MINNESOTA
Ground-Water Quality

Nearly one-half the population of Minnesota (fig. 1) depends on wells for drinking water. Virtually all the rural population and 94 percent of the public-water systems use ground water. In general, the quality of Minnesota's ground water is satisfactory for most uses, such as for domestic, public, and industrial supplies and for irrigation. Most of the water can be classified, on the basis of predominant ions, as a calcium-magnesium-bicarbonate type with less than 1,000 mg/L (milligrams per liter) dissolved solids (Adolphson and others, 1981). However, naturally occurring saline water (exceeding 1,000 mg/L dissolved solids) is common along the western border, the northern shore of Lake Superior, and below depths of about 1,000 feet in the southeastern part of the State. Statewide concentrations of iron and manganese commonly exceed 300 μg/L (micrograms per liter) and 50 μg/L, respectively, which are the maximum recommended concentrations for these constituents in drinking water (U.S. Environmental Protection Agency, 1986b). Concentrations of sulfate in water from Cretaceous rocks and overlying glacial drift in southwestern Minnesota commonly exceed the U.S. Environmental Protection Agency's (EPA) secondary drinking-water standard of 250 mg/L (fig. 2).

Ground-water quality in Minnesota has been degraded by contamination, with the most serious problems being in local areas. Major sources of contamination in the State, according to the Minnesota Pollution Control Agency (1986a, p. 47), include: (1) spills or improper disposal of industrial or manufacturing chemicals, (2) leachate from solid-waste landfills, (3) spills and leaks from petroleum-product storage areas and pipelines, and (4) feedlots and agricultural chemicals. A total of 132 sites have been identified, as of November 1986, by the Minnesota Pollution Control Agency (MPCA) and the EPA as priority sites for cleanup. Included in these priority sites are 36 hazardous-waste sites on the National Priorities List (NPL), and 6 sites at two U.S. Department of Defense facilities (fig. 3*A*). In addition, two principal aquifers in the State—the surficial-drift aquifers, which underlie much of the State (fig. 2*A*2), and the upper carbonate aquifer, which underlies karst-type terrain in the southeastern part of the State (fig. 2*A*1)—are very susceptible to contamination from land-surface sources, such as spills, leachates from landfills, infiltration of runoff from feedlots, and widespread application of agricultural chemicals.

A survey of 887 community water systems, which included about 1,800 wells, was made by Minnesota Department of Health (MDH) (1985) for the purpose of detecting volatile organic compounds (VOC) in drinking water. The survey showed detectable VOC concentrations in 109 wells (fig. 3*B*). In 15 communities, the concentration of VOC in water from some of the public-supply wells exceeded limits considered acceptable by the MDH. Various actions have been taken by the MDH to ensure safe drinking water for the approximately 100,000 persons in those communities (Minnesota Department of Health, 1985).

WATER QUALITY IN PRINCIPAL AQUIFERS

The 14 principal aquifers in Minnesota (Adolphson and others, 1981) can be grouped by general rock type into unconsolidated glacial drift, sedimentary rocks, and crystalline rocks (fig.

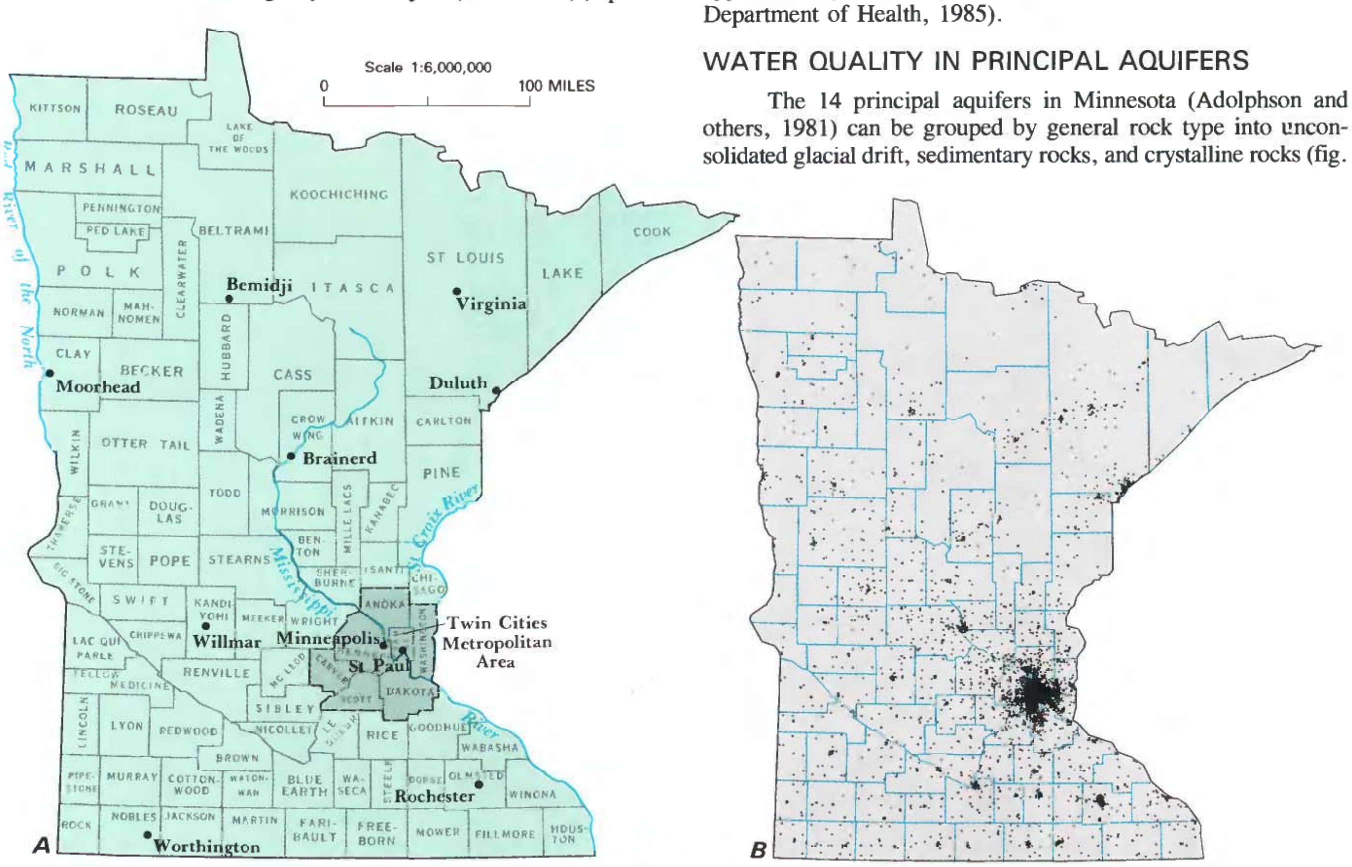


Figure 1. Selected geographic features and 1985 population distribution in Minnesota. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from Bureau of the Census 1980 decennial census files, adjusted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

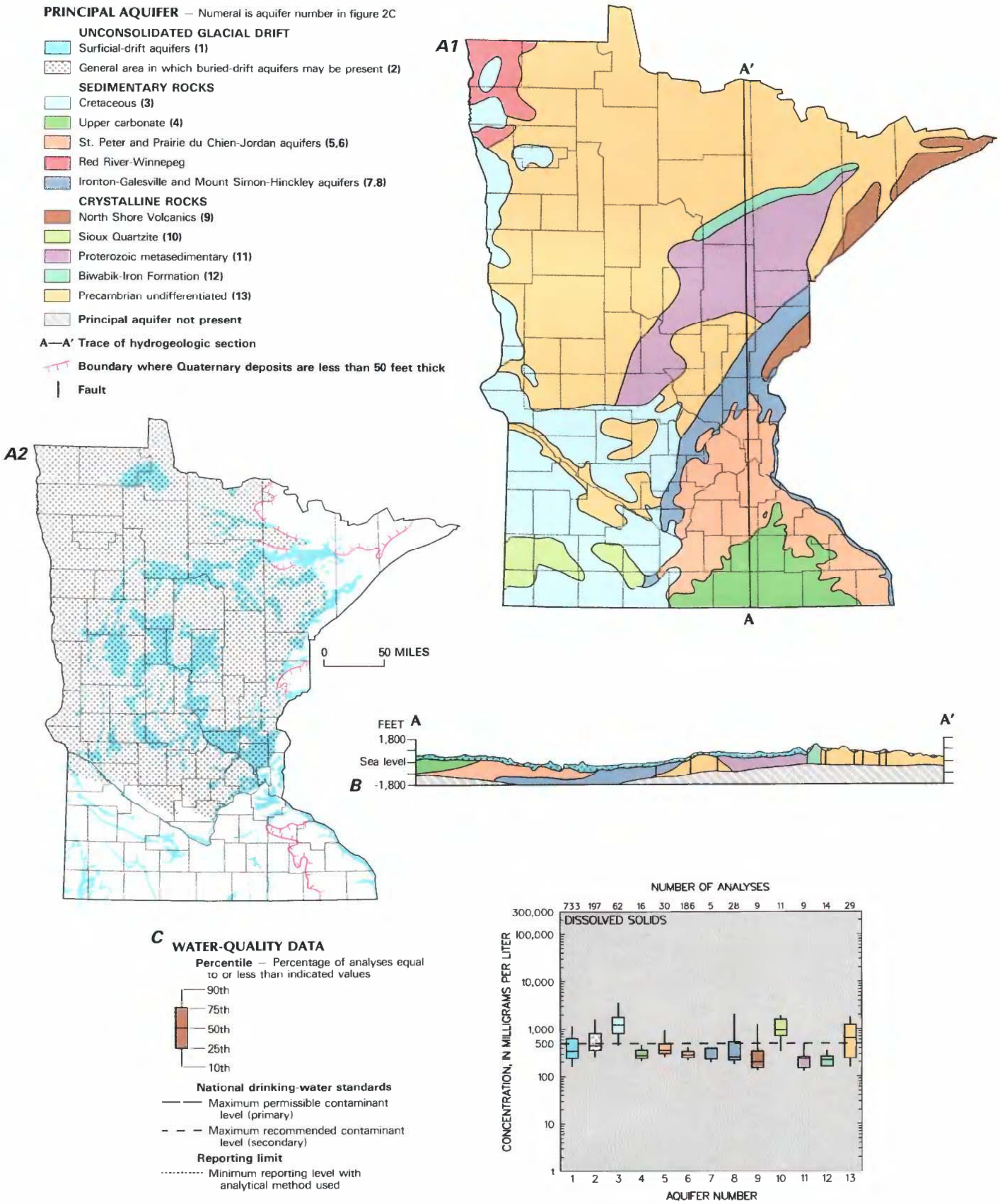


Figure 2. **Principal aquifers and related water-quality data in Minnesota.** *A1*, Principal aquifers; *A2*, Surficial- and buried-drift aquifers. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, from 1965 to 1985. (Sources: *A1*, *A2*, U.S. Geological Survey, 1985. *B*, Kanivetsky, 1978. *C*, Analyses complied from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986a,b.)

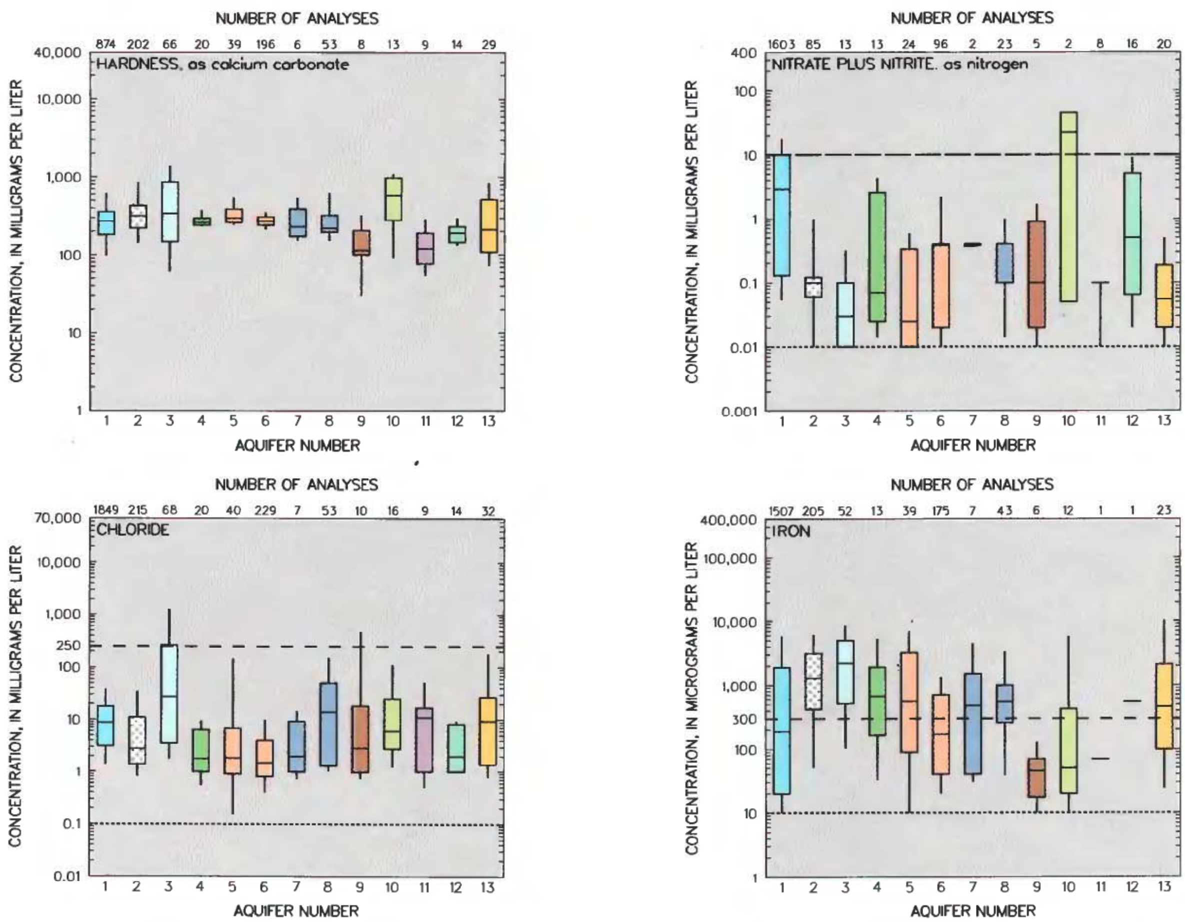


Figure 2. Principal aquifers and related water-quality data in Minnesota—Continued.

2*A*1). Glacial drift overlies much of Minnesota, and many water supplies have been developed from these unconsolidated deposits. Wells completed in outwash sand and gravel (surficial-drift aquifers) commonly yield 500 to 1,500 gal/min (gallons per minute) for irrigation and for public and industrial or commercial supplies. Sedimentary rocks consist mostly of sandstone, dolomite, and some limestone, and support large withdrawals of water for public supply and industrial or commercial use in southeastern Minnesota. Well yields of 500 to 1,000 gal/min are common. Crystalline igneous and metamorphic rocks form the basement complex in Minnesota and generally do not yield large amounts of water to wells. The rocks, however, are important as a source of water for many rural domestic supplies where no other aquifers occur. A summary of aquifer characteristics and ground-water use in Minnesota is given in "National Water Summary 1984" (U.S. Geological Survey, 1985, p. 261–268).

BACKGROUND WATER QUALITY

A graphic summary of selected water-quality variables compiled from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) is presented in figure 2*C*. The summary is based on dissolved-solids, hardness (as calcium carbonate), nitrate plus nitrite (as nitrogen), chloride, and iron analyses of water samples collected from 1965 to 1985 from the principal aquifers in Minnesota. 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 plus nitrite (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 iron.

Unconsolidated Glacial Drift

SURFICIAL-DRIFT AQUIFERS

Glacial drift underlies the land surface in most of Minnesota. In the central and western parts of the State, surficial-drift aquifers commonly consist of outwash sand and gravel (fig. 2*A*2 aquifer 1). Many water supplies, including large supplies for irrigation, have been developed in these aquifers. The water generally is a calcium-magnesium-bicarbonate type (Adolphson and others, 1981), but a mixed calcium magnesium bicarbonate sulfate type is present in places along the western border of the State. The quality of water from wells in the surficial-drift aquifers generally is suitable for most uses in relation to drinking-water standards. Dissolved-solids concentrations generally range from about 160 to 1,170 mg/L, with a median concentration of about 350 mg/L.

BURIED-DRIFT AQUIFERS

Buried-drift aquifers (fig. 2*A*2, aquifer 2) are present in glacial-drift deposits throughout most of the State, except in the northeast and southeast where the drift is thin or absent. These aquifers consist mainly of discontinuous layers of sand and gravel separated by till and are present commonly in areas of thick (200 to 600 feet) glacial drift. These "buried" sand and gravel deposits are being increasingly tapped by irrigation and public-supply wells. Water in the buried-drift aquifers generally is confined by till, which impedes the infiltration and downward percolation of contaminants from the land surface.

The water in the buried-drift aquifers generally is a calcium-magnesium-bicarbonate type, but water that contains significant concentrations of sulfate and chloride ions is present in the southwestern and northwestern parts of the State. In northwestern Minnesota, the buried-drift aquifers are underlain by rocks of Ordovician and Cretaceous age. Upward discharge of more mineralized water from the Ordovician and Cretaceous rocks affects the quality of water in the overlying buried-drift aquifers. Dissolved-soilds concentrations in the buried-drift aquifers generally range from about 260 to 1,600 mg/L, with a median concentration of about 450 mg/L.

Sedimentary Rock

CRETACEOUS AQUIFER

The Cretaceous aquifer (fig. 2*A*1, aquifer 3), which is present mainly in southwestern and western Minnesota, consists of shale and sandstone. The aquifer is not usually a water-supply source, except in areas where the surficial-and buried-drift aquifers are thin or absent. Many rural-domestic wells tap the Cretaceous aquifer in southwestern Minnesota, but the aquifer is seldom used for public-water supplies (Adolphson and others, 1981). Water from the Cretaceous aquifer, which generally is more mineralized than water from most other aquifers in Minnesota, commonly contains 450 to 3,600 mg/L dissolved solids. Water quality differs considerably from place to place; significant concentrations of sodium and chloride are present in ground water in northwestern Minnesota, and sodium and sulfate are present in the southwestern part. The widespread presence of large sodium concentrations (100 to 1,000 mg/L) is attributed to ion exchange and to the influx of sodium-bearing water from Cretaceous rocks to the west (Woodward and Anderson, 1986).

UPPER CARBONATE AQUIFER

The upper carbonate aquifer (fig. 2*A*1 , aquifer 4) consists primarily of limestone and dolomite and occurs in southeastern Minnesota. The aquifer yields adequate quantities of water to wells for most public-supply, industrial, and domestic uses. The water generally is a calcium-magnesium-bicarbonate type with a median dissolved-solids concentration of about 280 mg/L. Concentrations of sodium and sulfate increase to the southwest, where the aquifer is in contact with thick glacial drift and, possibly, with Cretaceous rocks (Ruhl and Wolf, 1984).

ST. PETER AQUIFER

The St. Peter aquifer (fig. 2*A*1, aquifer 5) is composed mainly of sandstone; it includes all but the basal silty part of the St. Peter Sandstone and extends throughout most of southeastern Minnesota. The St. Peter aquifer is seldom used for water supplies because larger well yields can be obtained from other aquifers. Water from the St. Peter aquifer generally is a calcium magnesium bicarbonate type that is suitable for most uses (Ruhl and Wolf, 1983). Dissolved-solids concentrations generally range from about 260 to 950 mg/L, with a median concentration of about 360 mg/L (fig. 2*C*).

The St. Peter aquifer is overlain by rocks of Cretaceous age in the southwestern part of its subcrop area. In this area, water from the St. Peter is a calcium sulfate type with a concentration of dissolved solids ranging from about 500 to 900 mg/L. This mineralized water is of limited use for public and industrial supplies (Ruhl and Wolf, 1983).

PRAIRIE DU CHIEN-JORDAN AQUIFER

The Prairie du Chien-Jordan aquifer (fig. 2*A*1, aquifer 6) consists mainly of sandstone (lower part) and dolomite (upper part). The aquifer extends throughout most of southeastern Minnesota and is the principal aquifer in the area. The Prairie du Chien-Jordan aquifer supplies about one-third of all ground water used in the State and 80 percent of the ground water used in the Twin Cities metropolitan area (Horn, 1983). About 54 billion gallons were withdrawn from the aquifer in 1980 in the metropolitan area. The water generally is suitable for most uses; it is a calcium magnesium bicarbonate type with a median dissolved-solids concentration of about 250 mg/L in most of southeastern Minnesota (Ruhl and others, 1983). However, dissolved-solids concentrations in the western part of the aquifer range from about 500 to 1,000 mg/L.

RED RIVER-WINNIPEG AQUIFER

The Red River-Winnipeg aquifer (fig. 2*A*1) consists of dolomitic limestone, mudstone, and sandstone. The aquifer underlies the extreme northwest corner of Minnesota and extends westward into a structural basin in North Dakota. Water from the aquifer is a very mineralized sodium chloride type in which dissolved-solids concentrations range from about 1,100 to 60,000 mg/L. (Selected water-quality constituents and properties are not shown in figure 2*C* because few samples were analyzed.) The only known uses of the water are for livestock and fire fighting (Ruhl and Adolphson, 1986). The naturally occurring saline water in the aquifer discharges upward into overlying alluvial deposits and to the Red River of the North, degrading the quality of both ground and surface water.

IRONTON-GALESVILLE AQUIFER

The Ironton-Galesville aquifer consists of sandstone and underlies southeastern Minnesota (fig. 2*A*1, aquifer 7). In part of the area, the aquifer includes part of the overlying Franconia Formation. Water from the aquifer generally is suitable for most uses; it is a calcium magnesium bicarbonate type, with dissolved-solids concentrations generally less than 400 mg/L. About 7 Mgal/d (million gallons per day) were being withdrawn from the aquifer in the 1970's, mostly for industrial and public supplies (Horn, 1983).

MOUNT SIMON-HINCKLEY AQUIFER

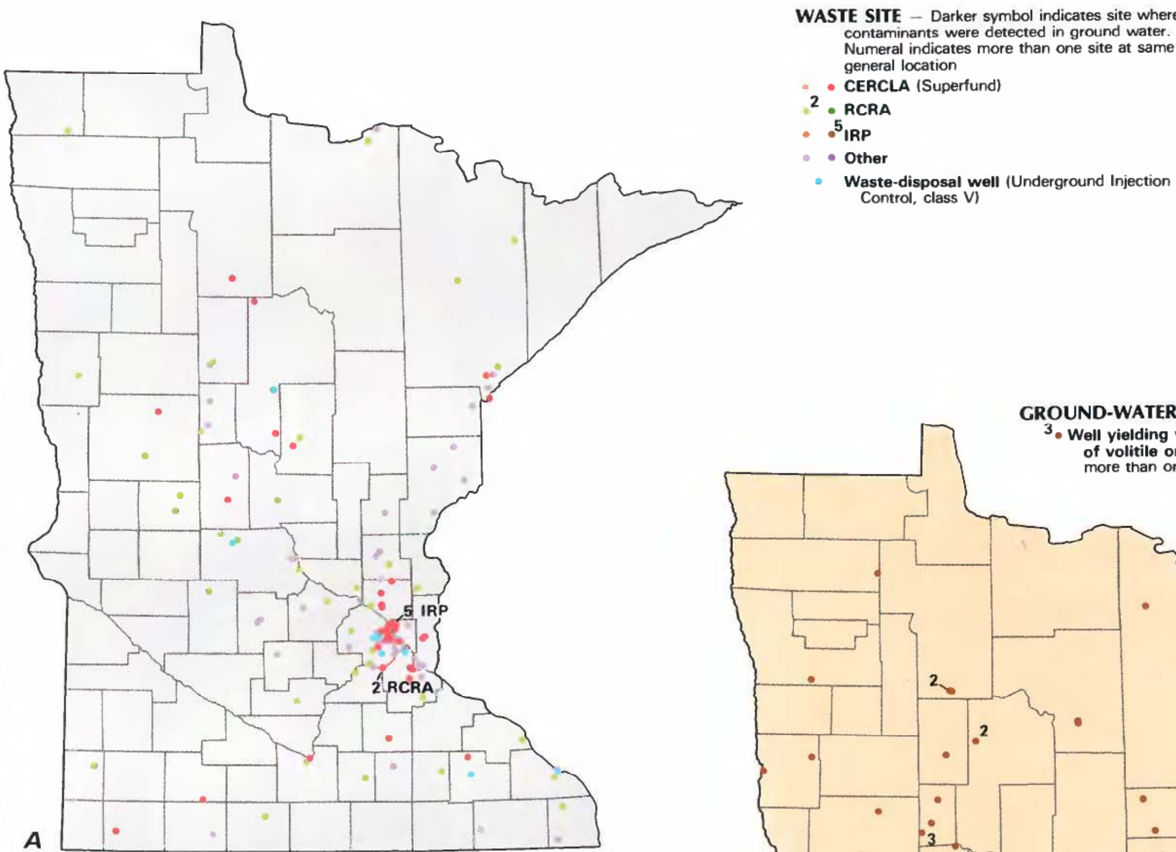
The Mount Simon-Hinckley aquifer (fig. 2*A*1, aquifer 8) consists of sandstone and is the most extensive of the sedimentary-rock aquifers underlying southeastern Minnesota. North of the Twin Cities metropolitan area, the aquifer also includes sandstone of the underlying Fond du Lac Formation (Wolf and others, 1983). Many wells have been completed in the aquifer north of the Twin Cities metropolitan area where it is the shallowest bedrock aquifer and, locally, the only aquifer. Withdrawals from the aquifer averaged about 19 Mgal/d in 1980, mostly for public and industrial supplies. The withdrawals represent about 10 percent of the total ground water used in the Twin Cities metropolitan area (Horn, 1983).

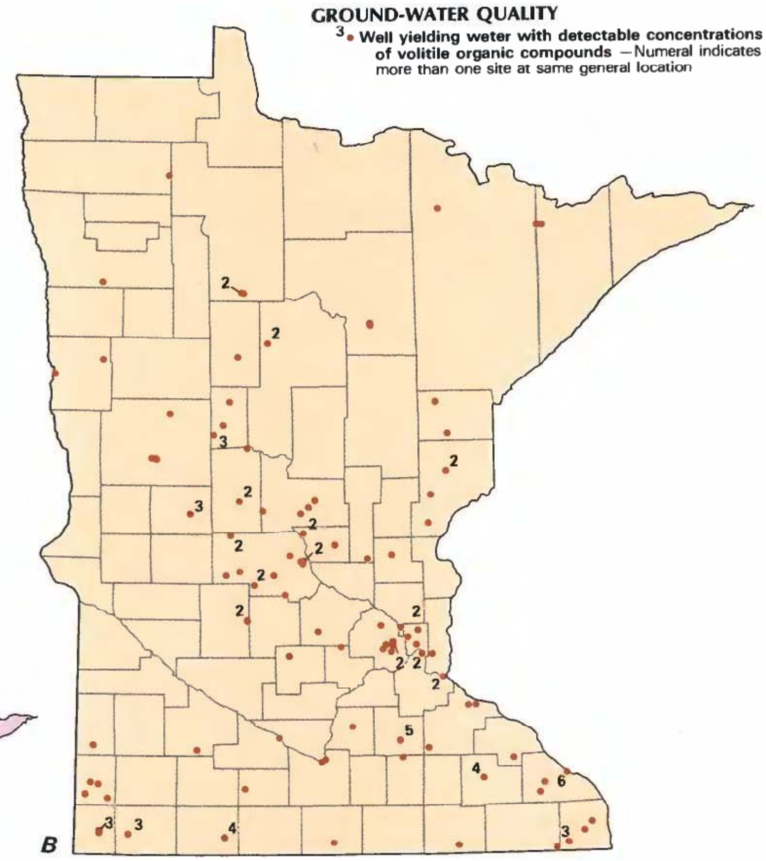
Water from the Mount Simon-Hinckley aquifer generally is suitable for most uses; it is a calcium magnesium bicarbonate type throughout most of the area, and concentrations of dissolved solids generally are less than 500 mg/L (Wolf and others, 1983). In part of southeastern Minnesota, sodium chloride type water is present in the aquifer below depths of about 1,000 feet. In the southwestern part of the area, where the aquifer is overlain by and receives recharge from rocks of Cretaceous age, the water contains significant concentrations of magnesium and sulfate. The aquifer is well protected from surface contamination throughout most of the area by overlying confining beds.

Crystalline Rock

NORTH SHORE VOLCANICS AQUIFER

The North Shore Volcanics aquifer (fig. 2*A*1, aquifer 9) consists of a thick series of basaltic lava flows that are exposed along the north shore of Lake Superior and the upper part of the St. Croix River valley. Water from the aquifer generally is a calcium magnesium bicarbonate type that is used mostly for domestic and





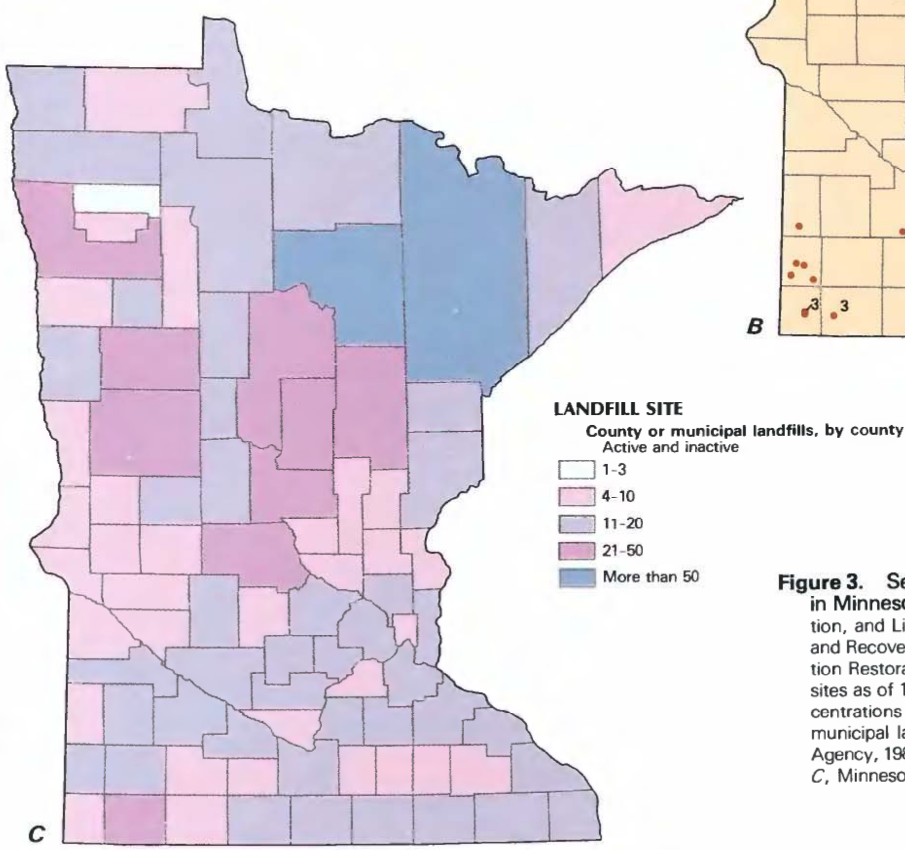


Figure 3. Selected waste sites and ground-water-quality information in Minnesota. *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of 1986; Resources Conservation and Recovery Act (RCRA) sites, as of 1986; Department of Defense Installation Restoration Program (IRP) sites, as of 1985; and other selected waste sites as of 1986. *B*, Location of wells that yield water with detectable concentrations of volatile organic compounds as of 1984. *C*, County and municipal landfills, as of 1980. (Sources: *A*, Minnesota Pollution Control Agency, 1983, 1986a; *B*, Minnesota Department of Health, 1985, Sabel 1985; *C*, Minnesota Pollution Control Agency, 1983.)

stock supplies, and dissolved-solids concentrations generally are less than 500 mg/L. Sodium-chloride type water is present locally along the north shore. Dissolved-solids and chloride concentrations in these local areas are as large as 74,300 mg/L and 46,000 mg/L, respectively (Anderson, 1986). This naturally occurring, very mineralized water is not used.

SIOUX QUARTZITE AQUIFER

The Sioux Quartzite aquifer (fig. 2*A*1, aquifer 10), which is present in southwestern Minnesota, consists of orthoquartzite with interbedded layers of mudstone and poorly cemented sandstone. The upper part of the aquifer typically is fractured and deeply weathered and yields from 1 to 450 gal/min to wells (Anderson, 1986). Water from the aquifer commonly is hard and is a mixed calcium-magnesium-bicarbonate-sulfate type. Dissolved-solids concentrations generally exceed 500 mg/L (fig. 2*C*) and are as large as 2,300 mg/L in areas where the aquifer is overlain by rocks of Cretaceous age (U.S. Environmental Protection Agency files).

PROTEROZOIC METASEDIMENTARY AQUIFER

The Proterozoic metasedimentary aquifer (fig. 2*A*1, aquifer 11) consists of argillite, slate, and metagraywacke (Anderson, 1986). The aquifer underlies central and northeastern Minnesota where it is used mostly for domestic water supplies. Water from the aquifer generally is suitable for domestic use because dissolved-solids concentrations typically are less than 500 mg/L. The water is a calcium-magnesium-bicarbonate type that generally is of better quality than water from most of the other crystalline-rock aquifers (Anderson, 1986). Although susceptible to contamination from land surface, contamination is not a serious problem in the Proterozoic metasedimentary aquifer.

BIWABIK-IRON FORMATION AQUIFER

The Biwabik-Iron Formation aquifer (fig. 2*A*1, aquifer 12) consists of ferruginous chert (Adolphson and others, 1981) that crops out in a narrow northeast-trending band in northeastern Minnesota. The aquifer yields as much as 1,000 gal/min of water to public-supply and industrial wells; largest yields are in areas where the aquifer has been altered by faulting and by the leaching of iron minerals (Anderson, 1986). Water from the aquifer is a calcium-magnesium-bicarbonate type that is suitable for most uses. Concentrations of iron, however, generally exceed the secondary drinking-water standard of 300 μg/L. Because the aquifer crops out at land surface, the water is susceptible to contamination from spills, landfills, septic systems, leaking tanks, and other such sources; however, contamination is not a widespread problem.

PRECAMBRIAN UNDIFFERENTIATED AQUIFER

Undifferentiated rocks of Precambrian age (fig. 2*A*1, aquifer 13) are tapped for rural domestic and livestock supplies in parts of southwestern and central Minnesota and in much of northern Minnesota. The aquifer consists of a variety of igneous and metamorphic rocks—mostly granite, greenstone, and slate (Adolphson and others, 1981). Water from the aquifer generally is a calcium-magnesium-bicarbonate type, but significant concentrations of sulfate are present in southwestern Minnesota. Sodium-chloride type water is present locally in the aquifer in the northeastern part of the State (Anderson, 1986). Dissolved-solids concentrations generally exceed 500 mg/L, and concentrations of 1,000 to 2,000 mg/L are relatively common.

EFFECTS OF LAND USE ON WATER QUALITY

Ground water is known to be contaminated at many of the sites shown in figures 3*A* and 3*B*, at many of the landfills and dumps shown in figure 3*C*, and in parts of southeastern and southwestern Minnesota. Contamination from the use of fertilizers and pesticides is suspected and may be increasing in the agricultural areas of Minnesota, but few data currently (1986) support this conclusion.

Thirty-six sites (fig. 3*A*) have been included in the NPL of Hazardous Waste Sites (U.S. Environmental Protection Agency, 1986c) for evaluation and cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Ground-water contamination is present at all 36 of these CERCLA sites. Forty-three hazardous-waste sites are included under the Resource Conservation and Recovery Act (RCRA) of 1976 (fig. 3*A*). The general distribution of the nearly 1,400 county or municipal landfills and dumps in Minnesota is shown in figure 3*C*. The number of landfills per county ranges from 2 in Pennington County to 180 in St. Louis County.

As of September 1985, 34 hazardous-waste sites at four facilities in Minnesota have 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 EPA Superfund program under CERCLA. The EPA presently ranks these sites under a hazardous ranking system and may include them in the NPL. Of the 34 sites evaluated under the program, 10 sites contained contaminants but did not present a hazard to people or the environment. Six sites at two facilities (fig. 3*A*) were considered to present a hazard significant enough to warrant response action in accordance with CERCLA. Remedial action at one of these sites has been completed under the program.

"Other sites" on figure 3*A* include sites identified by MPCA on the Minnesota Permanent List of Priorities and wells identified by EPA as Class-V injection wells in the Underground Injection Control (UIC) program, (U.S. Environmental Protection Agency, 1984).

In addition to individual sites, two principal aquifers (the surficial-drift and the upper carbonate aquifers areas) in the State are known or suspected to have widespread ground-water contamination from "nonpoint" sources, and principal aquifers in several areas have been affected locally.

Much of Minnesota is underlain by glacial drift (fig. 2*A*2) that consists, in part, of outwash deposits of sand and gravel. These outwash deposits, the surficial-drift aquifers, are at or near land surface in many parts of central and western Minnesota (fig. 2*A*) and generally contain large quantities of water at shallow (less than 200 feet) depths. Water in the surficial-drift aquifers is susceptible to contamination from land-use activities such as irrigated agriculture. Concentrations of nitrate plus nitrite (as nitrogen) beneath or adjacent to irrigated fields have exceeded 10 mg/L (Myette, 1984), which is the primary drinking-water standard. Nitrate concentrations that exceed this limit are common in ground water in glacial drift or alluvium in parts of southwestern Minnesota where feedlots are numerous (Minnesota Pollution Control Agency, 1986a, p. 47). Residual concentrations of commonly used pesticides have been found in water from a few wells that tap the surficial-drift aquifer (H.W. Anderson, Jr., U.S. Geological Survey, written commun., 1986).

Widespread contamination also occurs in southeastern Minnesota where karst topography has developed on carbonate rocks that are at or near land surface. The hydraulic connection between the streams and the shallow ground-water system in the karst area allows rapid movement of contaminants from feedlots and septic systems into the ground water. Runoff from croplands that have been fertilized and treated with pesticides also can readily enter the ground-water system and contribute to the contamination. Concentrations of nitrate plus nitrite in the karst area commonly exceed the primary drinking-water standard of 10 mg/L (Adolphson and others, 1981).

Aquifers that have been affected by contamination in local areas include the St. Peter, Prairie du Chien-Jordan, Ironton-

Galesville, and Sioux Quartzite aquifers. In the St. Peter aquifer, water-quality problems occur mainly in the Twin Cities metropolitan area, where layers of shale that normally overlie and protect the aquifer from contamination were breeched and eroded by glacial streams. In this area, the St. Peter aquifer commonly is in direct contact with glacial-drift or valley-fill deposits and is susceptible to contaminants percolating through these materials from the land surface. Locally, the aquifer has been affected by contaminants moving through multiaquifer wells and along deteriorated or improperly grouted well casings (Ruhl and Wolf, 1983).

Water in the Prairie du Chien-Jordan aquifer has been seriously contaminated in parts of the Twin Cities metropolitan area by downward movement of organic compounds through multiaquifer wells and through glacial-drift deposits where confining beds were breeched and eroded by glacial streams. This contamination is of concern because (1) some of the organic compounds are known carcinogens and (2) most public supplies in the metropolitan area are derived from wells completed in the Prairie du Chien-Jordan aquifer. Water in the aquifer also has been contaminated in places as a result of land uses such as landfills, salt storage, and agriculture.

The Ironton-Galesville aquifer also has been contaminated locally in the Twin Cities metropolitan area, even though this aquifer is generally well protected from surface contamination throughout most of the area by overlying confining beds.

The Sioux Quartzite aquifer is susceptible to contamination from land surface in areas where it crops out or where overlying glacial drift is thin. In these areas, concentrations of nitrate plus nitrite commonly exceed 10 mg/L.

POTENTIAL FOR WATER-QUALITY CHANGES

Additional sites where ground water has been contaminated by organic compounds are likely to be found in Minnesota, particularly as attention is given to the problem of the 40,000 to 50,000 underground storage tanks estimated by MPCA to be in place and subject to regulation by the State. The quality of water in aquifers contaminated by organic compounds should improve over the next several years as contamination sites are identified and remedial actions are taken. There is a growing awareness in Minnesota (Minnesota Pollution Control Agency, 1986b) of the effect of agricultural chemicals on water quality in the surficial-drift and upper carbonate aquifers. This awareness may lead to changes in land-use practices that could result in improved ground-water quality. Further deterioration in ground-water quality from new sources is less likely because of the State's awareness of contamination problems and the various regulatory and management programs that have been implemented.

A program for monitoring temporal and areal variations in the quality of Minnesota's ground water was begun in 1978 by the MPCA. Results of the program are summarized in a report by Sabel (1985), which includes data on the annual minimum, mean, and maximum concentrations of iron, chloride, nitrate, total organic carbon, dissolved solids, and pH of samples collected from the surficial-drift, buried-drift, Prairie du Chien-Jordan, and Ironton-Galesville aquifers from 1978 to 1984. The data indicate that chemical concentrations and properties fluctuate from year to year, but no trend is readily apparent. Mean and median concentrations of nitrate plus nitrite (as nitrogen) in water from the surficial-drift aquifers are shown in figure 4 for all samples collected since 1976 as part of the U.S. Geological Survey's program of water-resources investigations in Minnesota. Although the annual mean and median concentrations vary, the nitrate-plus-nitrite concentrations seem to be increasing, which may reflect the widespread application of agricultural fertilizers. However, the apparent trend may be biased because the Geological Survey's sampling programs have placed greater emphasis in recent years on water-quality investigations in agricultural areas.

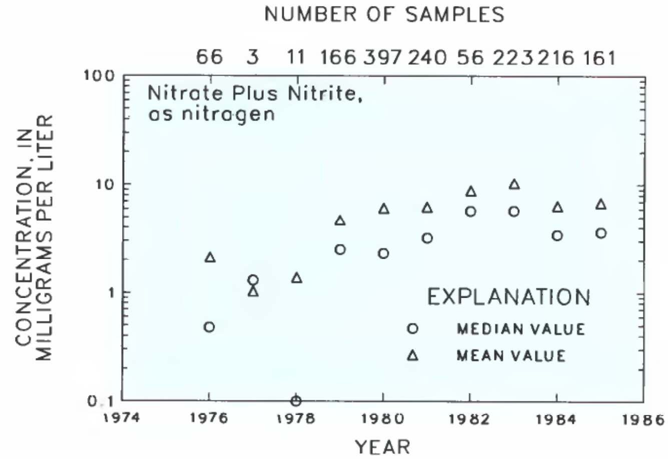


Figure 4. Mean and median concentrations of nitrate plus nitrite (as nitrogen) in the surficial-drift aquifers, 1976–85. (Source: U.S. Geological Survey files.)

GROUND-WATER-QUALITY MANAGEMENT

Management of ground-water quality in Minnesota potentially may involve one or more of five levels of government—Federal, interstate, State, regional, and local. Federal involvement generally is related to the Clean Water Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, the Toxic Substances Control Act, or the Comprehensive Environmental Response, Compensation, and Liability Act. These Federal programs complement State authority and promote consistency in water-quality management among the States. Interstate involvement is through various Commissions and Boards that function by agreement between Minnesota and neighboring States and the Canadian and Provincial governments. Regional and local involvement is through Regional Development Commissions, the Metropolitan Council of the Twin Cities, Soil and Water Conservation Districts, Watershed Districts, counties, and cities.

Most of the responsibility for management of ground water and its quality in Minnesota rests with three agencies—the Minnesota Department of Natural Resources (MDNR), the Minnesota Department of Health (MDH), and the Minnesota Pollution Control Agency (MPCA). The responsibility is divided by placing control of (1) water appropriations, which can be affected by water quality, with MDNR, (2) health-related and domestic-supply matters with MDH, and (3) water quality and pollution control with MPCA (Bruemmer and Clark, 1984).

Protection of ground-water quality by MPCA includes (1) regulating the land application of wastewater, (2) regulating construction and operation of feedlots, (3) administering a nonpoint-source-control program, (4) responding to contamination incidents, (5) regulating disposal of solid and hazardous wastes, and (6) comprehensive planning for prevention of contamination. Under the Minnesota Environmental Response and Liability Act, the MPCA has a $5-million fund to finance cleanup of hazardous-waste sites.

In 1986, the Minnesota Legislature amended Minnesota Statutes Chapter 115 to establish potable-water supply as the highest-priority use of water in the State. The amendment prohibits the location of hazardous- or radioactive-waste facilities where they might cause pollution of potable water. The comprehensive Local Water Planning Act, Minnesota Statutes 110B, 1986, enables counties to prepare water-management plans and to regulate water resources. The Legislature also passed a law directing the MPCA to authorize projects for testing controlled injection of oxygen-bearing material and microbiological systems into contaminated sites as a possible remedial measure. The State currently is surveying the occurrence of pesticides in ground water.

Minnesota's goal in managing the ground-water resource is to assure an adequate supply of sufficient quality to meet reasonable demands for use. The strategy for achieving the goal includes:

1. Improved management of water and land resources,
2. identification of areas where additional ground-water development would be feasible and beneficial and where it would not, and
3. protection of ground water from contamination to assure safe drinking-water supplies.

The goal can be achieved through enhancement of existing programs, particularly those with the objective of preventing ground-water contamination. Minnesota does not, for example, agree with a policy that would allow intentional degradation of water quality in selected aquifers. As stated by Bruemmer and Clark (1984), "...efforts should be directed at managing information needs for evaluating environmental and health risks; assessing ground water resources in terms of quality and quantity; developing effective monitoring and remedial strategies; investigating contaminant movement and behavior in soil and ground water systems (transport and fate); expanding the presently limited and hard-pressed analytical capabilities and capacities; providing technical assistance and training to state and local authorities; and disseminating information efficiently and effectively to those directly involved with water resource management and to the general public."

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