changes during the past 40 years have been associated with the development of the resource for irrigation. In some areas of the State, nitrate concentrations in ground water exceed the standard of 10 mg/L (milligrams per liter) as nitrogen (Nebraska Department of Environmental Control, 1978, p. 10), although median nitrate concentrations for all aquifers are less than the standard. Median dissolved-solids concentrations are less than the recommended concentration of 500 mg/L (U.S. Environmental Protection Agency, 1986b) for most water except that produced from the Niobrara aquifer, the Dakota aquifer system, and the undifferentiated aquifers in Paleozoic rocks in eastern Nebraska (fig. 2). Small concentrations of the pesticide atrazine have been detected in about one-third of the water samples from agricultural areas analyzed for pesticides by the U.S. Geological Survey during 1984–85. Contamination from several other organic compounds has been found in ground water at industrial sites or at locations where underground storage tanks have leaked.

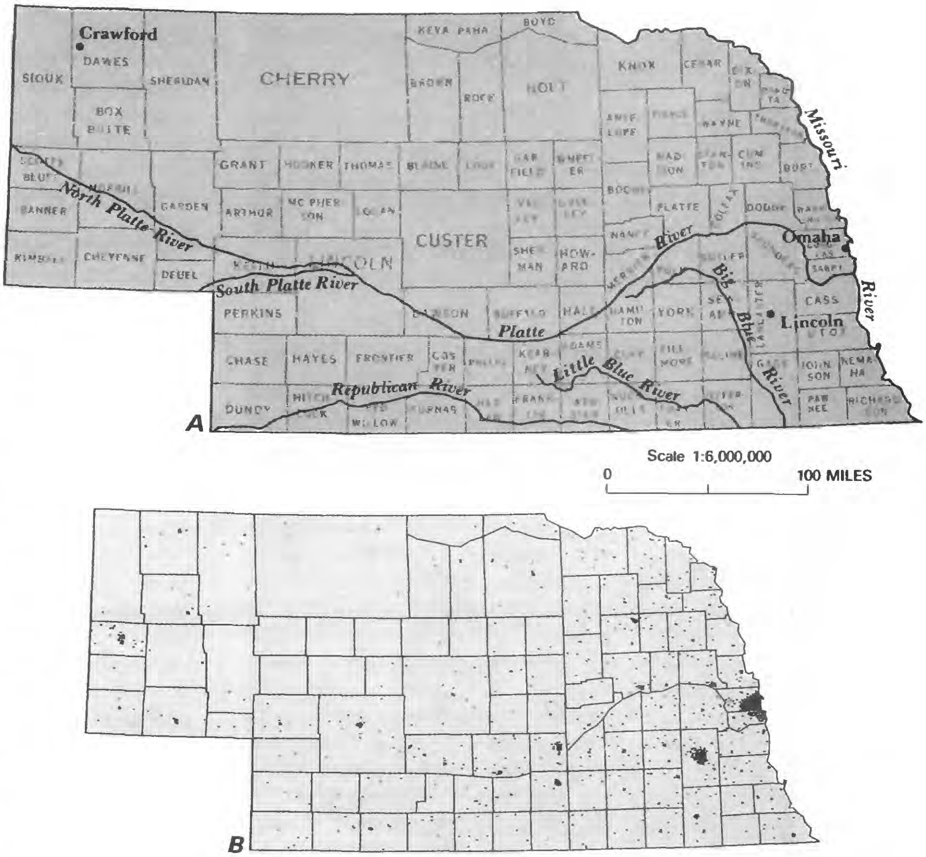

Figure 1. **Selected geographic features and 1985 population distribution in Nebraska.** *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files,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

Eleven hazardous-waste sites in Nebraska require monitoring of ground-water quality under the Federal Resource Conservation and Recovery Act (RCRA) of 1976. Two additional sites have been included in the National Priorities List of hazardous-waste sites (Superfund program) by the U.S. Environmental Protection Agency (1986c) and three other sites have been proposed and are under consideration. "Superfund" sites require additional evaluation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. At eight of the RCRA and CERCLA (Superfund) sites, contamination of ground water has been detected (see fig. 3). The Department of Defense has identified 137 hazardous-waste sites as having potential for contamination at 2 facilities in Nebraska.

WATER QUALITY IN PRINCIPAL AQUIFERS

The High Plains aquifer system is the most important aquifer in Nebraska (fig. 2*A*1 and 2*B*). This system underlies 64,770 mi² (square miles) (Pettijohn and Chen, 1983) or about 85 percent of the State. The High Plains aquifer system consists of: Quaternary-age alluvium, valley fill, and eolian sand and gravel; the Tertiary-age Ogallala Formation and Arikaree Group; and the fractured upper part of the Tertiary-age Brule Formation. The Tertiary-age deposits generally are composed of slightly consolidated gravel, sand, silt, and clay. About 96 percent of the irrigation wells in Nebraska are completed in the High Plains aquifer system, and an estimated 95 percent of the total withdrawals of ground water in the State are from this aquifer system.

Other aquifer systems are Quaternary-age sand and gravel in present stream valleys and in principal paleovalleys outside the areal extent of the High Plains aquifer system. In addition, the Cretaceous-age Niobrara Formation and the Dakota Sandstone are developed for water supplies in parts of eastern Nebraska. Sedimentary rocks of Paleozoic age underlie all but a small area of northern Nebraska but are used for water supplies only in southeastern Nebraska. Some Paleozoic rocks of Permian, Pennsylvanian, Devonian, Ordovician, and Cambrian age provide water to domestic and industrial wells.

Water in that part of the High Plains aquifer system located beneath the Nebraska Sand Hills (fig. 2*A*2), an area of about 20,000 mi² in north-central Nebraska, contains less than 250 mg/L dissolved solids. In some areas, principally in Brown County, dissolved solids are less than 100 mg/L. With the exception of small areas, principally in eastern Nebraska, dissolved solids in ground water in the rest of the High Plains aquifer system, the valley and principal paleovalley alluvial aquifers, and the Niobrara aquifer are less than 750 mg/L (Engberg, 1984). All but about 400 of the 70,701 registered irrigation wells in Nebraska, as of December 31, 1984, were completed in the High Plains aquifer system, the valley and principal paleovalley alluvial aquifers, and the Niobrara aquifer. Because the dissolved solids are less than 1,000 mg/L, the water in these aquifers generally can be used for all crops grown in the State.

Slightly more saline water generally is found in the Dakota aquifer system and in the undifferentiated aquifers in Cretaceous and Paleozoic rocks. Except for areas in eastern Nebraska where the Dakota aquifer system is near the land surface and receives local recharge, dissolved solids in water exceed 750 mg/L. For water samples from 36 wells completed in undifferentiated aquifers in Paleozoic rocks, the median dissolved-solids concentration is about 1,300 mg/L.

BACKGROUND WATER QUALITY

A graphic summary of selected water-quality variables from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) for principal aquifers in Nebraska from 1935 through 1985 is shown in figure 2*C*. Dissolved solids, hardness (as calcium carbonate), nitrate plus nitrite (as nitrogen), total alkalinity (as calcium carbonate) and sulfate concentrations are illustrated to characterize the variability of the chemical quality of water from eight aquifer groups. 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 nitrate (as nitrogen), and the secondary drinking-water standards include maximum concentrations of 500 mg/L dissolved solids and 250 mg/L sulfate.

Data for valley and principal paleovalley alluvial aquifers are combined into one group because the chemical quality of water from each is similar and because insufficient data were available to make statistical inferences for the principal paleovalley aquifers. Because the data base is large, data from the High Plains aquifer system are divided into four groups by geologic age, from youngest to oldest: Quaternary sand and gravel; the Ogallala Formation; the Arikaree Group; and the Brule Formation. Other groups are the Niobrara aquifer, the Dakota aquifer system, and undifferentiated aquifers in Paleozoic rocks.

Valley and Principal Paleovalley Alluvial Aquifers

Valley alluvial aquifers are located along the Missouri River and downstream reaches of the Platte River in eastern Nebraska, and along the downstream reaches of the Niobrara River in northern Nebraska. The principal paleovalley alluvial aquifers include the aquifer underlying Todd Valley in Saunders County, and the aquifers in several east-trending paleovalleys in southeastern Nebraska. Water from the alluvial and principal paleovalley alluvial aquifers is used for public supply, irrigation, and domestic purposes. No numerical standard for dissolved solids in drinking water has been established by Nebraska, but the median dissolved-solids concentration of 390 mg/L (aquifer1, fig. 2*C*) for water from valley and principal paleovalley alluvial aquifers was less than the 500 mg/L concentration for public supply established by the U.S. Environmental Protection Agency (1986b).

Calcium and magnesium, the principal components of hardness of water, were the principal cations generally present in water from valley and principal paleovalley alluvial aquifers. The median hardness concentration was 280 mg/L, which indicates that the water was very hard.

The median nitrate-plus-nitrite concentration of 0.25 mg/L as nitrogen was much less than the State established standard for nitrate of 10 mg/L as nitrogen. However, the median is for only 16 analyses.

Bicarbonate, the principal component of alkalinity, was the predominant anion in water from these aquifers. The median alkalinity for 113 analyses was 268 mg/L. Sulfate, another significant anion, had a median concentration of 50 mg/L, which is much less than the proposed State standard of 250 mg/L (Nebraska Department of Environmental Control, 1986).

High Plains Aquifer System

QUATERNARY SAND AND GRAVEL

Quaternary deposits of sand and gravel that are part of the High Plains aquifer system in the Big Blue and Little Blue River basins, in the Central Platte River basin, and in the loess hills southeast of the Sand Hills yield abundant supplies of water for all uses. An estimated 70 percent of the ground water pumped for irrigation in Nebraska comes from these deposits. In the Sand Hills (fig. 2*A*2), Quaternary sand and gravel and the Ogallala Formation constitute an aquifer that provides about 7 percent of the ground water pumped for irrigation in the State.

The quality of water from the Quaternary deposits is variable. Water quality is affected by recharge from surface-water irrigation projects and recharge from streams. In some places where the water table is shallow, the quality of ground water is affected largely by nonpoint sources, such as fertilizers, but it also is affected locally by point sources, such as feedlots. The median dissolved-solids concentration for 2,171 water samples collected from Quaternary deposits was 350 mg/L (aquifer 2, fig. 2*C*); dissolved solids exceeded 630 mg/L in only 10 percent of the samples. The areas from which this 10 percent were collected receive recharge from a three-county (Gosper, Phelps, and Kearney) surface-water irrigation project in central Nebraska or directly from the Platte River.

Water in Quaternary deposits associated with the High Plains aquifer system generally was very hard; the median hardness was 250 mg/L. Calcium was the principal cation. The median nitrate-plus-nitrite concentration for 1,236 samples from Quaternary deposits was 2.4 mg/L as nitrogen. However, the State standard of 10 mg/L as nitrogen was exceeded in more than 10 percent of all samples; in some areas where the water table is shallow and soils are sandy, nitrate-plus-nitrite concentrations were several times the limit. The median alkalinity for Quaternary deposits was 211 mg/L. Bicarbonate was the predominant anion. The median sulfate concentration was 40 mg/L. However, sulfate concentrations in ground water were greatest in areas where the Quaternary deposits receive recharge from irrigation projects or from the Platte River, and nearly equaled or exceeded bicarbonate concentrations.

OGALLALA FORMATION

The Ogallala Formation underlies most of central and western Nebraska, except for the west-central and northern parts of the panhandle. The Ogallala, which consists of loosely cemented sandstone, caliche, sand, gravel, and volcanic ash, ranges in thickness from 0 to 600 feet. In general, recharge to the Ogallala is derived locally. Together with Quaternary deposits, the Ogallala is the principal aquifer in the Sand Hills. About 16 percent of the ground water pumped for irrigation is solely from the Ogallala, predominantly from southwestern Nebraska, the southern part of the panhandle, and north-central Nebraska near the northeast border of the Sand Hills. Likewise, in these areas, the Ogallala Formation provides water for all other uses.

Water quality of the Ogallala Formation is similar to that of Quaternary alluvial sand and gravel, but the water generally is less mineralized and less variable. The median dissolved-solids concentration was 260 mg/L (aquifer 3, fig. 2*C*); dissolved solids exceeded 400 mg/L in water from only 10 percent of the 377 samples analyzed. Water in the Ogallala Formation generally was hard; the median hardness was 170 mg/L. Calcium was the principal cation. The median nitrate-plus-nitrite concentration was 2.0 mg/L as nitrogen for 321 water samples from the Ogallala Formation. The State standard of 10 mg/L as nitrogen was exceeded in only a few of the water samples from the Ogallala. The median alkalinity was 170 mg/L, and bicarbonate was the predominant anion. The median sulfate concentration was 15 mg/L, and sulfate concentrations rarely were of the same magnitude as bicarbonate concentrations (Engberg, 1984).

ARIKAREE GROUP

The Arikaree Group in the northern part of the panhandle of Nebraska consists of sand interlayered with sandy silt and concretions, and may be as thick as 500 feet (Engberg, 1984). Like recharge to the Ogallala Formation, recharge to the Arikaree generally is local. The Arikaree supplies abundant water for irrigation and all other uses. About 4 percent of the ground water pumped for irrigation in Nebraska is from the Arikaree.

Water quality in the Arikaree is nearly the same as that in the Ogallala Formation because soluble materials in deposits overlying and within both geologic units are similar. The median dissolved-solids concentration in water from the Arikaree was 245 mg/L (aquifer 4, fig. 2*A*) and dissolved solids exceeded 350 mg/L in only 10 percent of the 40 samples analyzed. Water in the Arikaree Group generally was hard; the median hardness was 160 mg/L. Calcium was the principal cation. Only 21 analyses were available for nitrate-plus-nitrite concentrations in water from the Arikaree Group. The median concentration was 3.1 mg/L as nitrogen, and the maximum concentration observed was 7.8 mg/L as nitrogen. Median alkalinity was 160 mg/L, and bicarbonate was the predominant anion. The median sulfate concentration was 16 mg/L. Sulfate concentrations were not of the same magnitude as bicarbonate concentrations.

BRULE FORMATION

The Brule Formation is used as water supply in the panhandle of Nebraska and is composed principally of silty clay as much as 600 feet thick. In some areas, as a result of fracturing of the upper 100 feet, the Brule Formation may yield water in sufficient quantities for irrigation, but it generally supplies water sufficient only for domestic use (Engberg, 1984).

Water quality in the Brule Formation is similar to that in the Arikaree Group. The median dissolved-solids concentration in water from 25 samples from the Brule was 260 mg/L (aquifer 5, fig. 2*C*), and the maximum concentration was 540 mg/L.

Water from the Brule Formation was hard; the median hardness was 140 mg/L. Calcium was the predominant cation. Few data are available for nitrate-plus-nitrite concentrations in water from the Brule Formation. Concentrations ranged from 2.3 to 9.9 mg/L in analyses of six water samples. The median alkalinity was 169 mg/L, and bicarbonate was the predominant anion. The median sulfate concentration was 17 mg/L.

Niobrara Aquifer

The Niobrara Formation of Cretaceous age ranges from 0 to 300 feet thick and underlies the Cretaceous-age Pierre Shale in most places, which in turn underlies the High Plains aquifer system. The Niobrara Formation, which is composed of shaley chalk and limestone, subcrops beneath Quaternary-age sand and gravel in south-central Nebraska, and beneath glacial drift in northeastern Nebraska. For much of its areal extent, the Niobrara Formation is not an aquifer, but in some areas where fracturing has occurred or solution channels have formed, it yields sufficient water for irrigation, public-supply, and domestic wells (Engberg, 1984).

In northeastern Nebraska, the Niobrara aquifer is recharged locally through glacial drift or directly in outcrop areas. In northern Cedar County (fig. 2*A*) the Niobrara aquifer, together with overlying saturated sand and gravel, is the principal aquifer.

Water in the Niobrara aquifer generally is more mineralized than water in the High Plains aquifer system. Dissolved-solids data for the Niobrara aquifer are few, but a median dissolved-solids concentration of 489 mg/L was estimated from specific-conductance data in five analyses (aquifer 6, fig. 2*C*) water from the Niobrara aquifer is considerably harder than water in the High Plains aquifer system. The median hardness was 330 mg/L, and calcium was the predominant cation. Limited data for nitrate plus nitrite are available for water from the Niobrara aquifer; the median was 0.28 mg/L as nitrogen for 14 available water analyses. Where the Niobrara aquifer is near the land surface, a potential for contamination of the aquifer by nitrate exists. The median alkalinity for the Niobrara aquifer, based on 19 water samples, was 287 mg/L. Bicarbonate was the predominant anion in water from areas where the aquifer is recharged locally. The median sulfate concentration was 100 mg/L.

Dakota Aquifer System

The Dakota Sandstone crops out in eastern Nebraska but is nearly 8,000 feet beneath land surface in the panhandle. The Dakota Sandstone ranges from 0 to more than 800 feet thick. In eastern Nebraska, where the Dakota extends from the land surface to a depth of 1,500 feet, it is an important aquifer. Farther west, with few exceptions, it is not used for water supply. The Dakota aquifer system is used for public supply by 38 communities in nine counties in eastern Nebraska, and for numerous domestic supplies (U.S. Geological Survey, 1985, p. 294). The Dakota supplies water to about 400, or less than 1 percent, of the irrigation wells in Nebraska.

The quality of water in the Dakota aquifer system is different depending on whether the aquifer system is recharged locally, whether the aquifer system has been leached, and residence time of the water in the aquifer system. The median dissolved-solids concentration for 79 water samples was 840 mg/L (aquifer 7, fig. 2*C*), but dissolved solids exceeded 1,300 mg/L in water from 25 percent of the samples.

Water from the Dakota aquifer system is harder than water from other aquifers in Nebraska. The median hardness was 430 mg/L. In areas where the Dakota aquifer system is recharged locally, calcium was the principal cation. In areas where the Dakota is at greater depth, the sodium concentration was almost equivalent to the calcium concentration.

The median nitrate-plus-nitrite concentration (0.13 mg/L) in water from the Dakota aquifer system was less than that of all other aquifers in Nebraska for which data are available. Where the Dakota is near the land surface and receives local recharge, a potential exists for contamination by nitrate. However, where the Dakota occurs at a depth of several hundred feet and is not recharged locally, the chances of detecting substantial concentrations of nitrate are slight.

The median alkalinity for water from the Dakota aquifer system was 218 mg/L, and bicarbonate was the principal source of alkalinity. The median sulfate concentration was 250 mg/L. Sulfate generally was the principal anion in water from the Dakota aquifer, but near outcrop areas where water is derived largely from local recharge, bicarbonate was the principal anion.

Undifferentiated Aquifers in Cretaceous Rocks

Undifferentiated aquifers in Cretaceous rocks serve as minor aquifers in northern Nebraska. They consist of chalk and sandstone and range from 75 to 1,300 feet in depth. In most cases, the Niobrara aquifer and the Dakota aquifer system are overlain locally by Quaternary sand and gravel deposits.

Few water-quality analyses are available for the undifferentiated aquifers in Cretaceous rocks; therefore, discussion of water quality for these aquifers was not attempted.

Undifferentiated Aquifers in Paleozoic Rocks

Paleozoic rocks ranging in thickness from 1,000 to 4,000 feet underlie nearly all of the State but are aquifers only in small areas of southeastern Nebraska. Some of the rocks crop out in these areas and are recharged locally. Water from Permian and Pennsylvanian rocks of Paleozoic age is used for domestic, industrial, and public supplies in 10 counties. Some deep industrial wells in or near the Omaha area are developed in older rocks and may produce water that is a mixture derived from Paleozoic rocks ranging in age from Mississippian to Cambrian.

Water quality from undifferentiated aquifers in Paleozoic rocks differs greatly. The few available data indicate that water produced from Devonian rocks is considerably more mineralized than water from underlying Ordovician and Cambrian rocks (Engberg, 1984). In areas where Pennsylvanian rocks are recharged locally, the quality of water is similar to that from nearby paleovalley alluvial aquifers, which also are recharged locally. The median dissolved-solids concentration in 36 samples of water from the undifferentiated aquifers in Paleozoic rocks was 1,300 mg/L (aquifer 8, fig. 2*C*); dissolved solids were greater than 3,450 mg/L in 10 percent of the samples.

A wide range of hardness characterizes water from the undifferentiated aquifers in Paleozoic rocks; 40 samples had a median of 402 mg/L. Calcium was the principal cation in water from Pennsylvanian rocks, which are recharged locally. Sodium was the principal cation in saline water from Devonian rocks.

Data for nitrate plus nitrite are not available for water from the undifferentiated aquifers in Paleozoic rocks. The median alkalinity was 221 mg/L in water from the undifferentiated aquifers in Paleozoic rocks, and the median sulfate concentration was 668 mg/L. Sulfate was the principal anion in water from the aquifers with two exceptions. Bicarbonate was the principal anion in the area where Pennsylvanian rocks are recharged locally. Chloride concentrations were nearly equivalent to those of sulfate in water from Devonian rocks.

EFFECTS OF LAND USE ON WATER QUALITY

Water quality has changed in many areas of the State principally because of human activities. Treatment and disposal of hazardous wastes and changes in land and water use, especially in response to the rapid development of the High Plains aquifer system for irrigation, have contributed to water-quality changes and possible ground-water contamination.

Hazardous Waste

In Nebraska, hazardous waste is treated, stored, or disposed of at 11 sites identified under RCRA. These RCRA sites constitute known or potential hazards to the quality of ground water (fig. 3*A*). The Nebraska Department of Environmental Control has detected ground-water contamination at six of the RCRA sites (Michael Steffensmeier, oral commun., 1986). Two hazardous-waste sites in Nebraska (fig. 3*A*) are included on the National Priorities List (CERCLA sites) of the U.S. Environmental Protection Agency (EPA). Volatile organic compounds have been detected in ground water at these sites located in Adams and Lancaster Counties. Three RCRA sites in Hall, Dawson, and northwest Platte Counties have been proposed for inclusion on the National Priorities List (NPL) and are still under consideration. Most of the RCRA and CERCLA sites are located near major population centers.

As of September 1985, 137 hazardous-waste sites at two facilities in Nebraska had been identified by the U.S. Department of Defense (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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The EPA presently ranks these sites under a hazard-ranking system and may include them in the NPL. One-hundred eight sites at one facility (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.

Areas that Yield Contaminated Water

Areas of water-quality concern and wells that yield contaminated water are shown in figure 3*B*. The 103 known wells that yield contaminated water are located in cities and towns with public ground-water supplies having one or more constituents that exceed U.S. Environmental Protection Agency (1986a,b) or Nebraska Department of Environmental Control (1978) maximum contaminant levels. In some instances, the entire water system of a community is represented by a single well site because analyses were determined for finished water delivered to customers rather than for individual public-supply wells. Many of the communities are, or have been, operating their water systems under Nebraska State Health Department administrative orders that specify remedial measures. Point sources are responsible for contamination of the ground water at many of these sites.

Nonpoint sources are responsible for the contaminated areas shown in figure 3*B* and for the wells that yield contaminated water included in these areas. Many of the sampled wells in which atrazine has been detected are located in these areas.

Present or previous military installations have, or have had, a variety of waste-disposal areas, including surface impoundments, evaporation ponds, and active or buried landfills. The munitions products 2,4,6 trinitrotoluene (TNT) and hexahydro-trinitro-triazine (RDX) have been detected in ground water at and downgradient from the former Cornhusker Army Ammunitions Plant in northeastern Hall County.

Active and inactive county and municipal landfills in Nebraska are shown in figure 3*C*. Insufficient data have been collected to evaluate the effects of these landfills on the quality of ground water in Nebraska.

Land Use

Cultivated land accounts for more than 40 percent of all land use in Nebraska (Engberg, 1984). More than one-third of all cropland is irrigated and more than 80 percent is irrigated by ground water (Engberg, 1984).

Temporal changes in ground-water quality are related indirectly to land use. Conversion of pastureland and nonirrigated cropland to irrigated cropland is accompanied by increased use of agricultural chemicals, which increases the possibility that residues of these chemicals may move into the ground water.

Water Use and Irrigation

Ground-water use in Nebraska increased 129 percent from about 3,100 Mgal/L (million gallons per day) during 1970 (Engberg, 1984) to 7,100 Mgal/L during 1980 (U.S. Geological Survey, 1985). Eighty-five percent of the ground water pumped in 1970 was used for irrigation, compared to 94 percent of the water pumped in 1980. For the same period, domestic, public, and industrial uses increased by less than 23 percent, from 357 to 438 Mgal/L.

The large increase in ground-water use for irrigation has affected the quality of ground water in some areas. Large increases in the use of fertilizers and pesticides have accompanied irrigation development and have provided the potential for widespread nitrate and pesticide nonpoint-source contamination of shallow ground water.

The area north of the Platte River in central Nebraska has the greatest density of irrigation wells in the State (Ellis and Pederson, 1985). For example, an average density of 7.7 registered irrigation wells per square mile has been reported in Merrick County (Engberg, 1984). From 1958 to 1982, the U.S. Geological Survey sampled six wells located north of the Platte River in Buffalo and Hall Counties in central Nebraska. Nitrate concentrations in water from these six wells are shown in figure 4. Water in three of the wells, located in lowlands near the river, showed substantial increases in nitrate concentrations with time. These wells were drilled in sandy soils, and the depth to water in the lowlands generally is less than 20 feet. Nitrate concentrations in water from the other three wells have remained nearly the same through time. These wells are located at greater distances from the Platte River in terrace deposits that are characterized by soils that contain some clay. Depth to water in the terrace deposits generally is more than 20 feet.

Exner and Spalding (1976) prepared a map showing the distribution of nitrate concentrations in 1974 for an extensive area north of the Platte River in central Nebraska. The map indicated that nitrate concentrations exceeded 10 mg/L as nitrogen in an area of about 340 mi^2. Seventy-eight percent of the wells sampled in 1974 were resampled in 1984 (Exner, 1985). A new map showed that the area in which nitrate concentrations exceeded 10 mg/L as nitrogen had increased by about 45 percent to about 490 mi^2. In Merrick County alone, the mean nitrate concentration for 36 wells increased from 22 to 26 mg/L as nitrogen.

Similar increases in nitrate have been detected in other parts of the State where large-scale development of ground water for irrigation has occurred more recently. Areas of nonpoint-source-derived nitrate in concentrations greater than 10 mg/L as nitrogen have been found in Holt, Kearney, and Phelps Counties (Hsiu-Hsiung Chen, U.S. Geological Survey, oral commun., 1986).

Pesticides in ground water are being detected in measurable concentrations. Measurable concentrations (greater than 0.04 microgram per liter) of the herbicide atrazine were detected in 43 of 132 water samples collected during 1984–85 by the U.S. Geological Survey from wells completed in the High Plains aquifer system in Nebraska.

Water-level rises as a result of surface-water irrigation may be accompanied by changes in ground-water quality. Infiltration from canal seepage and surface application supplements natural recharge and has caused substantial water-level rises in some areas of the State. If the infiltrating surface water is less mineralized than the ground water, the quality of the ground water improves. This has occurred in Howard and Sherman Counties in areas irrigated by surface water. If the infiltrating surface water is more mineralized than the ground water, the quality of ground water degrades. This has occurred in Gosper, Kearney, and Phelps Counties and elsewhere in areas irrigated by surface water diverted from the Platte River.

POTENTIAL FOR WATER-QUALITY CHANGES

Because Nebraska is primarily an agricultural State, the potential for most changes in water quality is related to agriculture and to nonpoint sources of ground-water contamination. Nitrate and pesticide contamination of ground water from nonpoint sources is expected to increase. Areas especially susceptible are adjacent to those where contamination presently exists (fig. 3*B*). Other areas where nitrate may cause changes in ground-water quality include the Big Blue and Little Blue River basins, the western part of the Republican River basin, and most of Box Butte County (fig. 1). These areas all have large-scale development of ground water for irrigation, and all have had water-level declines. Recharge, derived locally and enriched with agricultural chemicals, may cause gradual increases in nitrate and pesticide concentrations in ground water. If further irrigation development takes place in the Sand Hills, rapid contamination of the ground water from agricultural chemicals, such as documented in Holt County (Exner and Spalding, 1979), may be expected.

Radioactive constituents may change ground-water quality in Dawes and Sioux Counties, northwestern Nebraska. Extensive deposits of uranium are found in the White River Group at depths of 400 to 600 feet below land surface. A pilot plant has been constructed in Dawes County near Crawford, to recover uranium by in-situ solution-mining techniques. If these efforts prove feasible, large-scale mining may start in a few years. The deposits in which the uranium are found are virtually undeveloped as a source of water supply but do serve a few users for stock watering.

GROUND-WATER-QUALITY MANAGEMENT

The Nebraska Ground-Water-Quality Protection Strategy prepared by the Nebraska Department of Environmental Control (NDEC) (1985) provides an assessment of ground-water contamination in Nebraska and contains proposals to control, manage, or mitigate existing or potential contamination. The strategy has been accepted by the administration of Governor Robert Kerrey as a basis for upgrading State regulatory measures related to ground-water quality or to create new programs to address ground-water quality issues.

As an outgrowth of the strategy, four legislative bills designed to implement ground-water-quality protection were passed by the Legislature in 1986. Bill LB217 applies to underground chemical and fuel storage tanks. The law, administered by the NDEC (for ground-water-quality protection) and the State Fire Marshall (for public safety), requires the issuance of installation permits and registration of underground storage tanks and represents an effort to regulate leaky tanks.

Bill LB284, the Nebraska Chemigation Act, requires that all irrigation systems into which chemicals are injected must have, at the minimum, check valves in both the delivery pipe and injection line; a low-pressure drain, and vacuum-relief valve, and an inspection port between the check valve and the pump; and an interlock device between the chemigation unit and the irrigation pump in the event of pump or power failure. The law requires an operating permit and training and certification of operators, and provides for system inspections by representatives of the Natural Resources District in which the system is located.

Bill LB310 provides for the certification of all well drillers in Nebraska. The law further defines standards for well construction and includes penalties for noncompliance with the standards.

Bill LB894 authorizes the establishment of ground-water-quality protection areas by the local Natural Resources District or by the NDEC. Area designations are restricted to nonpoint sources of ground-water contamination. Local action toward protecting ground-water quality may include education of land users on nonpoint sources of contamination and regulated agricultural-management practices. This law will enable local groups to protect localized ground-water sources affected by land use, aquifer characteristics, and soil types unique to the area.

Several State and local agencies are involved in the administration of existing Federal and State regulations pertaining to ground-water-quality management:

1. The NDEC administers ground-water-quality protection standards for Nebraska. The NDEC also administers a hazardous-waste-management program in Nebraska that complies with RCRA. Permits are required for onsite storage of hazardous waste for periods longer than 90 days. Disposal of hazardous waste by underground injection also is regulated by the NDEC under a permitting program. Underground injection is prohibited above or into sources of drinking water. The NDEC is responsible for licensing

solid-waste disposal sites for municipalities with populations greater than 5,000, provided that hazardous wastes regulated by RCRA are not disposed of at the sites. Lagoons and surface impoundments used for storing or treating wastewater also are regulated by the NDEC. The operators of these facilities may be required to obtain effluent-discharge-limitation permits from the NDEC if there is a potential for leakage that will reach the ground-water system. The NDEC also regulates exploration for minerals other than gas and oil and processes such as solution mining. Regulations include monitoring ground-water restoration and proper plugging of abandoned wells or test holes.

2. The Nebraska Oil and Gas Conservation Commission (NOGCC) regulates gas and oil exploration and production wells. Regulations include plugging requirements but include no provisions for monitoring or cleanup.

3. The Nebraska Department of Health (NDH) regulates a safe drinking-water program in Nebraska patterned after the Federal Safe Drinking-Water Act. Public drinking-water supplies are monitored by the NDH, and suppliers are issued permits. If contaminant concentrations exceed "maximum contaminant levels" contained in the National Drinking-Water Regulations, wells may be closed or use of the water restricted. The NDH establishes compliance schedules for decreasing contaminants to safe concentrations. The NDH also may regulate siting of new wells to avoid contamination by existing or potential sources. In addition, the Department regulates construction standards for new wells and public-supply distribution systems.

4. The Nebraska Department of Water Resources (NDWR) is responsible for registration of all water wells drilled in the State except those used solely for domestic and stock purposes. The NDWR also is responsible for enforcing well-spacing regulations and well-abandonment requirements, both of which may affect ground-water quality. The Director of the NDWR presides over public hearings conducted by the Natural Resources Districts to consider creation of ground-water control areas, and the Director also has sole authority to decide whether a control area is to be established. None of the three control areas presently authorized have been established because of ground-water contamination.

5. The 24 Natural Resources Districts in Nebraska were mandated by the 1984 Nebraska Legislature to prepare ground-water-management plans. These plans were to be submitted for approval to the Director of the NDWR of by January 1, 1986. Several plans have been approved, and others are undergoing revisions. Although they differ considerably, ground-water-quality monitoring programs are key elements in many District plans.

SELECTED REFERENCES

Agency for Toxic Substances and Disease Registry—National Governors Association, 1984, Areas closed or restricted because of toxic contamination: Washington, D.C., U.S. Public Health Service, 286 p.

Ellis, M.J., and Pederson, D.T., 1985, Groundwater levels in Nebraska, 1984: University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Conservation and Survey Division, Nebraska Water Survey Paper No. 59, 67 p.

Engberg, R.A., 1984, Appraisal of data for ground-water quality in Nebraska: U.S. Geological Survey Water-Supply Paper 2245, 54 p.

Exner, M.E., 1985, Concentration of nitrate-nitrogen in groundwater, Central Platte region, Nebraska, 1984: University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Conservation and Survey Division, scale 1:500,000, 1 sheet.

Exner, M.E., and Spalding, R.F., 1976, Groundwater quality of the Central Platte Region, 1974: University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Conservation and Survey Division Resource Atlas No. 2, 47 p.

_____ 1979, Evaluation of contaminated groundwater in Holt County, Nebraska: Water Resources Research, v. 15, no. 1, p. 137–147.

Nebraska Department of Environmental Control, 1978, Title 118—Ground-water protection standards: Lincoln, 15 p.

_____ 1983, Ground-water pollution potential in Nebraska: Lincoln, scale 1:1,000,000, 1 sheet.

_____ 1985, Nebraska ground-water protection strategy—Final Report: Lincoln, 61 p.

_____ 1986 [draft], Title 118—Ground-water-quality protection standards and use classification: Lincoln, 32 p., 2 appendices.

Pettijohn, R.A., and Chen, Hsiu-Hsiung, 1983, Geohydrology of the High Plains aquifer system in Nebraska: U.S. Geological Survey Water-Resources Investigations, Open-File Report 82-502, scale 1:750,000, 3 sheets.

Spalding, R.F., Gormly, J.R., Curtiss, B.H., and Exner, M.E., 1978, Nonpoint nitrate contamination of groundwater in Merrick County, Nebraska: Ground Water, v. 16, no. 2, p. 86–95.

U.S. Department of Defense, 1986, Status of the Department of Defense Installation Restoration Program—Information paper: Washington, D.C., U.S. Department of Defense, Office of the Assistant Secretary of Defense (Acquisition and Logistics), Environmental Policy Directorate, February, 35 p.

U.S. Environmental Protection Agency, 1986a, Maximum contaminant levels (subpart B of part 141, National interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised July 1, 1986, p. 524–528.

_____ 1986b, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised July 1, 1986, p. 587–590.

_____ 1986c, Amendment to National Oil and Hazardous Substances Contingency Plan; national priorities list; final rule and proposed rules: Federal Register, v. 51, no. 111, June 10, 1986, p. 21053–21112.

U.S. Geological Survey, 1985, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkaline soils: U.S. Department of Agriculture Handbook 60, 160 p.

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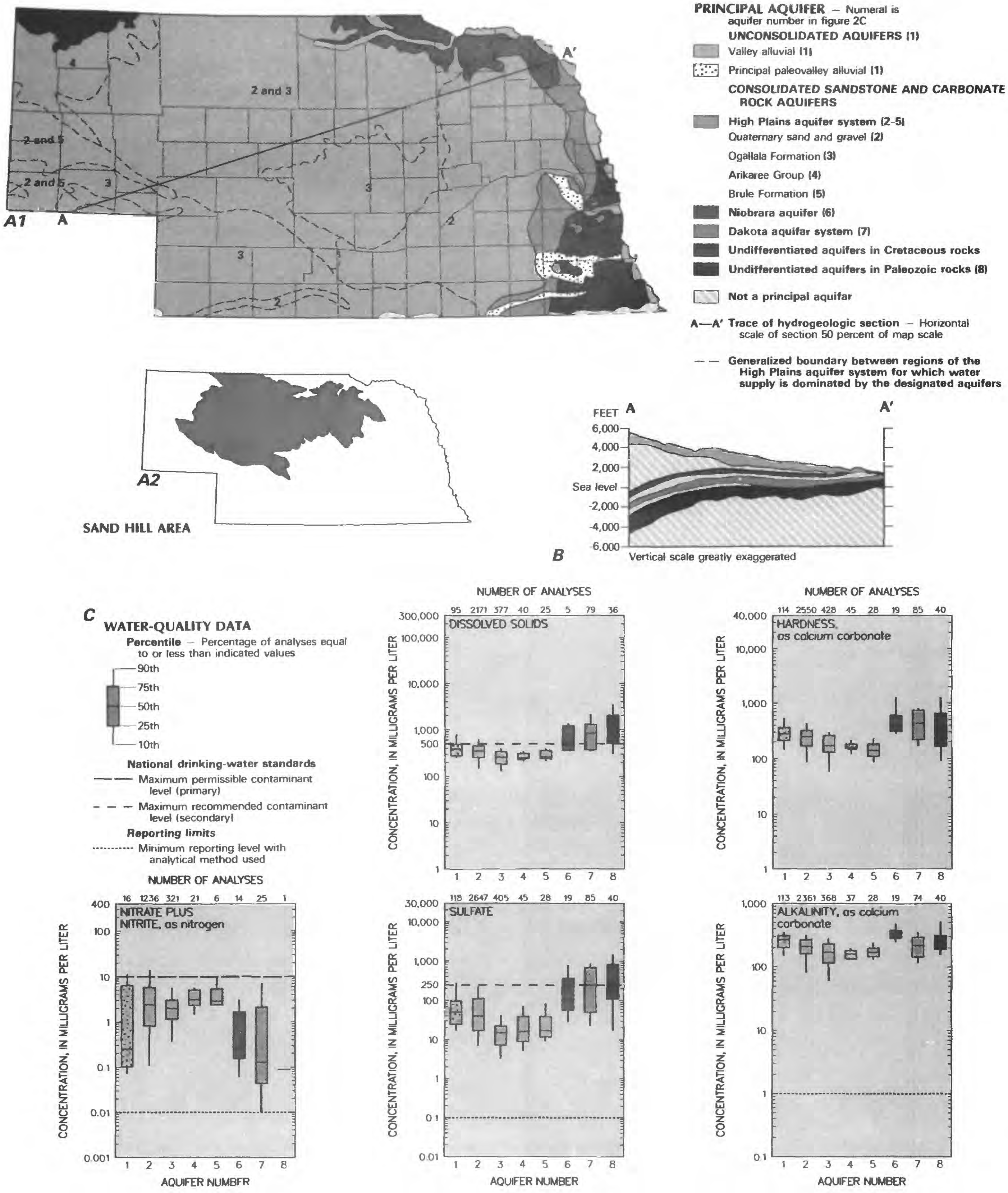

Figure 2. Principal aquifers and related water-quality data in Nebraska. *A1*, Principal aquifers; *A2*, Sand hill area. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, 1935-85. (Sources: *A*, U.S. Geological Survey, 1985. *B*, M.J. Ellis, U.S. Geological Survey, unpublished. *C*, Analyses compiled from U.S.Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986a,b.)

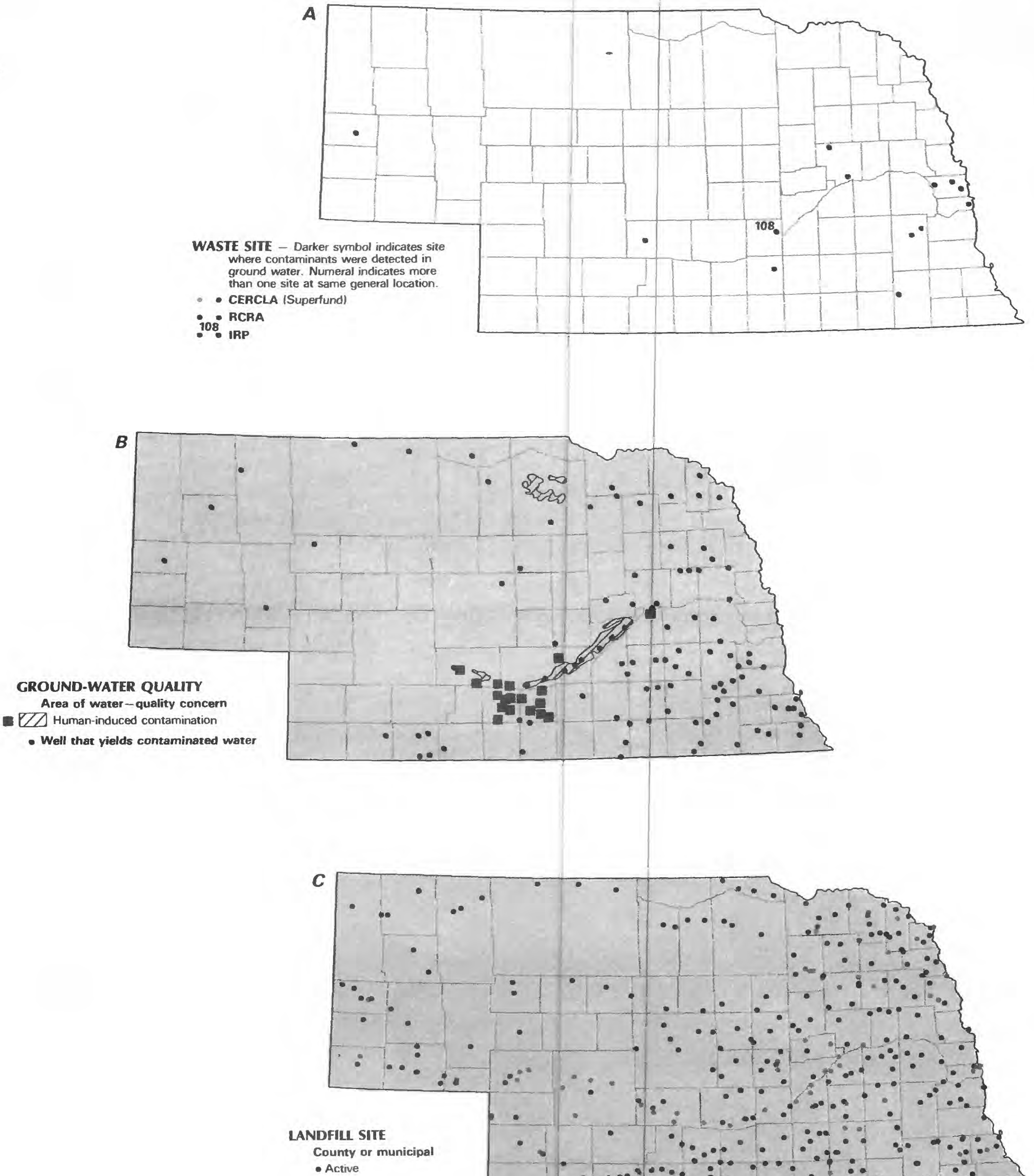

Figure 3. **Selected waste sites and ground-water-quality information in Nebraska.** *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of July 1986; Resource Conservation and Recovery Act (RCRA) sites, as of July 1986; and Department of Defense Installation Restoration Program (IRP) sites, as of 1985. *B*, Areas of human-induced contamination, and distribution of public wells that yield contaminated water, as of May 1986. *C*, County and municipal landfills, as of 1983. (Sources: *A*, U.S. Environmental Protection Agency, 1986c; Michael Steffensmeier, Nebraska Department of Environmental Control, oral commun., 1986. *B*, Exner, 1985; Exner and Spalding, 1976, 1979; Nebraska Department of Health, unpublished list of contaminated public wells, 1986; Spalding and others, 1978. *C*, Nebraska Department of Environmental Control, 1983.)

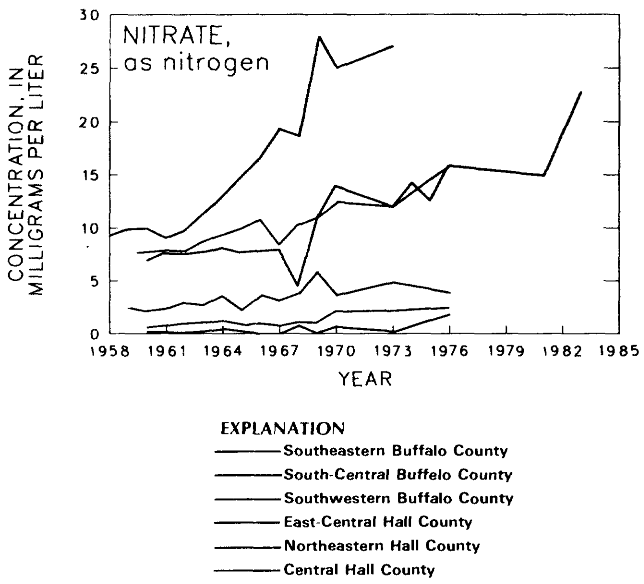

Figure 4. Trends in nitrate concentrations in water from six wells north of Platte River, central Nebraska. (Source: U.S. Geological Survey files.)