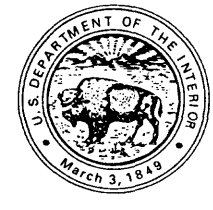
WATER-RESOURCES ACTIVITIES, NORTH DAKOTA DISTRICT, FISCAL YEAR 1994-95

Compiled by Cathy R. Martin

U.S. GEOLOGICAL SURVEY

Open-File Report 95-105



Bismarck, North Dakota

1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
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Denver, CO 80225

FOREWORD

The North Dakota District of the U.S. Geological Survey, Water Resources Division, collects water-resources data and conducts interpretative investigations in cooperation with many State, local, and other Federal agencies and with Indian tribes. The District operates extensive data-collection networks that provide the types of information on surface-water and ground-water quantity and quality that are needed on a continuing basis by those who are responsible for managing the State's water resources. The District also conducts interpretative projects that are relevant to contemporary water issues or problems in North Dakota. This "Water-Resources Activities" report is published every 2 years to inform our cooperators and others interested in the State's water resources of the entire scope of work we are doing in North Dakota. Although the basic data-collection activities (projects ND 00-001 through ND 00-007) tend to be quite stable from year to year, the mix of interpretative projects may change substantially over a 2-year period.

The foreword of the 1992 edition of this "Activities" report included a note of hope that North Dakota's 1988-92 drought would end soon. The drought ended dramatically, in fact, with what many midwesterners, particularly those in Iowa and Missouri, will long remember as the "Great Flood of 1993." Widespread intense rainfall that occurred during the summer of 1993 caused unusually high summer streamflows in the central and eastern parts of the State and localized flooding on the James, Sheyenne, and Red Rivers, as well as in the Devils Lake Basin. Interestingly, one of the outcomes of the extremely wet summer of 1993 was to modify the conventional thinking that ground-water and wetlands recharge occurs in the northern prairies only as a result of snowmelt and would require several years of greater-than-average snowmelt to accomplish. We saw substantial increases in ground-water levels in many shallow aquifers during the late summer and fall of 1993. Also, thousands of wetland basins in the central and eastern parts of the State actually contained much more water in the fall than at the beginning of the summer--a real hydrologic anomaly.

Recovery of lake and reservoir levels in North Dakota during 1993-94 also was dramatic. The level of Lake Sakakawea on October 31, 1992, was 1,821.3 feet (see figure 3, page 10). The lake level on October 31, 1994, was 1,840.3 feet, an increase of about 19 feet, which accounted for an increase of water in storage of about 5.4 million acre-feet or about one-third of the mean annual flow of the Missouri River at Bismarck. The level of Devils Lake on October 31, 1992, was 1,422.4 feet (see figure 4, page 10). The lake level on October 31, 1994, was 1,430.7 feet, an increase of 8.3 feet, which accounted for nearly a doubling of the volume of water in storage in Devils Lake (500,000 to 1 million acre-feet).

The changes in surface-water and ground-water conditions that occurred in North Dakota from 1992-94 remind us of how variable climatic and hydrologic conditions can be from season to season and year to year. Superimposed on that temporal variability is the geographic variability that causes such an uneven distribution, in quality as well as quantity, of water resources across North Dakota. These factors about hydrologic variability are noted to emphasize the importance of the continual gathering of information that may be used to assess the current status of our water resources and determine how they change through time and space. If we hope to be able to plan for the long-term water needs of our State, we need an appreciation for the full range of hydrologic conditions that could occur in the future. Our cooperative data-collection programs help provide the information that is essential to a perspective of past hydrologic conditions and the projection of future conditions, as well as assuring the availability of fundamental data that may be used in studies that address specific water issues of concern.

Wm. F. Horak
District Chief

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INTRODUCTION

The mission of the U.S. Geological Survey, Water Resources Division, is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States. This report describes water-resources activities of the Water Resources Division in North Dakota in fiscal year 1994. Information on each project includes objectives, approach, progress, plans for fiscal year 1995, and completed and planned report products.

Origin of the U.S. Geological Survey

The U.S. Geological Survey was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific classification of the public lands and examination of the geological structure, mineral resources, and products of national domain. An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and factfinding role of the U.S. Geological Survey has grown and been modified to meet the changing needs of the Nation. As part of that evolution, the U.S. Geological Survey has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, the primary source of data on the Nation's surface- and ground-water resources, and the employer of the largest number of professional earth scientists. Today's programs are designed to meet the needs of a diverse group of users. Programs include:

- Conducting an expanding national program to describe the status and trends in the quantity and quality of surface- and ground-water resources. The U.S. Geological Survey monitors more than 45,000 stations that measure the amount and quality of surface and ground water. Of these, about 7,300 are continuous recording streamflow stations; 3,000 of these gages are an integral part of the National Oceanic and Atmospheric Administration National Weather Service's flood forecasts system.
- Evaluating hazards associated with earthquakes, volcanoes, floods, droughts, toxic materials, landslides, subsidence, and other ground failures; developing methods for hazards forecasting; and providing information to help Federal, State, and local agencies in mitigating the effects of these natural disasters.
- Operating digital seismograph stations as part of the U.S. National Seismic Network, supporting the operation of 12 regional seismographic networks, and managing the National Strong Motion Network of 650 stations in 35 states. The information developed from these networks helps provide risk estimates for earthquake-prone regions of the Nation.
- Operating three volcano observatories and maintaining mobile monitoring equipment for responding to volcanic eruption threats around the world.
- Assessing energy and mineral resources, providing unbiased information about their quantity and quality, determining origin and manner of occurrence, and developing techniques for discovery.

SAMPLING GROUND WATER, 14 MILES NORTHEAST OF DAGGETT, SAN BERNARDINO COUNTY, CALIFORNIA, SEPTEMBER 6, 1917 (Thompson, D.G., 24)

• Developing technology to increase efficiency and expand collection of data for paper and digital maps to meet the needs of the public and the private sector.

• Publishing about 3,000 new or updated reports and maps each year and maintaining a stock of 88,500 maps. Some 54,000 maps are required to cover the lower 48 states at a working scale of 1:24,000. The U.S. Geological Survey distributed about 6.7 million maps in 1994 alone.

• Conducting and sponsoring basic and applied research in geology, hydrology, mapping, and related sciences.

• Establishing and maintaining national earth-science data bases for use by Federal, State, and local land-management and regulatory agencies; disseminating earth-science data and information; and producing and updating geographic, cartographic, and remotely sensed information in graphic and digital forms.

• Cooperating with more than 1,100 Federal, State, and local agencies. These partners provide nearly $300 million annually in direct financial support. The funds in the mapping and water co-op programs are matched by non-Federal cooperators. In 1995, to fund additional high priority work they want done, cooperators will provide an estimated $23 million over and above the dollar-for-dollar matching requirement.

COLLECTING A WATER SAMPLE USING COMPRESSED AIR

• Serving as the lead Federal coordinator for national geographic, geologic, and water-resources data, and providing other scientific and technical assistance.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the U.S. Geological Survey remains dedicated to its original mission to collect, analyze, interpret,

publish, and disseminate information about the natural resources of the Nation--providing earth science in the public service.

Mission of the Water Resources Division

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States. This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies by:

- Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources;
- Conducting analytical and interpretative water-resources appraisals describing the occurrence, the availability, and the physical, chemical, and biological characteristics of surface and ground water;
- Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or manmade;
- Disseminating water data and results of investigations and research through reports, maps, computerized information services, and other forms of public releases;
- Coordinating activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground waters;
- Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Power Commission, and to international agencies on behalf of the Department of State.

Sources of Information and Water Resources Division Publications

The U.S. Geological Survey disseminates earth-science information through a network of public access points and an extensive publications program. Information on U.S. Geological Survey programs may be obtained from U.S. Geological Survey Circular 900, "Guide to Obtaining USGS Information."

National Water Data Exchange (NAWDEX) Program

The Water Data Source Directory (WDSD) is a computerized data base developed and maintained by the National Water Data Exchange (NAWDEX) Program Office. The directory contains information about organizations that collect, store, and disseminate water data. This information includes the type of each organization; the major orientation of water-data activities conducted by each organization; the names, addresses, and telephone numbers of offices within each organization from which water data may be obtained; the types of data available from each organization and the geographic locations where these data have been collected; and alternate sources of an organization's data. Requests for information can be obtained from the U.S. Geological Survey, NAWDEX User Services Unit, 12201 Sunrise Valley Drive, MS 421, Reston, VA 22092.

National Water Information System (NWIS)

The national Water Data Storage and Retrieval (WATSTORE) system was a large-scale computerized storage and retrieval system used by the U.S. Geological Survey to store and disseminate water data. The

WATSTORE system had data-processing, storage, and retrieval capabilities as well as the capability of providing computer-printed tables and graphs, statistical analyses of data, and digital plots.

The WATSTORE system, which basically remained unchanged for about 10 years, gradually has been replaced by a new water-data management system. The new system is called the National Water Information System (NWIS). A fundamental change from the WATSTORE system to the NWIS was the distribution of water data from a central computer in Reston, Va., to minicomputers at district offices throughout the Nation. The Reston computer remains as an archival data repository. Data-management software has been enhanced to streamline data processing, allow for direct entry of data relayed through satellite, and permit processing of variable-interval data in addition to fixed-interval data. Data management has become easier, and data can be processed more quickly than before. Improvements in timeliness of data availability have occurred and further improvements are expected as software is developed for the new system. Since 1987, all surface-water, ground-water, water-quality, and water-use data for North Dakota have been processed and stored on the North Dakota District minicomputer.

Water-Data Program

Water-data stations at selected locations throughout the Nation are used by the U.S. Geological Survey to obtain records of streamflow, reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface and ground water. These data provide a continuing record of the quantity and quality of the Nation's surface- and ground-water resources and, thus, provide the hydrologic information needed by Federal, State, and local agencies and the private sector for the development and management of land and water resources. All data collected are stored in the NWIS and also are published, by water year, for each state in a publication series entitled "U.S. Geological Survey Water-Resources Data Reports" (see section "Water Resources Division Publications" for availability of these reports). Information about the water-data program can be obtained from the Assistant Chief Hydrologist for Operations at the headquarters office in Reston, Va., or from the District Chief of the state of interest.

Water Resources Division Publications

Information on a wide variety of earth-science specialties is published in many forms, including the Federal book series and the map series. Book publications include a formal series of water-supply papers, professional papers, bulletins, circulars, techniques of water-resources investigations, and special reports and an informal series of water-resources investigations reports, open-file reports, and administrative reports. Map publications include a formal series of hydrologic investigations atlases and miscellaneous investigations maps and an informal series of water-resources investigations reports, open-file reports, and miscellaneous field studies maps. New reports are announced monthly in "New Publications of the Geological Survey," subscriptions to which are available upon request from the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Formal series book publications are sold by the U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225; single copies of circulars still in print are available upon request from that address. Map publications pertaining to North Dakota are sold by the U.S. Geological Survey, Map Distribution Branch, Box 25286, Denver Federal Center, Denver, CO 80225.

Water-resources investigations reports and open-file reports pertaining to North Dakota are available for inspection at the U.S. Geological Survey, Water Resources Division, 821 East Interstate Avenue, Bismarck, ND 58501; information on their availability also may be obtained from the District Chief at that address. In addition, those reports having an alpha-numeric designation in parentheses at the end of the

citation may be purchased as paper copy or microfiche from the U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225--the alpha-numeric designation is required when ordering from the Open-File Reports Section.

The series of reports entitled "Water-Resources Data for (State) for (Year)," describing surface water, ground water, and water quality in each state, may be purchased from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. The reports can be inspected in U.S. Geological Survey libraries and in Water Resources Division district offices in the region of the report.

NORTH DAKOTA DISTRICT

The North Dakota District is 1 of 48 districts of the U.S. Geological Survey, Water Resources Division. The District boundaries generally are coincident with those of the State. Offices of the North Dakota District are located in Bismarck and Grand Forks (table 1). District organization is shown in figure 1.

Table 1. North Dakota District offices

Office	Telephone number	Address
District office	(701) 250-4601	U.S. Geological Survey Water Resources Division 821 East Interstate Avenue Bismarck, ND 58501
Grand Forks field headquarters	(701) 775-7221	U.S. Geological Survey Water Resources Division P.O. Box 1437 Grand Forks, ND 58206-1437

Funding

Funds to support water-resources activities of the North Dakota District are derived from three principal sources:

1. Federal program--Funds are appropriated by Congress for support of prescribed activities. In fiscal year 1994, Federal funding for North Dakota District program activities was $767,159.

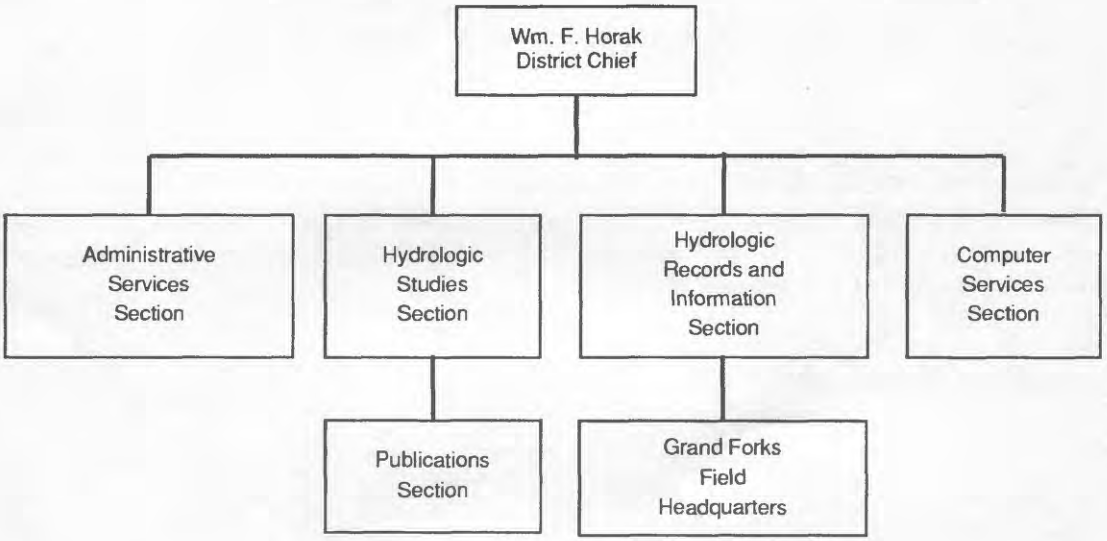


Figure 1. North Dakota District organizational structure.

2. Federal-State Cooperative program--Federal funds are appropriated by Congress and used to match those furnished by State and other tax-supported agencies. These funds are used for a variety of hydrologic data-collection activities and water-resources investigations in which the U.S. Geological Survey represents the national interest and the cooperating agencies represent State and local interests. In fiscal year 1994, Federal-State Cooperative funding for the North Dakota District was $1,449,216.
3. Other Federal Agencies (OFA) program--Funds are transferred to the U.S. Geological Survey as reimbursement for work conducted at the request of other Federal agencies. In fiscal year 1994, OFA funding was $1,081,055.

The total budget for fiscal year 1994 was $3,297,430. The percentage of funding from each principal source is shown in figure 2. Agencies cooperating in water-resources investigations in fiscal year 1994 are given in table 2.

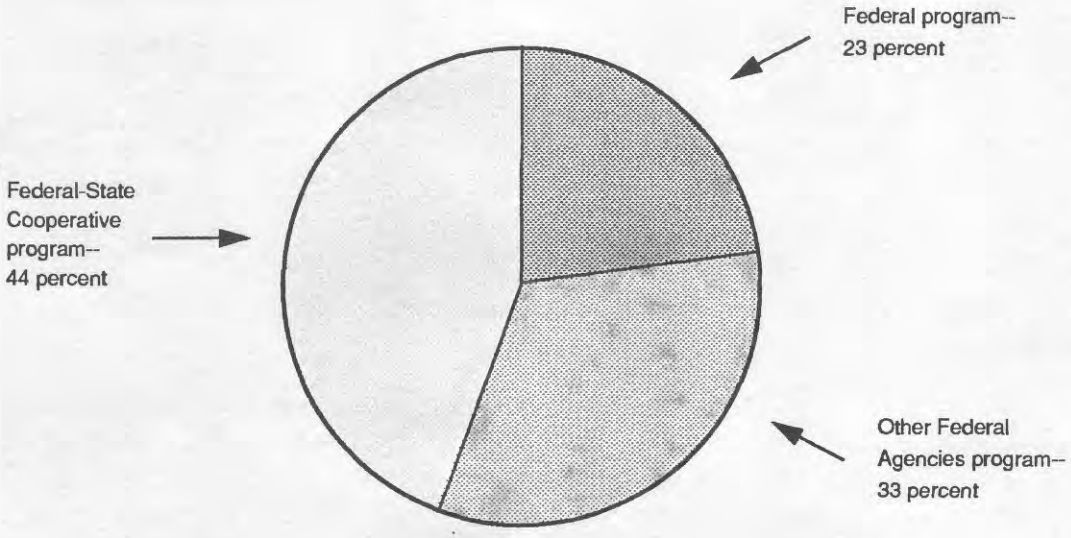


Figure 2. Percentage of funding from principal sources for fiscal year 1994.

The types of activities conducted by the North Dakota District include areal appraisals and interpretative studies and collection of hydrologic data. The relative District involvement in each of these activities, in terms of funding, is about 37 percent for areal appraisals and interpretative studies and about 63 percent for collection of hydrologic data.

Water Issues in North Dakota

Many water issues received attention in North Dakota during the past 12 months. Some of those issues are highlighted in the following paragraphs.

Table 2. Agencies cooperating in water-resources investigations in fiscal year 1994

Federal agencies
U.S. Department of the Army
Corps of Engineers
Omaha District
St. Paul District
U.S. Department of the Interior
Bureau of Indian Affairs
Bureau of Reclamation
Fish and Wildlife Service
National Biological Survey
U.S. Department of State
International Joint Commission
Waterways Treaty Program
U.S. Environmental Protection Agency
State agencies
North Dakota Department of Transportation
North Dakota Game and Fish Department
North Dakota Parks and Recreation Board
North Dakota State Department of Health and Consolidated Laboratories
North Dakota State Water Commission
Local agencies
City of Dickinson
City of Minot
Devils Lake Basin Joint Water Resource Board
Devils Lake Sioux Tribe
Lower Heart River Water Resource District
Nelson County Water Resource District
Oak Creek Water Resource District
Oliver County Water Resource District
Three Affiliated Tribes

From Drought to Flood

The drought of 1988-92 was severe from a hydrologic standpoint. Many streams had new record low streamflows during the period, and several streams ceased to flow entirely. Lake Sakakawea, one of the world's largest manmade lakes, had the lowest water level (1,815 feet in May 1991; fig. 3) since first reaching the normal maximum operating level in July 1969. The water level fell more than 32 feet from July 1986 until May 1991, and capacity was only 12 million acre-feet, about 50 percent of maximum capacity. Devils Lake, which reached an elevation of 1,428.8 feet above sea level in 1987, declined to 1,422.4 feet above sea level by the start of the 1993 water year (fig. 4). Concern over adverse effects of the drought on the sport fishery of Devils Lake was very high.

Spring breakup in 1993 was rather uneventful. Severe flooding occurred in July and August in the Devils Lake, Sheyenne River, and James River Basins. Localized flooding affected the urban areas of Bismarck, Jamestown, Valley City, and Fargo and other smaller communities. The flooding was preceded by near-normal precipitation in April and May and much greater-than-normal precipitation in June. July precipitation (300 to 600 percent of normal) generally ranged from 8 to 10 inches in the flooded areas. The maximum July precipitation of 13.75 inches occurred at Bismarck. Recurrence intervals for streamflows in the flooded areas generally ranged from 10 to 50 years; however, streamflow at the James River near

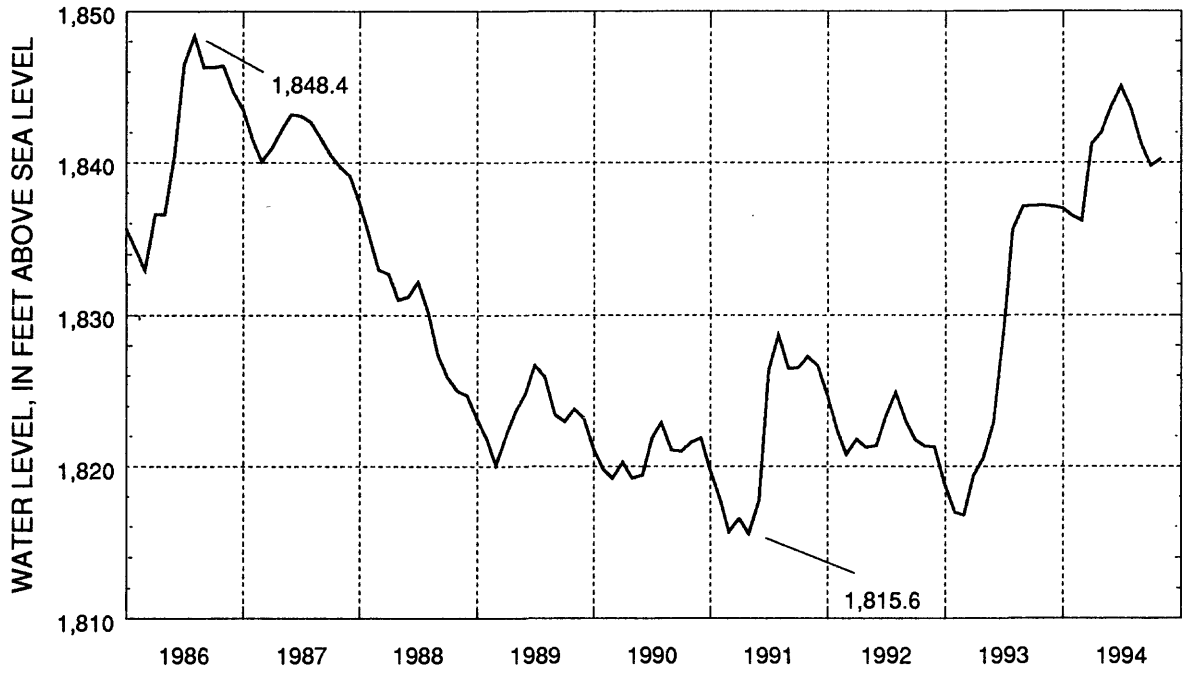


Figure 3. Water level of Lake Sakakawea, 1986-94.

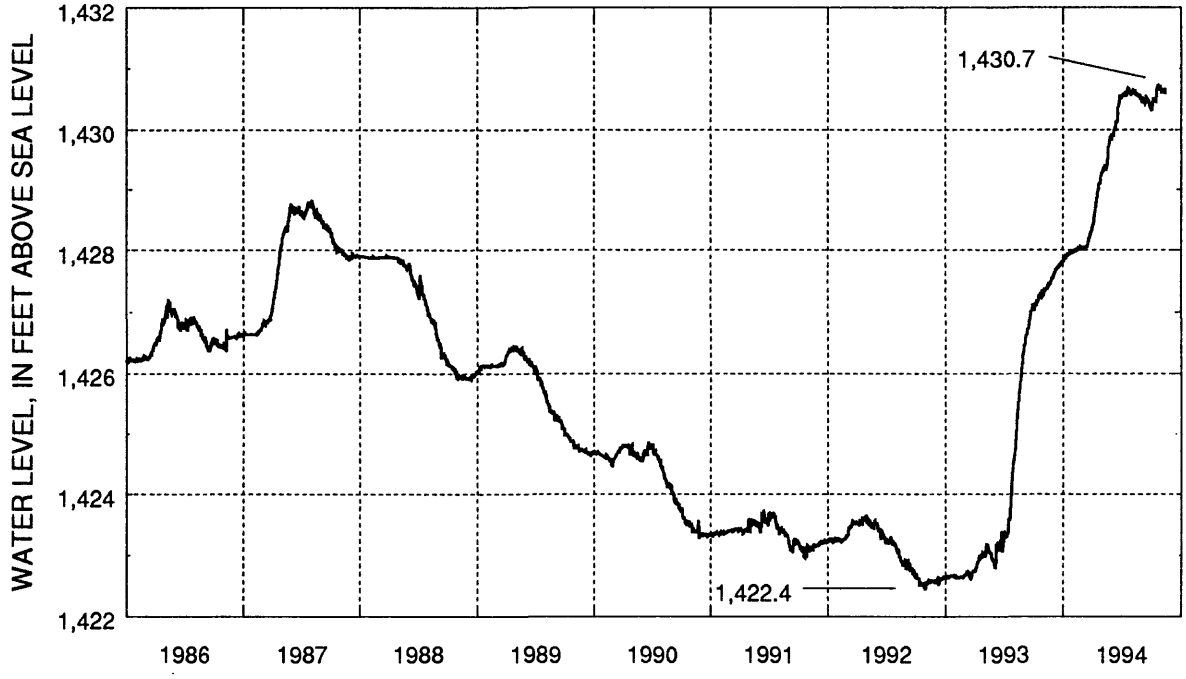


Figure 4. Water level of Devils Lake, 1986-94.

Manfred gaging station was the greatest for the period of record and the recurrence interval was greater than 100 years.

Devils Lake rose almost 4 feet from early July through December 1993. The water level continued to rise from 1,427.8 feet above sea level on January 1, 1994, to 1,430.7 feet above sea level on July 19, 1994, a new record high for this century.

Devils Lake Stabilization

During the last 2 years, the water level of Devils Lake rose dramatically, from 1,422.6 feet above sea level on March 23, 1993, to 1,430.7 feet above sea level on July 19, 1994 (fig. 4). The 8-foot increase in 17 months was the largest increase for any 18-month period during the last 110 years. Runoff into Devils Lake began during the intense rainfall and widespread flooding in the summer of 1993 and continued through the fall and winter as the upstream chain of lakes slowly drained. Some locations in the Devils Lake Basin had May-August precipitation totals of 30 inches. Mean annual precipitation at Devils Lake is only 16.5 inches! Record snowfall during the winter of 1993-94 sustained the runoff during the spring of 1994, and 4 to 6 inches of rain over the Devils Lake Basin in May 1994 added additional runoff to the lake. This extreme turn of events eliminated the various scenarios for emergency action that were being discussed to "save" the lake during the spring of 1993. The focus for most Federal, State, and local agencies has shifted from drought and low water levels to flood protection because of high water levels.

The only likely long-term solution to stabilize the water level of the lake is to construct an inlet and an outlet. The inlet includes transfer of Missouri River water into the lake via water-conveyance features that already have been built or are proposed as part of the Garrison Diversion Unit project. Congress has authorized the U.S. Army Corps of Engineers (in cooperation with the Bureau of Reclamation) to study the issue of stabilizing the water level of Devils Lake.

Missouri River and Lake Sakakawea

Public concern about the current operating plan for the six large dams and reservoirs on the Missouri River prompted the U.S. Army Corps of Engineers to begin a study in 1989 of numerous alternative operating plans and the economic, social, and environmental impacts of those plans. The Mainstem System is operated under the guidelines of the Master Water Control Manual (Master Manual), which identifies the current Water Control Plan. The study solicited input from interested parties, identified alternatives, and identified the "preferred" plan for operation of the Mainstem System. Review of the alternatives will help identify the operating plan that best meets the wide variety of contemporary needs served by the Missouri River system.

Highlights

Water-Quality Monitoring on Devils Lake and the Chain of Lakes

Water quality in Devils Lake, the chain of lakes, Stump Lake, and McHugh Slough is being monitored four times each year. Samples are collected and analyzed for nutrients, major ions, trace elements, and chlorophyll *a*. In addition, samples collected from Devils Lake are analyzed for phytoplankton and zooplankton. The waters are being monitored in cooperation with the North Dakota Game and Fish Department, the North Dakota State Department of Health and Consolidated Laboratories, the North Dakota State Water Commission, the Devils Lake Basin Joint Water Resource Board, and the Nelson County Water Resource District. Data collected will be published in the annual data report.

Surface-Water/Ground-Water Investigations

The North Dakota District is working with U.S. Geological Survey Headquarters to evaluate the ground-water/surface-water interactions in the upper Mississippi River Basin. The investigation consists of three components: (1) A general overview of ground-water/surface-water interactions as affected by flooding, (2) the identification and review of case studies that represent ground-water/surface-water interactions as affected by flooding, and (3) the implications for operation of present networks and possible future networks to address the ground-water/surface-water interactions. Literature is being reviewed and data on surficial and alluvial aquifers within a 12-state area are being collected and analyzed. The results of the investigation will be presented at the American Society of Civil Engineers International meeting in July 1995.

Interactions Between Hydrology, Water Quality, and Wetland Functions in the Prairie Pothole Region (ND 93-170)

The U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, is conducting a study to evaluate possible relations between readily available climatic and hydrologic data and indexes of the physical condition of wetlands. Historic climatic data were compiled from National Climatic Data Center data sets, and historic hydrologic data were compiled from U.S. Geological Survey data sets. Wetlands information was extracted from aerial photography obtained from Agricultural Stabilization and Conservation Service county offices. Wetlands indexes that describe the open-water area of wetlands as a percentage of wetlands area defined by the U.S. Fish and Wildlife Service and the open-water area of wetlands per square mile were developed. Statistical regressions of the wetlands index data sets and the climatic and hydrologic variables data sets were conducted.

Frequency Analysis for Devils Lake, North Dakota (ND 94-173)

In response to rising water levels from about 1969 through the early 1980's, the U.S. Army Corps of Engineers completed a feasibility study of possible flood-control projects to protect cities, roads, and other properties around Devils Lake. The U.S. Army Corps of Engineers has conducted a reconnaissance study for stabilizing the water levels of Devils Lake, but completion of the study required analyses of future lake-level probabilities and associated economic damage estimates. The U.S. Geological Survey, in cooperation with the North Dakota State Water Commission, began a study in November 1993 to estimate future lake-level probabilities using a statistical water mass-balance model. A multivariate time-series model was developed to generate future realizations of seasonal precipitation, evaporation, and inflow, which are used as input for the water mass-balance model. The time-series model was used to estimate 2,000 lake-level traces, each 50 years in length.

The success of the study is largely dependent on the joint effort of U.S. Geological Survey District and National Research Program personnel. Intensive technical oversight of the study has been provided by several organizations, including the U.S. Army Corps of Engineers at the District, Division, and Headquarters levels, and the Corps' Hydrologic Engineering Center; the North Dakota State Water Commission; and the U.S. Geological Survey, Office of Surface Water. Agencies providing the technical oversight have accepted the final results of the study and the draft report has been written.

Variations in Surface-Water Quantity and Quality as a Result of the 1993 Summer Flood in the Devils Lake Basin, North Dakota (ND 94-174)

Greater-than-normal precipitation in the Devils Lake Basin during the summer of 1993 caused peak runoffs and resulted in increased volumes of water in the chain of lakes and Devils Lake. Surface-water

quantity and quality conditions in the Devils Lake Basin were investigated by the U.S. Geological Survey in cooperation with the North Dakota State Department of Health and Consolidated Laboratories. Streamflow and lake levels were measured and water-quality samples were collected in the chain of lakes, Devils Lake, and coulees in the Devils Lake Basin during April through October 1993 to document the effects of the flood on hydrologic properties, major ions, and nutrients.

Response of the Sheyenne Delta Aquifer to Precipitation and Flooding During 1993-94 (ND 94-175)

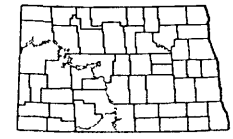
The physical response of the Sheyenne Delta aquifer to precipitation and flooding during 1993-94 was evaluated and variations in ground-water quality related to the precipitation and flooding were assessed. Water levels were measured in 49 wells every 3 weeks, when possible, from November 1993 through May 1994. The North Dakota State Department of Health and Consolidated Laboratories collected water samples from 16 of these wells in each of 4 months--November, March, April, and May--and analyzed the samples for major ions, nutrients, pesticides, and selected trace elements. This information, along with information from previous investigations, will provide the basis for describing the general response of the hydrology and water-chemistry characteristics of the Sheyenne Delta aquifer to precipitation and flooding during 1993-94.

SURFACE-WATER STATIONS

PROJECT NUMBER: ND 00-001.

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.


STATEWIDE

PROJECT CHIEF: Russell E. Harkness.

COOPERATING AGENCIES: (1) City of Dickinson; (2) Lower Heart River Water Resource District; (3) North Dakota Parks and Recreation Board; (4) North Dakota State Water Commission; (5) Three Affiliated Tribes; (6) U.S. Department of the Army, Corps of Engineers; (7) U.S. Department of the Interior, Bureau of Indian Affairs; (8) U.S. Department of the Interior, Bureau of Reclamation; (9) U.S. Department of the Interior, Fish and Wildlife Service; and (10) U.S. Department of State, International Joint Commission, Waterways Treaty Program.

PROBLEM: The operation of existing water projects and the planning of future work require the availability of accurate, unbiased streamflow and water-level data. The data must be available in a timely manner in order to assure efficient and effective operation of existing water projects. The data also must be available over a wide range of space and time in order to provide statistically accurate projections used for planning.

OBJECTIVES: Objectives are to (1) collect surface-water data needed for assessment of water resources, operation of reservoirs or industries, forecasting, disposal of wastes and pollution controls, compact and legal requirements, and research or special studies; (2) collect surface-water data needed to accompany water-quality measurements; and (3) collect surface-water data needed for analytical studies at specific locations to define statistical distributions of, and trends in, the occurrence of water in streams, lakes, and reservoirs for use in planning and design.

APPROACH: Standard methods of data collection are used as described in the U.S. Geological Survey techniques of water-resources investigations report series. Partial-record gages are operated instead of complete-record gages where daily streamflow data are not required for the entire year. Discharge or stage data will be obtained for the stations shown in figure 5. A station-classification summary is given in the following table:

Station classification		Number of stations
Stream stations		136
Continuous record:		
Stage and discharge	86	
Stage only	11	
Stage and peak flow	1	
Partial record:		
Discharge (seasonal)	23	
Stage only (seasonal)	8	
Peak (maximum flow only)	7	
Lake and reservoir stations		15
Stage and contents	12	
Stage only	3	
Total		151

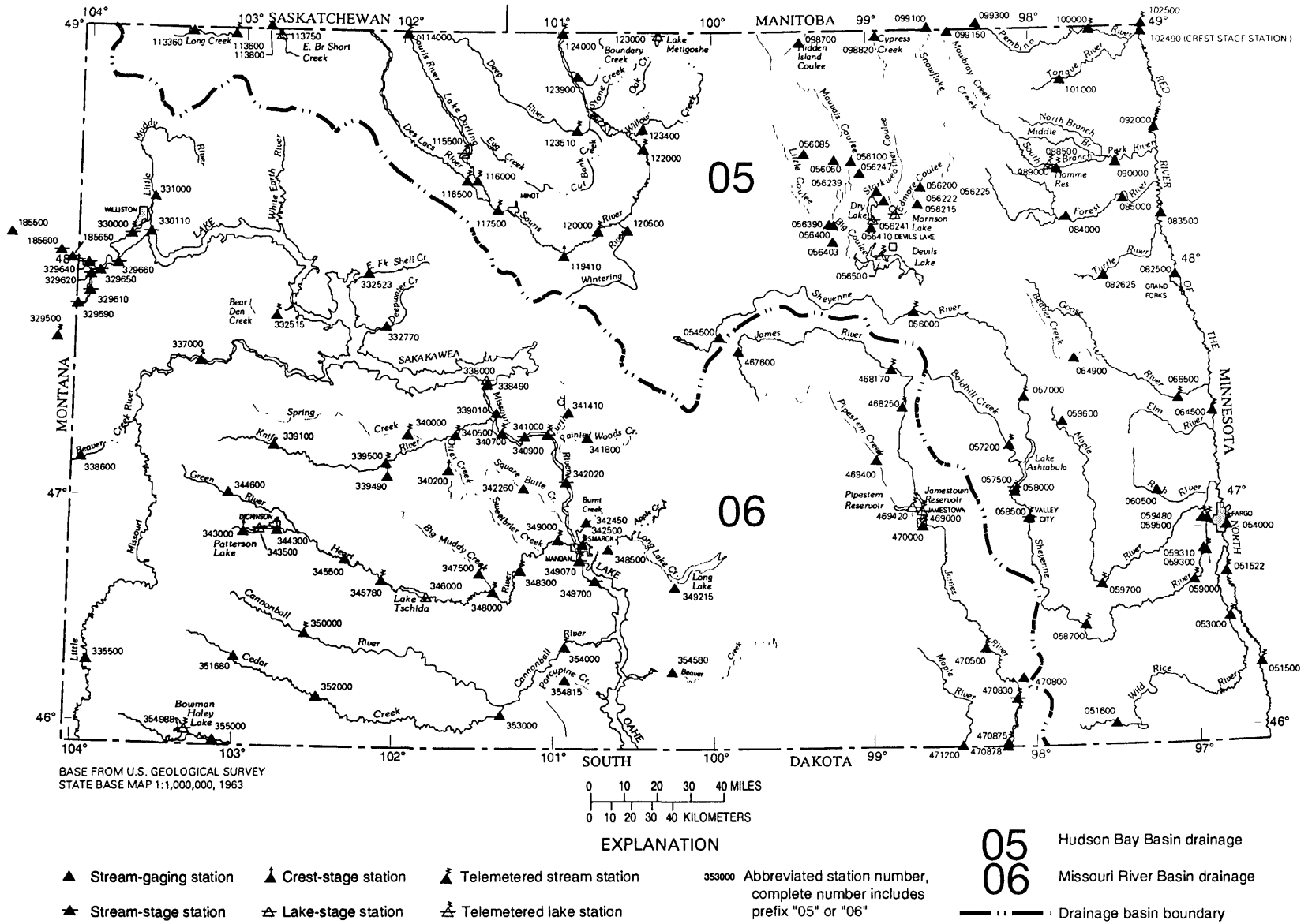


Figure 5. Locations of lake, crest-stage, and stream-gaging stations in 1994.

PROGRESS: All network data were collected on schedule, and records were prepared for publication. Three streamflow-gaging stations and one river-stage station were discontinued. Several manometers were replaced with pressure transducers.

PLANS FOR FISCAL YEAR 1995: The streamflow-station network will be operated as scheduled. Cooperative work with State agencies to upgrade controls at streamflow stations will continue. The water-resources data report for the 1994 water year will be prepared and published. One streamflow-gaging station will be discontinued. One new streamflow-gaging station and one new river-stage station will be installed. Twelve new crest-stage gages will be installed. Ten to fifteen manometers will be replaced with pressure transducers.

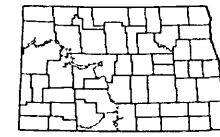
REPORT PRODUCTS:

Harkness, R.E., Haffield, N.D., Berkas, W.R., and Norbeck, S.W., 1994, Water-resources data, North Dakota, Water year 1993: U.S. Geological Survey Water-Data Report ND-93-1, 450 p.

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1994 (in progress).

GROUND-WATER STATIONS

PROJECT NUMBER: ND 00-002.


STATEWIDE

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: Russell E. Harkness.

COOPERATING AGENCIES: (1) North Dakota State Water Commission; and (2) U.S. Department of the Army, Corps of Engineers.

PROBLEM: Planning for management and development of ground-water resources requires extensive knowledge of the occurrence and availability of ground water and use of and impacts on the ground-water system.

OBJECTIVES: The first objective is to collect water-level data sufficient to provide a minimum long-term data base. The data base is used for continued observation of the impacts of climatic variation and man's activities on the ground-water system. A statewide data base is essential for efficient resource management. The second objective is to provide a data base against which short-term records acquired in areal studies can be analyzed.

APPROACH: Evaluation of regional geology allows a general definition of aquifer systems and their boundary conditions. Within this framework and with some knowledge of (1) changes in the ground-water system in time and space and (2) the hydrologic properties of the aquifers, subjective decisions can be made in upgrading the statewide ground-water observation-well network. The ground-water observation-well network currently consists of about 750 wells. Of the 750 wells, about half are measured quarterly or more frequently and half are measured annually. The network can be refined as data become available and detailed areal studies of the ground-water system better define the aquifers, their properties, and the stresses to which they are subjected.

PROGRESS: All ground-water data were collected on schedule, and records for a representative network of 30 wells were prepared for publication (fig. 6). Period-of-record hydrographs for the 30 wells were published along with the current year data. The North Dakota State Water Commission assumed operation of about 150 network wells because of other project activities in some areas. Two continuous-recorder sites were discontinued.

PLANS FOR FISCAL YEAR 1995: The U.S. Geological Survey and the North Dakota State Water Commission will evaluate the entire network and, if appropriate, develop a plan for its redesign. Changes to the network likely will be implemented in fiscal year 1996.

REPORT PRODUCTS:

Harkness, R.E., Haffield, N.D., Berkas, W.R., and Norbeck, S.W., 1994, Water-resources data, North Dakota, Water year 1993: U.S. Geological Survey Water-Data Report ND-93-1, 450 p.

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1994 (in progress).

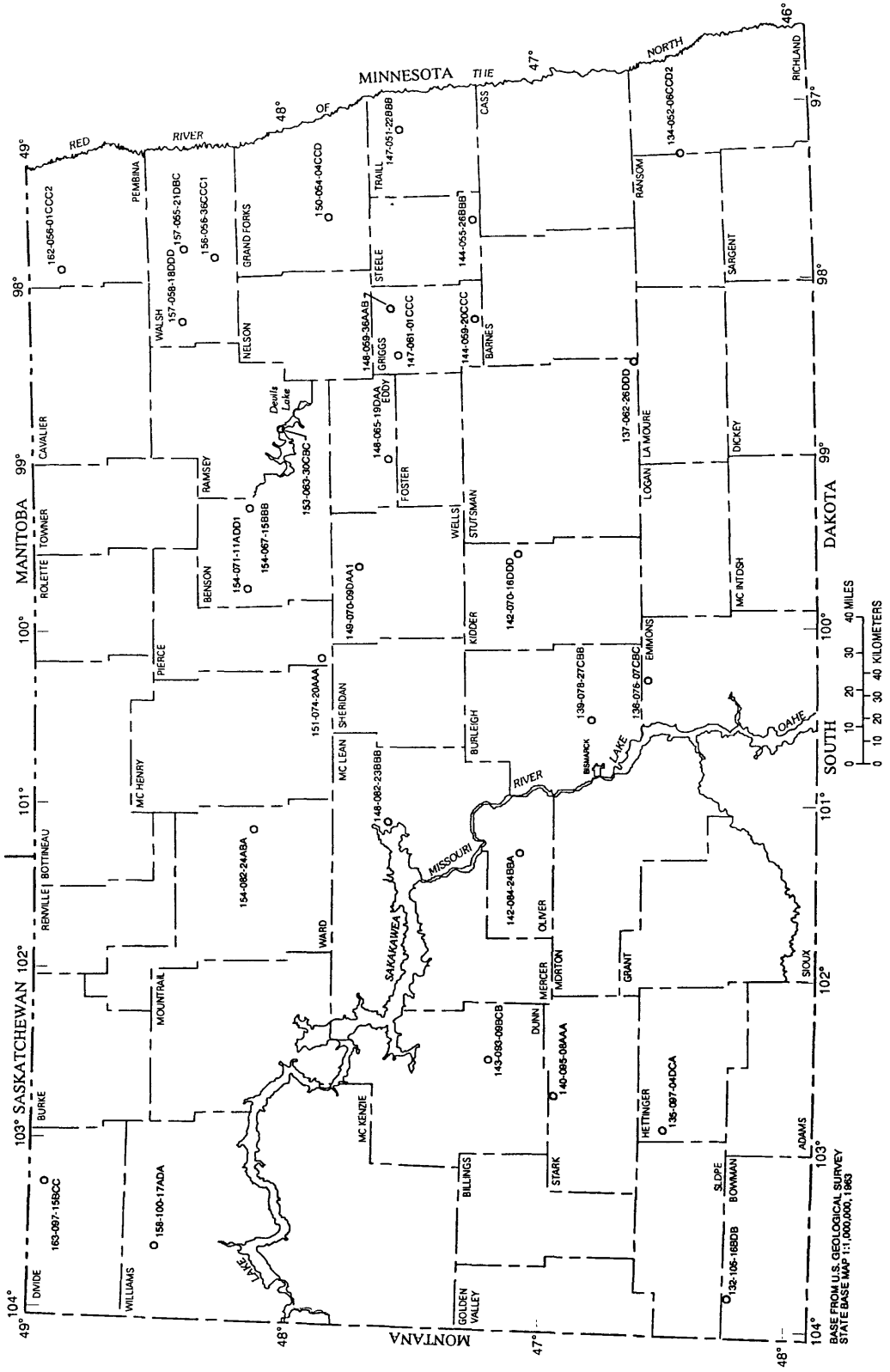
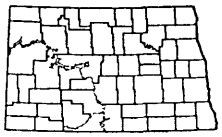


Figure 6. Locations of ground-water observation wells for which water-level data were published in 1994.

WATER-QUALITY STATIONS


STATEWIDE

PROJECT NUMBER: ND 00-003.

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: Russell E. Harkness.

COOPERATING AGENCIES: (1) City of Minot; (2) North Dakota State Department of Health and Consolidated Laboratories; (3) North Dakota State Water Commission; (4) Three Affiliated Tribes; (5) U.S. Department of the Army, Corps of Engineers; (6) U.S. Department of the Interior, Bureau of Indian Affairs; (7) U.S. Department of the Interior, Bureau of Reclamation; (8) U.S. Department of the Interior, Fish and Wildlife Service; and (9) U.S. Department of the Interior, National Biological Survey.

PROBLEM: Water-resources planning and water-quality assessment require a nationwide base level of relatively standardized information. For proper planning and assessment of the water resources, the chemical and physical qualities of surface water and ground water must be defined and monitored.

OBJECTIVES: Objectives are to (1) contribute to a national water-quality data base for use in broad Federal and State planning and management programs and (2) provide data for Federal and State management of interstate and international waters.

APPROACH: A network of water-quality stations (fig. 7) will be operated to provide data on the physical, chemical, and biological properties of the State's streams, lakes, reservoirs, and aquifers. Water-quality samples are collected at every streamflow-gaging station operated by the U.S. Geological Survey in North Dakota. At stations where water-quality monitoring is not supported by other agencies, the U.S. Geological Survey and the North Dakota State Water Commission cooperatively support the collection and analysis of one high-flow and one low-flow sample per year. Samples are collected by the U.S. Geological Survey and analyses are completed by the North Dakota State Water Commission. Multiple-agency cooperative monitoring programs for Devils Lake and Lake Sakakawea involve the collection of samples by the U.S. Geological Survey and the analysis of samples by the North Dakota State Department of Health and Consolidated Laboratories.

PROGRESS: All network data were collected on schedule where possible, and records were prepared for publication. Immunoassay samples for pesticides were collected at many sites during the year. Two National Stream Quality Accounting Network (NASQAN) stations were discontinued. The refuge monitoring component of the James River water-quality monitoring program was discontinued. A monthly monitoring site was added on Pool 357 of the J. Clark Salyer National Wildlife Refuge.

PLANS FOR FISCAL YEAR 1995: The number of NASQAN stations will be decreased from six to one because of redirection of the national program priorities and funds. Two new gaging stations will be added to the U.S. Geological Survey/State program. Parts per billion sampling protocol, when implemented nationally, will be followed for the one remaining NASQAN station.

REPORT PRODUCTS:

Harkness, R.E., Haffield, N.D., Berkas, W.R., and Norbeck, S.W., 1994, Water-resources data, North Dakota, Water year 1993: U.S. Geological Survey Water-Data Report ND-93-1, 450 p.

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1994 (in progress).

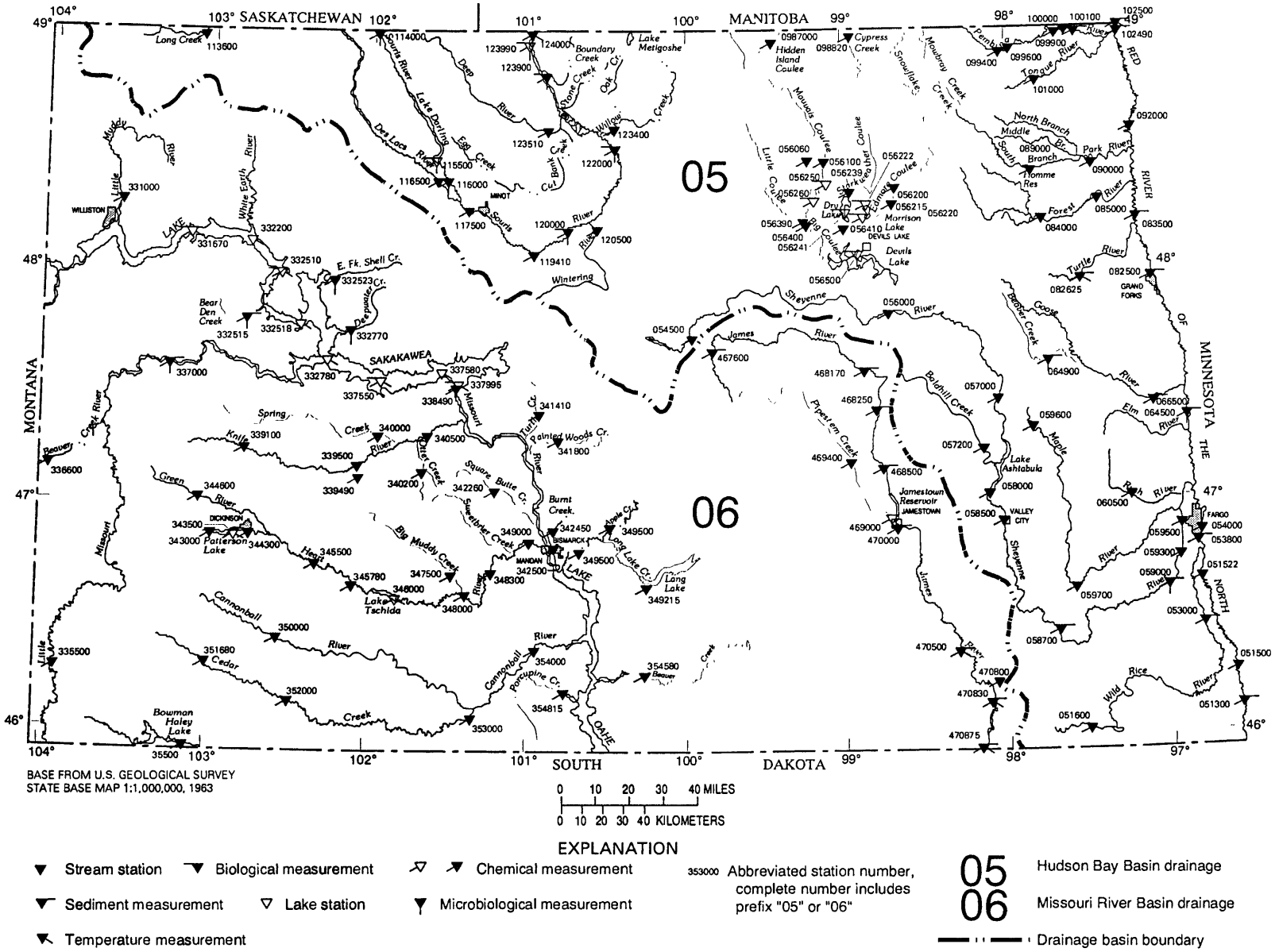
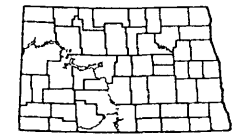


Figure 7. Locations of surface-water stations where water-quality data were collected in 1994.

SEDIMENT STATIONS

PROJECT NUMBER: ND 00-004.


STATEWIDE

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: Wayne R. Berkas.

COOPERATING AGENCIES: (1) U.S. Department of the Interior, Bureau of Reclamation.

PROBLEM: Water-resources planning for intrastate, as well as interstate, waters requires a standardized data base containing sediment transport information. The information must be accurate, unbiased, and available to the user.

OBJECTIVES: Objectives are to (1) contribute to a national sediment data base for use in broad Federal and State planning and management programs and (2) provide data for Federal management of interstate and international waters.

APPROACH: A network of sediment stations will be operated to provide sediment data that can be used to determine spatial and temporal averages and trends of sediment concentration and sediment discharge of rivers and streams.

PROGRESS: All network data were collected and analyzed on schedule. Data were collected and analyzed for partial-record sediment stations shown in figure 7.

PLANS FOR FISCAL YEAR 1995: Periodic sampling will be discontinued at five former NASQAN stations, but sampling will continue at three of the stations in the Red River of the North Basin under the NAWQA project. A proposal for reactivation of the daily sediment station on the Missouri River at Bismarck is being considered by the U.S. Army Corps of Engineers.

REPORT PRODUCTS:

Harkness, R.E., Haffield, N.D., Berkas, W.R., and Norbeck, S.W., 1994, Water-resources data, North Dakota, Water year 1993: U.S. Geological Survey Water-Data Report ND-93-1, 450 p.

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1994 (in progress).

NATIONAL TRENDS NETWORK FOR ATMOSPHERIC DEPOSITION

PROJECT NUMBER: ND 00-005

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.


STATEWIDE

PROJECT CHIEF: Bradley A. Sether.

PROBLEM: In order to determine atmospheric fluxes within the hydrologic system and man's influences on these fluxes, it is necessary to establish and operate a nationwide, long-term network for monitoring atmospheric deposition of selected chemical constituents.

OBJECTIVES: Objectives are to (1) establish and operate a nationwide, long-term monitoring network to detect and measure levels of atmospheric deposition and (2) determine variations in atmospheric deposition that occur on a week-to-week basis by collection of wet- and dry-deposition products for analysis of elements and constituents that can contribute to the chemical composition of surface waters.

APPROACH: Monitoring stations were operated at sites near Woodworth and at Icelandic State Park as part of the National Trends Network (NTN). Station equipment includes a wet/dry precipitation collector, a paper-chart recording precipitation gage with event marker, and a weighing precipitation gage with an electronic data logger as a backup gage. Stations will be maintained, and on-site measurements of precipitation weight, specific conductance, and pH will be made. Samples will be collected, processed, and submitted to the National Atmospheric Deposition Program NTN Central Analytical Laboratory, Illinois State Water Survey. Data will be verified and stored in the NWIS. Results will be reported to the national program coordinator.

PROGRESS: Two atmospheric deposition stations were operated. Records for 1993 were published, and data for 1994 were reviewed for publication.

PLANS FOR FISCAL YEAR 1995: Station operation will continue. Data will be stored in NWIS files and published in the annual data report.

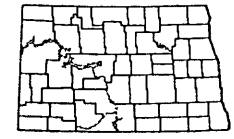
REPORT PRODUCTS:

Harkness, R.E., Haffield, N.D., Berkas, W.R., and Norbeck, S.W., 1994, Water-resources data, North Dakota, Water year 1993: U.S. Geological Survey Water-Data Report ND-93-1, 450 p.

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1994 (in progress).

WATER-USE DATA ACQUISITION AND DISSEMINATION PROGRAM

PROJECT NUMBER: ND 00-007.


STATEWIDE

LOCATION: Statewide.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: Kathleen M. Rowland.

COOPERATING AGENCY: North Dakota State Water Commission.

PROBLEM: The water resources of North Dakota and the Nation are being used more extensively each succeeding year. In North Dakota, competition among users for available water resources in certain areas of the State has increased. In order to manage the development of the resources and to project future trends, planners and managers must be aware of existing patterns and quantity of use.

OBJECTIVES: Objectives are to (1) collect site-specific data to provide water-use information for the optimum utilization and management of the State's water resources; (2) store data collected so they may be retrieved at national, regional, and various local levels; and (3) disseminate water-use data to complement data on availability and quality of State and national water resources.

APPROACH: As an integral part of the water-permit program, the North Dakota State Water Commission collects site-specific water-withdrawal information from an annual inventory of permitted water users. Information on water withdrawals is stored in the following categories: public supply (includes municipal use and rural water systems), irrigation, and self-supplied commercial and industrial (includes mining and thermoelectric).

The North Dakota State Water Commission and the U.S. Geological Survey conduct an ongoing cooperative program to contribute data to a U.S. Geological Survey national water-use data base. The North Dakota State Water Commission furnishes annual water-withdrawal information to the U.S. Geological Survey by magnetic tape. After the site-specific data are converted from State water-use categories to national water-use categories, the data are reformatted and stored in the U.S. Geological Survey's State Water Use Data System (SWUDS) and in the National Water Use Data System (NWUDS). As needed, amounts of nonpermitted water withdrawals for rural-domestic use and for agricultural use will be estimated based on human and animal population and per capita use.

PROGRESS: Data collection continued. Updates were made to the Site-Specific Water Use Data System (SSWUDS) and the Aggregated Water Use Data System (AWUDS) data bases. Parameter sets for the water-use section of NWIS-II were worked on by the District water-use specialist.

PLANS FOR FISCAL YEAR 1995: Data collection will continue. New header files will be added to the SSWUDS data base. Contacts will be made to obtain more in-depth water-use information for the 1995 Estimated Use of Water in the United States (EUOWITUS) report.

REPORT PRODUCTS:

U.S. Geological Survey, 1990, National water summary 1987--Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

Wesolowski, E.A., 1991, Estimated use of water in North Dakota in 1985 and trends during 1960-85: U.S. Geological Survey Water-Resources Investigations Report 89-4003, 1 p.

Estimated use of water in North Dakota in 1995 (planned).

BOARDS AND COMMISSIONS

PROJECT NUMBER: ND 73-064.

LOCATION: Bismarck, North Dakota.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: William F. Horak.

COOPERATING AGENCY: U.S. Department of State, International Joint Commission, Waterways Treaty Program.

PROBLEM: To coordinate water-resources activities with international, other Federal, State, and local agencies, District personnel participate on numerous boards and commissions. Participation frequently includes compiling, publishing, and disseminating meeting minutes or researching special concerns of participating agencies.

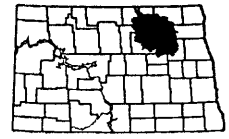
OBJECTIVES: Objectives are to (1) assure impartial Federal representation on the International Souris River Board of Control (International Joint Commission), the Souris River Bilateral Water-Quality Monitoring Group, and the Yellowstone River Compact Commission and (2) supply accurate, unbiased information to boards and commissions.

APPROACH: Chair the meetings and provide administrative support to the Yellowstone River Compact Commission. Serve as member for the United States to the International Souris River Board of Control and the Souris River Bilateral Water-Quality Monitoring Group. Furnish information requested by members of the International Souris-Red River Engineering Board.

PROGRESS: All meetings of the International Souris River Board of Control, the Souris River Bilateral Water-Quality Monitoring Group and its task forces, and the Yellowstone River Compact Commission were attended. The Yellowstone River Compact Commission annual report was published. The annual report of the Souris River Bilateral Water-Quality Monitoring Group for 1992 was prepared by the members and was published and distributed; the annual report for 1993 was drafted by the members.

PLANS FOR FISCAL YEAR 1995: Plans are to continue attending board and commission meetings and to prepare the annual report of the Yellowstone River Compact Commission. The fourth annual report of the Souris River Bilateral Water-Quality Monitoring Group will be released in 1995.

EVAPORATION AND GROUND-WATER INTERACTION OF DEVILS LAKE, NORTH DAKOTA



PROJECT NUMBER: ND 86-139.

LOCATION: Devils Lake Basin, northeastern North Dakota.

PERIOD OF PROJECT: April 1986 to September 1996.

PROJECT CHIEF: Gregg J. Wiche.

COOPERATING AGENCY: North Dakota State Water Commission.

PROBLEM: Historically, water levels of Devils Lake have fluctuated dramatically. In the early and mid-1980's, high water levels enabled the development of a multimillion-dollar fishing and tourist trade industry, but the high water threatened to inundate large areas of developed property. In the late 1980's and early 1990's, declining water levels threatened the fishing industry; and, in 1993-94, water levels increased dramatically. In order to develop a management model, State and local governments need information about how hydrologic components affect water levels. More information is needed on evaporation rates from the lake surface and on ground-water interaction.

OBJECTIVES: The purpose of this study is to measure the principal hydrologic components that cause water-level fluctuations of Devils Lake. The major emphasis will be to measure evaporation from Devils Lake and estimate the direction and magnitude of the ground-water flux component.

APPROACH: Evaporation will be computed with the energy-budget technique. Data that will be collected are incoming and reflected shortwave and longwave radiation, air temperature, dewpoint, water temperature of inlet streams, temperature and quantity of ground-water seepage, lake-surface temperature, and periodic temperature surveys of the entire water body to measure changes in stored heat. The ground-water flux will be estimated by installing a series of shallow water-table wells around Devils Lake in transects extending from the shoreline to the topographic divide.

PROGRESS: The interpretative phase of the project (1986-88) and the reports are complete. Data necessary to compute evaporation from the lake surface were collected for the 1994 water year. The project now is in a data-collection phase.

PLANS FOR FISCAL YEAR 1995: Collection of data necessary to compute mass-transfer evaporation will continue.

REPORT PRODUCTS:

Pusc, S.W., 1992, Ground water data: Interaction between ground water and a large terminal lake, Devils Lake, North Dakota: North Dakota State Water Commission Water Resources Investigation 12, 441 p.

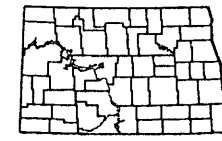
Pusc, S.W., 1992, Interaction between ground water and a large terminal lake: Hydrogeology of Devils Lake area: North Dakota State Water Commission Water Resources Investigation 13, 95 p.

Sether, B.A., and Wiche, G.J., 1989, Meteorologic and hydrologic data collected for computing evaporation from Devils Lake, North Dakota, 1986-88: North Dakota State Water Commission Water Resources Investigation 10, 172 p.

Wiche, G.J., 1992, Evaporation computed by energy-budget and mass-transfer methods and water-balance estimates for Devils Lake, North Dakota, 1986-88: North Dakota State Water Commission Water Resources Investigation 11, 52 p.

Wiche, G.J., and Pusc, S.W., 1994, Hydrology of the Devils Lake area, North Dakota: North Dakota State Water Commission Water Resources Investigation 22, 24 p.

PREDICTING SCOUR AT BRIDGE CROSSINGS ON STREAMS IN NORTH DAKOTA


STATEWIDE

PROJECT NUMBER: ND 90-155.

LOCATION: Statewide.

PERIOD OF PROJECT: June 1990 to September 1998.

PROJECT CHIEF: Tara J. Williams-Sether.

COOPERATING AGENCY: North Dakota Department of Transportation.

PROBLEM: Bridge designers need more reliable methods to predict bridge scour. Most of the existing scour-prediction equations are based on scale-model bridge-scour measurements. The equations have not been validated because of the lack of onsite measurements, which are difficult to collect during high-flow conditions. Data bases that reflect full-scale, prototype field conditions are needed to determine which scour-prediction equations should be used for a particular set of conditions.

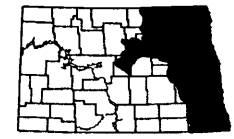
OBJECTIVES: Objectives are to (1) measure flow and scour during high-flow conditions to define the occurrence and extent of scour at 20 selected bridge sites, (2) compare scour depths measured onsite with scour depths estimated using published scour-prediction equations and evaluate the adequacy of the scour-prediction equations, (3) use regression analyses and(or) other curve-fitting techniques to attempt to develop improved scour-prediction equations if current equations fail to accurately estimate scour in North Dakota and if adequate scour data are collected, and (4) evaluate an additional 20 bridge sites for scour.

APPROACH: A total of 20 scour-measurement bridge sites have been selected. Bridge-scour measurements will be made during high-flow conditions. The collected bridge-scour data will be used to evaluate existing scour-prediction equations or to attempt to develop improved scour-prediction equations. An additional 20 bridge sites will be selected for scour evaluation. The 20 scour-evaluation bridge sites will be evaluated according to Federal Highway Administration guidelines.

PROGRESS: Five bridge sites were visited during 1994 spring high-flow conditions to check for scour. No significant scour existed. Bridge-scour surveys were completed for the eastern half of the State.

PLANS FOR FISCAL YEAR 1995: Bridge-scour surveys will be completed for the western half of the State. Bridge sites will be monitored and scour measurements will be made and analyzed when conditions warrant. New scour gages will be installed on the Cannonball River at Breien, North Dakota.

NATIONAL WATER-QUALITY ASSESSMENT, RED RIVER OF THE NORTH BASIN



PROJECT NUMBER: ND 92-163.

LOCATION: Northwestern Minnesota and eastern North Dakota.

PERIOD OF PROJECT: Continuous.

PROJECT CHIEF: Norman D. Haffield.

PROBLEM: Federal, State, and local governments and industry have made significant commitments to the protection of water quality over the past 2 decades. Large financial investments have been made for water-quality management and protection over the past 20 years and future expenditures are anticipated to abate and control water pollution. Nationally consistent information is needed to make valid regional comparisons and national statements about current water-quality conditions and about changes in these conditions. The U.S. Geological Survey began implementing a full-scale NAWQA program in 1991 to address this need for national water-quality information. Because it would be impractical to assess water quality in every area of the Nation, major activities of the NAWQA program will be conducted within a set of hydrologic systems called study units. The Red River of the North basin was selected as 1 of 60 study units because (1) the basin represents an important hydrologic region where good quality water is a valued resource vital to the region's economy; (2) the water quality of the Red River of the North, which flows north into Manitoba, Canada, is of international concern; (3) the basin represents a significant agricultural area in keeping with the President's Water-Quality Initiative and provides opportunities to study sediment, nutrients, and pesticides through the national assessment part of NAWQA; and (4) the northern location and potential interaction of surface and ground water are essential physical factors necessary for a complete national assessment of water quality.

OBJECTIVES: The purpose of this study is to describe the status and trends in the quality of a large, representative part of the basin's surface-water and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources. Objectives are to (1) identify the regional physical, chemical, and biological constituents of water quality (herein called target constituents) that are of concern in the Red River of the North study unit; (2) estimate the distribution and annual stream load of selected pesticides, nutrients, and sediment in the basin; (3) describe the relation of water quality to regional land-use practices in surficial and confined aquifers within the glacial drift and in major streams; (4) identify the predominant natural and human factors that affect the load and concentration of target constituents measured in water and aquatic animals; (5) describe seasonal variability of selected target constituents in major streams from agricultural runoff and from natural sources; (6) describe the long-term regional and subregional trends of target constituents in surface water and ground water; and (7) design sampling schemes of surface water, ground water, and aquatic animals to effectively monitor for long-term trends in water quality.

APPROACH: Project activities will be cyclic to accomplish the water-quality status and trends components of the study. The first 2 years will focus on planning and analysis of available data. The next 3 years will emphasize data collection and analysis. The following year will be used for report preparation. A lower level of data collection will continue for the subsequent 5 to 6 years to evaluate long-term trends in water quality after which the more intensive data-collection cycle will be repeated. Project planning will be coordinated through a liaison committee made up of State, local, and other Federal agencies and some Canadian agencies and private industries who will help identify key water-quality issues of the basin and sources of data and will assist with the project design. Large amounts of available water-quality and

ancillary data will be compiled into computer data bases, including geographic information system (GIS) data bases, for spatial comparisons and statistical analysis. Information from the available data will be used to design data collection needed to accomplish a comprehensive assessment of the basin water quality. Water will be sampled from networks of fixed and synoptic stream stations and wells and analyzed for target constituents. Suspended and bottom sediments will be collected from major streams and analyzed for grain-size distribution and selected chemical constituents. Algae and tissues of fish and macroinvertebrates will be sampled and analyzed for selected trace metals and organic pollutants. Short reports of significant findings will be prepared on specific water-quality topics throughout the study. A larger report summarizing results of the first 6-year cycle of the study will be completed in the seventh year.

PROGRESS: Progress for October 1993 through September 1994 aligns closely with that for the second of 3 years of intensive data collection. Water, aquatic biota, and suspended-sediment samples were collected from streams, and water samples were collected from wells throughout most of the year. Water samples were collected about monthly from four stream sites to determine the temporal variation in the concentration of pesticides, nutrients, sediment, organic carbon, and major ions during various seasonal and runoff conditions. The stream sites are in watersheds that contain a large percentage of cropland and other land use representative of the study unit. The site at the Red River of the North at Emerson, Manitoba, where surface water from the Red River of the North leaves the United States and enters Canada, also represents an integration of most of the surface water in the study area. Monthly stream sampling continued at 10 other stream sites to determine the seasonal variation in the concentration of nutrients, common ions, suspended sediment, and organic carbon in representative physiographic and ecological subregions of the Red River Basin. In addition, several other stream sites were sampled during summer runoff to broaden the understanding of water quality spatially within the entire basin and along each stream reach of three of the sites intensively sampled for pesticides and nutrients to understand nonpoint-source runoff.

Water samples from streams indicate that the most prevalent pesticides in streams in order of detection frequency were atrazine, triallate, metolachlor, trifluralin, and EPTC. During the summer of 1993, bentazon, atrazine, metolachlor, and cyanazine concentrations were significantly larger in the Red River of the North at Emerson than in tributaries that drained land cropped predominantly in small grains. During the second summer of intensive data collection, unusually large amounts of rainfall produced substantial runoff throughout most of the Red River Basin. Partial results from the laboratory indicate prometon, desethyl atrazine, and metribuzin concentrations in addition to the pesticide concentrations detected during the summer of 1993. However, none of the detected pesticides were at levels above U.S. Environmental Protection Agency drinking-water standards.

Stream habitat surveys were completed at 13 of 16 ecological sites and at all 6 intensive biological sites. Fish, macroinvertebrates, and algae were collected at 22 sites to describe stream aquatic communities across the 5 major ecoregions in the basin. Sample collections that were curtailed because of flooding in 1993 were delayed because of intense summer storms in 1994. Four of the ecological sites were located at intensive water-chemistry sampling sites. Data collected will be used along with data from a number of State and Federal agencies to develop an index of biotic integrity to be tested for aquatic-resource management specific to the Red River Basin. A draft of a report describing the aquatic communities and contaminants in fish tissues on the basis of available data for the Red River Basin was started.

Work was conducted at all three scales of the ground-water component of the assessment. Monitoring wells were installed and completed just below the water table of the Otter Tail outwash aquifer in the southeastern part of the Red River Basin. With these wells and some existing wells, a total of 29 randomly

selected locations were sampled downgradient from the primary land-use area of intensively irrigated corn, potatoes, edible beans, and alfalfa. The water samples were analyzed for pesticides, nutrients, major ions, and dissolved organic carbon to determine land-use effects on shallow ground-water quality.

Data from the 1993 sampling of wells in the Sheyenne Delta surficial aquifer indicate pesticide, nutrient, and volatile-organic compounds near or below detection limits. Small nutrient concentrations may be explained by effects of dilution caused by large amounts of summer recharge. The 1993 data from the 234 wells in the Minnesota Moraine physiographic subregion consistently indicate that calcium, magnesium, and bicarbonate comprised the dominant ions in the natural waters. Uranium, radium, and radon radionuclides were detected in the glacial-sediment aquifers but not at any unusual concentrations. Nitrate-nitrogen concentrations greater than 3 milligrams per liter and trace levels of six different pesticides were detected in about 25 percent of the Minnesota-Moraine area wells, which were mostly surrounded by cropland or pasture with some forest. Wells installed in nests along ground-water flow paths located within each of the two land-use study sites were sampled for the first time to evaluate in more detail the distribution of ground-water quality beneath principal land-use areas and near areas of discharge to streams. Existing wells were inventoried and sampled at 35 locations for the second phase of the basin-wide survey of ground-water quality in shallow aquifers.

Ancillary data, such as cropping patterns in intensively studied subbasins, were mapped by field checks. Major groups of subregions within the Red River Basin were defined to analyze the water-quality data collected for the study. The groups were selected on the basis of land cover, soils, physiography, and hydrography. Reprints of five interpretative reports were distributed during the sixth liaison-committee meeting in March 1993. Study members continue to actively participate in a water-quality work group to assess cumulative effects of surface-water impoundments in the Minnesota part of the Red River Basin as part of the National Environmental Protection Act. The background and existing water-quality conditions part of this environmental assessment references the recently published NAWQA reports. The reports describing the environmental setting and implications on water quality and the retrospective analysis of nutrients, pesticides, and suspended sediment in waters of the Red River Basin were published and distributed. Several topical papers and abstracts also were published in scientific symposia and conference proceedings.

PLANS FOR FISCAL YEAR 1995: Water-chemistry, sediment, and aquatic biota data will be analyzed and compared to natural and human factors that affect water quality. This analysis also will be used to refine specific approaches and sampling networks to collect additional water-quality data from streams and ground water. Selected stream sites will be sampled for chemical constituents, suspended sediment, and aquatic biota to better define the sources, fate, and transport of selected constituents. Synoptic surveys of stream chemistry will be conducted on selected watersheds where more data on the spatial distribution of nutrients are needed to assess the significance of spring runoff on chemical transport in the basin. Sampling of ground water will continue at all scales of assessment. Selected wells completed in surficial sand and gravel aquifers will be sampled seasonally to assess natural and human factors affecting the quality of that ground water. Basin-wide analysis of major land cover and cropping patterns will be continued by using the results of satellite-image processing and interpretation. The communication of project plans and preliminary findings and the exchange of information will continue through the liaison-committee process, public meetings, and scientific conferences. Chapters of the final interpretative report will be started for each component of the study.

REPORT PRODUCTS:

Brigham, M.E., 1994, Pesticides detected in surface waters and fish of the Red River of the North drainage basin: Proceedings, North Dakota Water Quality Symposium, Fargo, N. Dak., March 30-31, 1994, North Dakota State University Extension Service, p. 256-269.

Brigham, M.E., Tornes, L.H., and Lorenz, D.L., 1994, Load estimates for pesticides in the Red River of the North drainage basin: American Geophysical Union, EOS Transactions, Abstracts for Fall Meeting, December 5-9, 1994, p. 230.

Cowdery, T.K., 1994, Nutrient concentrations near the water table of the Sheyenne Delta aquifer beneath cropland areas--Preliminary results from a Red River of the North Basin land-use study: U.S. Geological Survey Open-File Report 94-397, Proceedings Abstracts, American Water Resources Association 30th Annual Conference, Symposium on National Water Quality Assessment Program, Chicago, Ill., November 7-9, 1994, p. 7.

Cowdery, T.K., and Brigham, M.E., 1992, Baseflow dissolved-solids loads to streams of the Red River of the North Basin, South Dakota, North Dakota, and Minnesota: 37th Annual Midwest Ground Water Conference Program with Abstracts, Sioux Falls, S. Dak., October 14-16, 1992, p. 38.

Cowdery, T.K., and Goff, K.L., 1994a, Nitrogen concentrations near the water table of the Sheyenne Delta aquifer beneath cropland areas, Ransom and Richland Counties, North Dakota: Proceedings, North Dakota Water Quality Symposium, Fargo, N. Dak., March 30-31, 1994, North Dakota State University Extension Service, p. 89-102.

———1994b, Nutrient concentrations near the water table of the Sheyenne Delta aquifer beneath cropland areas, Ransom and Richland Counties, North Dakota: Minnesota Water 1994 Conference Poster Session Abstracts, Minneapolis, Minn., April 21-22, 1994, p. 8-9.

Goldstein, R.M., Simon, T.P., Bailey, P.A., Ell, Michael, Pearson, Eric, Schmidt, Konrad, and Enblom, J.W., 1994, Concepts for an index of biotic integrity for streams of the Red River of the North Basin: Proceedings, North Dakota Water Quality Symposium, Fargo, N. Dak., March 30-31, 1994, North Dakota State University Extension Service, p. 169-180.

Lorenz, D.L., 1992, Using a geographical information system to describe the environmental setting of the Red River of the North Basin, *in* Balthrop, B.H., and Baker, E.G., comps., U.S. Geological Survey National Computer Technological Meeting--Program and Abstracts, Norfolk, Va., May 17-22, 1992: U.S. Geological Survey Open-File Report 92-64, p. 21.

———1994, Use of remotely sensed data to characterize vegetation in the Red River of the North Basin, Minnesota, North Dakota, and South Dakota, *in* Balthrop, B.H., and Baker, E.G., comps., U.S. Geological Survey National Computer Technological Meeting--Program and Abstracts, New Orlreans, La., April 10-15, 1994, U.S. Geological Survey Open-File Report 94-52, p. 27.

Stoner, J.D., 1991, National water-quality assessment program, Red River of the North: U.S. Geological Survey Open-File Report 91-151, 2 p.

Stoner, J.D., Brigham, M.E., and Cowdery, T.K., 1994, Water quality in surficial glacial-deposit aquifers in the Red River of the North drainage basin, Minnesota, North Dakota, and South Dakota: 39th Annual Midwest Ground Water Conference Program and Abstracts, Bismarck, N. Dak., October 16-18, 1994, p. 14.

Stoner, J.D., and Lorenz, D.L., 1992, Water-quality assessment strategy for the Red River of the North Basin, North Dakota, South Dakota, and Minnesota: Proceedings, North Dakota Water Quality Symposium, Bismarck, N. Dak., March 25-26, 1992, p. 24.

———1994, Environmental setting of the Red River of the North Basin, Minnesota, North Dakota, and South Dakota--Framework for a regional water-quality assessment: Minnesota Water 1994 Conference Oral Presentations Abstracts, Minneapolis, Minn., April 21-22, 1994, p. 2-3.

Stoner, J.D., Lorenz, D.L., Wiche, G.J., and Goldstein, R.M., 1993, Red River of the North Basin, Minnesota, North Dakota, and South Dakota: American Water Resources Association Monograph Series No. 19 and Water Resources Bulletin, v. 29, no. 4, p. 575-615.

Tornes, L.H., and Brigham, M.E., 1994a, Agricultural chemicals in streams of the Red River of the North drainage basin: Minnesota Water 1994 Conference Oral Presentations Abstracts, Minneapolis, Minn., April 21-22, 1994, p. 3.

———1994b, Nutrients, suspended sediment, and pesticides in waters of the Red River of the North Basin, Minnesota, North Dakota, and South Dakota, 1970-90: U.S. Geological Survey Water-Resources Investigations Report 93-4231, 62 p.

Tornes, L.H., Lorenz, D.L., Brigham, M.E., and Stoner, J.D., 1992, Plans for a water-quality assessment of the Red River of the North Basin, Minnesota, North Dakota, and South Dakota: Minnesota Water 1992: Sustaining Water Resources in the '90s and Beyond--Abstracts, Minneapolis, Minn., February 13-14, 1992, p. 24.

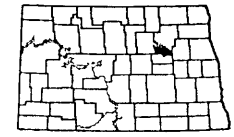
Tornes, L.H., Puckett, L.J., and Stoner, J.D., 1994, The effect of riparian wetlands in reducing nitrate-nitrogen from a sand and gravel aquifer to a stream: American Geophysical Union, EOS Transactions, Abstracts for Fall Meeting, December 5-9, 1994, p. 261.

Aquatic communities and contaminants in fish in streams of the Red River of the North Basin, Minnesota and North Dakota (planned).

National water-quality assessment--Red River of the North Basin (planned).

When and where are fertilizers and pesticides found in waters of the Red River of the North Basin (planned).

HYDROLOGY OF THE FORT TOTTEN INDIAN RESERVATION, NORTH DAKOTA



PROJECT NUMBER: ND 92-165.

LOCATION: Fort Totten Indian Reservation, North Dakota.

PERIOD OF PROJECT: June 1992 to September 1995.

PROJECT CHIEF: Edwin A. Wesolowski.

COOPERATING AGENCY: Devils Lake Sioux Tribe.

PROBLEM: The Devils Lake Sioux Tribe of the Fort Totten Indian Reservation is interested in resolving questions about the availability and quality of water resources on the reservation and in developing a water-management plan. However, detailed information on the hydrology of the reservation generally is not available or easily accessible.

OBJECTIVES: Objectives are to (1) compile all existing geologic, hydrologic, water-quality, water-use, and relevant ancillary data for the reservation, verify the data, and store the data in digital formats that are readily accessible to facilitate retrieval and processing by GIS software; (2) describe the distribution, geology, and hydrologic properties of aquifers that exist on the reservation; (3) investigate the Warwick aquifer in detail by identifying and evaluating directions of ground-water movement, areas of recharge and discharge, interrelations with surface water, hydrologic properties of the aquifer, and quantity and quality of ground water in storage; (4) improve the understanding of the surface-water system by documenting storage and water quality in lakes, ponds, and streams; (5) inventory water use on the reservation; and (6) develop and calibrate a ground-water flow model of the Warwick aquifer to evaluate concepts of the flow system and to identify potential effects of increasing withdrawals from the aquifer on ground-water levels, recharge, and potential ground-water contamination.

APPROACH: Existing geologic, geochemical, and hydrologic data will be reevaluated. Test drilling will be conducted to augment existing hydrogeologic data. Ground-water levels, lake levels, and streamflow will be measured. Water-quality samples will be obtained and analyzed. Data on water levels, aquifer thickness and areal extent, and aquifer hydraulic properties will be used to construct a digital ground-water flow model of the Warwick aquifer.

PROGRESS: A global-positioning survey of about 150 sites was completed. All survey data were reduced, analyzed, and verified. The survey data were needed to update the latitudes, longitudes, and land-surface altitudes in the ground-water site-inventory file. All of the wells in the monitoring network (about 200) were monitored on a monthly basis through December 1993 and March and April 1994. About 30 wells were sampled for nutrients and major ions. Four wetlands were monitored at least bimonthly. The steady-state ground-water flow model was calibrated to the October 1992 water levels.

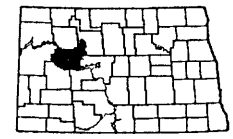
PLANS FOR FISCAL YEAR 1995: The steady-state ground-water flow model for the Warwick aquifer will be finalized. A transient model will be calibrated and two pumping simulations will be made. Two reports will be written and published.

REPORT PRODUCTS:

Simulation of ground-water flow in the Warwick aquifer on the Fort Totten Indian Reservation (planned).

Water quality of the Warwick aquifer (planned).

NONPOINT-SOURCE ASSESSMENT OF THE FORT BERTHOLD INDIAN RESERVATION, NORTH DAKOTA



PROJECT NUMBER: ND 93-168.

LOCATION: Fort Berthold Indian Reservation, North Dakota.

PERIOD OF PROJECT: May 1993 to September 1994.

PROJECT CHIEF: Robert M. Lent.

COOPERATING AGENCY: Three Affiliated Tribes.

PROBLEM: The Fort Berthold Indian Reservation is located in west-central North Dakota and is bisected by the Missouri River (Lake Sakakawea). Because the region is rural and the economy is dominated by agriculture, water resources in the region may be susceptible to nonpoint-source contamination. Potential sources of contamination include pesticides used on crops and rangeland and nutrients from agricultural fields and from livestock.

OBJECTIVES: Objectives are to (1) measure the occurrence of detectable agricultural chemicals, including pesticides and nutrient-derived fertilizers, in streams on the reservation and determine temporal variability of pesticides in the streams; (2) evaluate the effects of using riparian land for grazing livestock on the water quality of streams on the reservation; and (3) compare the results of the water-quality investigations with the existing land-use data to determine the relations between land use, pesticides, and water quality of streams on the reservation.

APPROACH: Discharge measurements and water-quality samples will be collected during all sampling periods. Discharge measurements will be incorporated into existing records and will be used in conjunction with water-quality data to calculate loads for specific constituents. Field parameters will include temperature, dissolved oxygen, pH, and specific conductance. Water samples will be collected for major ions, nutrients, total organic carbon, and selected pesticides. Pesticides concentrations will be determined using immunoassay methods and gas chromatography/mass spectrometry.

Water-quality samples will be collected during all sampling periods to evaluate the effects of using riparian land for grazing. Samples will be collected for determination of organic nitrogen plus ammonia and total phosphorus concentrations. The data will be used to calculate organic nitrogen and total phosphorus loads in the stream. Samples also will be collected for determination of fecal streptococci and fecal coliform to provide direct evidence of grazing animals. These data will be used to evaluate seasonal trends in the concentrations of organic matter and pathogens in the streams, along with variations in loads during precipitation and runoff events.

The water-quality data for each stream will be evaluated along with land-use information for each of the drainage basins. The data will be used to identify the effects of various land uses, including grazing, on surface-water quality on the reservation and to identify locations in specific drainage basins on the reservation where pesticides, nutrients, and pathogens may pose a threat to human health and the environment.

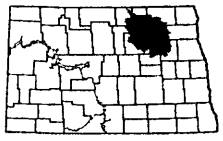
PROGRESS: Field data collection and laboratory analyses were completed. The draft of the final report was prepared.

PLANS FOR FISCAL YEAR 1995: Plans are to complete the review process and obtain Director's approval for publication of the report.

REPORT PRODUCTS:

Variations in land use and nonpoint-source contamination on the Fort Berthold Indian Reservation, North Dakota, 1990-93 (in progress).

EVALUATION OF WATER-QUALITY DATA FOR THE CHAIN OF LAKES AND ITS TRIBUTARIES, NORTH DAKOTA



PROJECT NUMBER: ND 93-169.

LOCATION: Devils Lake Basin, northeastern North Dakota.

PERIOD OF PROJECT: July 1993 to September 1994.

PROJECT CHIEF: Robert M. Lent.

COOPERATING AGENCY: North Dakota State Water Commission.

PROBLEM: The chain of lakes, including Sweetwater Lake, Morrison Lake, Cavanaugh Lake, Dry Lake, Mikes Lake, Chain Lake, Lake Alice, and Lake Irvine, are natural lakes located in the Devils Lake drainage basin and are recharged by surface runoff from the northern sections of the basin. These lakes provide two important functions to the area. The lakes are important habitats for migratory waterfowl, and they receive and store runoff from northern sections of the Devils Lake Basin. Artificial controls on Dry Lake and Lake Alice allow some regulation of flow from the chain of lakes to Devils Lake.

Recently, because of declining water levels in Devils Lake, there have been proposals to increase the amount of water released from the chain of lakes to Devils Lake. Before this is done, a number of questions need to be addressed. What are the seasonal and long-term variations in water quality of the lakes? Is the water quality improved by temporary storage in the lakes? What are the impacts (nutrient loadings) of migratory waterfowl and agricultural activities on the water quality of the lakes?

OBJECTIVES: Objectives are to (1) evaluate temporal (both seasonal and long-term) variations in the water quality (concentrations of major ions and nutrients) of the lakes; (2) calculate the mass (concentration times volume) of major ions and nutrients in the lakes and evaluate temporal variations in the mass; (3) evaluate variations in the concentrations of major ions and nutrients in the tributaries; (4) calculate the instantaneous loads of major ions and nutrients in the tributaries and evaluate temporal variations in the instantaneous loads; (5) compare the instantaneous loads and concentrations of nitrogen, phosphorus, and dissolved solids under different hydrologic and climatic conditions; and (6) evaluate the effect of storage in the lakes on the water quality of surface water in the basin.

APPROACH: Temporal variations in the water quality of the lakes will be investigated using graphical methods. Temporal variations in the mass of major ions and nutrients will be investigated using semilog plots. Existing elevation-capacity curves for Sweetwater Lake, Morrison Lake, and Lake Irvine will be used for the calculations. Variations in the water quality of the tributaries will be investigated using box plots of major-ion and nutrient concentrations. Variations in the mass of major ions and nutrients in the tributaries will be investigated using box plots of instantaneous loads of major ions and nutrients. The relation between concentration and load for each of the five tributaries will be illustrated using scatter diagrams of concentration versus load.

PROGRESS: Colleague reviews of the final report were completed. Long-term variations in dissolved-solids and nutrient concentrations and loads in the tributaries upstream and downstream of the chain of lakes are not apparent. However, seasonal variations are apparent. Long-term and seasonal variations in dissolved-solids and nutrient concentrations in the chain of lakes are not apparent except in

Sweetwater Lake, Lake Alice, and Lake Irvine. Dissolved-solids concentrations in Sweetwater Lake generally increased during the period of record. Dissolved-solids concentrations in Lake Alice and Lake Irvine exhibit seasonal trends; water samples collected during the spring routinely have smaller dissolved concentrations than water samples collected during the remainder of the year. Dissolved phosphorus concentrations in samples collected during the spring in Lake Alice generally increased during the period of record.

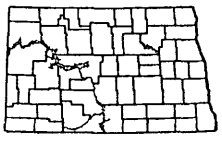
PLANS FOR FISCAL YEAR 1995: Plans are to complete the review process and obtain Director's approval for publication of the report.

REPORT PRODUCTS:

Temporal and spatial variations in surface-water quality in the chain of lakes and tributaries in the Devils Lake Basin, North Dakota, 1957-92 (in progress).

INTERACTIONS BETWEEN HYDROLOGY, WATER QUALITY, AND WETLAND FUNCTIONS IN THE PRAIRIE POTHOLE REGION

PROJECT NUMBER: ND 93-170.


STATEWIDE

LOCATION: Statewide.

PERIOD OF PROJECT: June 1993 to September 1995.

PROJECT CHIEF: Kevin C. Vining.

COOPERATING AGENCY: U.S. Environmental Protection Agency.

PROBLEM: The U.S. Environmental Protection Agency's Wetlands Research Program (WRP) has proposed a major research effort within the prairie pothole region to illustrate how the WRP's risk-based framework could be applied to wetland protection and management. The WRP's Landscape Function, Characterization and Restoration, and Wetland Function projects will conduct studies at different spatial scales. Information obtained then will be synthesized by the WRP's Risk Reduction project into an environmental risk assessment of the prairie pothole region. The risk assessment will focus on the risks to waterfowl production and water-quality improvement (two wetland-dependent functions) resulting from several environmental and anthropogenic stressors.

The role of the WRP's Landscape Function project is to examine wetland functions at the landscape scale. For the prairie pothole study, the Landscape Function project's specific objectives are to determine how prairie pothole wetlands contribute to waterfowl production and regional water quality and how drainage, sedimentation, and other stressors affect these functions. Given the strong dependence of wetlands and water quality on hydrology, an additional objective is to examine landscape-level relations between wetland functions, water quality, and hydrology.

One of the Landscape Function project's needs is information on the response of wetlands to climate and regional hydrology, and, in particular, the response of wetlands to drought cycles that occur seasonally and over much longer time periods such as decades. Such information is important because the prairie can experience extended droughts that may not reflect normal conditions. Information on how wetlands respond to wet and dry cycles will allow the WRP to consider risks within this context and permit risks from human impacts to be separated from the natural variability of pothole wetlands.

OBJECTIVES: The purpose of the proposed research is to evaluate possible relations between readily available climatic and hydrologic data and indexes of the physical condition of wetlands. Objectives are to (1) assemble maps and information necessary for the selection of wetlands study areas; (2) develop wetland indexes based upon factors describing wetland conditions, including wetland surface area, number of wetlands per study area, or other factors; and (3) examine records of temperature, precipitation, evaporation, ground-water levels, and streamflow for evidence of correlation to equivalent periods of record for one or several wetland indexes.

APPROACH: The research will be conducted in two phases. The first phase will involve a thorough search of U.S. Geological Survey data bases and other data bases readily available to the U.S. Geological Survey for hydrologic data that could be expected to relate to indexes of wetland water conditions. Information obtained from the search of data bases will be summarized in maps showing the locations of candidate wells and streamflow-gaging stations to facilitate selection of the final study areas.

The second phase will involve the actual evaluation of climatic, hydrologic, and wetland data relevant to the study areas selected in the first phase. These data will be compiled and plotted along with the hydrologic data identified in phase 1 to demonstrate graphical and statistical relations between climatic variations and trends in hydrologic responses, such as ground-water well water levels and stream discharges.

Wetlands in the study areas will be examined for development of a wetland water-condition index. The principal method of analysis to detect correlations between the climatic and hydrologic data in the wetland index will be to compare graphical plots of all the data for equivalent time periods.

PROGRESS: Candidate study areas within the prairie pothole region of North Dakota were identified on the basis of selected criteria. After conferring with the cooperator, 11 study areas were selected. An evaluation of climatic, hydrologic, and wetland data was completed and relations were identified.

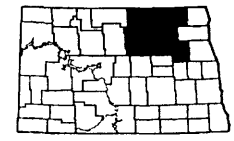
PLANS FOR FISCAL YEAR 1995: The historical information on wetlands, hydrology, and climate used in studies during the past fiscal year and information from additional wetlands and ground-water monitoring wells will be gathered and analyzed to produce GIS contour maps. The information will be used in statistical analyses to develop equations that could be used to predict wetlands indexes at various times and locations in the State from variables within the hydrologic and climatic data sets.

Water-level monitoring stations will be established at 18 wetlands at 6 locations across the State. The stations will be instrumented to record water levels in wetlands, ground-water levels near wetlands, and precipitation. These data will be used to verify and modify the prediction equations for wetlands indexes developed from the historical hydrologic and climatic data sets.

REPORT PRODUCTS:

Relation between hydrology, water quality, and wetland functions (planned).

FREQUENCY ANALYSIS FOR DEVILS LAKE, NORTH DAKOTA



PROJECT NUMBER: ND 94-173.

LOCATION: Devils Lake area, North Dakota.

PERIOD OF PROJECT: November 1993 to September 1994.

PROJECT CHIEF: Gregg J. Wiche.

COOPERATING AGENCY: North Dakota State Water Commission.

PROBLEM: In response to rising water levels from about 1969 through the early 1980's, the U.S. Army Corps of Engineers completed a feasibility study of possible flood-control projects to protect cities, roads, and other properties around Devils Lake. The U.S. Army Corps of Engineers has conducted a reconnaissance study for stabilizing Devils Lake water levels, but the study will not be approved until additional analyses of future lake-level probabilities and associated economic damage estimates are completed. An understanding of the hydrology of Devils Lake and better knowledge of future lake-level probabilities is needed as a basis for implementation of flood-control or lake-stabilization projects.

OBJECTIVES: The purpose of this study is to estimate future lake-level probabilities. Objectives are to (1) estimate lake levels for Devils Lake using an analysis of historic water levels and (2) estimate lake levels for Devils Lake using a statistical water mass-balance model. Lake-level probability data will be used by U.S. Army Corps of Engineers economists to develop damage-frequency relations for Devils Lake. Data used to develop the time-series models will be limited to hydrologic and meteorologic data available through June 1994.

APPROACH: Many approaches have been used to estimate future lake-level probabilities of terminal lakes, but no standard method currently exists. Two approaches will be used in this study. The first approach will be an analysis of historic lake levels of Devils Lake as outlined by the U.S. Army Corps of Engineers (written commun., June 11, 1993). The approach is based on an annual lake-volume model and is similar to a study of lake-level frequency relations for Devils Lake as described by Woodbury and Padmanabhan (1989, Estimating terminal lake level frequencies, Journal of Water Resources Planning and Management, v. 115, no. 3, May 1989, p. 321-336).

The second approach is based on a statistical water mass-balance model that generates seasonal lake volumes given seasonal inflow, precipitation, and evaporation. A multivariate time-series model will be developed to generate future realizations of seasonal precipitation, evaporation, and inflow, which will be used in conjunction with the water mass-balance model to generate future lake-level traces. The second approach is similar to the approach used by Bowles and James (1986, Issues associated with stochastic modeling of Great Salt Lake levels for planning purposes, *in* Kay, P.A., and Diaz, H.F., eds., Problems of and prospects for predicting Great Salt Lake levels: Center for Public Affairs Administration, University of Utah, May 1985, p. 218-235).

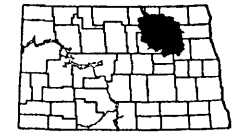
PROGRESS: The annual lake-volume and water mass-balance models were developed and 2,000 lake-level traces, each 50 years in length, were generated from each model. Model results were analyzed and a draft report was written.

PLANS FOR FISCAL YEAR 1995: Plans are to complete the review process and obtain Director's approval for publication of the report.

REPORT PRODUCTS:

Lake-level frequency analysis for Devils Lake, North Dakota (in progress).

VARIATIONS IN SURFACE-WATER QUANTITY AND QUALITY AS A RESULT OF THE 1993 SUMMER FLOOD IN THE DEVILS LAKE BASIN, NORTH DAKOTA



PROJECT NUMBER: ND 94-174.

LOCATION: Northeastern North Dakota.

PERIOD OF PROJECT: October 1993 to September 1994.

PROJECT CHIEF: Tara J. Williams-Sether.

COOPERATING AGENCY: North Dakota State Department of Health and Consolidated Laboratories.

PROBLEM: Large areas of farmland north and northeast of Devils Lake currently are flooded and are draining slowly through the chain of lakes to Devils Lake. Devils Lake rose from 1,423 feet above sea level on June 10, 1993, to 1,424.4 feet above sea level on July 31, 1993, largely in response to rain falling on the lake. Significant discharges into Devils Lake from Channel A and Big Coulee after July 31 caused the lake to rise to 1,427 feet above sea level by September 28, 1993. The 1993 flood increased the volume of water in Devils Lake by about 300,000 acre-feet; previously recorded summer floods (late 1800's to 1993) had increased the volume of water in the lake by no more than 30,000 acre-feet. Immediate and long-term water-quality changes that may occur in the chain of lakes and Devils Lake as a result of the 1993 summer flood are unknown.

OBJECTIVES: Objectives are to (1) describe the quantity and quality of streamflow in the Devils Lake Basin immediately before, during, and after the 1993 flood and (2) describe the hydrologic and chemical changes in the upstream chain of lakes and in Devils Lake during 1993.

APPROACH: An extensive amount of water quantity and quality data has been collected in the Devils Lake Basin during 1993. Much of this data was collected and continues to be collected in response to the unique nature of the 1993 summer flood. The climatic conditions that preceded the flood and the antecedent hydrologic conditions of the Devils Lake Basin will be evaluated in a general manner. Monthly precipitation totals for the nine subbasins within the Devils Lake Basin will be estimated using an isohyetal method. Peak discharge hydrographs for eight streamflow-gaging stations in the Devils Lake Basin will be generated and compared with selected past records. The hydrologic response of the chain of lakes and Devils Lake will be addressed by hydrographic comparisons of lake elevations and surface-water inflows.

Water-quality data for the tributaries that enter into the chain of lakes and Devils Lake will be analyzed statistically and graphically. Variations in concentrations of dissolved solids and calculated loads of selected nutrients will be evaluated from preflood to ice-up conditions. Similarly, the variations in concentrations of dissolved solids and in calculated mass of selected nutrients will be evaluated for the chain of lakes and Devils Lake.

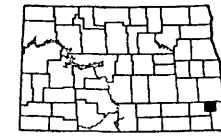
PROGRESS: Analysis of the quantity and quality of streamflow data for the Devils Lake Basin for the 1993 summer flood was completed. A draft report was prepared.

PLANS FOR FISCAL YEAR 1995: Plans are to complete the review process and obtain Director's approval for publication of the report.

REPORT PRODUCTS:

Variations in surface-water quantity and quality as a result of the 1993 summer flood in the Devils Lake Basin, North Dakota (in progress).

RESPONSE OF THE SHEYENNE DELTA AQUIFER TO PRECIPITATION AND FLOODING DURING 1993-94



PROJECT NUMBER: ND 94-175.

LOCATION: Sheyenne Delta aquifer, North Dakota.

PERIOD OF PROJECT: October 1993 to April 1995.

PROJECT CHIEF: Michael L. Strobel.

COOPERATING AGENCY: North Dakota State Department of Health and Consolidated Laboratories.

PROBLEM: Major precipitation and flooding, such as that experienced during the flood of 1993, significantly affects the water budgets and flow regimes in surficial aquifers adjacent to rivers. The large amount of recharge can prolong flooding problems because of the slow release of water by aquifers, cause seepage into low areas and structures, create a potential for ground-water contamination, and provide relief for previously diminished ground-water supplies.

OBJECTIVES: The physical effects of precipitation and flooding on the Sheyenne Delta aquifer will be studied and variations in ground-water quality related to the precipitation and flooding will be assessed. Objectives are to (1) evaluate the existing water-level, water-quality, and streamflow data for the study area; (2) monitor and sample selected wells; and (3) interpret and evaluate ground-water response to precipitation and flooding.

APPROACH: Data collected during the flood of July and August 1993 and data collected since the flood will be used to determine the short-term response of the system to the flood. Ground-water level measurements and water-quality sampling from November 1993 through May 1994 will be used to study the effects of snowmelt and possible additional flooding resulting from soil saturation during the winter of 1993-94.

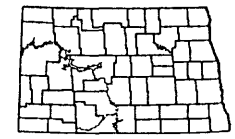
PROGRESS: Water levels were measured and water samples were collected. Data were analyzed and a draft report was prepared.

PLANS FOR FISCAL YEAR 1995: Plans are to complete the review process and obtain Director's approval for publication of the report.

REPORT PRODUCTS:

Precipitation and flooding effects on water levels and chemistry of the Sheyenne Delta aquifer, southeastern North Dakota, 1993-94 (in progress).

NORTH DAKOTA STREAMFLOW-GAGING NETWORK ANALYSIS


STATEWIDE

PROJECT NUMBER: ND 94-176.

LOCATION: Statewide.

PERIOD OF PROJECT: April 1994 to September 1995.

PROJECT CHIEF: Tara J. Williams-Sether.

COOPERATING AGENCY: North Dakota Department of Transportation.

PROBLEM: Any long-term data program needs to be evaluated periodically because of changes in objectives, technology, or external constraints. The last major evaluation of the streamflow-gaging program in North Dakota was done by O.A. Crosby in 1970. A network analysis that addresses the effect on the regional information that might be obtained from improved regional regression equations or the effect on the regional regression equations standard error of prediction has not been attempted recently.

OBJECTIVES: Objectives are to (1) evaluate the available streamflow-gaging network and (2) evaluate changes to the network that would provide additional data for improving regional flood information.

APPROACH: A network analysis will be conducted for three hydrologic regions. Tests will be conducted using peak discharges that have various recurrence intervals, such as 15-, 50-, and 100-year intervals, to insure that the information supplied by the network includes a wide range of flood frequencies. Flow characteristics will be analyzed on the basis of the value of present and future information. The network analysis strategy is to consider the available streamflow-gaging network, adding new crest-stage stations and establishing crest-stage stations at locations that previously had been discontinued. Emphasis will be placed on drainage areas of 100 square miles or less.

The generalized least-squares regression technique will be used to analyze the available streamflow-gaging network and the proposed crest-stage network. The generalized least-squares regression technique will be used because it provides a reliable estimate of the regression sampling error. The sampling error is the error in predicting peak flow caused by estimating the true regression parameters. The sampling error is affected by the length of peak-flow record at gaging stations, the variability of the peak flows, the cross correlation with data from other stations, and the combination of physical and climatic characteristics of the stations. The sampling error can be used as an indicator of the effectiveness of various peak-flow data network configurations if new stations are added to or existing stations are deleted from the original network.

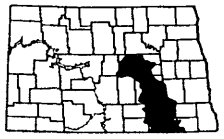
PROGRESS: Most of the network analysis was completed.

PLANS FOR FISCAL YEAR 1995: The network analysis will be completed. A report will be written, processed through Director's approval, and published.

REPORT PRODUCTS:

Streamflow-gaging network analysis in North Dakota (planned).

WATER RESOURCES OF THE JAMES RIVER BASIN, NORTH DAKOTA



PROJECT NUMBER: ND 94-177.

LOCATION: South-central North Dakota.

PERIOD OF PROJECT: October 1993 to September 1996.

PROJECT CHIEF: Wayne R. Berkas.

COOPERATING AGENCY: North Dakota State Water Commission.

PROBLEM: North Dakota is a semiarid state that depends on surface-water and ground-water resources for recreational and economic development. The need for water in the State has increased public awareness about the importance of water availability and water quality. Requests for hydrologic information are made continuously to State and Federal agencies. These agencies compile the information available but usually cannot completely fill the request. A report that describes North Dakota's water resources by river basin could be useful as a readily-available, comprehensive response to inquiries for general hydrologic, water-quality, and water-use information.

OBJECTIVES: The purpose of this study is to describe the water resources of the James River Basin. Objectives are to (1) describe the surface-water and ground-water hydrology and (2) describe the hydrologic processes of the James River Basin.

APPROACH: Existing data pertaining to the hydrologic system and hydrologic processes will be obtained from various State and Federal agencies. The report will define the hydrologic system in the James River Basin with reference to major rivers and related reservoirs, wetlands, major types of aquifers, and the soil system. The hydrologic processes that have a dominant effect on the system will be discussed. The general flow of water through the hydrologic system in reference to the hydrologic cycle (recharge/ discharge relations) and the qualitative magnitudes of each hydrologic process will be described sufficiently to show the variability of the water resource.

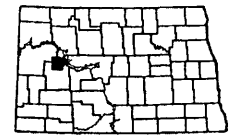
PROGRESS: Existing data were obtained from the various State and Federal agencies. A draft of selected sections of the report was written.

PLANS FOR FISCAL YEAR 1995: The draft report will be written and editorial and colleague reviews will be completed.

REPORT PRODUCTS:

Water resources of the James River Basin, North Dakota (planned).

SHALLOW GROUND WATER IN THE MANDAREE, NORTH DAKOTA, AREA



PROJECT NUMBER: ND 94-178.

LOCATION: West-central North Dakota.

PERIOD OF PROJECT: May 1994 to September 1995.

PROJECT CHIEF: Steven W. Cates.

COOPERATING AGENCY: Three Affiliated Tribes.

PROBLEM: Increased interest in residential development in the Mandaree area of the Fort Berthold Indian Reservation necessitates an adequate water supply for rural homes. Ground water obtained at depths exceeding 150 feet in this area is of poor quality and has large concentrations of dissolved solids, sodium, and either bicarbonate or sulfate. Ground water that is of sufficient quality for domestic use can be obtained at various locations from shallow aquifers. The shallow Sentinel Butte Member of the Fort Union Formation, glacial outwash, or Holocene alluvial deposits are the primary possible sources of ground water that is of sufficient quality for domestic use in rural homes in the area.

OBJECTIVES: The purpose of this study is to evaluate the shallow ground-water resources (less than 150 feet deep) within the Sentinel Butte Member near Mandaree, North Dakota. This study will provide a basis for the development of ground water for domestic use in rural homes. Objectives are to (1) develop an understanding of the distribution and stratigraphy of the shallow Sentinel Butte Member of the Fort Union Formation near Mandaree, North Dakota; (2) apply this understanding as a predictive tool for ground-water exploration in the area; and (3) investigate and describe the near-surface ground-water system of the Sentinel Butte Member, including the direction of ground-water movement, the hydrologic properties of the sediments, and the quality of the ground water.

APPROACH: This investigation will include a review of geologic and hydrologic information from previous studies. A review of existing geophysical and lithologic logs, soil survey information, and driller's test-hole logs will be used to construct a framework for understanding the distribution of shallow sediments. On the basis of this information, about 50 test holes will be drilled and logged to define the stratigraphy for the determination of the distribution of the Sentinel Butte Member.

Observation wells will be completed at about 20 of the test holes to allow water-level data collection, aquifer testing, and water-quality sampling. A network of observation wells will be established to measure water levels in the near-surface ground-water system and a potentiometric-surface map will be constructed to define the direction of ground-water movement. Slug test or short pumping tests (single well) that include recovery measurements will be conducted at selected observation wells to estimate values of hydraulic conductivity, transmissivity, and specific yield. Water samples will be collected from the wells and analyzed for selected physical properties and dissolved major ions.

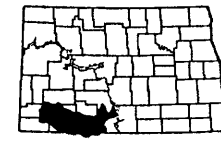
PROGRESS: An analysis of existing data was completed and the drilling program was begun.

PLANS FOR FISCAL YEAR 1995: The drilling program will be completed, the near-surface hydrologic system will be analyzed, and the final report will be written, reviewed, and published.

REPORT PRODUCTS:

Shallow ground water of the Mandaree, North Dakota, area (planned).

WATER RESOURCES IN THE CANNONBALL RIVER BASIN, NORTH DAKOTA



PROJECT NUMBER: ND 94-179.

LOCATION: Cannonball River Basin, North Dakota.

PERIOD OF PROJECT: August 1994 to September 1995.

PROJECT CHIEF: Edwin A. Wesolowski.

COOPERATING AGENCY: U.S. Department of the Interior, Bureau of Reclamation.

PROBLEM: The Bureau of Reclamation, in cooperation with the Standing Rock Sioux Tribe and the North Dakota State Water Commission, has begun a water-management study of the Cannonball River Basin under a planning effort known as the Missouri River Basin Tribes Water Management Study. The purpose of the Missouri River Basin Tribes Water Management Study is to assist the Tribes with the preparation of water-development and water-management plans relative to the use of Tribal reserved water rights. The Bureau of Reclamation needs assistance in developing the hydrologic data and information needed for water-development and water-management plans for the Cannonball River Basin Water Management study.

OBJECTIVES: The purpose of this study is to assist in developing the needed hydrologic data and information for the Cannonball River Basin. Objectives are to (1) identify and summarize all available hydrologic data for the Cannonball River Basin; (2) compile and extend monthly regulated and unregulated streamflow for the Cannonball River Basin; and (3) compile, analyze, and generate water-quality data needed for a water-quality model for the Cannonball River Basin.

APPROACH: All existing surface-water, ground-water, and water-quality data will be identified and obtained from various State, Federal, Tribal, and local agencies. A literature search will be completed to locate pertinent published literature about the basin. Statistical summaries of streamflow data will be computed for each site where data are available and will include the monthly and annual maximum, minimum, mean, standard deviation, coefficient of variation, and percent of annual runoff. Statistical summaries of water-quality data will be computed for each site where data are available and will include the sample size, maximum, minimum, mean, and standard deviation for each constituent. The percentage of samples in which values were less than or equal to those listed also will be given. Water use will be summarized for major categories.

Streamflow records will be compiled and extended where necessary to develop monthly streamflow for five gaging stations on the Cannonball River and its tributaries for 1950-93. Monthly unregulated streamflows at these gaging stations also will be estimated for 1950-93.

Water-quality data for October 1950 through September 1993 for the five gaging stations on the Cannonball River and its tributaries will be reviewed for consistency with quality-assurance relations. The primary method for estimating monthly mean dissolved solids will be a direct relation between dissolved solids and streamflow.

PROGRESS: U.S. Geological Survey data were retrieved. Other Federal, State, Tribal, and local agencies were contacted to obtain their data. Data summarizing was begun.

PLANS FOR FISCAL YEAR 1995: Data summarizing and record extension for dissolved solids and streamflow will be completed. A data report will be prepared and published.

REPORT PRODUCTS:

Water-resources data for the Cannonball River Basin (planned).

OTHER ACTIVITIES OF THE NORTH DAKOTA DISTRICT

To provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources, the U.S. Geological Survey, Water Resources Division, is involved in numerous activities other than its regular programs of data collection and hydrologic investigations. Representatives of the U.S. Geological Survey serve on advisory committees, task forces, and ad hoc groups set up for specific purposes. Members of the North Dakota District staff participate in meetings, provide administrative support, and furnish information requested by various committees and task forces. Included are the North Dakota Nonpoint Source Water Quality Task Force, the Red River Water Resources Council, the Yellowstone River Compact Commission, the International Souris River Board of Control, the Souris River Bilateral Water-Quality Monitoring Group and its task forces, and the International Souris-Red River Engineering Board.

District staff review Environmental Impact Statements for selected Federal projects to insure that available hydrologic data are used, that the data are used correctly, and that the impact of proposed developments on water features and resources is accurately evaluated. From time to time, the District also is asked to review reports and projects of other Federal agencies, primarily because of the Survey's hydrologic expertise and impartiality. District personnel occasionally are called upon to provide expert testimony concerning hydrologic information gathered or developed by the District that is relevant to a water-resources issue under litigation.

In addition to the U.S. Geological Survey's formal programs and studies, water information and assistance are provided to other agencies with specific problems. The District continually receives calls, visits, and mail requests for information on ground-water availability and water levels, streamflow magnitudes, water quality, and water use from scientists with other agencies, landowners, consultants, public officials, and business concerns.

Supplement 1. Reports approved from October 1, 1992, through September 30, 1994

Date approved	Report title	Author	Publication media
12/23/92	Simulation of effects of discharging treated wastewater to the Red River	E.A. Wesolowski	Official Bulletin, North Dakota Water and Pollution Control Conference
1/19/93	Marine seismic technique as a tool for paleoclimatic research, Devils Lake, North Dakota	S.W. Cates and R.M. Lent	Abstract, North Dakota Academy of Science Symposium on Global Climate Change Research in the Northern Great Plains, Jamestown, North Dakota, April 29-30, 1993
1/22/93	Physical-property, water-quality, plankton, and bottom-material data for Devils Lake and East Devils Lake, North Dakota, September 1988 through October 1990	S.K. Sando and B.A. Sether	Open-File Report 93-66
1/25/93	Paleoclimatic conditions and timing of recharge to buried-valley aquifers in North Dakota--Evidence from $\delta^{18}O$, δD, and tritium data	R.M. Lent	Abstract, North Dakota Academy of Science Symposium on Global Climate Change Research in the Northern Great Plains, Jamestown, North Dakota, April 29-30, 1993
2/05/93	Relations between upper-air flow patterns, climate, and hydrologic variability in the Red River of the North Basin, United States and Canada	G.J. Wiche and J.L. Knox	Abstract, North Dakota Academy of Science Symposium on Global Climate Change Research in the Northern Great Plains, Jamestown, North Dakota, April 29-30, 1993
3/04/93	Water-resources activities, North Dakota District, fiscal year 1992	C.R. Martin	Open-File Report 93-52
4/26/93	Occurrence of 2,4-D in a prairie stream tributary to Lake Sakakawea on the Fort Berthold Indian Reservation, North Dakota	R.M. Lent, K.M. Macek-Rowland, and K.P. Baker	Abstract, Northern Prairie Wildlife Research Center, Wetland Symposium, Jamestown, North Dakota, August 9-13, 1993
4/28/93	User documentation for North Dakota geochemical data-base software system--Input, update, and retrieval procedures	J.W. Atwood	Open-File Report 93-117
5/05/93	Hydrogeologic and anthropogenic influences on the occurrence of saline wetlands in the Red River of the North Valley, northeastern North Dakota	M.L. Strobel and P.J. Gerla	Abstract, Northern Prairie Wildlife Research Center, Wetland Symposium, Jamestown, North Dakota, August 9-13, 1993

Supplement 1. Reports approved from October 1, 1992, through September 30, 1994—Continued

Date approved	Report title	Author	Publication media
5/05/93	Variations in water quality and detection of agricultural chemicals in small lakes and wetlands associated with the Warwick aquifer on the Fort Totten Indian Reservation, North Dakota	R.M. Lent, M.L. Strobel, and O.S. Gourd	Abstract, Northern Prairie Wildlife Research Center, Wetland Symposium, Jamestown, North Dakota, August 9-13, 1993
8/18/93	Flood of April 1989 in the Wahpeton-Breckenridge and Fargo-Moorhead areas, Red River of the North Basin, North Dakota and Minnesota	G.L. Ryan and R.E. Harkness	Water-Resources Investigations Report 93-4155, Map Report
10/18/93	Simulated effects of the proposed Garrison Diversion Unit on streamflow and dissolved solids in the Sheyenne River and the Red River of the North, North Dakota and Minnesota	R.S. Guenthner	Water-Resources Investigations Report 93-4200
12/21/93	Hydrology of the Devils Lake area, North Dakota	G.J. Wiche and S.W. Pusc	North Dakota State Water Commission Water Resources Investigation 22
1/13/94	Flowing wells in northeastern North Dakota and their possible effect on water quality in the Red River of the North Basin	M.L. Strobel, J.B. Kelly, S.T. Carlson, and H.A. Salender	Abstract, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994
1/31/94	Development of historic and synthesized unregulated streamflow for the James River in North Dakota and South Dakota, 1983-91	D.G. Emerson, and C.A. Niehus	Water-Resources Investigations Report 94-4018
2/01/94	Effects of flooding on surface-water quantity and quality in the Devils Lake Basin, North Dakota, 1993	R.M. Lent, G.J. Wiche, and T.J. Williams-Sether	Abstract, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994
2/01/94	Water-quality trends in North Dakota: U.S. Geological Survey surface-water monitoring program	W.R. Berkas	Abstract, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994
2/11/94	Proposed streamflow modeling of selected reaches of the Souris River between Lake Darling and J. Clark Salyer National Wildlife Refuge	E.A. Wesolowski	Abstract, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994
2/18/94	Flowing wells in northeastern North Dakota and their possible effect on water quality in the Red River of the North Basin	M.L. Strobel, J.B. Kelly, S.T. Carlson, and H.A. Salender	Paper, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994
3/11/94	Effects of flooding on surface-water quantity and quality in the Devils Lake Basin, 1993	R.M. Lent, G.J. Wiche, and T.J. Williams-Sether	Paper, North Dakota Water Quality Symposium, Fargo, North Dakota, March 30-31, 1994

Supplement 1. Reports approved from October 1, 1992, through September 30, 1994—Continued

Date approved	Report title	Author	Publication media
4/18/94	Calibration, verification, and use of a water-quality model to simulate effects of discharging treated wastewater to the Red River of the North at Fargo, North Dakota	E.A. Wesolowski	Water-Resources Investigations Report 94-4058
5/31/94	Climatic and hydrologic aspects of the 1988-92 drought in North Dakota	T.J. Williams-Sether	Abstract, 39th Annual Midwest Ground-Water Conference, Bismarck, North Dakota, October 16-18, 1994
5/31/94	Effects of the 1993 flood on ground-water levels and quality in the Sheyenne Delta aquifer, southeastern North Dakota	M.L. Strobel and T.K. Cowdery	Abstract, 39th Annual Midwest Ground-Water Conference, Bismarck, North Dakota, October 16-18, 1994
5/31/94	Preliminary results of the effects of the 1993 flood on surface-water/ground-water interactions in the upper Mississippi River Basin	M.L. Strobel	Abstract, 39th Annual Midwest Ground-Water Conference, Bismarck, North Dakota, October 16-18, 1994
8/15/94	Climatic and hydrologic aspects of the 1988-92 drought and the effect on people and resources of North Dakota	T.J. Williams-Sether, K.M. Macek-Rowland, and D.G. Emerson	North Dakota State Water Commission Water Resources Investigation 29
9/14/94	Sources and cycling of major ions and nutrients in Devils Lake, North Dakota	R.M. Lent	Water-Resources Investigations Report 94-4171
9/30/94	Extent and magnitude of precipitation and flooding during 1993 in the upper Mississippi and Red River of the North Basins	G.J. Wiche	Abstract, 39th Annual Midwest Ground-Water Conference, Bismarck, North Dakota, October 16-18, 1994