WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MINNESOTA, FISCAL YEAR 1985

Compiled by J. A. Jannis

U.S. GEOLOGICAL SURVEY

Open-File Report 86-133

St. Paul, Minnesota

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

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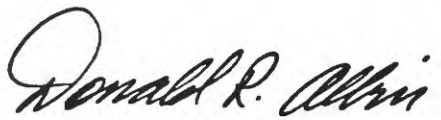
FOREWORD

Since the U.S. Geological Survey began water-resources activities in Minnesota in 1903, a large amount of hydrologic data has been collected and many areal investigations and research projects have been completed. Over the years, these activities have reflected the need for water-resource information on priority issues of the time. I am gratified by these past accomplishments and pleased to be part of the current program. This report contains brief summaries of our current activities, which are being done in cooperation with many State, local, and other Federal agencies. Future activities undoubtedly will be oriented mainly toward water-quality problems and the increasing need for real-time data. I look forward to continuation of a challenging cooperative program that will aid resolution of water-resources issues in Minnesota.



Donald R. Albin
District Chief

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WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MINNESOTA, FISCAL YEAR 1985

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INTRODUCTION

The Geological Survey was established as an agency in the Department of the Interior by an Act of Congress in 1879. The growth of its scientific and engineering investigations has paralleled the growth of the United States and has contributed to that development. Initially, the mission of the Geological Survey was to assess the mineral resources of the United States. However, as need arose, the Survey mission expanded and the organization eventually was divided into several operating Divisions and Offices, each addressing specific aspects of natural resources. As a result of its expanding research and fact-finding role, the Geological Survey has become the Nation's largest earth-science research agency, the largest civilian mapmaking agency, the primary source of data on the Nation's surface-water and ground-water resources, and the employer of the largest number of professional earth scientists. Today's programs, which serve a diversity of needs and users, include:

- Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.
- Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the geologic structure of the Nation.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.
- Developing and producing digital cartographic data bases and products.
- Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.
- Conducting water-resource appraisals in order to describe the consequences of alternative plans for developing land and water resources.
- Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.
- Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.

- Providing earth-science information through an extensive publications program and a network of public access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the nation, the 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." Organizational units of the Survey that currently have activities in Minnesota are the Water Resources, Geologic, National Mapping, and Information Systems Divisions, the Office of Earth Sciences Applications, the Office of Hazardous Waste Hydrology, and the Office of National Water Summary.

Effective management of water resources requires that up-to-date scientific hydrologic information be readily available for planners and managers. The Water Resources Division has the principal responsibility within the Federal Government for providing hydrologic data and appraising water resources to facilitate evaluation of water problems. The Division's program is designed to present accurate and unbiased data and scientific analyses. The Water Resources Division supplies reports and maps to the public as Federal, State, and local publications, in technical journals, and through selected libraries.

The U.S. Geological Survey provides extensive support to the missions of other Federal agencies and, under the Federal-State Cooperative Program, to State and local agencies. In this way, the Survey keeps abreast of water-information needs at all levels of government and develops programs responsive to those needs.

A major responsibility was assigned to the Survey in 1964 when it was designated the lead agency for coordinating water-data-acquisition activities of all Federal agencies, including information on streams, lakes, reservoirs, estuaries, and ground water. This coordination effort minimizes duplication of data collection among Federal agencies and strengthens the overall data base and its accessibility.

The Federal Program

The water-data collection, resource investigation, and research activities of this program are carried out in areas where the Federal interest is paramount. These include bodies of water in the public domain, river basins and aquifers that cross State boundaries, and other areas of international or interstate concern. Activities include operation of stations throughout the country for measurement of surface- and ground-water quantity and quality, operation of the Survey's Central Laboratories, hydrologic research and analytical studies, and a variety of supporting services.

The Federal-State Cooperative Program

Geological Survey programs have multiple objectives to serve the earth-science and related information needs of a large number of government agencies and private groups. As major users of this information, State, regional, and local agencies have an important role in helping to define the scope of Survey

programs. Accordingly, selected projects judged to be of mutual benefit to Federal, State, and local governments are funded on a 50-50 basis in the Federal-State Cooperative Program.

Planning the annual program in each State is a joint effort, with the Survey representing national interests and the cooperating agencies representing State and local interests. As the need arises for additional or new kinds of water information, programs are adjusted within the framework of priorities and resources. As a result, the work is problem oriented and responsive to State and local needs.

The strength of the Federal-State Cooperative Program lies in (1) coordinated programming for water information that responds to identified and developing needs of people at all levels and relates to environmental aspects of water use, (2) the quality and consistency of the water data accumulated through uniform programs in 50 States and several of the territories, and (3) the nonadvocacy position of the Geological Survey in carrying out and impartially reporting on its work.

Support of Missions of Other Federal Agencies

With funds transferred from other Federal agencies, the Geological Survey performs work related to specific needs of each agency. Examples of work done in cooperation with several of these agencies are as follows:

Department of Defense, U.S. Army Corps of Engineers
- Streamflow data collection and streamflow modeling, sediment and water-quality studies.

Cold Regions Research Engineering Laboratory
- Collecting streamflow and sediment data from a small watershed.

Department of Energy
- Mathematical modeling of thermal-energy storage in aquifers.

Department of the Interior

Bureau of Indian Affairs
- Water-resources appraisals of Indian Reservations.

National Park Service
- Appraisal of water quality in Voyageurs National Park.

Environmental Protection Agency
- Studies related to the transport of organic compounds in ground-water systems.
- Delineation of the baseline chemical quality of water in the 14 principal aquifers in Minnesota.
- Assessment of the impact on water quality of discharging treated municipal sewage to wetlands.

Department of State
  Collecting streamflow data at international gaging stations operated under terms of the Waterway Treaty with Canada.

Federal Emergency Management Agency
  Flood-hazard studies.

Federal Energy Regulatory Commission
  Review and publish streamflow data collected by power companies.

This report contains a brief summary of the status of water-resources projects in the Minnesota District of the Geological Survey at the end of fiscal year 1985. The projects are conducted by personnel located in the District Office in St. Paul and in Field Headquarters in St. Paul, Grand Rapids, and Montevideo. In addition, the research unit for hydraulic and sedimentologic processes is located at the St. Anthony Falls Hydraulics Laboratory in Minneapolis. More information concerning any of the projects listed can be obtained by contacting the District Chief, Water Resources Division, at the address given on page 6.

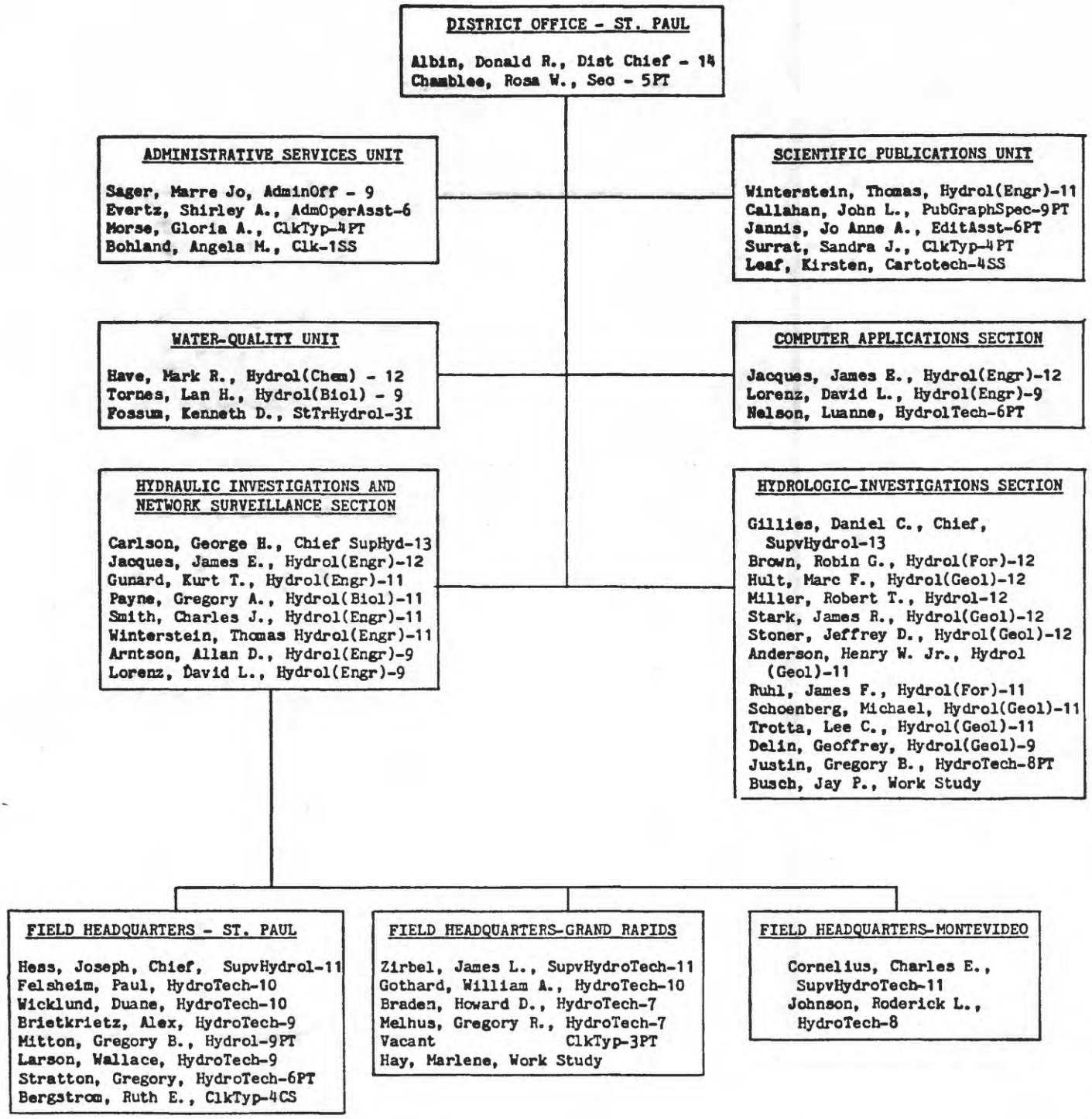


Figure 1.--Geological Survey organization chart

WATER RESOURCES DIVISION

DISTRICT OFFICE

U.S. Geological Survey
702 Post Office Building
180 East Kellogg Boulevard
St. Paul, Minnesota 55101
(612) 725-7841

District Chief	Donald R. Albin
Chief, Hydrologic Investigations	Daniel C. Gillies
Chief, Hydraulic Investigations	George H. Carlson
Chief, St. Paul Field Headquarters	Joseph H. Hess
Chief, Publications Unit	Thomas A. Winterstein
Chief, Water-Quality Unit	Mark R. Have
Chief, Computer Unit	James E. Jacques
Administrative Officer	Marre Jo Sager

FIELD HEADQUARTERS

415 South Pokegama Avenue
Grand Rapids, Minnesota 55744
(218) 326-1297

Technician-in-Charge	James L. Zirbel

FIELD HEADQUARTERS

P.O. Box 150 - 301 First Street
Montevideo, Minnesota 56265
(612) 269-6869

Technician-in-Charge	Charles E. Cornelius

OFFICE OF THE REGIONAL HYDROLOGIST

St. Anthony Falls Hydraulics Laboratory
Hennepin Island & Third Avenue S.E.
Minneapolis, Minnesota 55415
(612) 349-3352

Hydrologist-in-Charge	John V. Skinner
Hydrologist	Joseph P. Beverage
Mechanical Engineer	Joseph J. Szalona
Clerk-typist	Florence L. Wright

c/o Dept. of Geology & Geophysics
Pillsbury Hall, University of Minnesota
Minneapolis, Minnesota 55455
(612) 373-4569

Geologist	Frederick M. Swain

STAFF OF THE MINNESOTA DISTRICT

WATER RESOURCES DIVISION

The staff of the Minnesota District includes 49 personnel, of which 26 are professional Hydrologists and 23 are technical and support personnel. In Fiscal Year 1985, the work of the District was being carried out through 26 projects funded by 9 local, 6 State, and 10 Federal agencies and by the U.S. Geological Survey itself. Major new projects planned for Fiscal Year 1986 include an investigation of water resources on the Leech Lake Indian Reservation, the hydrogeology of the Bemidji-Bagley sand plain, and the source of nitrate in ground water in central Minnesota.

COOPERATING AGENCIES--1985

The U.S. Geological Survey and local, State, and other Federal agencies have had joint agreements for the systematic collection of water records or for interpretive studies and research since 1903. Organizations that participated through cooperative or interagency agreements with the Survey during 1985 are:

Board of Water Commissioners, City of St. Paul
Bureau of Indian Affairs
Cold Regions Research Engineering Laboratory
County Soil and Water Conservation Districts
Elm Creek Conservation, Management, and Protection Commission
Federal Emergency Management Agency
Federal Energy Regulatory Commission
Fond du Lac Reservation Business Committee
Lower Red River Watershed District
Metropolitan Waste Control Commission of the Twin Cities
Middle River/Snake River Watershed District
Minnesota Department of Natural Resources
Minnesota Department of Transportation
Minnesota Geological Survey
Minnesota Pollution Control Agency
Minnesota State Planning Agency
Pomme de Terre Ground-Water Study Steering Committee
Red Lake Reservation Business Committee
Red Lake Watershed District
U.S. Army Corps of Engineers
U.S. Department of State, Water Way Treaty
U.S. Environmental Protection Agency
University of Minnesota
WesMin Resource Conservation and Development Association
White Earth Reservation Business Committee

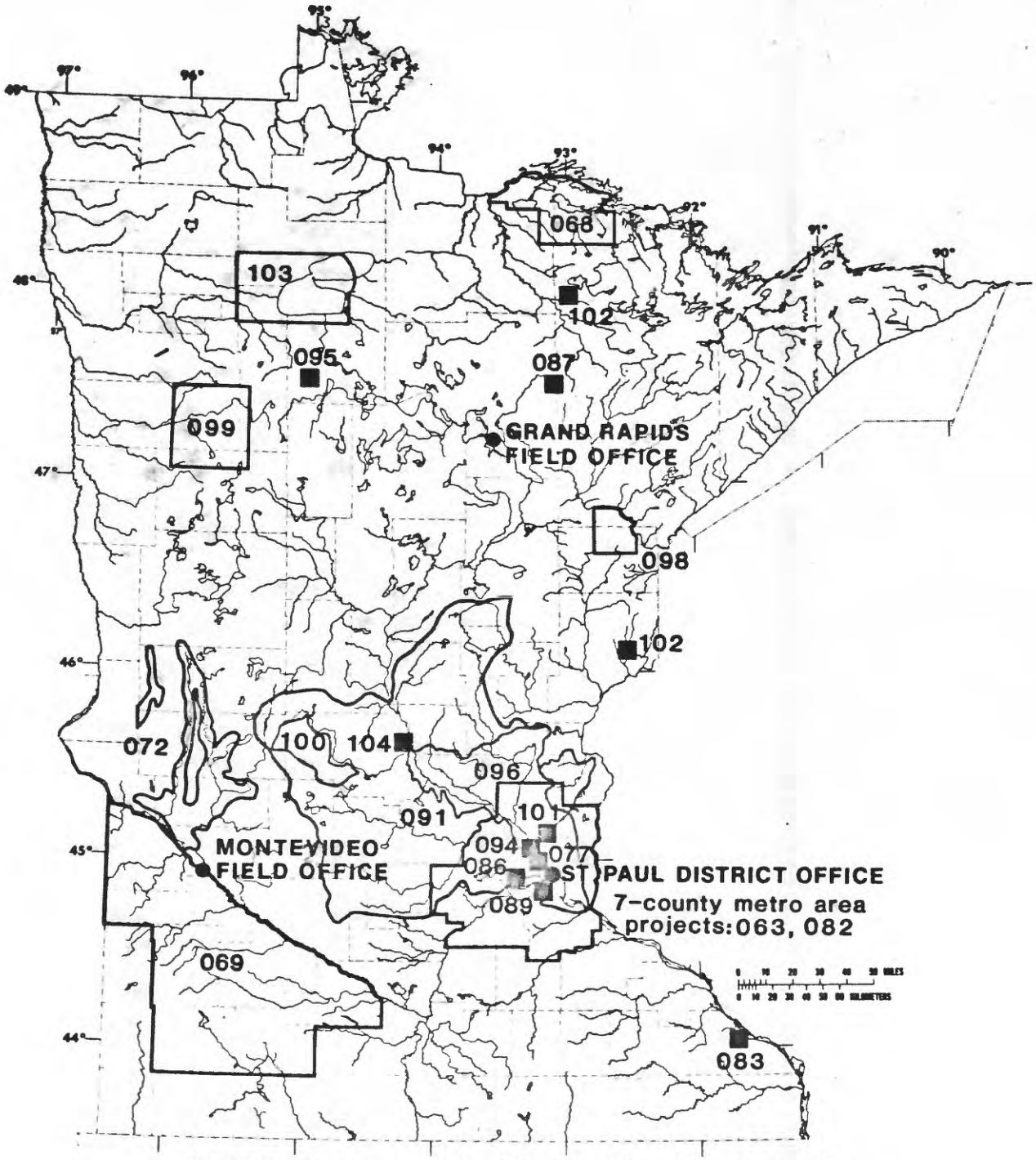


Figure 2.--Project location and number

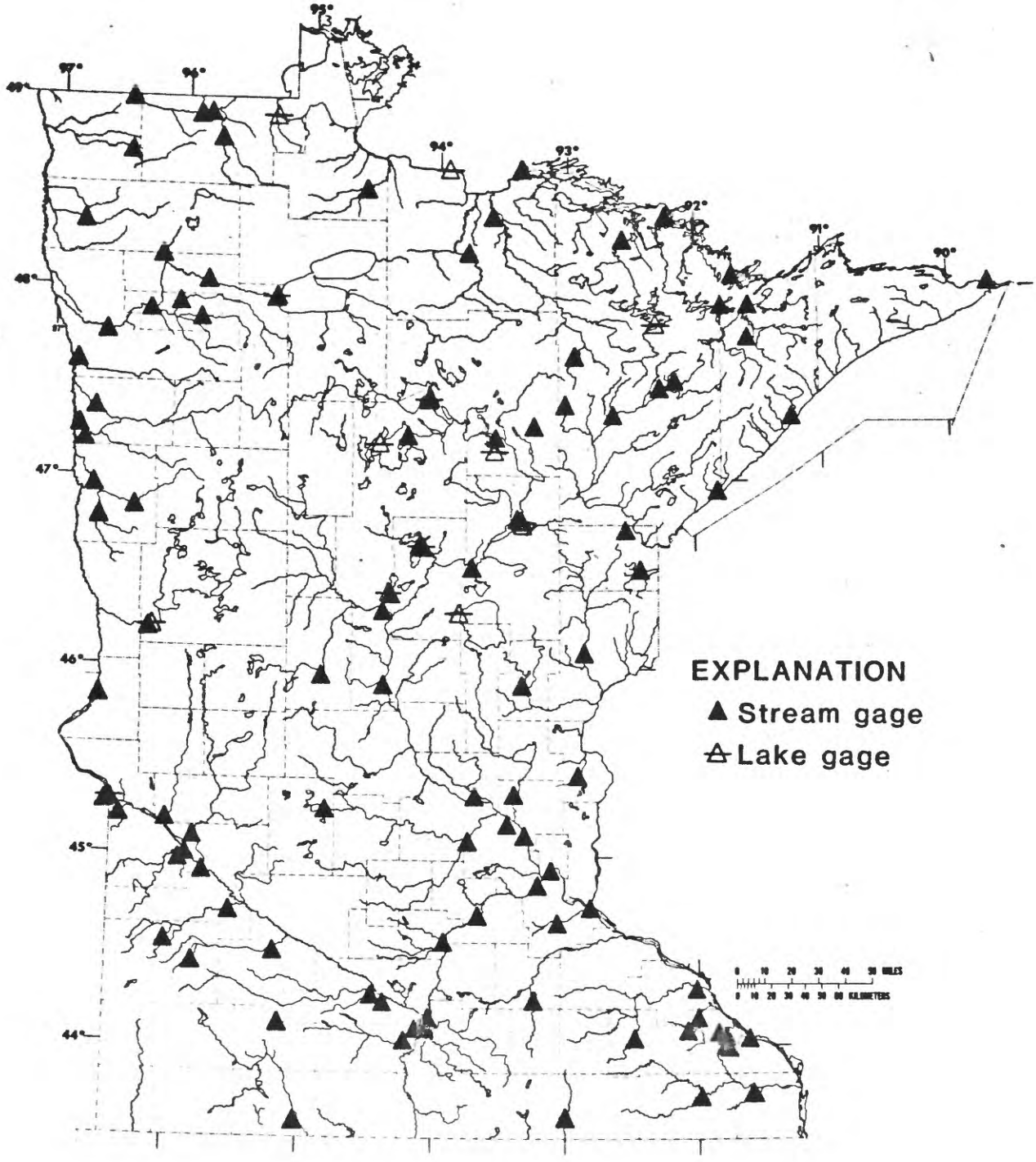


Figure 3.--Surface-water network

PROJECTS OF THE MINNESOTA DISTRICT

SURFACE-WATER STATIONS
(MN 00-001)

Date Project Began: May 1903

Date Project Ends: Continuing

Project Leader: Gunard, Kurt T.

Location: Statewide

Principal Cooperating Agencies: Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, Department of State, Federal Energy Regulatory Commission

Objectives: A. To collect data on the surface waters of Minnesota for current-purpose uses such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) forecasting, (4) disposal of wastes and control of pollution, (5) interpretation and evaluation of water-quality data, (6) compact and legal requirements, and (7) research or special studies.

B. To collect data for analytical studies, planning, and design that will define statistical properties and trends in the occurrence of water at any location in Minnesota streams, lakes, reservoirs, and estuaries.

Progress in FY 85: The annual report on water-resources data for 1984 is nearing completion. At present (1985), a surface-water network of 113 continuous-record stations, 133 high-flow partial-record stations, and 285 low-flow partial-record stations is in operation. Mean daily discharges are determined for 99 of the 113 continuous-record stations, elevation only is determined for seven stations, and contents of lakes or reservoirs are determined for seven stations. Significant rainfall occured on September 2-3, 1985, in east-central Minnesota. Runoff at 3 crest-stage sites in this area was the greatest for the period of record, which is 25 years at 2 of the sites and 14 years at the other. Five surveys for indirect determination of peak discharge were made in north-central and east-central Minnesota due to this storm and another storm which occurred earlier in the year on May 11, 1985. Discharge measurements were made at 116 low-flow stations during the year in addition to 60 low-flow measurements made for a project in the Brooten-Belgrade area. Eleven stations in northern Minnesota are now equipped with data-collection platforms to provide real-time data capability. Eleven additional data-collection platforms were installed during the year by the U.S. Army Corps of Engineers on streamflow stations operated by this District in southern Minnesota. A "formal" network analysis was begun in 1983, using the cost effective resource allocation (k-cera) method of evaluation for each streamflow station currently in operation. The objective of the analysis is to indicate how the maximum amount of needed information, preferably with high-transfer capability, can be collected at a minimum cost while maintaining a specified

reliability. This analysis is now about 80 percent completed (only the "traveling hydrographer" part of the analysis remains to be completed). The daily values file will be updated for the 1984 water year, and data in the peak-flow and station-header files have been checked for consistency. Peak-flow data for 1984 and partial-duration peak data (peaks above a "base discharge") will be entered in the peak-flow file in National Water Data Storage and Retrieval System (WATSTORE). The station-header file is continuously updated to reflect changes in the records.

Plans for FY 86: Continue the surface-water program at about the same level as in 1985. Complete the analysis and compilation of data for water year 1985, publish the annual report, and maintain the data in WATSTORE. The low-flow program will be continued, and low-flow characteristics will be updated. The high-flow program will be continued with about 50 stations discontinued and 15 new stations established to give more complete areal coverage. The report "Techniques for estimating magnitude and frequency of floods on small streams in Minnesota" has progressed through regional review and is presently being revised based on reviewers comments. The report "Evaluation of a peak-flow gaging network in Minnesota" will be given at the Cold Regions Hydrology Symposium in Fairbanks, Alaska, in July 1986 and published in those proceedings. The network analysis begun in 1983 will be completed.

Completed Reports:

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report MN-83-1, 202 p.

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 2, Upper Mississippi and Missouri River basins: U.S. Geological Survey Water-Data Report MN-83-2, 447 p.

Reports in Preparation:

Arntson, A. D., Hydrologic data and analysis for the Clearwater River Flood of June 23, 1983, in Stearns, Meeker and Wright Counties, Minnesota: U.S. Geological Survey Open-File Report.

Jacques, J. E., and Lorenz, D. L., Techniques for estimating magnitude and frequency of floods in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Jacques, J. E., and Lorenz, D. L., An analysis of a stream-gaging network for regional information in Minnesota: Abstract.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

Winterstein, T. A., and Arntson, A. D., Cost-effectiveness of the stream-gaging program in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Stream gaging

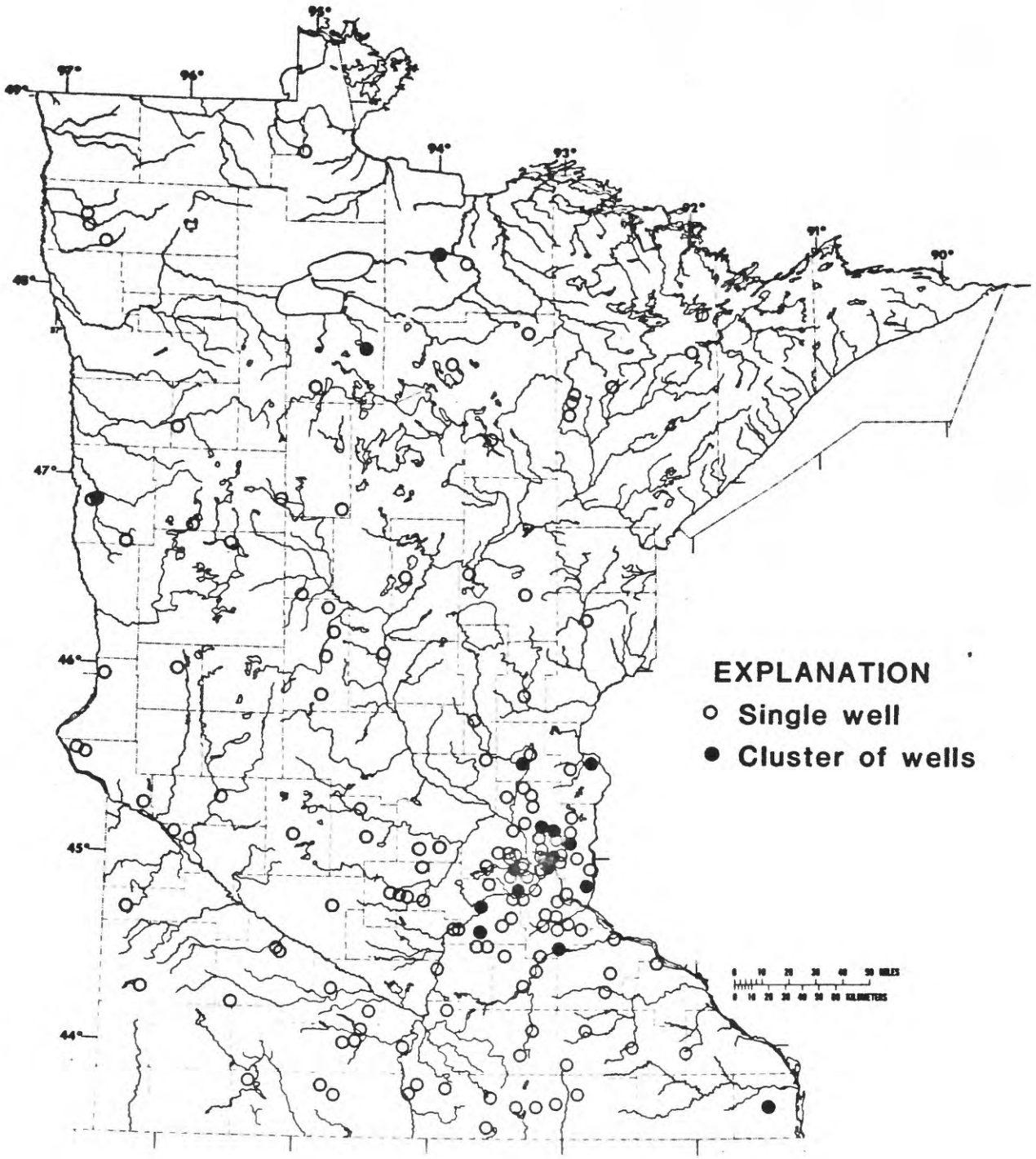


Figure 4.--Observation-well network

GROUND-WATER STATIONS
(MN 00-002)

Date Project Began: July 1947

Date Project Ends: Continuing

Project Leader: Anderson, Henry W., Jr.

Location: Statewide

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objectives: A. To collect water-level data needed for a continuing long-term evaluation of the response of the 14 principal aquifers in Minnesota to climatic variations and to induced stresses. The data will help define known and potential problems and aid overall planning and management of the ground-water resource.

B. To provide a data base against which short-term project records can be analyzed. This analysis must (1) assess ground-water resources, (2) allow prediction of future conditions, (3) define supply problems, and (4) provide the data base necessary for development and management of the resource.

Progress in FY 85: The observation-well network for FY 1985 included 179 wells, 16 with continuous recorders. This is 100 fewer wells than in FY 1984 because 34 wells previously measured monthly by paid observers and 57 wells previously measured monthly by County Soil and Water Conservation District (SWCD) personnel were transferred from the U.S. Geological Survey (USGS)/Minnesota Department of Natural Resources (MDNR) network to the MDNR/SWCD network. During FY 1985, 12 wells were discontinued for various reasons and three wells were added to the USGS/MDNR network. Water-level data for the 1984 water year were compiled in the computer data base, and transmitted to the MDNR near the end of December 1984. Annual summary hydrographs were prepared for 40 wells in volume 1 (northern Minnesota) and for 90 wells in volume 2 (central and southern Minnesota) of the 1984 annual data report. Ground-water levels in unconfined surficial aquifers generally rose in October and November 1984 but declined in December 1984 through February 1985. Levels rose seasonally during spring 1985. Levels generally rose in the north and declined in the south during July and August 1985, and rose statewide in September 1985. Levels were generally near seasonal average levels statewide through the first three quarters of water year 1985, but by the end of the water year were generally several feet above seasonal average levels in the north and near or above average in the south.

In the Minneapolis-St. Paul area, the primary pumping center of the State, the potentiometric surface of the Prairie du Chien-Jordan bedrock aquifer generally rose seasonally in fall 1984 and winter 1985, began to decline seasonally in April 1985, but generally was above seasonal average. Levels declined

seasonally during early summer 1985 but rose in August and September to several feet above seasonal average levels. The potentiometric surface of the deeper Mount Simon-Hinckley aquifer generally declined throughout the year to about 20 feet below seasonal average levels.

Plans for FY 86: Water-level measurements will be maintained on the 179 wells in the ground-water network. Summary hydrographs will be prepared for analysis of hydrologic conditions and for publication in the annual data report.

Completed Reports:

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report MN-83-1, 202 p.

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 2, Upper Mississippi and Missouri River basins: U.S. Geological Survey Water-Data Report MN-83-2, 447 p.

Reports in Preparation:

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

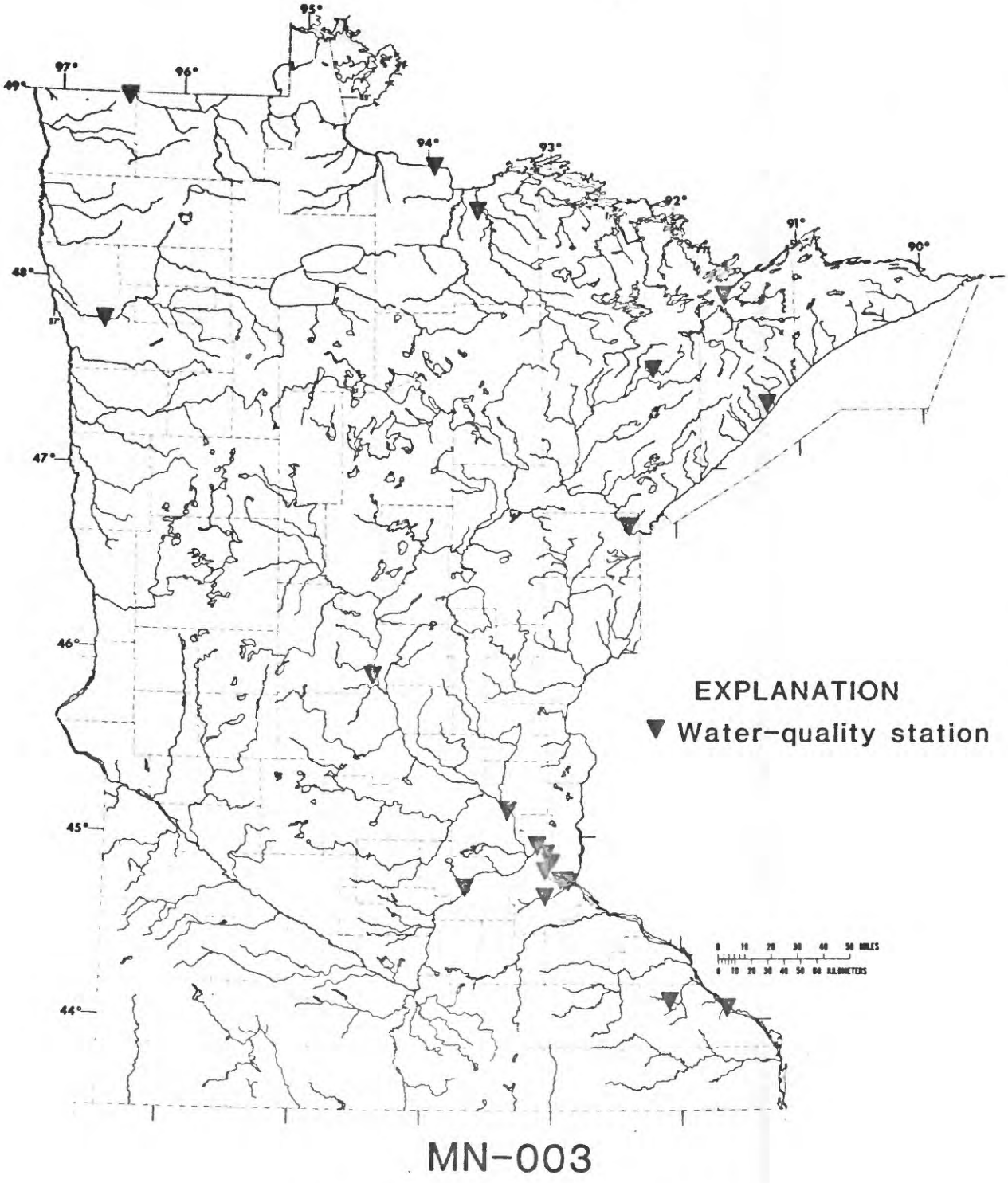


Figure 5.--Water-quality network

QUALITY OF WATER STATIONS
(MN 00-003)

Date Project Began: June 1955

Date Project Ends: Continuing

Project Leader: Have, Mark R.

Location: Statewide

Principal Cooperating Agencies: Minnesota Department of Natural Resources, Metropolitan Waste Control Commission of the Twin Cities, U.S. Army Corps of Engineers

Objectives: To provide water-quality data for local, State, and Federal planning and the management of interstate and intrastate water resources.

Progress in FY 85: Ten NASQAN, 2 Benchmark, and 8 automatic monitor sites (one of which is a NASQAN station) were operated during the 1985 water year. Four NASQAN stations were sampled bimonthly and six quarterly. One Benchmark station was sampled bimonthly and the other was sampled quarterly. Constituents analyzed under the NASQAN and Benchmark programs included major ions, trace metals, radioisotopes, and nutrients. Seven of the automatic monitor sites are located within the seven-county metropolitan area. Measurements at the sites include specific conductance, temperature, pH, and dissolved oxygen.

Water year 1984 data are being reviewed and compiled for publication in the annual water-data report.

The District's field-procedures manual was updated. In addition to field procedures, the manual contains figures and tables needed for calculations and for completion of sampling forms.

Plans for FY 86: Discontinue monitor station 05331005, Mississippi River at Industrial Molasses, St. Paul.

Completed Reports:

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report MN-83-1, 202 p.

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 2, Upper Mississippi and Missouri River basins: U.S. Geological Survey Water-Data Report MN-83-2, 447 p.

Reports in Preparation:

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

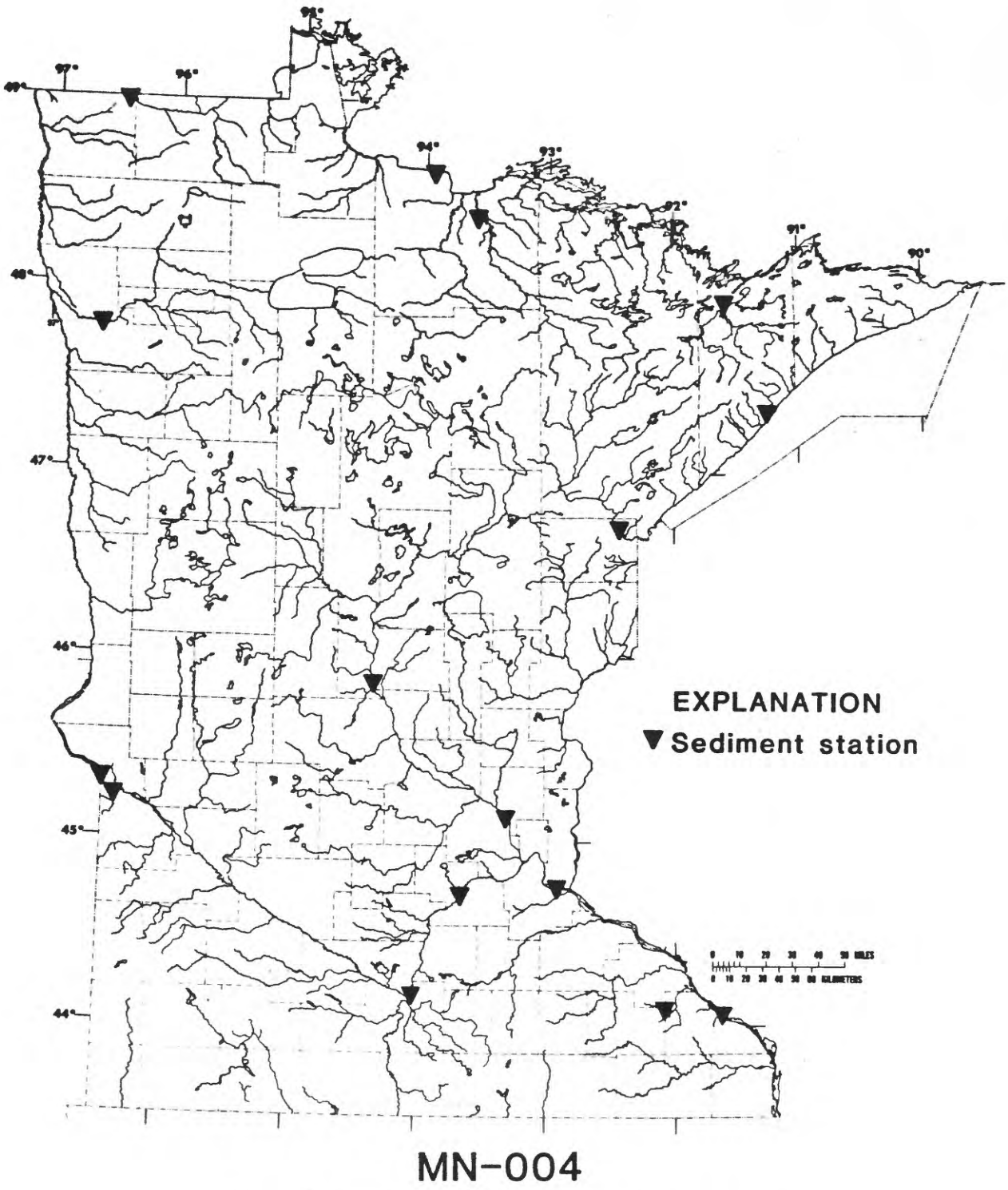


Figure 6.--Suspended-sediment network

SEDIMENT STATIONS
(MN 00-004)

Date Project Began: March 1967

Date Project Ends: Continuing

Project Leader: Hess, Joseph H.

Location: Statewide

Principal Cooperating Agency: U.S. Army Corps of Engineers

Objectives: To provide standardized sediment data for broad Federal and State planning and action programs, and to provide data for Federal management of interstate and international waters.

Progress in FY 85: Three 12-month daily sediment-record stations, two 6-month daily sediment-record stations, and 12 periodic sediment stations were operated during water year 1985. Ten of the periodic stations, including one of the daily sediment-record stations, are National Stream Quality Accounting Network (NASQAN) sites and two are Benchmark sites. Data were collected as scheduled except at the Minnesota River at Mankato where a newly hired observer did not collect samples for about 6 weeks, and at the Mississippi River at Winona where a bridge used for sample collection was removed from service. Daily and periodic sediment data from all stations operated in water year 1984 have been entered in the National Water Data Storage and Retrieval System (WATSTORE). The Water-Resources Investigations report "Suspended sediment in Minnesota streams," by L. H. Tornes, has been approved by the Northeast Region for publication. Log-linear sediment-transport-curve equations were used to estimate long-term sediment yields for 33 stations in Minnesota. Average annual yields ranged from less than 1.0 to more than 200 tons per square mile. More than 90 percent of the annual sediment load was carried during 3 to 9 months of the year, and estimates indicated that the average annual sediment load for 2 years could be transported in slightly more than one day.

Plans for FY 86: Continue the same sampling program as in 1985 except for Winona. Mississippi River at Winona will either have to be moved to another location or discontinued as a daily station.

Publish and distribute the report "Suspended sediment in Minnesota streams."

Completed Reports:

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report MN-83-1, 202 p.

U.S. Geological Survey, 1984, Water resources data, Minnesota, water year 1983, volume 2, Upper Mississippi and Missouri River basins: U.S. Geological Survey Water-Data Report MN-83-2, 447 p.

Reports in Preparation:

Tornes, L. H., Suspended sediment in Minnesota streams: U.S. Geological Survey Water-Resources Investigations Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1984, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 1, Great Lakes and Souris-Red-Rainy River basins: U.S. Geological Survey Water-Data Report.

U.S. Geological Survey, Water resources data, Minnesota, water year 1985, volume 2, Upper Mississippi River and Missouri River basins: U.S. Geological Survey Water-Data Report.

PRECIPITATION STATIONS
(MN 83-005)

Date Project Began: August 1983

Date Project Ends: Continuing

Project Leader: Have, Mark R.

Location: Camp Ripley, central Minnesota

Principal Cooperating Agency: U.S. Geological Survey

Objectives: Collect the information needed to (1) detect temporal and spatial trends in the chemical composition of precipitation, (2) gain a better understanding of the sources, movement, and transformation of materials contributing to or associated with acidic precipitation, and (3) gain a better understanding of the effects of acidic precipitation on the environment and manmade structures.

Progress in FY 85: This site is part of the NADP/NTN national network. The wet-side bucket is changed every Tuesday morning and, if enough water is present, specific conductance and pH are determined on site. Sample buckets are sent to the Illinois State Water Survey Laboratory in Champaign, Illinois. Results of laboratory analyses reviewed and entered into WATSTORE.

A recording rain gage and stick gage also are serviced every Tuesday. The value for total weekly precipitation is ascertained and entered into WATSTORE with the chemical data.

Specific conductance ranged from 3 to 44 us/cm and pH ranged from 3.6 to 6.3. Nitrite plus nitrate nitrogen and sulfate ranged from 0.03 to 1.3 and 0.41 to 4.2 mg/L, respectively.

Plans for FY 86: Continue collecting wet-side samples.

FLOOD-INSURANCE STUDIES
(MN 84-006)

Date Project Began: March 1984

Date Project Ends: September 1986

Project Leader: Carlson, George H.

Location: Statewide

Principal Cooperating Agency: Federal Emergency Management Agency

Objectives: To conduct the hydrologic and hydraulic evaluations and studies of areas needed by FEMA for flood-insurance studies.

Progress in FY 85: Flood-insurance studies for four counties presently are underway. Lake of the Woods County--Four developing areas along the shore of Lake of the Woods are to be mapped in detail. A contract for the needed aerial photography and topographic mapping was let in September. Photography will be completed in October 1985. Murray County--The study involves three lake complexes; Fulda Lakes, Lake Sarah, and Lake Shetek. Reconnaissance and field surveying were completed in August. Surveying included establishing vertical control, confirming gage datum, and surveying bridges and valley cross-sections for step-backwater and flood-routing models at the outlets of Fulda Lakes and Lake Sarah. Pennington County--A reconnaissance trip was completed in May 1985. A line of vertical-control points was established by a subcontractor along the 30-mile study reach in September. Surveying of the underwater part of cross sections was completed. St. Louis County--This study involves extending an earlier study upstream on the Floodwood River. Reconnaissance and surveying of additional river and valley cross sections were completed in September 1985.

Plans for FY 86: Lake of the Woods County--Mapping and study reports will be completed. Murray County--Analysis of complex hydrology will be accomplished and study report completed. Pennington County--The step-backwater model will be developed, flood profiles computed, and report prepared. St. Louis County--The step-backwater model will be completed and study report prepared. Six new studies in FY 86 will include Carlton County, the city of Cloquet, Grant County, Meeker County, the city of Litchfield, and Stevens County.

MINNESOTA PROGRAM FOR WATER-USE DATA
(MN 79-007)

Date Project Began: October 1978

Date Project Ends: Continuing

Project Leader: Trotta, Lee C.

Location: Statewide

Principal Cooperating Agencies: Minnesota Department of Natural Resources, Minnesota State Planning Agency (Land Management Information Center)

Objectives: To develop a statewide system to collect, store, and disseminate information on water use in Minnesota that is compatible with the U.S. Geological Survey's National Water-Use Data System (NWUDS). The State system will provide ready access to water-use information by planners and managers at all levels, local, State, and Federal.

Progress in FY 85: Information from the State water-appropriation permits and estimates of unreported water use for 1983 were entered into the State Water Use Data System (SWUDS) by the Minnesota Department of Natural Resources (MDNR). Efforts were made to improve the accuracy and completeness of these data in cooperation with MDNR. Data-aggregation procedures were reorganized and responsibility was shifted from the Land Management Information Center (LMIC) to USGS and MDNR. Aggregation programs were revised and run for 1981-83. Water-use and return-flow data for 1981-83 were entered into NWUDS for all 87 counties and 81 watersheds for all 8 MDNR water-use categories, except for domestic use by watershed. Nuclear power water-use data for 1981-83 also were entered into NWUDS. Domestic use by watershed, livestock use, hydropower use, and aquaculture use were compiled by the USGS and are ready for computerization and entry. Methods used in aggregating data have been compiled in a system documentation and work has begun on program documentation. These documents will be combined with data-transfer procedures and other necessary information to form a District Water-Use Procedures Manual. Data on water export across subbasin boundaries in Minnesota were compiled for the USGS Office of National Water Summary and work has continued to verify findings. Export, or interbasin diversion, of water may be occurring at 107 sites. Of the five sites where export was verified by telephone inquiries, four are for public water supplies and one is for agricultural irrigation.

Plans for FY 86: Reports on development of a water-use data system in Minnesota and on water use for aquaculture in 1984 will be reviewed in headquarters, approved, published, and distributed. Other reports on water use for irrigation in 1982 and water export across Minnesota watershed boundaries will be reviewed and approved for publication. Remaining 1980 data and all 1984 and 1985 data will be aggregated and transferred from the State data base to NWUDS in all categories required for the 1985 national water-use report. Efforts to improve the accuracy of reported data will continue in cooperation with MDNR.

Completed Report:

Horn, M. A., Development of a Water-Resources Information System in Minnesota: U.S. Geological Survey Water-Resources Investigations Report 85-4306. [In press]

Reports in Preparation:

Schoenberg, M. E., Estimating seasonal and monthly water use from annual values: Journal article.

Trotta, L. C., Estimated irrigation water use in Minnesota, 1982: Water Fact Sheet.

Trotta, L. C., Aquaculture 1984, the forgotten user of Minnesota's water: Journal Article.

Trotta, L. C., Water transfer across major watershed boundaries in Minnesota: Water-Resources Investigations Report.

Water use example

FLOOD PLAIN HYDROLOGY, HYDRAULICS, AND COORDINATION--MINNESOTA (MN 73-015)

Date Project Began: July 1972

Date Project Ends: Continuing

Project Leader: Carlson, George H.

Location: Statewide

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objectives: Provide flood information for designated reaches of streams and municipalities in a form suitable for flood-plain management. Provide a basis for the State to coordinate, evaluate, and establish local flood-plain management programs and ordinances in Minnesota.

Progress in FY 85: Areas to be included in "less detailed" type flood-insurance studies of four Minnesota counties were reviewed and coordinated with the Minnesota Department of Natural Resources, Division of Waters. The hydrologic analysis for the city of Detroit Lakes flood-insurance study was reviewed and the results were recommended for use. Flood discharges and profiles for the Mississippi River in the reach from Elk River to St. Cloud, Minnesota, were coordinated with the Corps of Engineers for the flood-insurance study of Wright County. Hydrologic analyses for the Cedar River, Dobbins Creek, and Turtle Creek for updating the Austin, Minnesota, flood-insurance study were evaluated for the cooperator. Detailed information from the USGS study of the Mississippi and Rum Rivers in Anoka, Minnesota, (Re: WRI Open-File Report 80-972, Flood plain areas of the Mississippi River, mile 866.8 to mile 888.0) was provided to the St. Paul District Corps of Engineers for use in levee studies in areas of significant flood hazard. Much of the basic information needed, including calibrated step-backwater models and large-scale maps, were made available to the Corps and should result in considerable cost saving for the intended studies.

Plans for FY 86: Review of hydrologic analyses for coordination with State and Federal agencies will continue. Flood-plain information will continue to be provided to assist the State and local communities in flood-plain management activities.

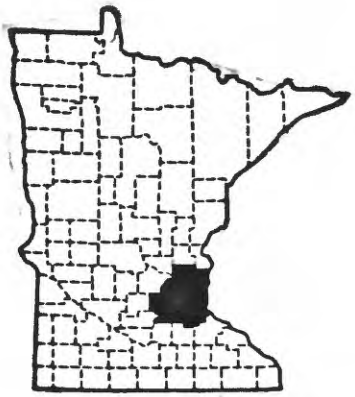
APPRAISAL OF THE GROUND-WATER RESOURCES OF THE TWIN CITIES METROPOLITAN AREA, MINNESOTA (MN 79-063)

Date Project Began: January 1979

Date Project Ended: September 1985

Project Leader: Schoenberg, Michael E.

Location: Seven-county metropolitan area of the Twin Cities



Principal Cooperating Agencies: Metropolitan Council of the Twin Cities, Minnesota Geological Survey, and Minnesota Department of Natural Resources

Objectives: The objectives of this study are to (1) develop a detailed understanding of the hydrologic system and geologic framework within which it operates, (2) apply this detailed understanding, using the USGS three-dimensional ground-water-flow model, to an evaluation of the hydrologic effects of continued development of the ground-water resources, and (3) provide State and local water managers and planners the information and the means to evaluate alternative development and management schemes that they may propose.

Progress in FY 85: Steady-state calibration of the ground-water model for the period 1970-79 was improved by (1) representing lakes in the modeled area as constant heads in the uppermost model layer, (2) assigning hydraulic properties similar to the Mount Simon-Hinckley and Ironton-Galesville aquifers to the Eau Claire confining unit near the northern edge of the modeled area, and (3) varying the streambed-leakage coefficient for the Minnesota, Mississippi, and St. Croix Rivers. As a result, the number of residues (differences between measured and simulated ground-water levels) in excess of 50 feet was reduced from 61 to 36, out of a total of 384 residues. Model results indicate that leakage from the approximately 1,000 lakes in the Twin Cities area accounts for a significant part of total inflow to the ground-water system. Leakage from lakes is equivalent to about 0.7 inch per year over the modeled area, whereas areal recharge is about 3.5 inches per year.

After calibration, the model was used to simulate four scenarios of future ground-water use for the years 1990 and 2000. These scenarios reflect projected increases in withdrawal due to industrial expansion and population growth, use of ground water for heating and cooling commercial buildings, and use of supplemental ground-water supplies by the St. Paul and Minneapolis water utilities. Results were compared to the 1970-79 base period when ground-water withdrawals averaged about 200 million gallons per day (mgd). The simulations of 1990 show that the differences in effects of withdrawing about 10 mgd of the total 370 mgd from the Mount Simon-Hinckley aquifer instead of the drift is a

head decline in the Mount Simon-Hinckley aquifer instead of a maximum 150-foot head decline from the base simulation, 1970-79. Maximum simulated head declines in the Prairie du Chien-Jordan were about 250 feet.

The simulations of year 2000 compared the effects of projected withdrawals (about 510 mgd) and of withdrawals under drought conditions (about 665 mgd). Maximum computed head declines from the base simulation for projected withdrawals were 230 and 425 feet for the Mount Simon-Hinckley and Prairie du Chien-Jordan aquifers, respectively. Maximum head declines were 370 and 580 feet, respectively, for withdrawals during drought. Model results indicated that withdrawals simulated for the year 2000 would produce some localized dewatering of the Prairie du Chien-Jordan aquifer.

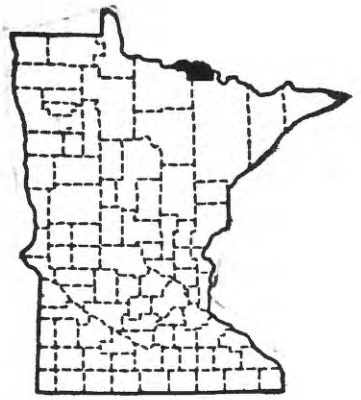
Plans for FY 86: The final technical report for the project will be completed, reviewed, and approved for publication.

Report in Preparation:

Schoenberg, M. E., Effects of present and future withdrawals on the groundwater system in the Twin Cities Metropolitan Area, Minnesota: U.S. Geological Survey Water-Resources Investigatons Report.

St. Paul skyline

WATER-QUALITY INVESTIGATIONS IN VOYAGEURS NATIONAL PARK, MINNESOTA (MN 79-068)



Date Project Began: October 1978

Date Project Ended: September 1984

Project Leader: Payne, Gregory A.

Location: Voyageurs National Park, north-central Minnesota

Principal Cooperating Agency: U.S. National Park Service

Objectives: The objectives are to monitor water quality in areas of proposed park development, with emphasis on definition of natural water-quality characteristics and the effects of recreational use and waste disposal in the Park on the water quality.

Progress in FY 85: Data collected from 1977 through 1984 were analyzed and interpreted in preparation of the final report. The results showed that water quality in Kabetogama Lake, Black Bay, and Sullivan Bay (western part of the Park) is distinctly different from water quality in Sand Point Lake, Namakan Lake, and Rainy Lake (eastern part of Park). Much of the difference can be attributed to the influence of (1) the Namakan River, which supplies a large amount of dilute, low-nutrient inflow to the eastern part of the Park and (2) the Ash River, which contains high dissolved solids and nutrients and flows into the western part of the Park. The lack of continuous summer stratification was shown to further influence water quality in Black Bay and Kabetogama Lake. These water bodies, along with Sullivan Bay are characterized by high dissolved solids and high trophic levels compared to Namakan, Rainy, and Sand Point. Data collected from 19 small lakes located in the Park's interior showed that most of these lakes have low trophic levels and low buffering capacity. Trophic state in many of these lakes declines from spring to fall as nutrient levels in their epilimnions decline. The decline probably is a result of low external nutrient input and a lack of internal nutrient cycling caused by early onset of sharp thermal stratification that takes place shortly after spring overturn. The final report has been prepared and is undergoing District-office review.

Plans for FY 86: Publish final report.

Report in Preparation:

Payne, G. A., Quality of water in Kabetogama, Sand Point, Namakan, and Rainy Lakes, Voyageurs National Park, northern Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

ASSESSMENT OF WATER QUALITY IN IMPOUNDMENTS IN THE COTEAU DES PRAIRIES, UPPER MINNESOTA RIVER BASIN (MN 79-069)

Date Project Began: June 1979

Date Project Ended: June 1984

Project Leader: Smith, Charles J.

Location: Coteau des Prairies, southwest Minnesota

Principal Cooperating Agency: U.S. Army Corps of Engineers

Objectives: The objectives of this study are to (1) assess the quality of water in streams and impoundments in the Coteau des Prairies, and (2) predict the effects of the proposed impoundments on the water quality in the streams. This assessment will be made by determining the water quality at existing impoundment sites and comparing it to water-quality data for sites where similar impoundments will be constructed. Water-quality data will be related to land use, storm runoff, topography, and soil type.

Progress in FY 85: Preimpoundment water-quality assessment: Draft of report by C. J. Smith, G. A. Payne, and L. H. Tornes is in review. Analysis of chemical samples for nutrients, major ions, and biological parameters, and the measurement of transparency, water temperature, dissolved oxygen, and specific conductance indicated that the quality of water varied significantly between impoundments. The most significant differences were those related to trophic-state indicators and the occurrence, extent, and persistence of stratification. The data suggest that future impoundments in the Coteau will be eutrophic, containing high concentrations of total phosphorus, nitrate, and organic nitrogen from surface runoff. Thermal stratification ranged from dimictic (spring and late summer overturn) to highly polymictic (frequent overturn). Ammonia commonly was present in high concentrations during periods of stratification. Analysis of suspended sediment indicated that a significant amount of suspended sediment dropped out between the inlets and outlets of the impoundments. The highest concentrations of dissolved solids, calcium, sodium, chloride, sulfate, and fluoride were found in streams in the Cottonwood River basin.

Plans for FY 86: Plans are to complete the final report.

Report in Preparation:

Smith, C. J., Payne, G. A., and Tornes, L. H., Assessment of water quality in impoundments in the Coteau des Prairies--upper Minnesota River basin: U.S. Geological Survey Water-Resources Investigations Report.

APPRAISAL OF GROUND WATER IN THE POMME DE TERRE AND CHIPPEWA VALLEYS, WESTERN MINNESOTA (MN 80-072)

Date Project Began: October 1979

Date Project Ended: September 1984

Project Leader: Delin, Geoffrey N.

Location: Pomme de Terre and Chippewa River valleys, west-central Minnesota

Principal Cooperating Agencies: Minnesota Department of Natural Resources, Pomme de Terre and Chippewa Ground-Water Study Steering Committee

Objectives: To map the areal extent and thickness of surficial and buried-drift aquifers, estimate potential well yields, determine the availability of water from the aquifers, describe chemical quality of the water, and determine probable effects of development on flow and storage of water in the aquifers through mathematical analyses or digital-model simulation.

Progress in FY 85: Two interpretive reports describing results of the study were completed. One report describes the hydrogeology of confined-drift aquifers in the area and the other summarizes results of the ground-water-flow model. Both in- and out-of-District colleague reviews have been completed for each report. Results of the study were presented to representatives of the cooperating agencies and to audiences in the study area at several meetings and seminars.

Plans for FY 86: The interpretive reports will be approved for publication and printed.

Completed Report:

Delin, G. N., Confined-drift aquifers studied near the Pomme de Terre and Chippewa Rivers, west-central Minnesota: U.S. Geological Survey Water Fact Sheet.

Reports in Preparation:

Delin, G. N., Hydrogeology of confined-drift aquifers near the Pomme de Terre and Chippewa Rivers, western Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Delin, G. N., Evaluation of availability of water, effects of drought, and effects of future ground-water development on drift aquifers near the Pomme de Terre and Chippewa Rivers, western Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

THERMAL-ENERGY STORAGE IN THE IRONTON-GALESVILLE AQUIFER, ST. PAUL, MINNESOTA (MN 80-077)

Date Project Began: May 1980

Date Project Ended: September 1985

Project Leader: Miller, Robert T.

Location: University of Minnesota, St. Paul Campus

Principal Cooperating Agency: University of Minnesota

Objectives: The objectives of the U.S. Geological Survey's participation in this study are to (1) develop an understanding of the ground-water flow system in the vicinity of the site, (2) identify the hydraulic properties of the ground-water system that are most important with respect to thermal-energy storage, and identify data-collection needs for long-term monitoring and evaluation of aquifer-system performance, (3) develop a method to evaluate flow and thermal-energy transport for various cyclic injection and withdrawal schemes and to aid selection of an efficient well-system design, and (4) aid in the collection of hydraulic and thermal data during injection/withdrawal tests and design a data-processing system that will facilitate entry of the data into computer storage.

Progress in FY 85: A long-term (180 day), hot-water test was conducted, which consisted of approximately 60 days each of injection, storage, and withdrawal. The average injection rate and temperature were 240 degrees Fahrenheit and 290 gallons per minute, respectively. Aquifer thermal efficiency and final well-head temperature after withdrawal were 66 percent and 115 degrees Fahrenheit, respectively.

A fully three-dimensional, anisotropic, nonisothermal, energy-transport and ground-water flow, finite-difference model was constructed to simulate the long-term hot-water test cycle. The model simulation was found to be very sensitive to rates of pumping during withdrawal. Initial simulations of the withdrawal period used an average rate of 292 gallons per minute. Examination of field-recorded rates show a fairly linear decrease in withdrawal rate from a maximum of 299 gallons per minute at the start of pumping to a minimum of 286 gallons per minute at the end. To determine the sensitivity of simulated well-head temperature to variable withdrawal rates, the 60-day withdrawal period was divided into 12 five-day periods and an average pumping rate was determined and simulated for each of the 12 periods. Comparison of the field-recorded final well-head temperatures and model-computed values showed significant improvement in the model's ability to simulate the field-recorded well-head temperatures with time.

The final fine-tuning of the model was performed by adjusting the value of thermal dispersivity. The best value for the simulation of the short-term cycles was found to be a longitudinal thermal dispersivity of 10.0 feet and a transverse thermal dispersivity of 0.375 foot. The best long-term values of longitudinal and transverse dispersivity are 13.0 feet and 1.3 feet, respectively. The final calibrated model calculated an aquifer thermal efficiency of 65.7 percent and final well-head temperature of 120 degrees Fahrenheit.

Plans for FY 86: Work on the project in FY 1986 is dependent on the availability of funding from the U.S. Department of Energy. A second long-term hot-water test is possible, but unlikely. If the long-term test is not funded, then only shut-down activities would take place. USGS participation in the shut down would consist of debugging data recorded on magnetic tape for the long-term test and preparation of final reports on data collection and model simulation.

Completed Reports:

Miller, R. T., 1984, Preliminary modeling of an aquifer thermal-energy storage system: U.S. Geological Survey Open-File Report 84-811, 48 p.

Miller, R. T., and Voss, C. I, Finite-difference grid for a doublet-well in an anisotropic aquifer: Approved for publication in "Ground Water."

Reports in Preparation:

Miller, R. T., Cyclic injection, storage, and withdrawal of heated water in a sandstone aquifer at St. Paul, Minnesota: Observation network design, field observations, and preliminary model analysis--Chapter B: U.S. Geological Survey Professional Paper.

Miller, R. T., Cyclic injection, storage, and withdrawal of heated water in a sandstone aquifer at St. Paul, Minnesota: Field observations, data analysis, and nonisothermal modeling of short-term test cycles--Chapter C: U.S. Geological Survey Professional Paper.

Miller, R. T., Thermal-energy storage in a deep sandstone aquifer in Minnesota: Field observations and thermal-energy-transport modeling: Article for ENERSTOCK 85, Toronto, September 22-26, 1985.

HYDROGEOLOGIC AND WATER-QUALITY CHARACTERISTICS OF AQUIFERS IN MINNESOTA (MN 80-078)

Date Project Began: June 1980

Date Project Ended: September 1984

Project Leader: Ruhl, James F.

Location: Statewide

Principal Cooperating Agency: U.S. Environmental Protection Agency

Objectives: (1) Delineate the underground sources of drinking water in Minnesota and present the rationale for designating 14 principal aquifers in the State, (2) describe the general geohydrology and geochemistry of the aquifers, (3) show the major aspects of the ground-water system related to underground injection control using maps, geologic sections, and stratigraphic columns, and (4) compile dissolved-solids data and prepare maps showing the areal distribution of dissolved solids for each aquifer.

Progress in FY 85: Although the UIC project was not funded by USEPA in FY 1985, some progress was made. The report on the Prairie du Chien-Jordan aquifer was drafted and printed. The report on Proterozoic aquifers was reviewed and revised in preparation for transmittal to USGS Headquarters for approval. However, four other approved reports await final drafting and printing: St. Peter aquifer, Upper Carbonate aquifer, Cretaceous aquifer, and Red River-Winnipeg aquifer. The report on the Drift aquifers is in early stages of preparation.

During the last quarter of the year, an agreement was negotiated with the USEPA Underground Injection Control Program to fund final preparation, drafting, and printing of all uncompleted reports in FY 1986. Near the end of FY 1985, final drafting of the report on the St. Peter aquifer resumed and the report on the Cretaceous aquifer was sent to the Texas District office for final drafting.

Plans for FY 86: During the first quarter of FY 1986, the St. Peter report will be printed, the Cretaceous report will be drafted, the Proterozoic report will be submitted to USGS Headquarters, and drafting of the Upper Carbonate and Red River-Winnipeg reports will begin. All five of these reports will be printed and distributed by July 1986. During the second quarter of FY 1986, preparation of the report on the Drift aquifers will resume. Emphasis in the Drift report will be on areal differences in ground-water quality in the Drift and on differences in water quality between surficial- and confined-drift aquifers. The Drift report will be prepared, reviewed, approved, and printed by the end of FY 1986.

Reports in Preparation:

Anderson, H. W., Jr., Hydrogeologic and water-quality characteristics of Proterozoic and Archean aquifers, Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Ruhl, J. F., Hydrogeologic and water-quality characteristics of drift aquifers in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

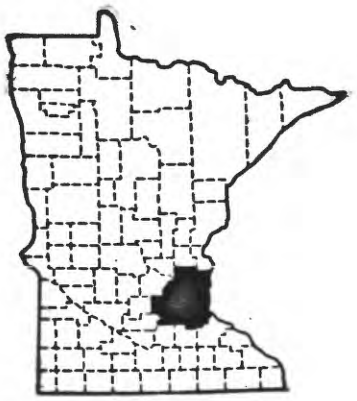
ALTERNATIVES FOR DEVELOPMENT OF GROUND WATER IN THE TWIN CITIES METROPOLITAN AREA, MINNESOTA (MN 81-082)

Date Project Began: February 1981

Date Project Ended: September 1984

Project Leader: Schoenberg, Michael E.

Location: Seven-county metropolitan area of the Twin Cities



Principal Cooperating Agency: U.S. Geological Survey

Objectives: (1) Develop a nontechnical report discussing alternatives for development of ground water in the Twin Cities Metropolitan Area, and (2) use this report as a text for workshops given to nontechnical audiences.

Progress in FY 85: In conjunction with the Twin Cities ground-water study (MN 79-063), four scenarios of possible ground-water development were simulated with the regional ground-water-flow model: (1) ground-water use in 1990 assuming continuation of present (1985) economic and population trends, with a significant increase in use from drift aquifers where the Prairie du Chien-Jordan aquifer is absent, (2) the same as item (1), but with a significant increase in use from the Mount Simon-Hinckley aquifer, (3) ground-water use in 2000 assuming continuation of present (1985) economic and population trends, and (4) ground-water use in 2000 assuming drought conditions.

Plans for FY 86: The final report for the project will be the report written for the Twin Cities ground-water study (MN 79-063). That report will be completed, reviewed, and approved for publication.

Report in Preparation:

Schoenberg, M. E., Effects of present and future withdrawals on the ground-water system in the Twin Cities Metropolitan Area, Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

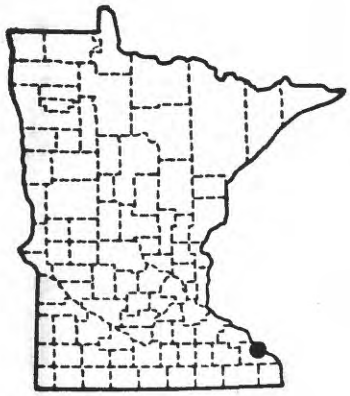
FLOW AND SEDIMENT TRANSPORT IN GARVIN BROOK, WINONA COUNTY, SOUTHEASTERN MINNESOTA (MN 81-083)

Date Project Began: June 1981

Date Project Ended: September 1985

Project Leader: Payne, Gregory A.

Location: Garvin Brook, Winona County, southeastern Minnesota

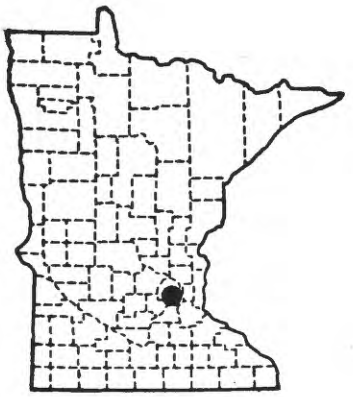


Principal Cooperating Agency: Minnesota Pollution Control Agency

Objectives: Streamflow gaging stations and suspended-sediment sampling sites have been established in Garvin Brook and its tributaries to (1) measure streamflow and suspended-sediment transport on an annual and event basis, (2) determine present water-quality conditions with respect to suspended sediment in terms of concentrations, particle size, seasonal trends, and areal variability in yield, and (3) monitor water quality with respect to suspended sediment for trends related to the application of best-management practices.

Progress in FY 85: Two gaging stations, GBNMC (Garvin Brook near Minnesota City) and SVCAS (Stockton Valley Creek at Stockton), were operated for collection of streamflow and suspended-sediment data. All runoff periods during 1985 resulted from spring snowmelt. At GBNMC, peak daily sediment load was 4,930 tons per day, the highest daily load measured since data collection began during 1982. Spring 1985 marked the only occurrence during this study when snowmelt runoff contributed significantly to the annual load. While the peak daily load, 4,930 tons, (snowmelt) was very high relative to the next highest measured load, 2,740 tons (rainfall runoff 1984), the snowmelt event produced about 30-percent less sediment load per unit of water discharge than the rainfall-runoff event. Similar comparisons are seen in peak-concentration data. During 1984, peak rainfall runoff (803 ft^3/s) produced a suspended-sediment concentration of 8,600 mg/L while the peak flow from snowmelt in 1985, which was much greater at 1,570 ft^3/s, produced a peak concentration of only 7,960 mg/L. Nine snowmelt events occurred during 1985. A very close correlation between concentration and discharge was indicated by samples collected during the snowmelt events, but these data do not correlate with similar data collected during rainfall events. Comparison of particle-size data for similar flow rates showed that snowmelt events move about 10 percent more particles in the fraction greater than 0.062 mm than are moved by rainfall events. The data collected during 1985 suggest that sediment transport can be significant during snowmelt, but processes of soil loss, particularly those affecting fine particles, are much more severe during runoff from rainfall.

TECHNICAL ASSISTANCE TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY ON HAZARDOUS-WASTE PROBLEMS--ST. LOUIS PARK AREA, MINNESOTA (MN 82-086)



Date Project Began: January 1982

Date Project Ended: September 1985

Project Leader: Hult, Marc F.

Location: St. Louis Park, east-central Minnesota

Principal Cooperating Agency: U.S. Environmental Protection Agency

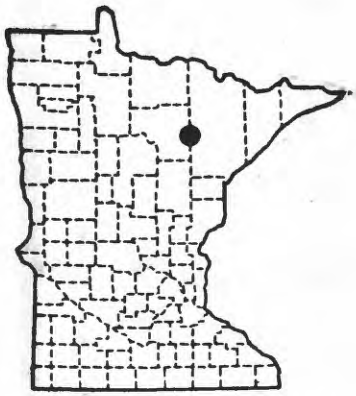
Objectives: To provide ground-water data and technical assistance to U.S. Environmental Protection Agency.

Progress in FY 85: A report was prepared that summarizes results in previously published reports and updates technical conclusions about ground-water contamination by coal-tar derivatives at St. Louis Park, Minnesota. The report, titled "Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota," by M. F. Hult, was approved as Open-File Report 84-867. The report was submitted to the Federal Court, Third District, in St. Paul as written expert testimony in the still-pending litigation against Reilly Tar and Chemical Corporation. M. F. Hult was deposed by attorneys for Reilly, and 375 pages of testimony were recorded, most of which dealt with findings published in USGS reports. A series of settlement meetings between the Federal/State plaintives and Reilly was held and it seems likely that the case will be settled without actually going to trial. No further requests for USGS assistance in the matter are expected.

Completed Report:

Hult, M. F., 1984, Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Open-File Report, 84-867, 57 p. [Pending publication as a Water-Supply Paper.]

WATER AND SEDIMENT DISCHARGE FROM A TACONITE-TAILINGS BASIN, NORTHERN MINNESOTA
(MN 82-087)



Date Project Began: June 1982

Date Project Ended: September 1984

Project Leader: Myette, Charles F.

Location: Keewatin, northeastern Minnesota

Principal Cooperating Agencies: Minnesota Iron Range Resources & Rehabilitation Board, Minnesota Pollution Control Agency

Objectives: The objectives of this project are to determine (1) the water and sediment yield from a taconite-tailings basin that has been temporarily abandoned, (2) the response of surface- and ground-water flow to rainfall and snowmelt, (3) the impact of a tailings basin on the flow and chemical quality of ground water, and (4) the chemical quality of water and sediment discharging to downstream areas.

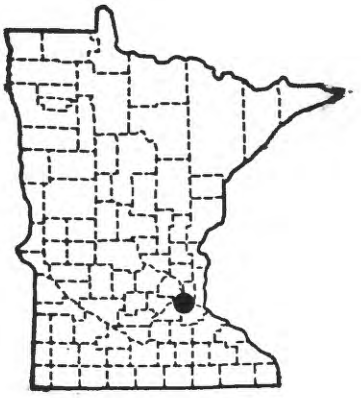
Progress in FY 85: Surface-water gages at the tailings-basin outlet and in the pond were operated and ground-water levels were measured through June 1985, when data collection ceased. Transient simulations of ground-water flow were made to simulate seasonal water-level changes in the tailings and adjacent drift aquifers. Model results indicate that the timing of ground-water-level fluctuations can be simulated adequately. However, to simulate the magnitude of observed fluctuations, values of model-simulated specific yield of the tailings must be lower than 0.1. After transient calibration, the model was used to simulate the effects of an extremely wet year on water levels in the tailings and on the magnitude of ground-water seepage out of the tailings basin.

Plans for FY 86: The first draft of the interpretive report will be completed during the first quarter of FY 1986. The report will receive colleague review and will be submitted for approval during the second and third quarters of the year, respectively.

Report in Preparation:

Myette, C. F., Water and sediment discharge from a taconite-tailings basin in northern Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

WATER-QUALITY TRENDS OF SELECTED LAKES IN EAGAN, MINNESOTA (MN 82-089)



Date Project Began: August 1982

Date Project Ended: September 1984

Project Leader: Have, Mark R.

Location: Eagan, southeast Minnesota

Principal Cooperating Agency: City of Eagan

Objectives: To document changes in water quality of the Eagan lakes from the first sampling period (1972-78) to the second (1982-83). Evaluate the changes with respect to continuing urbanization and water-quality trends. Improve the data base so that effects of future chemical loading can be more accurately predicted.

Progress in FY 85: Sixteen lakes in the city of Eagan, Minnesota, were sampled during 1982-83 to detect changes that might have occurred because of urbanization since a previous study conducted during 1972-78. Each of the lakes was sampled five times to determine pH, specific conductance, dissolved oxygen, water temperature, transparency, and the concentration of dissolved chloride. Three determinations of chlorophylls were made for each of the lakes near the end of the study and additional determinations were made for a few lakes of particular interest.

The lakes appear to be impacted by substantial amounts of urban runoff. Most of the lakes studied have been incorporated into the city's storm-runoff system to work as retention basins during large storms. Chloride concentrations were significantly higher in six lakes and remained elevated, about 30 milligrams per liter, in four other lakes that received urban runoff during the previous study. The association between increased chloride and conductance with runoff from urban surfaces suggests that the lakes are subject to contamination by materials often found in urban runoff.

Plans for FY 86: Publish the report of findings entitled "Impact of urban runoff on the quality of lakes in Eagan, Minnesota."

Report in Preparation:

Tornes, L. H., Impact of urban runoff on the quality of lakes in Eagan, Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

DEVELOPMENT OF SURFACE GEOPHYSICAL TECHNIQUES FOR THE EXPLORATION OF BURIED-DRIFT AQUIFERS IN MINNESOTA (MN 83-090)

Date Project Began: October 1982

Date Project Ended: September 1986

Project Leader: Stoner, Jeffrey D.

Location: Statewide

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objective: (1) Develop a capability for conducting seismic refraction and reflection surveys of thick drift deposits in Minnesota, and (2) develop field strategies and interpretation techniques for utilizing geophysical methods to determine depth to bedrock and to delineate unconsolidated aquifers in buried bedrock valleys, in river valleys, and interbedded in thick drift.

Progress in FY 85: Analysis of seismic reflection and refraction data indicated reflection depths that correlated within 5 feet of the depth to the contact between a sand and gravel aquifer and clay-rich till at study sites in Swift and Marshall Counties. Additional data collection at both sites verified this preliminary finding with the use of newly installed seismograph analogue filters and signal enhancement. Sites studied in Swift County and Beltrami County using the new techniques showed less improvement. Reflection data were collected at 22 new sites in the Brooten-Beltrade area of Stearns and Kandiyohi Counties. Preliminary analysis indicated the presence of at least one seismic reflector within the glacial drift at about one-third (eight) of the sites surveyed. A suite of borehole geophysical logs, including acoustic velocity, was collected in several uncased test holes drilled for the Brooten-Belgrade ground-water study (MN 84-100). The surface seismic results correlated within 7 feet of the tops of two confined sand and gravel aquifers, at 81 and 155 feet, and the bottom of a surficial sand aquifer at 58 feet. The most identifiable reflectors correlated best to geologic contacts that coincide with velocity differences indicated by borehole geophysics. The following conditions were common to all sites in which seismic records correlated to boundaries of confined glacial-drift aquifers (1) water table with 10 feet of land surface, (2) sand-clay soil with high moisture content, (3) depth to seismic target greater than 65 feet, (4) thickness of aquifer greater than 25 feet, and (5) the use of 40 Hertz geophones buried at least 18 inches below land surface. Digital filtering of data on site also was necessary to identify some reflectors.

Plans for FY 86: The study will be extended for two more years to complete analysis and interpretation of surface seismic data for comparison to geologic sections at all study sites. Data analysis will be concentrated at the areas where borehole geophysics is available in order to evaluate physical features conducive to aquifer delineation by the shallow seismic reflection method. Additional seismic records also will be collected in these areas. A journal article will be prepared that highlights the significant results of the study to date.

Completed Reports:

Woodward, D. G., 1985, Seismic-refraction study of suspected drift-filled bedrock valleys in Ramsey County, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 85-4107, 20 p.

Woodward, D. G., 1985, Areal lithologic changes in aquifers in southeastern Minnesota as determined from natural-gamma bore-hole logs: Abstract approved for publication in Program for Conference, "Surface and Borehole Geophysical Methods 1984, in Ground-Water Investigations," San Antonio, Texas, February 7-9, 1984.

Woodward, D. G., 1985, Study of buried-drift aquifers in Minnesota using surface seismic geophysics: Water Fact Sheet.

Planned Reports:

Stoner, J. D., Application of seismic surveys in the delineation of buried-drift aquifers in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Stoner, J. D., Delineation of confined sand and gravel aquifers in central Minnesota using shallow seismic reflection: U.S. Geological Survey Water-Resources Investigations Report.

Stoner, J. D., and Streitz, A., Locating confined aquifers in glacial drift with seismic refraction and reflection, Minnesota: Journal article.

AREAL PROFILE INVESTIGATION OF NASQAN ACCOUNTING UNIT 070102, UPPER MISSISSIPPI RIVER BASIN, MINNESOTA (MN 83-091)

Date Project Began: January 1983

Date Project Ended: September 1985

Project Leader: Have, Mark R.

Location: East-central Minnesota

Principal Cooperating Agency: U.S. Geological Survey

Objectives: (1) Describe the quality of water in streams throughout accounting unit 070102 upstream of the NASQAN site Mississippi River at Nininger, Minn., (2) relate water-quality variability to selected basin characteristics, including land and water use, and (3) assess the usefulness of water-quality data collected at the NASQAN station in representing the quality of streams in accounting unit 070102. If the data are not representative, describe the minimum data-collection program needed.

Progress in FY 85: Analysis of data and report writing continued. The watershed is divided into its seven hydrologic units (subbasins) in the report. Typical seasonal water-quality variations occur in the Mississippi River near Royalton (subbasin 1) with dissolved solids changing inversely with streamflow. Water quality in the Sauk River watershed (subbasin 2) is influenced by the many lakes in and along the Sauk River. Water quality in subbasin 3, which includes the Elk River watershed, is uniform with an average conductance of around 300.

Subbasin 4 includes the Crow and North Fork Crow River watersheds. This subbasin is 62 percent cultivated and yields water with much higher concentrations of nitrate than subbasins 1-3. Dissolved solids increase significantly in the downstream direction.

Subbasin 5 is the South Fork Crow River watershed, which is 80-percent cultivated. There appear to be water-quality problems associated with point-source pollution (probably STP's) at times. Concentrations of various constituents are known to increase 20 fold in Buffalo Creek and, perhaps, in the South Fork Crow River.

Subbasin 6, which encompasses the Twin Cities, yields water of more variable quality than any of the other subbasins, owing to wide differences in the quality of runoff from various urban areas.

Subbasin 7, the Rum River watershed, has the best water quality of all seven subbasins. In general, chemical concentrations are lower and dissolved oxygen is maintained at fish-survival levels.

Plans for FY 86: Prepare report for publication as a U.S. Geological Survey Water-Resources Investigations Report.

Report in Preparation:

Have, M. R., Areal profile investigation of NASQAN unit 070102: U.S. Geological Survey Water-Resources Investigations Report.

DRAINAGE-BASIN CHARACTERISTICS OF MINNESOTA STREAMS (MN 83-093)

Date Project Began: October 1982

Date Project Ends: August 1989

Project Leader: Payne, Gregory A.

Location: Statewide

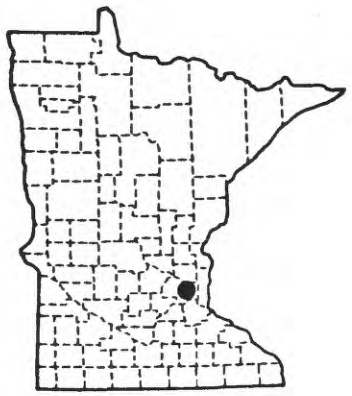
Principal Cooperating Agency: U.S. Army Corps of Engineers and the Minnesota Land Management Information Center

Objectives: (1) To develop accurate and consistent information on basin characteristics of Minnesota streams draining more than about 15 mi^2 and (2) provide these data in published reports and in computer files for use by the Survey, other agencies, and the public.

Progress in FY 85: Data on watershed boundaries, main-channel lengths, and percent of area in lakes, ponds, and swamps have been compiled for the Minnesota River basin. Stream slopes have been determined for the Lac qui Parle watershed in the Minnesota River basin. In addition, drainage areas for all gaging stations in the Crow River basin have been delineated. Digitizing is complete for 30 percent of the Crow River basin.

Plans for FY 86: Slope determinations will be made for major tributaries in the Minnesota River basin. Drainage areas for all stream-gaging stations in the Crow River basin will be digitized. Data for both basins will be compiled and tabulated in the Geological Survey's downstream-order system. Data will be listed in a report generated from the computer data base. Funding has been obtained to expand the data base to include the Des Moines River, Rock River, Shell Rock River, and Cedar River basins in FY 86.

MODELING OF CONTAMINANT MIGRATION FROM A CHEMICAL-WASTE-DISPOSAL SITE IN THE TWIN CITIES METROPOLITAN AREA (MN 83-094)



Date Project Began: July 1983

Date Project Ends: September 1985

Project Leader: Stoner, Jeffrey D.

Location: Fridley, southeast Minnesota

Principal Cooperating Agency: University of Minnesota

Objectives: (1) Test the field applicability of an analytical model to improve concepts of contaminant migration at a known chemical-waste-disposal site and to anticipate future migration, (2) use the model to test effectiveness of possible remedial action, and (3) suggest a network of observation wells for monitoring future contaminant migration based on the modeling results and newly collected data.

Progress in FY 85: Seeps, lakes, and marshes were mapped to better define hydrologic boundaries of the unconfined aquifer near a site in Fridley, Minnesota, where soil and ground water have been contaminated by wood-treating compounds. Data from a well inventory and measurement of water levels in 84 municipal, domestic, and monitoring wells were used to construct maps of winter-time potentiometric surfaces. The hydrogeologic data were used to calibrate analytic-element (code developed by O. D. L. Strack, University of Minn.) and finite-difference (USGS--modular) models that simulate steady-state flow through the layered (three aquifer) ground-water system underlying the waste site. The potentiometric surfaces computed by each model compared closely. Due to finer discritization, simulation of confining-layer leakage was more precise with the finite-difference method. However, lateral boundary conditions were better represented by the analytic-element method. These properties along with areal recharge and confining-layer geometry were the most sensitive properties to computed head and flow in both models.

Results of streamline tracing done with the analytic-element model indicated that the primary path of contaminant migration is through the unconfined aquifer to local seepage faces where ground water discharges to the banks of Norton and Rice Creeks. However, model results also indicated that a small part of the flow passing through the waste site could ultimately reach one of three municipal well fields in the area. Streamline-tracing results for simulation of the steady-state flow system and for simulation of a drain field

for contaminant containment would be very useful for development of a "worst-case" monitoring plan. A final progress report for the cooperator and a conference abstract outlining significant findings were prepared. The final interpretive report was delayed until development of the analytic-element code was completed by the cooperator.

Plans for FY 86: An interpretive report will be prepared describing the site hydrology and comparing results of analytic-element and finite-difference simulations of ground-water flow. The project will be extended for two additional years. Transient-flow and solute-transport features will be developed for the analytic-element model and another waste site in the Twin Cities area will be studied and modeled. Chemical and hydrologic data will be collected and analyzed for input to the new model. Preliminary steady-state and transient simulations will be made to establish critical data needs.

Report in Preparation:

Stoner, J. D., Simulation of ground-water flow near a former wood-treating site in Fridley, Minnesota--A practical application of an analytic-element model: Abstract.

Digitizing data for computer analysis

CRUDE-OIL CONTAMINATION OF GROUND WATER NEAR BEMIDJI, MINNESOTA (MN 83-095)

Date Project Began: March 1983

Date Project Ends: September 1986

Project Leader: Hult, Marc F.

Location: Bemidji, north-central Minnesota

Principal Cooperating Agency: U.S. Geological Survey, Office of Hazardous Waste Hydrology (OHWH)

Objectives: To obtain a more complete understanding of the mobilization, transport, and fate of petroleum derivatives in the shallow subsurface and to develop predictive models of contaminant behaviour.

Progress in FY 85: D. A. Franzi mapped the surface and subsurface extent of 10 geologic units within the drift near the site. The outwash on which the spill occurred, and through which contaminated water is moving, is surrounded and underlain by complexly bedded ice-contact deposits and till (diamictons). The surface of the outwash is extensively pitted and dissected. Locally it is underlain by as much as 5 meters of fine-grained lacustrine sediments that formed in depressions in the underlying diamicton.

R. T. Miller prepared a preliminary three-dimensional regional ground-water-flow model. Flow is primarily horizontal except near a lake downgradient from the spill where vertical components of hydraulic head are substantial and the direction of flow reverses depending on lake stage and short-term hydrologic events. Horizontal temperature gradients in the aquifer are mappable and, during spring, increase with increasing distance down the flow path. Seasonal variations and application of heat-transport modeling are being investigated.

D. I. Siegel determined the distribution of inorganic constituents in the plume of contaminated water. Three-fold increases in alkalinity, magnesium, and calcium were noted and were accompanied by even greater increases in trace metals and minor constituents--particularly manganese. These constituents apparently are derived from dissolution of the aquifer matrix as evidenced by scanning electron micrographs and the absence of manganese in the oil itself. Near the oil source, individual sand grains show distinct pitting and etching whereas, at the downgradient margin of the plume, some constituents are being redeposited on the matrix and are seen as overgrowths. The phenomenon may be caused in part by a shift in carbonate equilibria owing to carbon dioxide

produced by bacterially mediated mineralization of petroleum. Organic acids produced by the partial microbial oxidation of the petroleum also may be involved.

R. P. Eganhouse and M. J. Baedecker completed a survey of volatile and dissolved petroleum derivatives. Low-molecular weight aromatic compounds predominate in the volatile fraction. These constituents (particularly benzene, toluene, and xylenes) are of considerable interest in part because of recent regulations and controls on leaking underground storage tanks. Compared to aliphatic compounds of similar molecular weight, the aromatic compounds are present in the water at much higher proportions than in the petroleum presumably because they are more soluble. Laboratory oil-water equilibration studies showed a higher proportion of alkanes in the equilibrated water than in highly contaminated ground water suggesting that either the ground water is not in equilibrium with the oil or that the oil has undergone biodegradation. Several individual alkyl-benzenes seem to be moving through the aquifer more conservatively than other compounds and may be useful geochemical markers.

M. J. Baedecker found that contaminated ground water contains relatively minor amounts of the major original constituents of the petroleum (primarily normal and branched alkanes). Much of the dissolved organic carbon measured in the water may be due to the presence of degradation products of the alkanes, including organic acids. The distribution of organic constituents in sediment samples is characterized by an extreme reduction (more than 1,000 fold) in the concentration of petroleum derivatives over small vertical (less than 1 meter) and horizontal (10 meters) distances from the oil source. Downgradient sediment samples contain normal alkanes, phytane, and pristane in ratios characteristic of naturally occurring plant waxes.

H. O. Pfannkuch completed an initial round of laboratory experiments to determine the rate of dissolution of petroleum by the ground water flowing past it. Mass transfer coefficients were determined for pentane and heptane. A strong, systematic dependence of the transfer rate on water velocities was quantified using dimensionless coefficients (Peclet and Sherwood numbers).

M. F. Hult found that the petroleum floating on the water table at the site varies systematically in specific gravity, refractive index, and viscosity. Laboratory experiments indicate that the differences observed in field samples can be accounted for by the selective removal of volatile constituents from a single sample. This supports the conclusion that the petroleum spilled was originally nearly uniform in composition and that present differences are due to subsequent weathering. The relative concentration of volatile constituents in the head-space of oil samples was in good agreement with the trends noted in physical properties.

M. F. Hult and R. R. Grabbe conducted a qualitative reconnaissance of hydrocarbon vapors in the unsaturated zone in order to delineate plume geometry. The results from near-surface sampling were misleading because vertical concentration gradients are exceedingly steep. Subsequent efforts by Hult focussed on obtaining quantitative data on the three-dimensional distribution of individual petroleum compounds, oxygen, carbon dioxide, and methane in the unsaturated zone. The areal distribution of total volatile hydrocarbons 1-3 feet above the

water table is in close agreement with the areal distribution of dissolved organic carbon in water-table wells. Although some transport of volatile aliphatic hydrocarbons is due to movement with ground water, a major part is moving through the unsaturated zone by diffusion. Immediately downgradient from the oil body a 10,000-fold increase in the concentration of total volatile hydrocarbons was measured between depths of 2 and 15 feet (approximately one-half the thickness of the unsaturated zone). Between 15 feet and the water table, the concentration increased only about 50 percent. The distribution of methane, oxygen, carbon dioxide, and individual hydrocarbons indicates that methanogenesis occurs in an anaerobic zone above the main body of the plume. At the plume periphery, hydrocarbons are apparently being oxidized by microorganisms. Steep gradients in hydrocarbon concentration near land surface probably are not due to oxygen limitation; rather, the limiting factors may be nutrient availability, toxicity owing to high concentrations, or climatologic and hydrologic processes.

Using laboratory microcosms filled with sediment and ground water from the site, F. H. Chang found that the availability of nutrients and, to a lesser extent, the low ambient temperatures are limiting the rate of petroleum degradation. Degradation rates were at least 10 times greater under aerobic than under anaerobic conditions. Petroleum-degrading bacteria and fungi were isolated from the aquifer and the unsaturated zone and were tested to determine their ability to degrade hydrocarbons. All eight bacterial and four fungal isolates were able to utilize crude petroleum as their sole energy source but the isolates varied significantly in their ability to utilize the model hydrocarbons tested (cyclohexane, hexadecane, naphthalene, and phenanthrene).

Completed Reports:

Three papers were presented at a symposium in Houston, Texas, on ground-water contamination by hydrocarbons. The symposium was sponsored by the American Petroleum Institute and the National Water Well Association November 5-7, 1984. The papers were:

Hult, M. F., 1984, Non-disruptive measurement of organic fluid thickness and position in the shallow subsurface.

Pfannkuch, H. O., 1984, Determination of the contaminant source strength from mass exchange processes at the petroleum-ground-water interface in shallow aquifer systems.

Pfannkuch, H. O., and Hult, M. F., 1984, Influence of transient hydrologic events on oil-to-water transfer in shallow aquifers.

Eight papers were presented by project participants at the Toxic Waste Technical Meeting sponsored by the USGS October 21-25, 1985, in Hyannis, Massachussets. Extended abstracts of the papers, which cover most aspects of the project, will be published by the Office of Hazardous Waste Hydrology. The papers presented were:

Chang, F. H., Hult, M. F., Noben, N.,and Brand, D., 1985, Microbial degradation of crude oil and some model hydrocarbons.

Eganhouse, R. P., Baedecker. M. J., Phinney, Curtis, and Hopple, Jessica, 1985, Organic constituents in the subsurface: The composition and alteration of hydrocarbons in ground water at the Bemidji, Minnesota, oil-spill site.

Franzi, D. A., 1985, The surficial and subsurface distribution of aquifer sediments at the Bemidji Research Site, Bemidji, Minnesota.

Hult, M. F. and Grabbe, R. R., 1985, Permanent gases and hydrocarbon vapors in the unsaturated zone.

Miller, R. T., 1985, Hydrogeology and preliminary regional flow model at the Bemidji, Minnesota, Research Site.

Olhoeft, G. R.,1985, Site geophysics at Bemidji, Minnesota.

Pfannkuch, H. O., Nourse, S. M., and Hult, M. F., 1985, Mass transfer at the alkane-water interface in laboratory columns of porous media.

Siegel, D. I., Bennett, P. C., Baedecker, M. J., Berndt, M. P., and Franzi, D. A., 1985, Inorganic geochemistry of ground water and aquifer matrix, Bemidji Research Site--First year results.

Reports in Preparation:

Chang, F. H., Noben, N., and Hult, M. F., Biodegradation of crude oil and model hydrocarbons by indigenous microorganisms in the subsurface at an oil-spill site. To be submitted to Journal of Applied and Environmental Microbiology.

Hult, M. F., Oxidation of hydrocarbon vapors in the shallow subsurface. To be submitted to Water Resources Research.

Hult, M. F., Delineation of ground-water contamination by petroleum derivatives using soil-gas analysis. To be submitted to Ground Water.

Hult, M. F., Risk, Zein, Nourse, S. M., and Pfannkuch, H. O., Changes in composition and physical properties of crude oil contaminating a water-table aquifer. To be submitted to Ground Water.

Miller, R. T.,and Franzi, D. A., Hydrogeology and regional flow modeling of a crude-oil contamination site near Bemidji, Minnesota. To be submitted to Ground Water.

Pfannkuch, H. O., Nourse, S. M., and Hult, M. F., Mass transfer to ground water of individual components in petroleum-derived fluids. Journal article.

At least eight other journal articles are being prepared presently by researchers outside the Minnesota District based on research conducted at the Bemidji site.

IMPACT OF AGRICULTURE AND RURAL-RESIDENTIAL DEVELOPMENT ON GROUND-WATER QUALITY IN THE ANOKA SAND PLAIN, EASTERN MINNESOTA (MN 83-096)

Date Project Began: July 1983

Date Project Ends: September 1985

Project Leader: Anderson, Henry W., Jr.

Location: Eastern Minnesota

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objectives: (1) Assess areal and seasonal variations in water quality in surficial aquifers of the Anoka sand plain in relation to hydrogeologic and climatic conditions and land use, (2) determine the degree of horizontal and vertical mixing of poor- and good-quality water in these aquifers, (3) determine long-term changes in water quality by comparison of current and previous chemical analyses, (4) provide baseline water-quality data for use in future assessments of long-term trends and effects due to land-use practices, and (5) establish a regional network of wells in each aquifer that may be incorporated into a statewide water-quality-monitoring network.

Progress in FY 85: In June 1985, ground-water quality sampling in the Anoka sand-plain aquifer was completed and statistical tests were performed on the data. In different land-use settings, mean nitrate concentrations for spring 1984, winter 1985, and spring 1985, respectively, were: for natural areas 1.2, 1.3, and 0.93 mg/L; for nonirrigated cultivated areas 5.2, 6.3, and 6.7 mg/L; for irrigated areas 7.8, 9.1, and 8.7 mg/L; and for residential areas using septic systems 3.0, 3.3, and 4.2 mg/L. At different depths below the water table, mean nitrate concentrations for the same seasons, respectively, were: at less than 10 feet, 6.2, 7.8, and 8.0 mg/L; at 10 to 20 feet, 5.6, 6.0, and 4.9 mg/L; and at more than 20 feet below water table, 0.78, 3.5, and 1.7 mg/L. Triazine herbicides were present in all 18 samples collected for pesticide analysis; concentrations as great as 4.9 micrograms per liter were determined.

Ground-water quality was sampled from 38 wells in sand-plain aquifers in 8 counties in west-central Minnesota in spring 1983, 1984, and 1985. Median value for specific conductance, and median concentrations of sulfate and nitrate declined between spring 1983 and spring 1984 and rose again in 1985 but not as high as in spring 1983. Relative concentrations of nitrate and ammonia in some of these wells suggest denitrification at 10 or more feet below the water table. At a well nest sampled seven times from 1982-85, the shallow well

completed at the water table had a mean concentration of nitrate nitrogen of 26 mg/L and ammonia 0.09 mg/L. The adjacent deep well (26 ft below water table) had a mean concentration of nitrate of 6.4 and ammonia 0.67 mg/L. The higher concentration of ammonia associated with decreased nitrate concentration may indicate denitrification at the depth of the deeper well with nitrate reduced to ammonia, nitrous oxide, and nitrogen gas. Similar relationships were observed at other well nests and in individual wells where decreases in nitrate were associated with increases in ammonia.

Plans for FY 86: A report will be prepared describing the impact of agriculture and residential septic systems on water quality in the Anoka sand-plain aquifer from data evaluated using statistical methods. Data from 99 wells in Anoka, Chisago, Isanti, Sherburne, and Stearns Counties will be evaluated. The land-use settings represented by these wells include 11 in natural settings with minimal impact of man, 30 in nonirrigated cultivated settings, 38 in irrigated settings, and 20 in residential settings with septic systems. Data also will be compared for vertical differences in water quality at less than 10 feet below the water table, 10 to 20 feet below, and more than 20 feet below the water table in the surficial-sand aquifer.

Planned Report:

Anderson, H. W., Jr., Ground-water quality and land use in the Anoka sand plain, east-central Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

HYDROLOGY OF THE FOND DU LAC INDIAN RESERVATION IN MINNESOTA (MN 84-098)

Date Project Began: April 1983

Date Project Ends: September 1986

Projet Leader: Ruhl, James F.

Location: Fond du Lac Indian Reservation, northeastern Minnesota

Principal Cooperating Agencies: Bureau of Indian Affairs, Fond du Lac Reservation Business Committee

Objectives: To conduct an appraisal of the water resources of the Fond du Lac Indian Reservation. The various components of the hydrologic system will be studied to estimate (1) flow characteristics and availability of ground and surface water, (2) quality of ground and surface water, (3) current water use, (4) seasonal and annual fluctuations of streamflow, ground-water levels, and water quality, and (5) the annual water budget.

Progress in FY 85: Field-data collection on the Fond du Lac Indian Reservation was completed during fiscal year 1984. In FY 1985, emphasis was on interpretation of hydrologic data and on report preparation.

Stage-discharge data collected during water year 1984 were used to generate rating curves and total discharge for gages on four streams within the Reservation. Mean monthly discharge of Stoney Brook, the major stream within the Reservation, varied from 234 cubic feet per second in April 1984 to 14.3 cubic feet per second in August 1984. Estimates were made of the total annual runoff for each of the four stream basins. Stoney Brook basin produced the most runoff, which was 14 inches. The mean runoff from the entire study area was 12 inches, the total precipitation was about 36 inches, and evapotranspiration, estimated as the residual, was 24 inches. Hydrograph analysis indicates that about 30 percent of the streamflow is direct runoff from storms, and the remainder is base flow from ground-water discharge.

Interpretation of well-log data showed that the most heavily used aquifers in the Reservation are confined drift, which consist of sand and gravel that underlies less-permeable till. The depths of wells open to these aquifers generally range from 75 to 150 feet. Water use in the Reservation, which is strictly for domestic supply, was estimated to be 40 million gallons per year.

A detailed report outline was prepared and preliminary drafts of many of the figures in the report were completed. First drafts of the introduction and the sections on ground water and surface water were written.

Plans for FY 86: The first draft of the report will be completed during the first quarter of FY 1986. The sections that remain to be written are on water quality and the summary. The summary will include some discussion of the water budget and water use. The report will be submitted to USGS Headquarters for approval and publication late in FY 1986.

Report in Preparation:

Ruhl, J. F., Water resources of the Fond du Lac Indian Reservation, northeast Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Leveling for an indirect measurement of discharge for a storm event

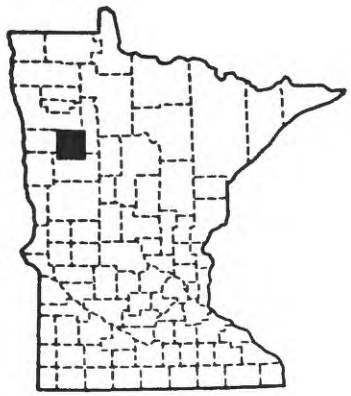
HYDROLOGY OF THE WHITE EARTH INDIAN RESERVATION IN MINNESOTA (MN 84-099)

Date Project Began: February 1984

Date Project Ends: September 1986

Project Leader: Ruhl, James F.

Location: White Earth Indian Reservation, northwestern Minnesota



Principal Cooperating Agencies: Bureau of Indian Affairs, White Earth Reservation Business Committee

Objectives: To conduct an appraisal of the water resources of the White Earth Indian Reservation. The various components of the hydrologic system will be studied to estimate (1) flow characteristics and availability of ground and surface water, (2) quality of ground and surface water, (3) current water use, (4) seasonal and annual fluctuations of streamflow, ground-water levels, and water quality, and (5) the annual water budget.

Progress in FY 85: Data collection in FY 1985 concentrated on development of stage-discharge relations for streams flowing out of the Reservation. Streamflow during the open-water period was estimated at sites on the Wild Rice, Ottertail, Buffalo, and Straight Rivers based on stage readings made several times per week and 8 to 10 discharge measurements. Most surface runoff leaves the Reservation in the Wild Rice River, which drains about three fourths of the study area. Peak flow, at near flood stage, during the 1985 water year was estimated to be about 600 ft^3/s and mean flow for the year was estimated to be 265 ft^3/s.

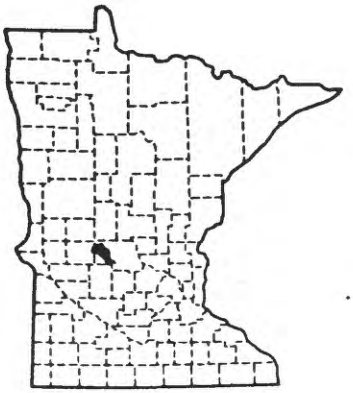
Confined-drift aquifers are the major source of ground water in the study area. Most wells completed in the drift are less than 100 feet deep, although some are as deep as 400 feet. Wells completed in the Bagley and Park Rapids sand-plain aquifers, which are in the north-central and southeastern parts of the study area, generally are 50 to 75 feet deep. A few wells are completed in crystalline bedrock, which underlies the drift, and are as deep as 500 feet.

To investigate possible nutrient loading of a representative lake from shoreline septic systems, a minipiezometer was used to collect seepage samples along the shore of Strawberry Lake. Nitrate concentrations in the seepage-flow samples generally were at or below background concentrations, indicating leachate from septic systems was not affecting nutrient loading to the lake.

Samples were collected in September 1984 from eight wells and four stream sites as part of a reconnaissance of inorganic priority pollutants in ground and surface waters. Results indicate that concentrations of trace metals such as arsenic, barium, cadmium, chromium, cyanide, mercury, and selenium were all within drinking-water standards established by the U.S. Environmental Protection Agency.

Plans for FY 86: Interpretion of water-quality data from wells, lakes, and streams will continue. The confined-drift aquifers will be described in terms of well depths, which will be plotted on maps. Specific-capacity data will be analyzed to estimate transmissivity of confined-drift aquifers. Rating curves will be defined for the four gaged streams, and total annual runoff will be estimated for each. A first draft of the report will be prepared.

GROUND-WATER AVAILABILITY FROM CONFINED AQUIFERS IN THE BROOTEN-BELGRADE AREA, WEST-CENTRAL MINNESOTA (MN 84-100)



Date Project Began: October 1984

Date Project Ends: September 1987

Project Leader: Delin, Geoffrey N.

Location: Brooten-Belgrade area, west-central Minnesota

Principal Cooperating Agency: Minnesota Department of Natural Resources

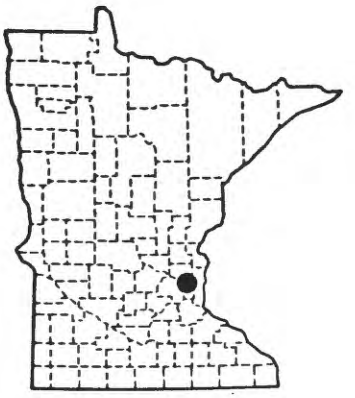
Objectives: The objectives are to (1) determine the areal extent, thickness, and hydraulic properties of confined-drift and Cretaceous aquifers in the study area, (2) investigate the vertical hydraulic connection between confined-drift and surficial aquifers and estimate the quantity of vertical leakage into confined-drift aquifers from overlying deposits, (3) estimate the long-term yield of wells penetrating confined-drift aquifers, (4) estimate the effects of continued development on water levels and on streamflow, (5) provide the MDNR with a set of management tools that can be used to assess the effects of future ground-water withdrawals, and (6) assess the quality of water from confined-drift and Cretaceous aquifers and its suitability for irrigation and other purposes.

Progress in FY 85: A field reconnaissance of the Brooten-Belgrade area in October 1984 located seepage faces, springs, and wetlands and potential test-drilling, stream-gaging, and aquifer-test sites. Data recorded on 790 water-well logs were used to prepare a series of hydrogeologic sections and to determine the areal extent of six confined-drift aquifers. Maps were constructed for each aquifer defining thickness, top, and transmissivity. Transmissivity values were obtained from 7 aquifer tests and 630 specific-capacity tests. Median confined-aquifer hydraulic-conductivity values range from 100 to 180 feet per day. Transmissivities range from 500 to 20,000 feet squared per day. Water samples were collected and analyzed at 17 sites. Seven test holes, ranging in depth from 207 to 505 feet, were drilled to bedrock in areas where hydrogeologic data were lacking. A previously unidentified bedrock valley and confined-drift aquifer were identified. Borehole geophysical logs were run in all test holes, and six test holes were completed as observation wells. Seismic-reflection surveys were conducted at 22 sites to supplement test-hole data. Base-flow measurements were made at 60 sites along the main stem and tributaries of the major streams in the area for use in model calibration. Water levels are being measured monthly in 18 observation wells

open to confined-drift aquifers in the area. Input for the preliminary ground-water-flow model is nearly complete. The model has a 43 by 59 uniformly spaced grid covering approximately 2,500 square miles. Interpretive-report outlines were prepared and submitted for review.

Plans for FY 86: Water-table wells will be installed adjacent to deep wells installed in FY 85 to determine head differences between the surficial and confined-drift aquifers. The hydrogeologic data collected during FY 85 will be interpreted. Construction of the preliminary ground-water-flow model will be completed and the model calibrated. Additional deep test holes will be drilled and observation wells installed. Additional seismic geophysical surveys will be conducted to supplement test-hole data. Hydraulic testing of till will determine vertical hydraulic conductivity. Additional water samples will be collected and analyzed for the common cations and anions, selected trace metals, and nutrients. An aquifer test will be conducted using an irrigation well completed in a confined-drift aquifer. Parts of the interpretive report will be written.

RAINFALL-RUNOFF AND RUNOFF-LOAD RELATIONS IN TRIBUTARIES OF LAKES USED FOR WATER SUPPLY IN RAMSEY COUNTY, MINNESOTA (MN 84-101)



Date Project Began: April 1984

Date Project Ends: September 1986

Project Leader: Brown, Robin G.

Location: Ramsey County, east-central Minnesota

Principal Cooperating Agency: Board of Water Commissioners, City of St. Paul

Objectives: (1) Develop and calibrate deterministic rainfall-runoff models to simulate discharge and transport of suspended solids, total phosphorus, and total ammonia and organic nitrogen in the Lamberts Creek watershed and possibly in the Wilkenson and Vadnais Creek watersheds, and (2) use these models to simulate changes in discharge and water quality in the study watersheds that may occur when present land use changes and maximum development occurs.

Progress in FY 85: Continuous records of stage and precipitation were obtained beginning with snowmelt in April 1985 in three watersheds that drain into Vadnais Lake and in four subwatersheds of Lamberts Creek, the largest tributary to Vadnais Lake. Snowmelt and 16 storms were sampled for water quality at six of the seven sites using discrete and composite sampling methods. Stage data from April through August have been compiled and used to calculate discharge for all seven sites. Dye dilution was successfully used in July at a storm-sewered site in the Lamberts Creek watershed to establish a stage-discharge relation. Precipitation data were compiled into hourly and daily totals at one continuously recording gage and into daily totals at 14 bulk-rainfall gages.

Thus far, water-quality data for six storms in 1984 have been compiled and interpreted. During May through September 1984, flow-weighted concentrations of phosphorus and total nitrogen ranged from 0.11 to 0.77 mg/L and 1.8 to 2.7 mg/L, respectively. The lower concentrations occurred in Charley Creek and Wilkenson Creek, whose watersheds average 8 percent urbanized and 35 percent wetland. In contrast, the higher concentrations occurred in Lamberts Creek and Vadnais Creek, whose watersheds average 38 percent urbanized and only 10 percent wetland.

Calibration of the deterministic rainfall-runoff models for the Lamberts, Wilkenson, and Vadnais Creek watersheds was completed for both daily and storm discharges. Model simulation also included storm flow-routing and sediment

transport (including sediment-related nutrients) using data collected in 1984. Model results for Lamberts Creek discharge indicate that between May 1 and September 30, 1984, 12 percent of the total discharge was from surface runoff, 80 percent from subsurface flow or interflow, and 8 percent from ground-water flow. Simulation of Wilkenson Creek watershed showed that the total discharge was 1 percent surface runoff, 93 percent subsurface flow, and 6 percent ground-water flow. Simulation of the more urbanized watershed, Vadnais Creek, indicated that the discharge was primarily the result of surface runoff (54 percent of the total) and subsurface flow (45 percent) and that ground-water flow was minimal (less than 1 percent).

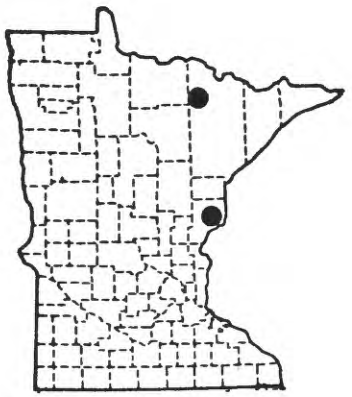
Plans for FY 86: An additional flow and water-quality site will be established in Lamberts Creek watershed. Data collection will continue from snowmelt to October 1986 at all sites. Sampling of water quality will be automated by use of a microprocessor at the seven water-quality sites. Instrumentation will be added in October 1985 to measure soil moisture, soil temperature, snowfall, and snowmelt, and to estimate evapotranspiration. This additional instrumentation will be used to collect field data for verification of the simulation of these parameters in the deterministic models. Deterministic rainfall-runoff models will be calibrated using 1984 and 1985 data for the three watersheds. The models also will be used for preliminary simulation of expected changes in land use within the watersheds and the resulting changes in runoff, sediment transport, and nutrient loading.

Planned Reports:

Brown, R. G., Preliminary deterministic and statistical modeling of small urbanizing watersheds in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

Brown, R. G., Rainfall-runoff modeling of four watersheds in the St. Paul Water Utility water-supply-lakes system, Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

PRELIMINARY EVALUATION OF POSSIBLE GROUND-WATER CONTAMINATION NEAR PESTICIDE-BURIAL SITES IN MINNESOTA (MN 84-102)



Date Project Began: July 1984

Date Project Ends: September 1985

Project Leader: Stark, James R.

Location: St. Louis and Pine Counties, northeastern, Minnesota

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objectives: The objectives are to (1) characterize the geology, ground-water hydrology, and degree of ground-water contamination at two sites used for disposal of pesticides during the 1970's, (2) develop sufficient understanding of chemical transport at the sites to estimate potential movement of ground-water contaminants, and (3) assist the MDNR (Minnesota Department of Natural Resources) in design and evaluation of appropriate remedial actions at each site.

Progress in FY 85: An investigation of two pesticide burial sites, in St. Louis and Pine Counties, Minnesota, was completed in cooperation with the Minnesota Department of Natural Resources (MDNR). The study assessed the chemical effects on ground water and soil of the burial of pesticides at those sites. Approximately 1,500 pounds of lead arsenate were buried in shallow trenches at the St. Louis County site in 1970. Organic and inorganic pesticides, including 300 pounds of DDT and 10,000 pounds of lead arsenate, were buried at the Pine County site in 1971. Fourteen observation wells were installed at the St. Louis County (Greaney) site. Wells were located several hundred feet from the burial trenches to define the direction of ground-water flow in the unconfined sand and gravel aquifer. Additional wells were installed closer to the trenches along equipotential lines downgradient (to the east) from the trenches. Chemical analyses of soil and ground water indicate that concentrations of lead and arsenic are at or near background concentrations. Contaminant migration from the site probably has been limited by the low solubility of lead and arsenic and by the 25-foot thick unsaturated zone. The drilling of 41 test holes and installation of observation wells at the Pine County (Duxbury) site showed that a seasonally saturated clay lens underlies the burial trenches. This clay lens is approximately 20 feet above the regional water table in a silt and sand formation that underlies the area. Chemical analyses of soil and water samples indicate that pesticides have

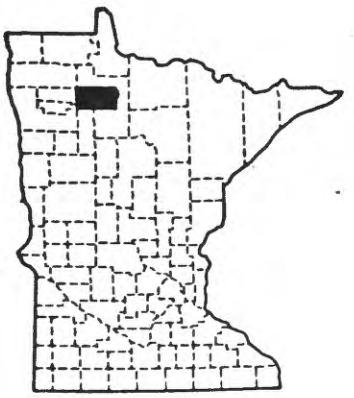
migrated only about 10 feet from the trenches and are confined to the upper clay-rich lens. The low solubility of the pesticides and the high capacity for sorption by fine-grained sediments probably has limited migration of the pesticides.

Plans for FY 86: An interpretive report, summarizing project activities and results, will be completed during the first quarter of FY 86. The report is planned to contain three major sections. The first section will describe the history of pesticide burial at the two sites. The following sections will describe the geologic, topographic, and hydrologic characteristics of the two sites and will interpret ground-water-quality data as it relates to contamination from the burial sites.

Planned Report:

Stark, J. R., Preliminary evaluation of possible ground-water contamination near pesticide-burial sites in Minnesota: U.S. Geological Survey Water-Resources Investigations Report.

HYDROLOGY OF RED LAKE INDIAN RESERVATION (MN 85-103)



Date Project Began: October 1984

Date Project Ends: September 1987

Project Leader: Ruhl, James F.

Location: Northwestern Minnesota

Principal Cooperating Agency: Red Lake Reservation Business Committee

Objectives: To conduct an appraisal of the water resources of the Red Lake Indian Reservation. The various components of the hydrologic system will be studied to estimate (1) flow characteristics and availability of ground and surface water, (2) quality of ground and surface water, (3) current water use, (4) seasonal and annual fluctuations of streamflow, ground-water levels, and water quality, and (5) the annual water budget.

Progress in FY 1985: Shallow test holes were drilled and two observation wells were installed along the south shore of Lower Red Lake in the Red Lake Indian Reservation. In this area, the surficial material consists of clean, medium to fine sand. Water-level recorders were installed on the wells to measure seasonal fluctuations in ground-water levels. Water levels are about 5 feet above the lake surface, indicating ground-water inflow to the lake.

Staff gages were installed in midsummer on the three main inflowing streams to Lower Red Lake (Pike Creek, Mud River, Sandy River), and an observer was hired to make three to four readings per week of each gage. Near the end of fiscal year 1985, continuous recorders were installed on these streams to be operated until freeze-up. Several discharge measurements have been made on each stream.

Water-quality samples were collected from both Upper and Lower Red Lakes and from sites on five streams that drain into the lakes. Profiles of temperature, pH, conductivity, and dissolved oxygen indicated the water in each was well mixed. Phytoplankton samples collected from both Upper and Lower Red Lakes showed that Anacystis marina, which is a blue-green algae, is the dominant genus of algae in both lakes. Bacterial samples were collected at several sites along Pike Creek, at the mouth of the creek where it flows into Lower Red Lake, and at a point several hundred yards offshore. Bacterial contamination in Pike Creek, which seems to be elevated above background levels, may be caused by housing developments, a sewage lagoon, and other sources of waste in the town of Red Lake.

Plans for FY 86: Well logs supplied by the Indian Health Service (U.S. Department of Health and Human Services) will be evaluated and field-checked for location. Following an assessment of the well-log data, the need for additional hydrogeologic data will be determined. Shallow test drilling with the District auger rig or deeper drilling by contractors are possibilities during the upcoming field season. Additional water-quality samples will be collected from domestic wells and the two observation wells. Stage and discharge data will be collected from the three gaged streams and rating curves will be defined. Report preparation will begin during the last quarter of the year.

EFFECTS OF TREATED WASTEWATER DISCHARGE ON HYDROLOGY AND WATER QUALITY OF WETLANDS IN MINNESOTA AND WISCONSIN (MN 85-104)

Date Project Began: April 1985

Date Project Ends: September 1987

Project Leader: Brown, Robin G.

Location: Central Minnesota and northeastern Wisconsin

Principal Cooperating Agency: U.S. Environmental Protection Agency

Objectives: (1) Determine hydrologic effects by analysis of hydrologic budgets, surface-water-flow patterns, and ground water-surface water interactions, (2) determine water-quality effects by sampling surface water in the wetlands and in receiving streams and sampling ground water underlying and adjacent to the wetlands for analyses for the same chemical constituents found in the treated wastewater, (3) design and implement a reconnaissance-level approach for future assessments of wetlands that outlines the minimum data collection and analysis needed to adequately assess effects of discharge of treated wastewater, (4) assist USEPA in the design of a strategy for monitoring future effects of treated wastewater discharge to wetlands, and (5) increase the general knowledge of the hydrology of small wetlands in the Upper Midwest.

Progress in FY 85: The following data-collection instrumentation was installed at both wetland study sites (St. Joseph, Minnesota, and Phelps, Wisconsin) in June and September 1985 (1) precipitation--one rainfall/snowfall gage and three rainfall gages, (2) evapotranspiration--pyranometer, relative humidity, and air temperature, (3) surface water--inlet, outlet, and wetland stage, and wastewater-effluent-discharge flume, and (4) ground water--six water-level recorders at St. Joseph and three at Phelps. All instrumentation is connected to a microprocessor and datalogger located at each site.

During summer 1985, discharge at the storm-sewer inlet to the St. Joseph wetland varied from 0.01 to 27.6 cubic feet per second. Discharge at the St. Joseph wetland outlet varied from 1.21 to 4.48 cubic feet per second. Test-hole and water-level data from 25 wells and piezometers indicate that the St. Joseph wetland is underlain by about 60 feet of saturated outwash sand and gravel. Hydrologic sections and a water-table map prepared for the St. Joseph site show that (1) ground water flows horizontally into the wetland from the south, west, and east, (2) a ground-water mound exists between the wetland and the Watab River to the west, and (3) ground water flows vertically upward into the wetland through the organic sediments. A preliminary ground-water-flow

model of the St. Joseph wetland has been developed to evaluate hydrologic properties and to aid location of additional observation wells.

Eight observation wells were installed at the Phelps site of which two are in a piezometer nest. Hydrogeologic data indicate that the Phelps wetland is perched about 70 feet above the regional water table by an underlying clay layer several feet thick. Geologic facies changes in the uplands surrounding the wetland have created smaller perched zones 7 to 12 feet above the wetland that probably discharge into the wetland. The Phelps wetland has no channelized surface-water inlet and the outlet apparently flows intermittently.

Plans for FY 86: Data collection will continue throughout the year, except for surface-water data that will be collected only during the open-water period (snowmelt through September 1986). Water-quality data collection will begin in November 1985 with sampling of ground-water and treated wastewater discharge. Water-quality sampling will be expanded to include surface water beginning at snowmelt and continue through the water year. Additional instrumentation will be installed in November 1985 to measure evapotranspiration by evaporation-pan and energy-budget methods. A preliminary ground-water-flow model will be completed in October 1985 for St. Joseph wetland with a detailed model being developed following the preliminary modeling. Twenty additional wells will be installed at the St. Joseph site in November 1985 to improve the understanding of areal ground-water movement. A ground-water-flow model at Phelps will be used to understand the movement of ground water in the perched zone. Several additional wells will be installed at the Phelps site to better define flow in the regional water-table aquifer. Lysimeters will be installed at the Phelps site to define downward leakage from the perched zones to the regional water-table aquifer.

Taking dissolved-oxygen reading

AVAILABILITY OF SURFACE WATER IN MINNESOTA
(MN 85-105)

Date Project Began: June 1985

Date Project Ends: October 1986

Project Leader: Jacques, James E.

Location: Statewide

Principal Cooperating Agency: Minnesota Department of Natural Resources

Objectives: The project will provide information from a historical perspective (e.g. high- and low-flow statistics) on the major streams in the State's 39 principal watersheds. The extremes of availability as well as a "typical" situation will be assessed. In addition, a prototype simulation of the hydrology of a selected watershed will be developed as part of the project for evaluation of changing watershed conditions and of the effects of those changes on the amount and frequency of runoff.

Plans for FY 86: Statistical analyses of low and high flows will be updated through water year 1983 for each continuous-record station in Minnesota. Transfer techniques will be developed for estimation of low-flow statistics at ungaged sites. A deterministic watershed model will be calibrated and verified for the St. Louis River Watershed.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT
(NR 39-081)

Date Project Began: 1939

Date Project Ends: Continuing

Project Leader: John V. Skinner

Location: St. Anthony Falls Hydraulic Laboratory
University of Minnesota

Principal Cooperating Agencies: U.S. Geological Survey, U.S. Army Corps of Engineers, Forest Service, Bureau of Reclamation, Agricultural Research Service, Federal Highway Administration, Bureau of Land Management

Objectives: The Federal Interagency Sedimentation Project serves the cooperating agencies' needs by conducting research, standardizing techniques, developing sediment-sampling equipment, and serving as a center for equipment supply and maintenance.

Progress in FY 85: Project personnel worked on several sediment problems; however, only one activity--testing an automatic sediment-concentration gage--is covered in this report. The instrument, which consists of a vibrating U-shaped tube, was installed at a gaging station on Willow Creek near Madison, Wisconsin. The tube's vibrational frequency is set by the density of the water-sediment mixture flowing through the tube. Density values are, in turn, set by the temperature of the water, by the concentration of dissolved solids, and most importantly, by the concentration of suspended sediment.

Readings of water temperature, water conductivity, and vibrational frequency were automatically transmitted by telephone to a computer at the Madison district office. During storms, physical samples of flows through the tube were collected manually every few hours. Figure 7 shows a comparison of suspended-sediment concentrations obtained from the transmitted data and suspended-sediment concentrations obtained from laboratory analysis of the physical samples. Figure 8 shows a temporal record of plotted sediment concentration for the storm of October 18-19, 1984. All points plotted on this figure were obtained from the transmitted data.

The experimental gage has considerable potential for sediment monitoring applications; however, certain improvements must be made before the gage is ready for routine use.

Plans for FY 86: Research will focus on methods of simplifying the gage and eliminating the sampling pump. A new gage is designed for submerged operation is being built. This gage is streamlined to reduce drag forces and is built around a straight vibrating tube.

Completed Report:

Skinner, John V., Beverage, Joseph P., and Goddard, Gerald L., 1985, Continuous measurement of sediment concentration: Proceedings of Fourth Federal Interagency Sedimentation Conference.

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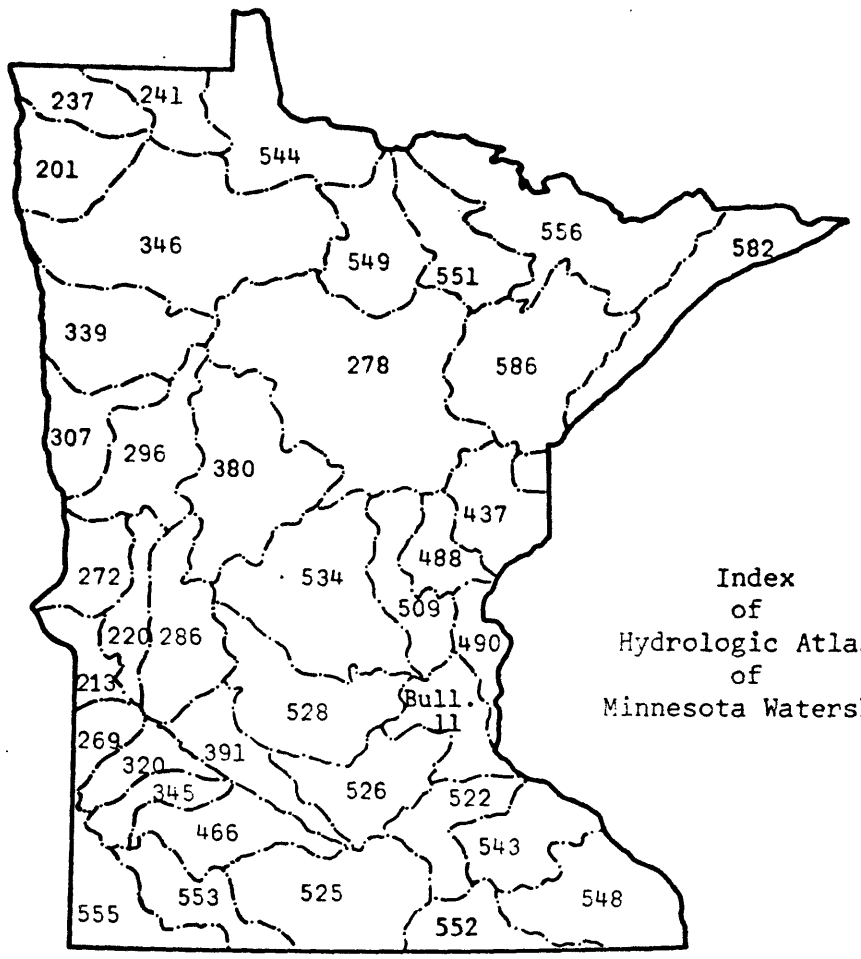
Skinner, John V., Temperature response of a straight-tube gage: Minneapolis, Minn., Interagency Advisory Committee on Water Data, Federal Interagency Sedimentation Project.

Szalona, Joseph J., A straight-tube fluid-density gage for measuring suspended-sediment concentration in streams: Minneapolis, Minn., Interagency Advisory Committee on Water Data, Federal Interagency Sedimentation Project, Report HH.



EXPLANATION

Bull.—Minnesota Department of Natural Resources, Division of Waters, HA—U.S. Geological Survey Hydrologic Investigation Atlas

Bull. 11	Metropolitan Area	HA 488	Snake River
HA 201	Middle River	HA 490	Lower St. Croix
HA 213	Big Stone Lake	HA 509	Rum River
HA 220	Pomme de Terre River	HA 522	Cannon River
HA 237	Two Rivers	HA 525	Blue Earth River
HA 241	Roseau River	HA 526	Lower Minnesota River
HA 269	Lac Qui Parle River	HA 528	Crow River
HA 272	Mustinka-Bois de Sioux	HA 534	Mississippi-Sauk
HA 278	Mississippi Headwaters	HA 543	Zumbro River
HA 286	Chippewa River	HA 544	Lake of the Woods
HA 296	Otter Tail River	HA 548	Root River
HA 307	Buffalo River	HA 549	Big Fork River
HA 320	Yellow Medicine River	HA 551	Little Fork River
HA 339	Wild Rice River	HA 552	Cedar River
HA 345	Redwood River	HA 553	Des Moines River
HA 346	Red Lake River	HA 555	Rock River
HA 380	Crow Wing River	HA 556	Rainy River
HA 391	Minnesota River-Hawk Creek	HA 582	Lake Superior
HA 437	Kettle River	HA 586	St. Louis River
HA 466	Cottonwood River		

Figure 9.--Index of Hydrologic Atlases of Minnesota watersheds

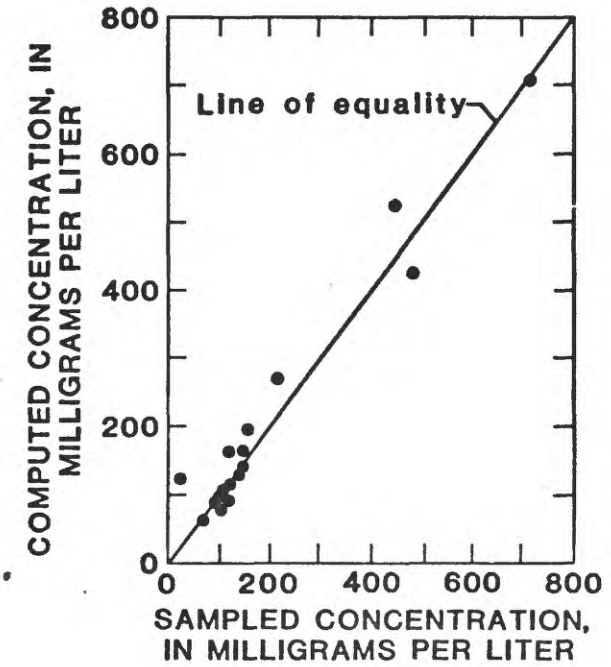


Figure 7.--Comparison of computed and sampled concentrations for storm of October 18-19, 1984

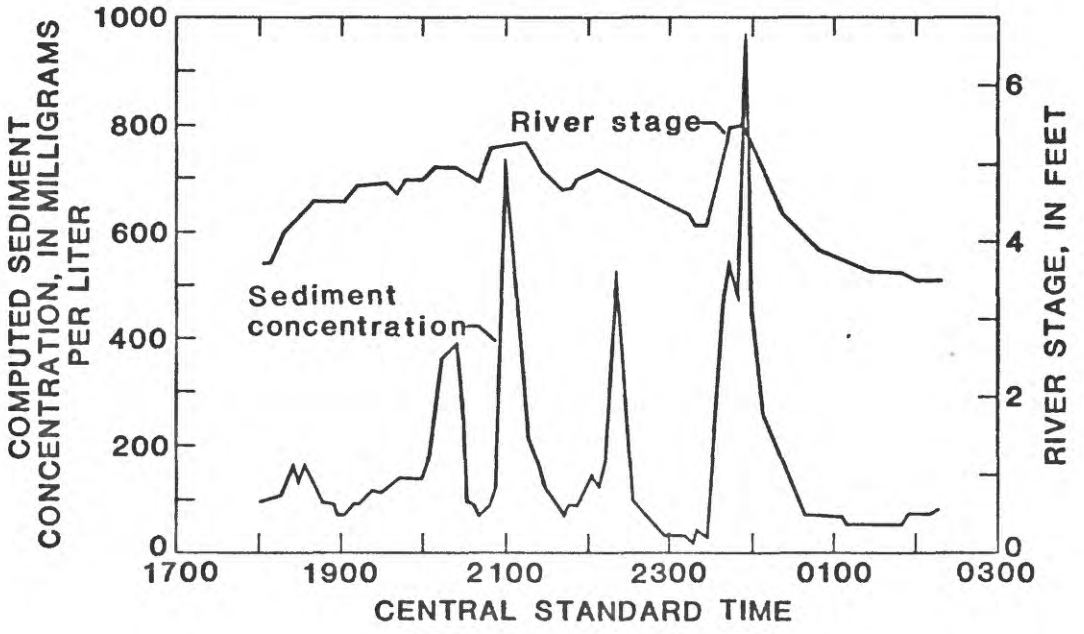


Figure 8.--Stage and computed sediment-concentration hydrograph for storm of October, 1984

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Arntson, A. D., and Tornes, L. H., 1984, Hydrologic and water-quality assessment of the Coon Creek watershed, Anoka County, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 84-4013, 97 p.

Ayers, M. A., Brown, R. G., and Oberts, G. L., 1985, Runoff and chemical loading in small watersheds in the Twin Cities Metropolitan Area, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 85-4122, 35 p.

Brown, R. G., 1984, Hydrologic effects of impoundments in Sherburne National Wildlife Refuge, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 84-4175, 20 p.

_____ 1985, Errors in estimating ground-water components of hydrologic and phosphorus budgets of lakes: U.S. Geological Survey Water-Supply Paper. [In press].

_____ 1985, Effects of wetlands on quality of runoff entering lakes in the Twin Cities Metropolitan Area, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 85-4170.

_____ 1985, Lake-level fluctuations in Big Marine Lake, Washington County, Minnesota: U.S. Geological Survey Water-Resources Investigations Report 85-4176.

_____ 1985, Lake-level fluctuations in Big Marine Lake, Washington County, Minnesota: Abstract approved for publication for AWRA conference, La Crosse, Wisconsin, March 7-8, 1985.

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Chang, F. H., Hult, M. F., Noben, N., and Brand, D., 1985, Microbial degradation of crude oil and some model hydrocarbons: Paper presented at the U.S. Geological Survey Toxic Waste Technical Meeting Hyannis, Massachusetts, October 21-25, 1985, will be published by the Office of Hazardous Waste Hydrology.

Delin, G. N., 1985, Confined-drift aquifer studied near the Pomme de Terre and Chippewa Rivers, west-central Minnesota: U.S. Geological Survey Water Fact Sheet.

Delin, G. N., and Woodward, D. G., 1984, Hydrogeologic setting and the potentiometric surfaces of regional aquifers in the Hollandale embayment, southeastern Minnesota, 1970-80: U.S. Geological Survey Water-Supply Paper 2219, 56 p.

Eganhouse, R. P., Baedecker, M. J., Phinney, Curtis, and Hopple, Jessica, 1985, Organic constituents in the subsurface--The composition and alteration of hydrocarbons in ground water at the Bemidji, Minnesota oil-spill site: Paper presented at the U.S. Geological Survey Toxic Waste Technical Meeting Hyannis, Massachusetts, October 21-25, 1985, will be published by the Office of Hazardous Waste Hydrology.

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Hult, M. F., 1984, Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Open-File Report 84-867, 57 p. [Pending publication as a Water-Supply Paper.]

____ 1984, Nondisruptive measurement of organic fluid thickness and vertical position in the shallow subsurface: Abstract approved for publication for NWWA-API conference, Houston, Texas, November 5-7, 1984.

Hult, M. F., and Grabbe, R. R., 1985, Permanent gases and hydrocarbon vapors in the unsaturated zone: Paper presented at the U.S. Geological Survey Toxic Waste Technical Meeting Hyannis, Massachusetts, October 21-25, 1985, will be published by the Office of Hazardous Waste Hydrology.

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Miller, R. T., 1984, Preliminary modeling of an aquifer thermal-energy storage system: U.S. Geological Survey Open-File Report 84-811, 48 p.

____ 1985, Thermal-energy storage in a deep sandstone aquifer in Minnesota: Field observations and thermal-energy-transport modeling: Abstract approved for ENERSTOCK 85, Toronto, Canada, September 22-26, 1985.

____ 1985, Hydrogeology and preliminary regional flow model at the Bemidji, Minnesota, Research Site: Paper presented at the U.S. Geological Survey Toxic Waste Technical Meeting Hyannis, Massachusetts, October 21-25, 1985, will be published by the Office of Hazardous Waste Hydrology.

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