UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS IN NORTH DAKOTA--FISCAL YEAR 1983

Compiled by Nancy K. Lankford and Luverne L. Albright

U.S. GEOLOGICAL SURVEY

Open-File Report 83-220

Bismarck, North Dakota

March 1983

UNITED STATES DEPARTMENT OF THE INTERIOR
JAMES G. WATT, Secretary
GEOLOGICAL SURVEY
Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
821 East Interstate Avenue
Bismarck, ND 58501

For sale by:

Open-File Services Section
Distribution Branch
U.S. Geological Survey, MS 306
Box 25425, Denver Federal Center
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

WATER-RESOURCES INVESTIGATIONS

IN NORTH DAKOTA--1983

INTRODUCTION

The U.S. Geological Survey, through its Water Resources Division, investigates the occurrence, quantity, quality, distribution, and movement of the surface and underground water that composes the Nation's water resources. This publication contains a brief description of the ongoing investigations of the North Dakota District.

Much of the Geological Survey program is conducted in cooperation with other Federal agencies and several state agencies. The publications resulting from the program are listed periodically in a miscellaneous release titled, "Water Resources Investigations in North Dakota, 19XX." The last such release was issued in 1976. They are also listed in a monthly nationwide release titled, "New Publications of the Geological Survey, List XXX--Publications issued in month 19XX."

DATA-COLLECTION PROJECTS

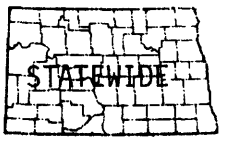
The U.S. Geological Survey continually records stage, discharge, quality of water, sediment concentrations, and ground-water levels at selected sites throughout North Dakota. Some of the stites are operated on a long-term basis to sample trends in the gross water supply, while others are operated for short terms for correlation with long term to gain wider areal coverage or for specific purposes. The information is published annually in water-data reports and stored in computer files for retrieval and processing.

PROJECT TITLE: Surface-Water Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness



OBJECTIVES.--To collect surface-water data sufficient to satisfy needs for current purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) forecasting, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or special studies. To collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, etc., for use in planning and design.

APPROACH.--Standard methods of data collection will be used as described in the series, "Techniques of Water Resources Investigations of the United States Geological Survey." Partial-record gaging will be used instead of complete-record gaging where it serves the required purpose.

PROGRESS IN 1982.--All network (fig.1) data were collected on schedule and annual water-year records are being prepared for publication. An acoustic velocity meter was installed on the James River.

PLANS FOR 1983.--Continue to operate network. Two continuous-record stations will be converted to crest-stage gages and five stations will be discontinued.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1982 (planned).

U.S. Geological Survey, 1981, Water-resources data, North Dakota, Water year 1981, Vol. 1. Hudson Bay basin: U.S. Geological Survey Water-Data Report ND-81-1, 325 p.

U.S. Geological Survey, 1981, Water-resources data, North Dakota, Water year 1981, Vol. 2. Missouri River basin: U.S. Geological Survey Water-Data Report ND-81-2, 492 p.

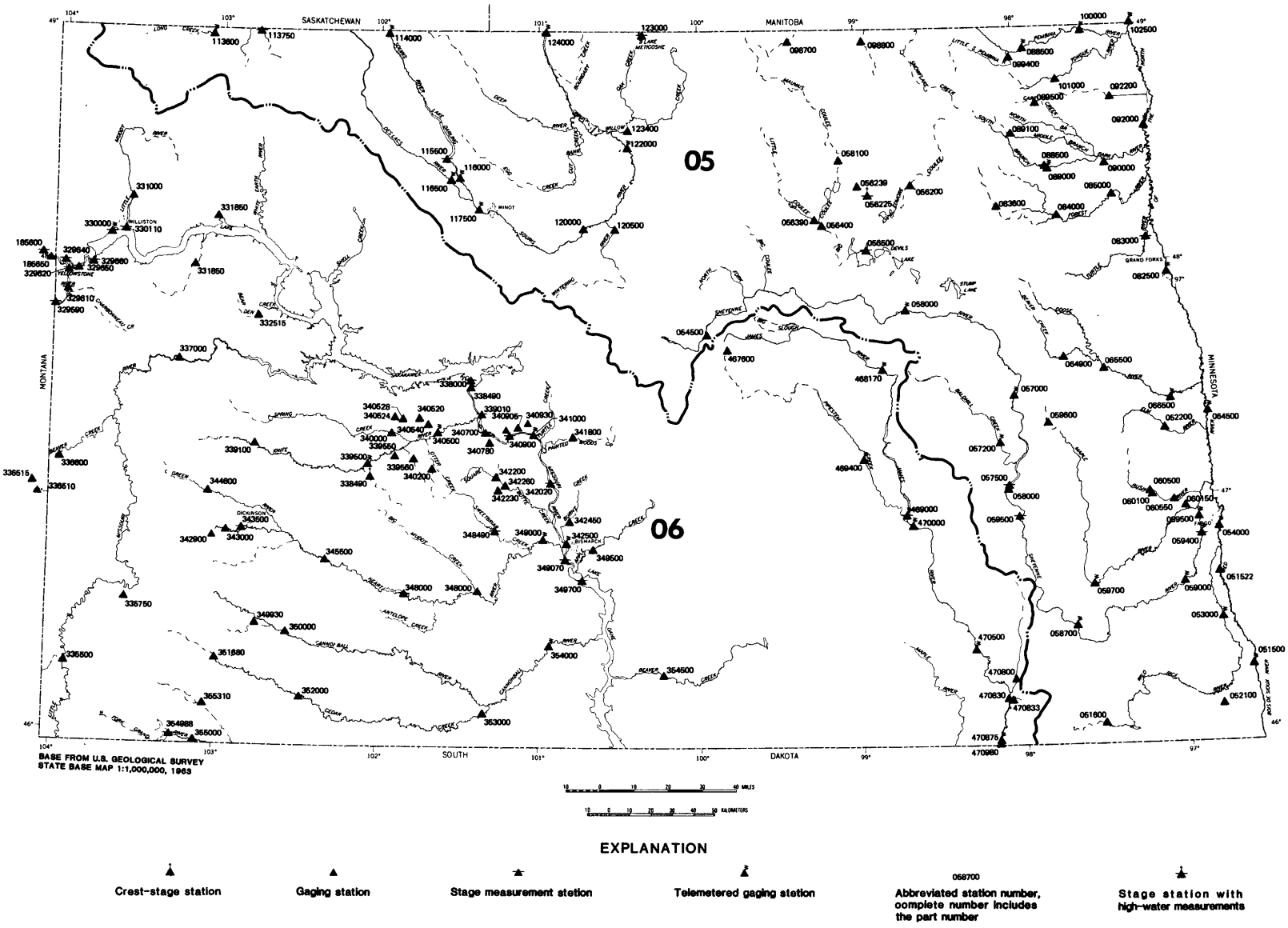


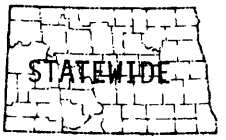
FIGURE 1.—Locations of lake, crest-stage, and stream-gaging stations.

PROJECT TITLE: Water-Quality Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Robert L. Houghton



OBJECTIVES.--To provide a national bank of water-quality data for broad Federal planning and action programs and to provide data for Federal management of interstate and international waters.

APPROACH.--Operation of a network of water-quality stations to provide average chemical concentrations, loads, and time trends as required by planning and management agencies.

PROGRESS IN 1982.--All network (fig. 2) data were collected on schedule and records are being prepared for publication.

PLANS FOR 1983.--The network will continue to operate with a few cooperator-requested modifications. Total trace element and pesticide analyses will be discontinued at all NASQAN and Hydrologic Bench-Mark Network stations. A collection network will be established on the outflow of New Johns Lake and stretches of Painted Woods Creek and its tributaries to sample for major constituents and nutrients.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1982 (planned).

U.S. Geological Survey, 1982, Water-resources data, North Dakota, Water year 1981, Vol. 1, Hudson Bay basin: U.S. Geological Survey Water-Data Report ND-81-1, 325 p.

U.S. Geological Survey, 1982, Water-resources data, North Dakota, Water year 1981, Vol. 2, Missouri River basin: U.S. Geological Survey Water-Data Report ND-81-2, 492 p.

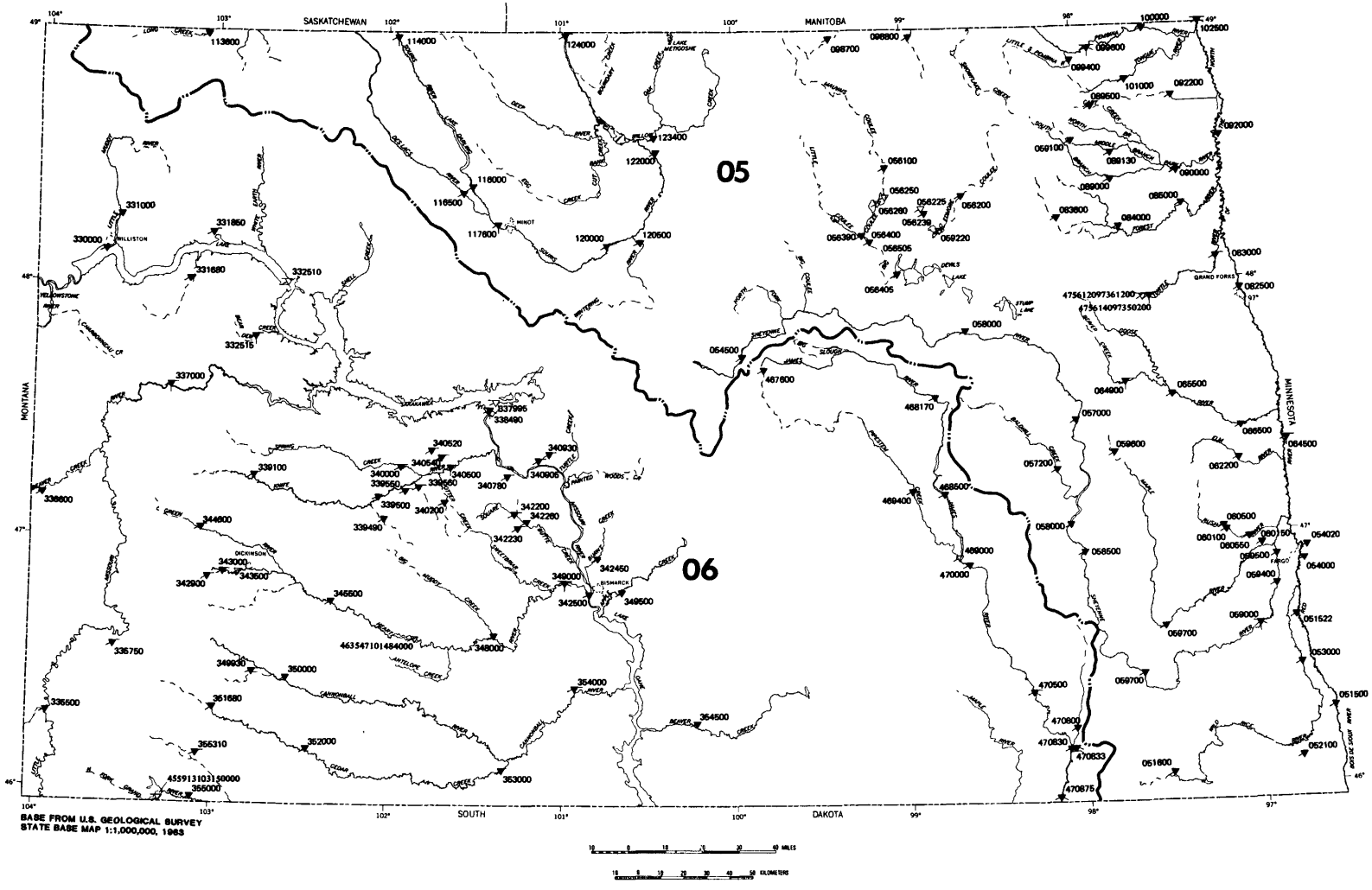


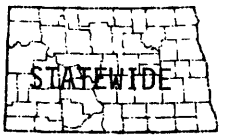
FIGURE 2.—Locations of water-quality stations.

PROJECT TITLE: Sediment Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness



OBJECTIVES.--To provide a national bank of sediment data for use in broad Federal and state planning and action programs and to provide data for Federal management of interstate and international waters.

APPROACH.--Establish and operate a network of sediment stations to provide spatial and temporal averages and trends of sediment concentration, sediment discharge, and particle size of sediment being transported by rivers and streams.

PROGRESS IN 1982.--Data were collected and analyzed for 33 partial-record stations (fig. 2). Records are being prepared for publication.

PLANS FOR 1983.--Continue to operate network.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1982 (planned).

U.S. Geological Survey, 1981, Water-resources data, North Dakota, Water year 1981, Vol. 1. Hudson Bay basin: U.S. Geological Survey Water-Data Report ND-81-1, 325 p.

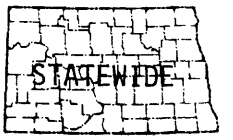
U.S. Geological Survey, 1981, Water-resources data, North Dakota, Water year 1981, Vol. 1. Missouri River basin: U.S. Geological Survey Water-Data Report ND-81-2, 492 p.

PROJECT TITLE: Ground-Water Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness



OBJECTIVES.--To collect water-level data sufficient to provide a minimum long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and potential problems can be defined early enough to allow proper planning and management. To provide a data base against which the short-term records acquired in areal studies can be analyzed. This analysis must (1) provide an assessment of the ground-water resources, (2) allow prediction of future conditions, (3) detect and define pollution and supply problems, and (4) provide the data base necessary for management of the resources.

APPROACH.--Evaluation of regional geology allows broad, general definition of aquifer systems and their boundary conditions. Within this framework and with some knowledge of the stress on the system in time and space and the hydrologic properties of the aquifers, a subjective decision can be made on the most advantageous locations of observation wells to determine long-term system behavior. This network can be refined as records become available and detailed areal studies of the ground-water system more closely define the aquifers, their properties, and the stresses to which they are subjected.

PROGRESS IN 1982.--All network data were collected on schedule. All data were tabulated and stored in District and Watstore files.

PLANS FOR 1983.--McKenzie County will be added to the network completing the statewide network. The review and update of historic ground-water level records will be completed.

REPORT PRODUCTS.--U.S. Geological Survey, 1977, Ground-water levels in the United States, 1972-74, North Central States: U.S. Geological Survey Water-Supply Paper 2163, p. 57-61.

Ground-water data for the basic network (fig. 3) have been and will continue to be published in the annual report series,"U.S. Geological Survey, Water-Resources Data, North Dakota."

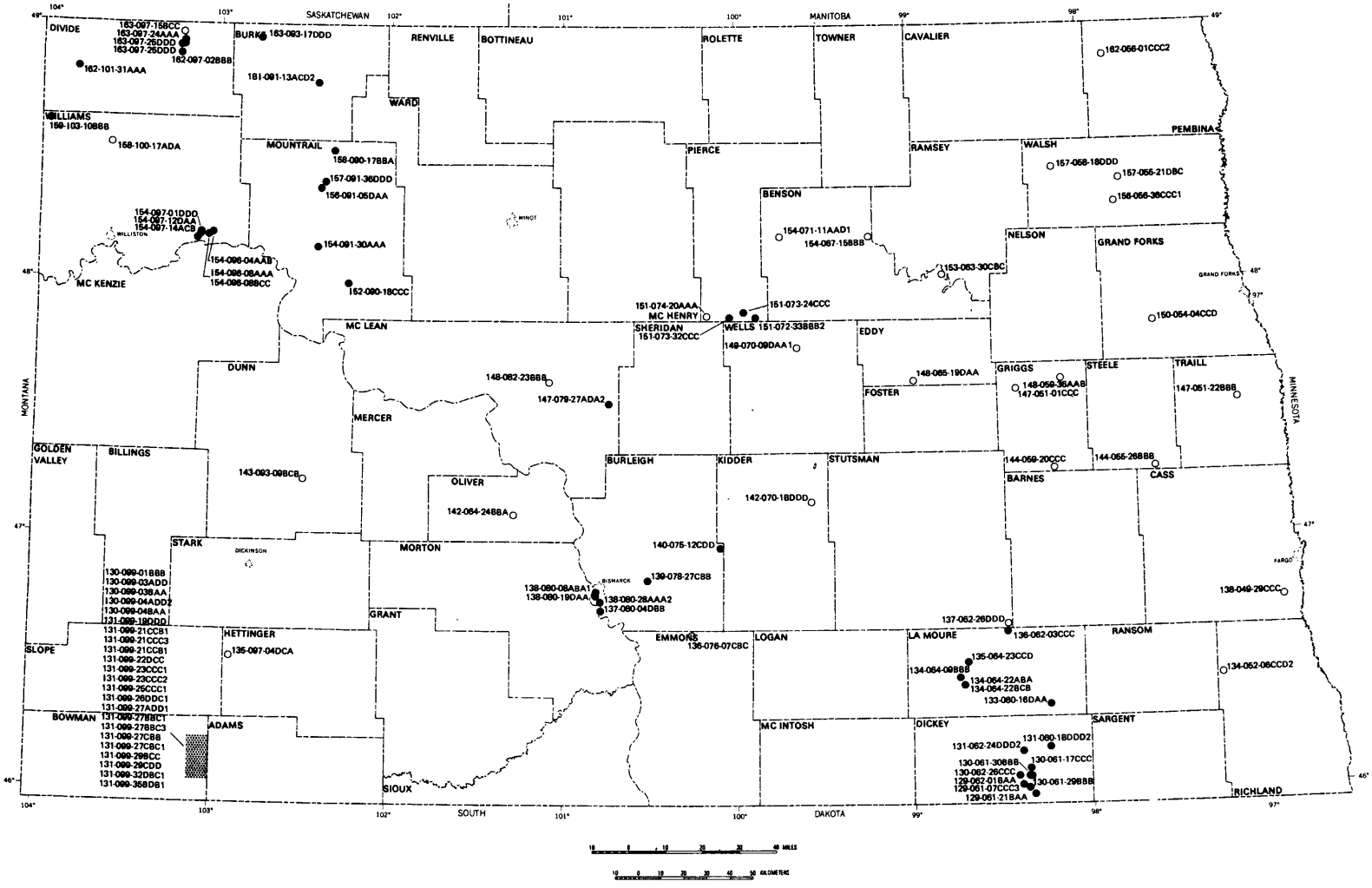


FIGURE 3.—Locations of ground-water observation wells.

PROJECT TITLE: Water-Use Data Acquisition and Dissemination Program

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Jon Patch, North Dakota State Water Commission and Norman D. Haffield, U.S. Geological Survey

OBJECTIVES.--This study will establish a program to provide water-use information for the optimum utilization and management of the State's water resources. The program will collect, store, and disseminate water-use data to complement data on availablity and quality of the State's water resources.

APPROACH.--Withdrawal uses can be evaluated quantitatively because they require removal of the water from the ground, stream, lake, or reservoir. The categories that would be applicable for obtaining the total withdrawals are irrigation, municipal use, industrial self-supply, agricultural (nonirrigation), dewatering, and injection. The total quantity of the water withdrawn can be obtained by adding together the known amounts of withdrawals. Two nonwithdrawal uses that need to be considered are recreation and preservation. For each of these categories, not only the record of withdrawal would be collected but other pertinent information that would be useful in water-use analysis.

PROGRESS IN 1982.--The major cooperator, North Dakota State Water Commission, has implemented a site specific data base on their IBM computer. They are now capable of making selective retrievals of withdrawal data by use type on either a county or hydrologic unit basis. The system will aggregate the data, but it still must be manually coded for entry into the National Water Use Data System, NWUDS.

PLANS FOR 1983.--(1) Enter all required 1980 water use data into the National Water Use Data System, NWUDS; (2) prepare a map report utilizing 1982 water use data; (3) develop a system for estimating and storing non-reported water use in state-level data system; and (4) develop software for computer entry of aggregated water-use data from state-level data base into NWUDS.

REPORT PRODUCTS.--Smith, M. L., and Harkness, R. E., 1980, Water use in North Dakota, 1980: North Dakota State Water Commission Information Series No. 31 (map).

U.S. Geological Survey, Water-use data, North Dakota, 1982 (planned).

COUNTY GROUND-WATER STUDIES

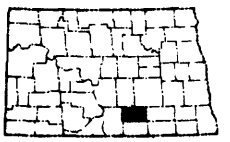
The Geological Survey has for many years had a continuing program in cooperation with state and other Federal agencies to investigate the ground-water resources of the counties in North Dakota. The studies are conducted under county or multicounty boundaries and every county has a study completed or in progress (fig. 4).

PROJECT TITLE: Ground-Water Resources of Logan County, North Dakota

LOCATION: South-Central North Dakota

PERIOD OF PROJECT: October 1977 to September 1980

PROJECT CHIEF: Robert L. Klausing



OBJECTIVES.--The purpose of the investigation is to determine the quantity and quality of ground water available for municipal, domistic, livestock, industrial, and irrigation uses. Specifically, the objectives are (1) to determine the location, extent, and nature of the major aquifers; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; (3) to estimate the quantity of water stored in the aquifers; (4) to estimate the potential yields to wells tapping the major aquifers; (5) to determine the chemical quality of the water; and (6) to identify current and projected use of ground water.

APPROACH.--This is a relatively comprehensive study of the ground-water resources. The methods of study are categorized by the following activities: (1) Project planning, (2) water records, (3) test drilling, (4) chemical quality of water sampling and analysis, (5) aquifer test and special studies, (6) data compilation and analysis, and (7) report preparation.

PROGRESS IN 1982.--The ground-water data report was published. The report "Ground-water resources of Logan County, North Dakota," has been completed and is in review.

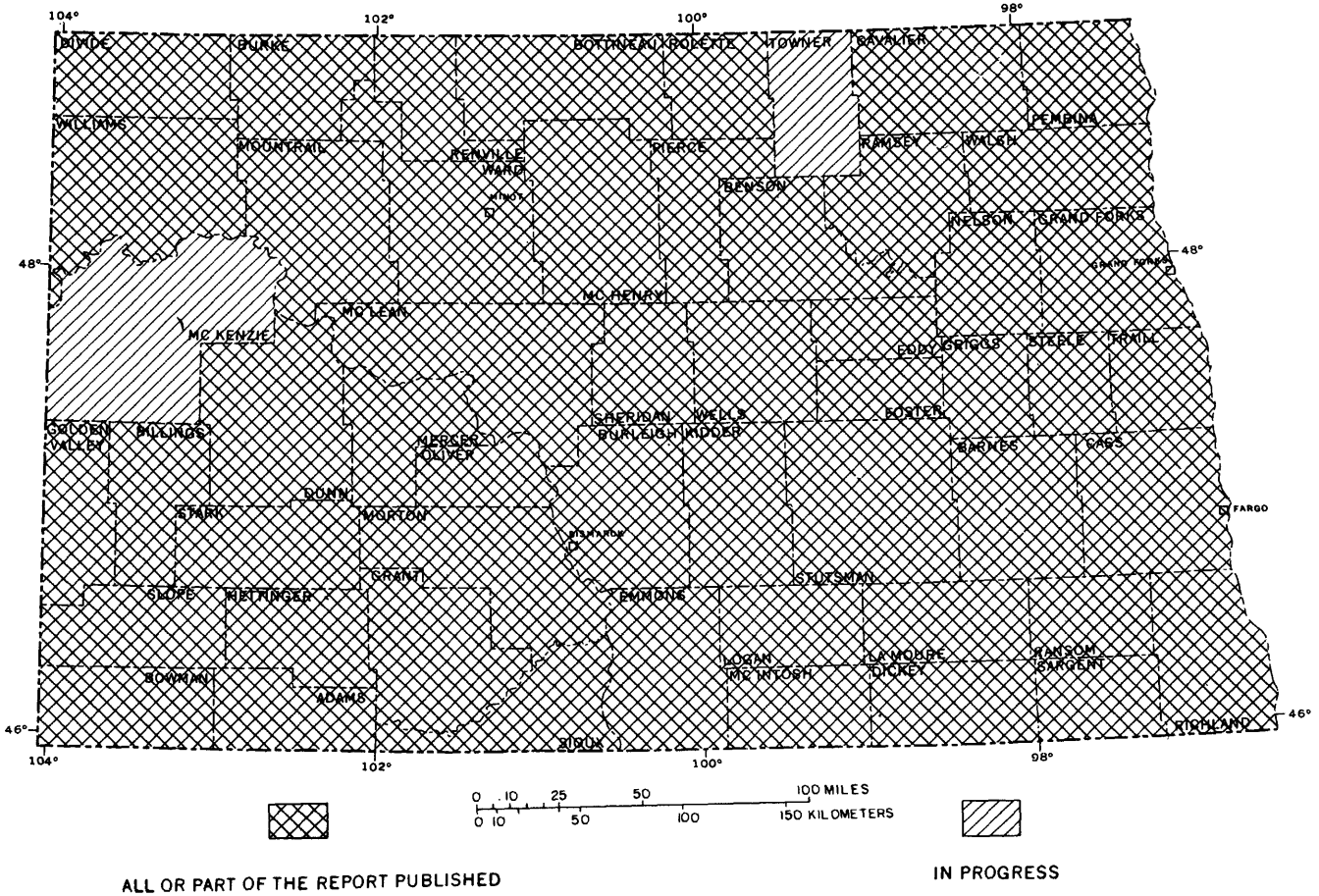


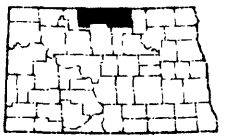
FIGURE 4.—Locations of county ground-water studies.

PLANS FOR 1983.--Complete review of final report, make necessary revisions based on reviews, comments and obtain Director's approval for publication.

REPORT PRODUCTS.--Klausing, R. L., 1982, ground-water data for Logan County, North Dakota; North Dakota State Water Commission Ground-Water Studies 34, pt. II and North Dakota Geological Survey Bulletin 77, pt. II, 299 p.

Ground-water resources of Logan County, North Dakota by R. L. Klausing (in preparation).

PROJECT TITLE: Ground-Water Resources of Bottineau and Rolette Counties, North Dakota



LOCATION: North-Central North Dakota

PERIOD OF PROJECT: October 1977 to October 1981

PROJECT CHIEF: Philip G. Randich

OBJECTIVES.--The purpose of the investigation is to determine the quantity and quality of ground water available for municipal, domestic, livestock, industrial, and irrigation uses. Specifically, the objectives are (1) to determine the location, extent, and nature of the major aquifers; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; (3) to estimate the quantities of water stored in the aquifers; (4) to estimate the potential yields to wells tapping the major aquifers; (5) to determine the chemical quality of the ground water; and (6) to identify current and potential use of ground water.

APPROACH.--This is a relatively comprehensive study of the ground-water resources. The methods of study are categorized by the following activities: (1) Project planning, (2) water records, (3) geologic mapping, (4) test drilling, (5) chemical quality of water sampling and analyses, (6) aquifer tests and special studies, (7) data compilation and analysis and (8) report preparation.

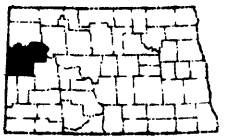
PROGRESS IN 1982.--The ground-water data report was published. The report, "Ground-water resources of Bottineau and Rolette Counties, North Dakota," has been completed and is in review.

PLANS FOR 1983.--Complete review of final report, make necessary revisions based on reviewer's comments and obtain Director's approval for publication.

REPORT PRODUCTS.--Kuzniar R. L. and Randich P. G., 1982, ground-water data for Bottineau and Rolette Counties, North Dakota: North Dakota State Water Commission Ground-Water Studies 35, pt. II and North Dakota Geological Survey Bulletin 78, pt. II, 742 p.

Ground-water resources of Bottineau and Rolette Counties, North Dakota by P.G. Randich and R.L. Kuzniar (in preparation).

PROJECT TITLE: Ground-Water Resources of McKenzie County, North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1978 to September 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The purpose of the investigation is to determine the quantity and quality of ground water available for municipal, domestic, livestock, industrial, and irrigation uses. Specifically, the objectives are (1) to determine the location, extent, and nature of the major aquifers and confining beds; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; (3) to estimate the quantities of water stored in the aquifers; (4) to estimate the potential yields to wells tapping the major aquifers; and (5) to determine the chemical quality of the ground water.

APPROACH.--This is a relatively comprehensive study of the ground-water resources. The methods of study are categorized by the following activities: (1) Project planning, (2) water records, (3) geologic mapping, (4) test drilling, (5) chemical quality of water sampling and analyses, (6) aquifer tests and special studies, (7) data compilation and analysis, and (8) report preparation.

PROGRESS IN 1982.--Three test holes ranging from 1,800 to 2,100 feet deep have been drilled to the Pierre Shale. Thirty test wells have been drilled to the base of the Tongue River Formation. Glacial channels, some containing gravel, have been outlined in the northern part of the county and about 100 test wells have been drilled into them. The well canvas is about 95 percent complete. About 150 water samples have been collected and analyzed.

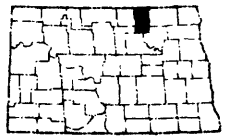
PLANS FOR 1983.--Plans for 1983 include development of the Tongue River wells, and collecting water samples. The well inventory will be completed. An analysis will be made of the remaining data, and reports will be completed.

REPORT PRODUCTS.--Geology and ground-water resources of McKenzie County, North Dakota, pt. I, Geology (planned).

Geology and ground-water resources of McKenzie County, North Dakota, pt. II, Basic data by M.G. Croft (in preparation).

Geology and ground-water resources of McKenzie County, North Dakota, pt. III, Ground-water resources by M.G. Croft (in preparation).

PROJECT TITLE: Ground-Water Resources of Towner County, North Dakota



LOCATION: North-Central North Dakota

PERIOD OF PROJECT: October 1979 to September 1982

PROJECT CHIEF: Philip G. Randich

OBJECTIVES.--The purpose of the investigation is to determine the quantity and quality of ground water available for municipal, domestic, livestock, industrial, and irrigation uses. Specifically, the objectives are (1) to determine the location, extent, and nature of the major aquifers; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; (3) to estimate the quantities of water stored in the aquifers; (4) to estimate the potential yields to wells tapping the major aquifers; (5) to determine the chemical quality of the ground water; and (6) to identify current and potential use of ground water.

APPROACH.--This is a relatively comprehensive study of the ground-water resources. The methods of study are categorized by the following activities: (1) Project planning, (2) water records, (3) geologic mapping, (4) test drilling, (5) chemical quality of water sampling and analyses, (6) aquifer tests and special studies, (7) data compilation and analysis, and (8) report preparation.

PROGRESS IN 1982.--Ground-water data report and ground-water resources report in process. A preliminary map showing availability of water from glacial-drift aquifer was published.

PLANS FOR 1983.--Complete review of reports, make necessary revisions based on reviewer's comments and obtain Director's approval for publication.

REPORT PRODUCTS.--Randich, P. G. and Kuzniar, R. L., 1982, preliminary map showing availability of water from glacial-drift aquifer in Towner County, North Dakota: U.S. Geological Survey Open-File Report 82-767.

Ground-water data for Towner County, North Dakota by P. G. Randich and R. L. Kuzniar (in preparation).

Ground-water resources of Towner County, North Dakota by P. G. Randich and R. L. Kuzniar (in preparation).

REGIONAL STUDIES

In anticipation of water demands on a scale unlimited by political boundaries or local problems, the Geological Survey is conducting studies of regional ground-water systems. Some of these studies are in cooperation with other agencies. The studies are directed toward definition of the systems and prediction of the effects of stresses that could be imposed by present and future management plans.

PROJECT TITLE: Availability of Ground Water from Aquifers in the Cretaceous and Tertiary Systems in the Fort Union Coal Region

LOCATION: Northern Great Plains (SD ND MT WY)

PERIOD OF PROJECT: July 1974 to June 1977

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The major objectives are (1) to determine the location, extent, and nature of the major aquifers and confining beds in the Cretaceous and Teritiary systems in the Fort Union coal region; (2) to evaluate the occurrence, movement, and availabilty of ground water, including sources of recharge and discharge; and (3) to determine the chemical quality of the ground water.

APPROACH.--The investigation will be concerned mainly with the compilation, analysis, and interpretation of existing pertinent data from available sources in the States of North Dakota, South Dakota, Wyoming, and Montana. Major aquifers in the Cretaceous and Tertiary systems will be identified, described, and correlated mainly through the use of geophysical and lithologic logs. Three regional hydrogeologic sections will be prepared that will illustrate the structural and stratigraphic relationships of the major aquifers. A structural map will be prepared, using the top of the Pierre Formation which, for much of the region, also will represent the lower limit of potable ground water. The final report will be prepared in the professional paper or water-resources investigations series.

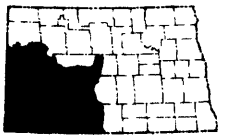
PROGRESS IN 1982.--The final interpretive report was revised following extensive in-house and colleague review and sent to the regional ground water specialist for resolution of some of the problems.

PLANS FOR 1983.--Revisions following the current reviews followed by reviews leading to Director's approval for publication.

REPORT PRODUCTS.--Thorstenson, D. C., Fisher, D. W., and Croft, M. G., 1979, the geochemistry of the Fox Hills-basal Hell Creek aquifer in southwestern North Dakota and northwestern South Dakota: Water Resources Research, v. 15, no. 6, p. 1479-1498.

Croft, M. G., and others, Geology and ground-water resources of Late Cretaceous and Teriary rocks, Fort Union coal region (in preparation).

PROJECT TITLE: Hydrology of Area 47, Northern Great Plains Coal Province, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: March 1981 to September 1982

PROJECT CHIEF: Orlo A. Crosby

OBJECTIVES.--The purpose is to describe the hydrology of Area 47 in a format readily usable by the coal-mining industry, the regulatory agencies, interest groups (such as environmental organizations), and the general public. The specific objectives of the study are to present (1) a description of the area in a hydrologic framework, (2) a quantitative assessment of the occurrence and availability of water, (3) an assessment of the present quality of available water, and (4) an identification of current and planned utilization of water.

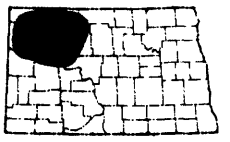
APPROACH.--A topic outline will be developed, based on previous reports. Only existing data will be utilized to establish an information framework for the study area. All available data will be used to prepare graphs, maps and text to fulfill the objectives of the study. The report will be prepared in accordance with the STOP (Sequential Thematic Organization of Publications) format.

PROGRESS IN 1982.--The final report was completed through colleague review.

PLANS FOR 1983.--Plans are to effect the revisions indicated by the colleague review and process the report through Director's approval.

REPORT PRODUCTS.--Hydrology of Area 47, northern Great Plains coal province, North Dakota by O. A. Crosby and R. L. Klausing (in preparation).

PROJECT TITLE: Hydrology of Area 46
Northern Great Plains Coal
Province, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The purpose is to describe the hydrology of Area 46 in a format readily usable by the coal-mining industry, the regulatory agencies, interest groups (such as environmental organizations), and the general public. The specific objectives of the study are to present (1) a description of the area in a hydrologic framework, (2) a quantitative assessment of the occurrence and availability of water, (3) an assessment of the present quality of available water, and (4) an identification of current and planned utilization of water.

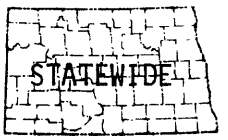
APPROACH.--A topic outline will be developed, based on previous reports. Only existing data will be utilized to establish an information framework for the study area. All available data will be used to prepare graphs, maps, and text to fulfill the objectives of the study. The report will be prepared in accordance with the STOP (Sequential Thematic Organization of Publications) format.

PROGRESS IN 1982.--Work on ground water sections was started.

PLANS FOR 1983.--Complete ground-water and surface water sections of report, process through reviews and obtain Director's approval for publication.

REPORT PRODUCTS.--Hydrology of Area 46, northern Great Plains coal province, North Dakota (ground-water sections are in preliminary form).

PROJECT TITLE: Changes in Precipitation Chemistry Resulting from Coal-fired Energy Conversion Plants in North Dakota



LOCATION: North Dakota

PERIOD OF PROJECT: October 1981 to September 1983

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--Detailed geochemical investigations will be made to (1) determine baseline concentrations of certain elements in aerosol, precipitation, soil, and water prior to large-scale development of fuel resources; (2) examine this base line data for evidence of current influences by coal-fired generating facilities; (3) determine the variation in composition of atmospheric precipitation both temporally and spatially; (4) identify and evaluate mechanisms by which elements transfer within the ecosystem among atmosphere, water and soil components; and (5) determine the impact of changes in precipitation chemistry on surface- and ground-water quality. The results of these studies should provide the necessary basis to (1) develop a conceptual model of the processes controlling the composition of atmospheric deposition, (2) follow with a mathematical model for quantitative predictions of future changes in precipitation quality network to determine long-term changes in the quality of precipitation.

APPROACH.--Representative receptor locations will be chosen within and downwind of the energy development area in western North Dakota. Meteorological data and chemical data for wetfall and dryfall collected at each receptor location will be statistically evaluated to determine the covariance of parameters measured. Parameters indicative of differing types of energy development will be identified and monitored on an event basis. Stable isotopes will be monitored periodically to determine the proportion of acidic substances in precipitation contributed by biogenic processes and fossil fuel combustion. A mass balance-flux type model will be used to evaluate the effects of changing precipitation composition on the hydrologic system. An atmospheric model developed by the North Dakota State Health Department may be used to evaluate the effects of power-plant emissions on precipitation quality and predict future impacts. The composition of streams and lakes in the vicinity of precipitation stations will be monitored to measure the effects of precipitation chemistry on local surface waters. If impacts of degraded atmospheric deposition are recognized in local surface waters, regional surface- and ground-water quality data collected as part of the statewide network will be evaluated to determine the extent of these impacts.

PROGRESS IN 1982.--Chemical analyses of atmospheric deposition collected during 1980 and 1981 at collection sites near Wibaux, Montana, and Gascoyne and Beach, North Dakota were compiled and statistically evaluated to determine parametric covariance and apparent meteorologic controls on precipitation composition. Parameters influenced by fossil fuel combustion were identified. Additional atmospheric deposition was collected at Canfield Lake, North Dakota, and compared to data collected by the North Dakota State Health Department at Dunn Center and Woodworth and data collected by the National Atmospheric Deposition Program in the North Unit of the Theodore Roosevelt National Park, North Dakota. The quality of water in potholes adjacent to the precipitation collection stations at Canfield Lake and Woodworth and a small-basin, headwater stream near Dunn Center was determined monthly to determine the hydrologic consequences of changing precipitation chemistry.

PLANS FOR 1983.--Statistical evaluation of data obtained during 1982 will continue. Atmospheric deposition will continue to be monitored at Canfield Lake, Dunn Center, and Woodworth. Additional sites will be installed at Canfield Lake or Woodworth and Icelandic State Park, North Dakota, for weekly operation as National Trends Network (NTN) precipitation chemistry stations. The composition of surface waters adjacent to precipitation stations will continue to be monitored.

REPORT PRODUCTS.--Houghton, R. L., 1983, Composition of atmospheric deposition in western North Dakota: Proceedings, 75th Annual Meeting of the North Dakota Academy of Science, Grand Forks, ND, April 28-30, 1983.

Houghton, R. L., Berger, M. E., Zander, N., and Dutchuk, S. K., Atmospheric deposition: Sample handling, storage, and analytical procedures for chemical characterization of event-based samples in North Dakota (in preparation).

Houghton, R. L., Acidification of North Dakota surface waters: Proceedings, Symposium on Acid Rain in Western Canadian Provinces, Regina, Saskatchewan, May 26-27, 1983 (planned).

Houghton, R. L., Elevated mercury levels in the basin of the Red River of the North, North Dakota (planned).

Relationship between energy development and precipitation chemistry in western North Dakota (planned).

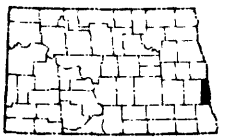
Acid Rain?--Composition of precipitation in North Dakota (planned).

Acid Rain: Geological Survey fact sheet (in progress).

AQUIFER EVALUATIONS

As the county ground-water resources studies have been completed, there has generally been renewed interest in irrigation or other uses, where suitable water was found to be available. The stress placed on some of the somewhat limited drift aquifers has led to a program aimed at evaluating the aquifers for development of the ground-water supply and to enhance the assessment of the State's water resources.

PROJECT TITLE: Evaluation of Hydrologic Effects of Withdrawal on the West Fargo Aquifer



LOCATION: Eastern Cass County, North Dakota

PERIOD OF PROJECT: October 1979 to September 1982

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--(1) To describe the geometric and geologic characteristics of the aquifer. (2) to define the spatial distribution of the water-bearing properties of the aquifer, the head relationships, and the sources and amounts of recharge and discharge.

APPROACH.--There will be a careful review of published data and interpretations and data available from recent test drilling followed by a program of drilling of selected new test holes. A digital model of the aquifer will be developed as an aid in determining boundary conditions and data gaps and as a verification of the conceptual model.

PROGRESS IN 1982.--Data compilation and analysis were completed and the final report prepared for the project. Due to the complexity of the aquifer system, the North Dakota State Water Commission will make further studies as financial considerations permit.

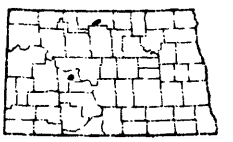
PLANS OF 1983.--Complete report through the review process to Director's approval for publication.

REPORT PRODUCTS.--"Hydrologic effects of withdrawal on the West Fargo aquifer system, Cass County, North Dakota," by C. A. Armstrong (in progress).

SPECIAL INVESTIGATIONS

Special hydrologic investigations are often needed to supplement the ongoing program. These special investigations include water-supply problems, drainage problems, ground-water and surface-water relationships, ground-water recharge, and water management. The objective is to assist State and Federal agencies in solving water-resources problems on short notice.

PROJECT TITLE: Sampling Landscape-Stratified Snow Covers by Ground and Airborne Snow Survey Techniques



LOCATION: North Central North Dakota

PERIOD OF PROJECT: October 1980 to September 1982

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The objectives of the investigation are (1) to investigate the possibilities of combining airborne snow survey and landscape-stratified ground snow survey techniques to determine snow water equivalents on selected landscape units, and (2) to investigate the possibilities of delineating the airborne snow survey data to account for snow distribution.

APPROACH.--Two methods of making snow surveys will be used to obtain the objectives of the study. The first method is a ground snow survey using a terrain type land-use method as outlined by Steppuhn and Dyck[1/]. Pastures, cultivated fields, sloughs, brush, etc., within the same climatic region tend to accumulate snow according to recurring patterns unique to specific terrain type and land use. Therefore, snow samples are collected within similar areal units resulting in a ready, but statistically valid, method of estimating true snow-water equivalents. The second method is an airborne snow survey system based on the attenuation of natural terrestrial gamma radiation due to snow cover. The operational program serves primarily National Weather Service River Forecast Centers in the upper Midwest. The delineation of the airborne snow survey data into smaller segments to determine the variation of snow cover will be examined.

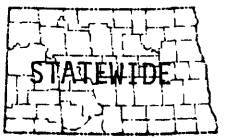
1/ Steppuhn, H., and Dyck, G.E., 1974, Estimating true basin snow cover; Proceedings of Symposium on Advanced Concepts and Techniques in the Study of Snow and Ice Resources: U.S. National Academy of Sciences, Washington, D.C., p. 314-324.

PROGRESS IN 1982.--Snow survey data were collected and analyzed. A draft of the interpretive report was prepared and is in review.

PLANS FOR 1983.--Plans for 1983 are to complete the review for the interpretive report and obtain Director's approval for publication.

REPORT PRODUCTS.--Sampling landscape-stratified snow cover by ground and airborne snow survey techniques by Emerson, D. G., Carroll, T. R., and Steppuhn, H. (in preparation).

PROJECT TITLE: Pumping Technique Bias in Chemistry of Ground-Water Samples



LOCATION: Statewide

PERIOD OF PROJECT: October 1980 to September 1982

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The objective of this investigation is to determine the nature and magnitude of chemical biases introduced during the sampling of ground water by several different common pumping methods. Pumps being investigated include airlift, air squeeze, gas-driven reciprocating, peristaltic, and submersible. The use of bailers for water-quality sampling also is evaluated. Comparison of analyses of ground water sampled by these techniques should provide a basis for evaluating historical ground-water data and determining preferred methods for future sampling.

APPROACH.--In phase 1 of the project, only wells cased with polyvinyl-chloride (PVC) liners and packed with nonreactive silica were studied, thus minimizing water alteration due to well conditions. Metal casings can contribute significant trace metal loads to the samples, while PVC liners may enchance determined organic carbon values. During phase 2, wells of all types were studied; but only water from wells of similiar construction and composition were considered in each statistical group. To fully assess the affected parameter, deep, intermediate, and shallow wells were included. Further, to assure applicability of the results to all water types, wells yielding sulfate, bicarbonate, and chloride water were studied.

PROGRESS IN 1982.--All sampling and data compilation were completed. Statistical analysis of the data was initiated.

PLANS FOR 1983.--Statistical analysis of the data will be completed. A report of project results will be finalized.

REPORT PRODUCTS.--Effect of sampling method on the apparent quality of ground water by Houghton, R. L., and Berger, M. E. (in preparation).

PROJECT TITLE: Kinematic-Wave Approximation of One-Dimensional Dynamic Waves

LOCATION: Not related to location

PERIOD OF PROJECT: October 1981 to September 1982

PROJECT CHIEF: Jeffrey E. Miller

OBJECTIVES.--The objective of this study is to provide a basic reference on the theory and application of the kinematic-wave model and to describe the limitations of the model in relation to the other approximations of the dynamic-wave model.

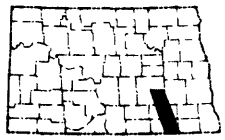
APPROACH.--The project examines the development, assumptions and approximations, properties, criteria for application, current applications, and solution techniques of kinematic-wave theory in water routing.

PROGRESS IN 1982.--The draft of the report and colleague review was completed.

PLANS FOR 1983.--Obtain Directors approval for publication.

REPORT PRODUCTS.--Basic concepts of kinematic-wave models by J. E. Miller (in preparation).

PROJECT TITLE: Hydrology of the Lower James River Basin in North Dakota



LOCATION: Southeastern North Dakota

PERIOD OF PROJECT: October 1981 to September 1984

PROJECT CHIEF: Jeffrey E. Miller and Paul K. Christensen

OBJECTIVES.--The objectives of this study are to (1) define the hydrology of the ground-water and surface-water system and (2) develop a numerical model of the system and determine its predictive capabilities for the evaluation of water-use impacts.

APPROACH.--The project will be done in a series of stages over a 3-year period. The ground-water and surface-water system will be defined as far as possible with currently available data. Based on this definition, a data-collection procedure will be designed so that the system can be redefined in detail. Ground-water levels, flow data, and ground-water and surface-water quality differences will be used to define the system. A prelim inary report will be prepared. Additional data needs, again will be determined and the data collected before the final system definition is completed. Based on the system and approach, a model will be developed, tested, and described in the final report.

PROGRESS IN 1982.--Based on the results of over 21,000 feet of drilling and the development of 100 monitoring wells an updated conceptual model of the ground-water and surface-water system has been developed. The digital modeling system for simulating the ground-water and surface-water system has been designed and initial programming completed. The system is based on the USGS modular ground-water model.

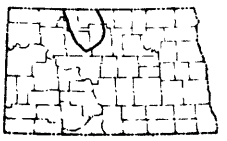
PLANS FOR 1983.--Final preparation of the first report will be completed. Additional data collection including a seepage run under ice and drilling will be completed. Preliminary work on the data report will be done. Final development of the digital ground-water and surface-water model will be done.

REPORT PRODUCTS.--Preliminary report on the effects of water use on the ground-water and surface-water system of the lower James River basin, North Dakota (planned).

Ground-water and surface-water data for the lower James River basin, North Dakota (planned).

Effects of water use on the ground-water and surface-water system of the lower James River basin, North Dakota (planned).

PROJECT TITLE: Water Quality Assessment of the Souris River within North Dakota



LOCATION: Souris River within North Dakota

PERIOD OF PROJECT: October 1981 to September 1984

PROJECT CHIEF: Edwin A. Wesolowski

OBJECTIVES.--(1) To define the hydrologic system and the current water-quality problems. (2) To determine time-of-travel, dispersion, and rearation characteristics. (3) To quantitatively evaluate water-quality processes. (4) To develop conceptual and digital models to evaluate the waste load and water-quality relationships and to predict the effect of waste discharges on the river at various flows and at selected reaches of the river.

APPROACH.--Existing data will be used to identify seasonal water-quality and hydrologic trends and conditions when the river is susceptible to degradation. At these critical periods additional data will be collected to isolate the processes that degrade the stream. A one-dimensional, steady-state, water-quality model will evaluate these processes using the new data and field determined times-of-travel and dispersion and reaeration coefficients.

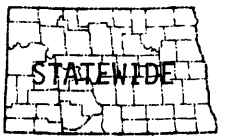
PROGRESS IN 1982.--Twenty-four sampling sites were located on the Souris River and four sets of synoptic samples were collected under different flows and climatic conditions. One 13-mile reach of the Souris River was analyzed for time-of-travel dispersion and reaeration characteristics.

PLANS FOR 1983.--Using data collected in 1982, calibrate and verify steady-state water-quality model. Collect another set of synoptic samples if required to verify the model or if extreme low-flow conditions exist in the river. Perform dye and gas tracer studies on six 5-mile reaches. Collect at selected sites additional benthic samples.

REPORT PRODUCTS.--Techniques for evaluating water-quality in the Souris River (planned).

Water-quality of the Souris River (planned).

PROJECT TITLE: Inventory and Analysis of Information for Flood Plain Management in North Dakota



LOCATION: Statewide

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The objectives of this study are to (1) determine all data available regarding flood hazards, hydraulics, and hydrology for particular areas, (2) analyze these data to determine their adequacy for flood-plain management purposes, (3) if adequate, present these data in a format usable to local flood-plain administrators, and (4) if inadequate, determine the effort necessary to produce "best engineering judgment" flood elevations.

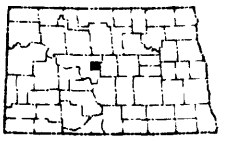
APPROACH.--A systematic and comprehensive data search will be conducted for each site. The data search will include files of the USGS, other Federal agencies, and the State agencies. Direct contact will be made with governmental units responsible for area under consideration. The data obtained through the systematic search will be analyzed for its adequacy in defining flood information. If found adequate, data will be put into a format that can be used by managers. If the data are found inadequate, an attempt will be made to establish the fieldwork and analytical work necessary to provide at least a minimal base for flood management decisions.

PROGRESS IN 1982.--None. New project.

PLANS FOR 1983.--Plans for 1983 are to complete compilation and flood data analysis for selected areas.

REPORT PRODUCTS.--Public-oriented report of data search and analyses of selected areas (planned).

PROJECT TITLE: Evaluation of the Effects on Ground-Water Levels Due to the Rise in Water Level in Lake Audubon, McLean County, North Dakota



LOCATION: Central North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--The purpose of the investigation is to describe in the detail possible with available records the changes in ground-water levels and the levels of surface-water bodies since the filling of Lake Audubon. A second phase may result which would entail monitoring of water levels and the development of a model to predict future effects of Lake Audubon on water levels.

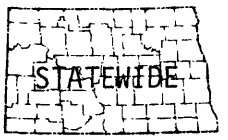
APPROACH.--Compile all available data on ground-water levels and lake levels in the Lake Audubon area. Process the data to produce water-level maps and hydrographs. The resulting data and figures will then be used to evaluate the problems of rising water levels and their relationship to the filling of Lake Audubon.

PROGRESS IN 1982.--A detailed project proposal and work plan was prepared.

PLANS FOR 1983.--Assemble, compile and analyze existing data and complete final report. Process through review to obtain Director's approval for publication.

REPORT PRODUCTS.--Evaluation of the effects of Lake Audubon on ground-water levels in the Lake Nettie area, eastern McLean County, North Dakota by C. A. Armstrong (in preparation).

PROJECT TITLE: Evaluation of the Theory and Methodology for Quantifying Recharge and Evapotranspiration for Shallow Glacial Aquifers in North Dakota



LOCATION: Statewide

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: William F. Horak Jr.

OBJECTIVES.--Several of North Dakota's shallow glacial aquifers have been extensively developed for irrigation and municipal water supplies. Requests for new ground-water use permits for these aquifers are evaluated with regard to the impact of the proposed use on prior appropriators and on the overall water budget of the geohydrologic system. The evaluation procedure, particularly for the aquifers that are already heavily appropriated, generally includes the use of ground-water flow models. The models frequently have given unsatisfactory results, however, because reliable data concerning recharge and evapotranspiration magnitudes for North Dakota aquifers are lacking. This study is designed therefore, to provide information concerning recharge and evapotranspiration that will strengthen the credibility of aquifer management decisions. Specifically, the study objectives are to (1) review the hydrologic literature dealing with the determination of ground-water recharge and evapotranspiration; (2) review the theory and methodology for the determination and estimation of the critical soil and meteorological parameters; (3) consider the relative merits of a rigorous, data-intensive approach versus an estimation, parametric approach; and (4) Review the agronomic research, past and present, in North Dakota for applicability of the research and the data generated to the study of recharge and evapotranspiration.

APPROACH.--This study will involve no original data collection. Rather, achievement of the objectives will involve an extensive study of the literature and a canvassing of appropriate scientific agencies and institutions. The study will have application to all shallow glacial aquifers in North Dakota. It is expected that this study provide the background research, preliminary planning, and sound approach for a subsequent project that would actually acquire the data and make the analyses and interpretations necessary for quantifying recharge and evapotranspiration.

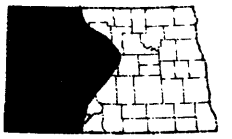
PLANS FOR 1983.-- This is a one-year study. The project will be completed, including the final report, in FY 83.

REPORT PRODUCTS.-- The final report,"Drift aquifer recharge in North Dakota," will be published in the Water Resources Investigations series of the U.S. Geological Survey.

ENERGY-RELATED STUDIES

The expanding domestic energy demand has resulted in increased coal production and associated development in North Dakota. To meet the requirements for coal leasing and environmental protection, the Geological Survey has developed a program to evaluate the water resources in areas of current and planned development. This program is effected through the cooperation of interested agencies and Geological Survey funds.

PROJECT TITLE: Hydrologic Changes Due to Lignite Mining in North Dakota, Part 1-Reconnaissance of Strippable Lignite Deposits



LOCATION: Western North Dakota

PERIOD OF PROJECT: July 1974 to June 1977

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--The project objectives are to define for each strippable lignite deposit (as identified in publications of the U.S. Bureau of Mines and the U.S. Geological Survey) the following information: (1) A summary of local geologic conditions; (2) description of the local ground-water flow system; (3) flow characteristics of the streams; (4) chemical quality of water from streams, lakes, and aquifers; (5) stream sediment loads; and (6) recommendations for more intensive hydrologic studies in probable problem areas.

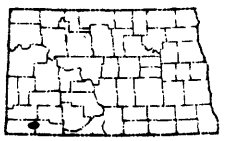
APPROACH.--A field reconnaissance will be made to evaluate the deposit areas in regard to geology, topography, and land use. A literature and data search will be made and all hydrologic and geologic data computerized. Conceptual models will be developed for each site through preliminary analysis and interpretation of available data. Additional data needs will be defined and a program of data collection instituted. These data will then be used to further develop and test the conceptual models. The probable hydrologic changes due to mining will be evaluated for each deposit, and recommendations for areas of future intensive hydrologic study will be made.

PROGRESS IN 1982.--The ground water aspects of the lignite deposit areas has been completed. These are being incorporated into second generation reports. One area, the Avoca deposit, is being reported on separately.

PLANS FOR 1983.--Complete the review of the report on the Avoca deposit and process through Director's approval.

REPORT PRODUCTS.--Hydrologic reconnaissance of lignite deposit areas in North Dakota, Avoca deposit by W. F. Horak and O. A. Crosby (in preparation).

PROJECT TITLE: Hydrologic Effects of Strip Mining in the Gascoyne Area, Bowman County, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: July 1975 to June 1978

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The purpose of the investigation is to determine and evaluate the effects upon the hydrologic system created by the expansion of the Gascoyne lignite mine. Specifically, the objectives are (1) to measure and predict the changes in the runoff characteristics, sediment load, and water quality of streams draining the mine area; and (2) to determine the location and extent of the major aquifers and predict the changes in chemical quality of water within them.

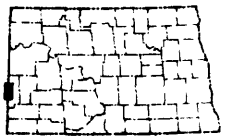
APPROACH.--The existing hydrologic system will be simulated with a digital conceptual model involving finite element and difference approximations of the ground-water and surface-water flow equation. Data for the models will be obtained from new and existing test wells and gaging stations.

PROGRESS IN 1982.--Owing to problems in getting the original report processed, the results of this investigation were incorporated into a report for a followup investigation (see p. 46 of this report). The final report has been through colleague review.

PLANS FOR 1983.--Make necessary revisions following colleague review and process report through Director's approval.

REPORT PRODUCTS.--Geochemistry of the Upper Fort Union Group as related to impacts of strip mining of lignite in the Gascoyne area, North Dakota: geologic, hydrologic and geochemical framework by Houghton, R. L., Thorstenson, D. C., Fisher, D. W., Croft, M. G., and Gronewold, G. H. (in preparation).

PROJECT TITLE: Evaluation of Probable Hydrologic Effects of Future Lignite Mining and Reclamation Activities in the Wibaux-Beach Deposit Area, Wibaux County, Montana, and Golden Valley County, North Dakota



LOCATION: Montana-North Dakota Border, Central Latitude

PERIOD OF PROJECT: October 1977 to September 1981

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--(1) Define the stratigraphic sequence within a few hundred feet above and below the minable lignite; (2) define the premining hydrologic and hydrochemical regime of the Wibaux-Beach deposit area; and (3) describe some of the hydrologic implications attendant the strip-mining process. A fourth objective, the establishment of a historical data base with which to access any modifications to the system attributable to future mining, should be accomplished as a byproduct of the other three.

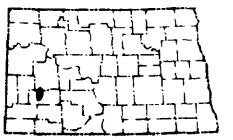
APPROACH.--Data from 200 test holes and 100 observation wells were the basis for interpretations of the geologic framework of the study area in terms of dominant lithologies and bed associations. The major aquifers were identified and mapped and the ground-water flow regime of each aquifer was described. The mode and degree of interaction between the aquifers was also hypothesized. Sampling of most of the observation wells for chemical analysis enabled the water-quality characterization of the aquifers and the identification of possible mechanisms for the genesis of those characteristics, particularly for the Harmon lignite aguifer. Streamflow magnitudes and water quality were monitored at gaging stations on the four streams that drain most of the minable area. Qualitative considerations of the hydrologic and hydrochemical impacts of mining were presented and the types of data that would be required for a more rigorous analysis of impacts were identified.

PROGRESS IN 1982.--The final report was completed and submitted for review. In-house and editorial reviews were completed.

PLANS FOR 1983.--Continue the review process through Director's approval.

REPORT PRODUCTS.--The report,"Geohydrology and water-quality of the Wibaux-Beach lignite deposit qrea, eastern Montana and western North Dakota," by W. F. Horak will be submitted for publications in the Water Resources Investigations series of the U.S. Geological Survey.

PROJECT TITLE: Evaluation of Probable Hydrologic Effects of Future Lignite Mining and Reclamation Activities in the Rattlesnake Butte Area, North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1978 to September 1982

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--(1) Determine the geographical extent of the minable lignite beds and identify aquifers to a depth of about 400 feet beneath the lower minable lignite; (2) assess the ground-water flow regime in all aquifers encountered; (3) evaluate the flow characteristics of the two streams draining the study area; (4) evaluate the water quality of the aquifers and streams in the study area; and (5) qualitatively assess the impacts on the hydrologic system that mining might impart.

APPROACH.--Data from 65 test holes and 40 observation wells were the basis for interpretations of the geologic framework of the study area in terms of dominant lithologies and bed associations. The major aquifers were identified and mapped and the ground-water flow regime of each aquifer was described. The mode and degree of interaction between the aquifers was also hypothesized. Sampling of most of the observation wells for chemical analysis enabled the water-quality characterization of the aquifers. Streamflow magnitudes and water quality were monitored at gaging stations on the two streams that drain the minable area. Qualitative considerations of the hydrologic and hydrochemical impacts of mining was presented.

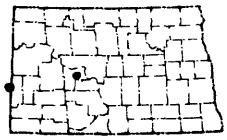
PROGRESS IN 1982.--The final report was completed and submitted for review. In-house and editorial reviews were completed.

PLANS FOR 1983.--Continue the review process through Director's approval.

REPORT PRODUCTS.--The report,"Water resources of the Ratttlesnake Butte Area, a site of potential lignite mining in west-central North Dakota," by W. F. Horak, will be submitted for publication in the Water Resources Investigations series of the U.S. Geological Survey.

PROJECT TITLE: Evaluation Through Modeling of Probable Surface-Water Hydrologic Effects of Future Lignite Mining and Reclamation Activities in the Antelope Creek Area, Mercer County, North Dakota, and the Wibaux-Beach Deposit Area, Wibaux County, Montana, and Golden Valley County, North Dakota

LOCATION: Mercer County, North Dakota, and Wibaux County, Montana



PERIOD OF PROJECT: October 1979 to September 1982

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The objectives of this investigation are (1) to determine premining hydrologic conditions in a small representative drainage basin, (2) to provide historical data with which to compare the magnitude of change with mining, and (3) to develop the capability of making reasonably accurate projections of hydrologic effects resulting from the various land treatments imposed by surface mining.

APPROACH.--This will be a very comprehensive study of two small representative watersheds. A surface-water model will be developed through coupling of snowmelt-rainfall-runoff models. A modular-design program will be used with each element of the hydrologic system being defined by a subroutine. This program has the capability of combining subroutines to best fit a particular problem. A distribution-parameter approach is being used by having the basin partitioned into subunits based on slope, aspect, vegetation type, soil type, and snow distribution. Each subunit will be considered homogeneous with respect to these parameters. Partitioning into subunits will help define the temporal and spatial variations of the hydrologic characteristics, climatic variables, and overall system response.

PROGRESS IN 1982.--Data collection for the investigation was discontinued in May. The USGS's Precipitation Runoff Modeling System was calibrated for both watersheds for the snowmelt runoff. Drafts of a data report and an analysis report were prepared and are in review.

PLANS FOR 1983.--Plans for 1983 are to complete the review for the data and analysis reports and obtain Director's approval for publication.

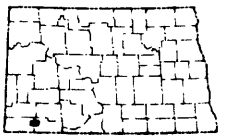
REPORT PRODUCTS.--Emerson, D. G., 1981, Progress report on the effects of surface mining on the surface-water hydrology of the selected basins in the Fort Union Coal Region, North Dakota and Montana: U.S. Geological Survey Open-File Report 81-678.

Emerson, D. G., 1982, Hydrologic analysis of high flow from snowmelt on small basins in the Fort Union Coal Region: Proceedings of North Dakota Academy of Science 74th Annual Meeting, Bismarck, ND, April 22-24, 1982, V. 36, p. 42.

Data from the surface-water hydrologic investigations of the Hay Creek study area, Montana and the West Branch Antelope Creek study area, North Dakota, October 1976 through April 1982 by D. G. Emerson, S. W. Norbeck, and K. L. Boespflug (in preparation).

Hydrologic analyses of Hay Creek, Montana and West Branch Antelope Creek, North Dakota by D. G. Emerson (in preparation).

PROJECT TITLE: Geochemistry of the Upper Fort Union Group as Related to Impacts of Strip Mining of Lignite in the Gascoyne Area, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: October 1979 to September 1983

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The purpose of this investigation is to quantitatively describe major controls on the movement of critical solutes in local and regional ground-water systems within the Fort Union Group affected by surface mining of lignite in western North Dakota. Specific objectives at the Gascoyne site are to define the hydrogeologic and hydrogeochemical character of the shallow ground-water system in the area and to ascertain the source of observed anomalous sulfate concentrations. The effects of discharge of mine-impacted ground water on the surface-water system in the area are also of concern.

APPROACH.--The first phase was to establish a clear and complete understanding of the hydrologic regime. Next the mineralogy and mineral chemistry of the Fort Union Group was determined. Thirdly, determinations of formation cation-exchange rates and constants were determined. Fourth oxidation-reduction reactions were defined for important species pairs. Finally, the solute flux from mine to locations of water use must be defined as mining expands.

PROGRESS IN 1982.--Evaluation of the geologic and hydrologic regimes in the vicinity of the Gascoyne mine was completed. A conceptual model of geochemical controls on ground-water composition was developed and used to synthesize an inverse solute transport simulation of the shallow aquifer system beneath the mine area. As this simulation is not unique, continued data collection is required to verify the model.

PLANS FOR 1983.--Ground-water flow and inverse solute transport models will be documented and published. Water-quality monitoring of 20 ground-water wells and one surface-water station on a tributary of Buffalo Creek draining the mine area will continue. An additional surface-water station will be installed above the mine to further constrain water-quality changes which may be due to mining. The existing data base will be evaluated to identify which chemical parameters in ground water and surface water are good indicators of mine impact.

REPORT PRODUCTS.--Hydrogeochemical indicators of strip mine impacts in the Fort Union coal region, North Dakota (planned).

Houghton, R. L., and Croft, M. G., Geochemistry of the Upper Fort Union Group as related to impacts of strip mining of lignite in the Gascoyne area, North Dakota: Hydrologic flow and inverse solute transport models (planned).

Houghton, R. L., Thorstenson, D. C., Fisher, D. W., Croft, M. G., and Groenewold, G. H., Geochemistry of the Upper Fort Union Group as related to impacts of strip mining of lignite in the Gascoyne area, North Dakota: Geologic, hydrologic, and geochemical framework (planned).

Houghton, R. L., Probable and observed hydrologic consequences of lignite strip mining in the Fort Union Group near Gascoyne in southwestern North Dakota (planned).

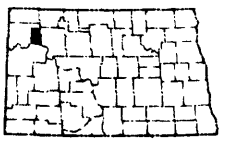
Houghton, R. L., Weathering of coal scoria -- a source for diagenetic silica cements? [abs.]: Proceedings of the U.S. Geological Survey Workshop on Diagenesis, Denver, CO, March 1982 (planned).

Houghton, R. L., 1982, Hydrogeochemical consequences of strip mining in the Fort Union Group of southwestern North Dakota: Proceedings of the 1982 National Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, Lexington, KY, December 6-10, 1982, p. 79-86.

Houghton, R. L., 1982, Hydrochemistry of shallow ground water from the Fort Union Group near the Peerless lignite strip mine, Gascoyne, southwestern North Dakota [abs.]: Proceedings 74th Annual Meeting of the North Dakota Academy of Science, Bismarck, ND, p. 40.

Houghton, R. L., and Davison, D., 1982, Stratigraphy and paleoenvironment of the Paleocene Fort Union Group of the Williston basin near Gascoyne, southwestern North Dakota [abs.]: Proceedings, 74th Annual Meeting of the North Dakota Academy of Science, Bismarck, ND, p. 15.

PROJECT TITLE: Evaluation of Probable Hydrologic Effects of Future Lignite Mining and Subsequent Reclamation Activities in the M & M Deposit, Williams County, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1980 to September 1983

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--Define the hydrologic regime in the greatest possible detail consistent with the duration of the study and funding. This will include assessment of the ground-water flow system and its chemical characteristics, determination of flow frequencies and magnitude, chemical quality, and sediment concentration and load of the larger streams. Establish a historical data base. Develop the capability for projecting the hydrologic effect of physical treatments imposed by surface mining.

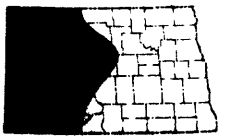
APPROACH.--Data will be assembled and collected for use in conjunction with digital models to define the ground-water flow system. The surface-water system will be defined through available records, data collection, and regionalized equations. Quality of water will be defined through an intensive sampling program. Methods for estimating the hydrologic effects of various land treatments imposed by mining will be developed.

PROGRESS IN 1982.--Data collection completed and data stored in files. Ground-water illustrations drafted. Interpretations and report writing started.

PLANS FOR 1983.--Complete report and process through Director's approval.

REPORT PRODUCTS.--Hydrologic characteristics and possible effects of surface mining in the M & M lignite deposit area, North Dakota by O. A. Crosby, W. F. Horak and P. G. Randich (in preparation).

PROJECT TITLE: Surface-Water Resources, Fort Union Coal Region of Western North Dakota



LOCATION: West Central North Dakota

PERIOD OF PROJECT: October 1977 to September 1982

PROJECT CHIEF: Norman D. Haffield

OBJECTIVES.--The purpose of the study is to describe the surface-water resources of the Fort Union Coal Region of western North Dakota in a readily usable format. The specific objectives are (1) to determine the streamflow and water quality characteristics for the streams located in the region and (2) to describe seasonal and areal variations that occur within the various stream systems.

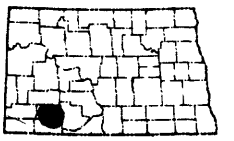
APPROACH.--All existing data will be condensed and analyzed in order to define the characteristics of the various components of the streamflow systems that are located within the region.

PROGRESS IN 1982.--A data base utilizing the data collected at all of the surface water gaging stations located in the area was established. The data analysis and statistical computations that will be used to define the characteristics of the system have been essentially completed.

PLANS FOR 1983.--The data analysis will be completed. Illustrations will be prepared and the report completed.

REPORT PRODUCTS.--Streamflow and water-quality for streams in Fort Union Coal Region in North Dakota by N. D. Haffield (in progress).

PROJECT TITLE: Evaluation of the Hydrologic System in the New England-Mott Coal Area, Adams and Hettinger Counties, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: October 1982 to December 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The primary objective will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality, sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

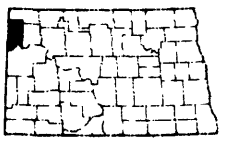
APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collected in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

PROGRESS IN 1982.--A detailed project proposal and work plan was prepared. A limited canvas of wells and collection of additional water samples was completed in the area.

PLANS FOR 1983.--Assemble existing data, collect necessary field data, compile and analyze data, and complete final report.

REPORT PRODUCTS.--Hydrology of New England-Mott, North Dakota coal area (planned).

PROJECT TITLE: Evaluation of the Hydrologic System in the Sand Creek-Hanks Coal Area, Williams County, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--The primary objective will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality, sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

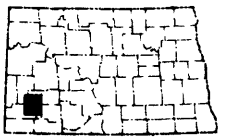
APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collected in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

PROGRESS IN 1982.--A detailed project proposal and work plan was prepared. A limited canvas of wells and collection of ground-water samples were done in the area.

PLANS FOR 1983.--Assemble existing data, collect necessary field data, compile and analyze data, and complete final report.

REPORT PRODUCTS.--Hydrology of Sand Creek-Hanks coal area (planned).

PROJECT TITLE: Evaluation of the Hydrologic System in the Dickinson Coal Area, Stark County, North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--The primary objective will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality, sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

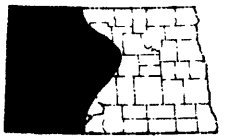
APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collected in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

PROGRESS IN 1982.--A detailed project proposal and work plan was prepared. A limited canvas of wells and collection of ground-water samples were done in the area.

PLANS FOR 1983.--Assemble existing data, collect necessary field data, compile and analyze data, and complete final report.

REPORT PRODUCTS.--Hydrology of the Dickinson coal area (planned).

PROJECT TITLE: Hydrochemical Impacts of Surface Mining of Lignite--The Sulfur Cycle



LOCATION: Fort Union Coal Region
North Dakota

PERIOD OF PROJECT: October 1983 to September 1984

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--Detailed geochemical investigations will be made to quantitatively describe the sulfur sources which contribute to ground-water sulfate in strip mines situated in recharge zones and to determine the hydrogeochemical processes which control the sulfur path to the ground water. Isotopic studies will be employed to: (1) trace sulfur transformations among solid and aqueous species present throughout the sulfur cycle, (2) quantify the relative magnitude of each transformation as a contributor to ground-water sulfate concentrations, and (3) determine which transformations are affected by biological activity.

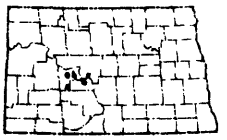
APPROACH.--Cores and ground- and pore-water samples will be obtained from two active strip mines and one potential mine site. Sulfur species present at various depths will be identified and the sulfur isotopic ratio of each species determined. Sulfur isotopic ratios will be used to determine transformation paths. Samples will also be obtained with minimal contamination for determination of the presence and activity of sulfur-metabolizing microorganisms. Comparison of organism distributions and isotopic ratios will be used to determine the stages at which biological activity affects the sulfur cycle. Observations will be simulated in the laboratory as a control check.

PROGRESS IN 1982.--None. New project.

PLANS FOR 1983.--Ground- and pore-water samples will be collected seasonally within and adjacent to lignite strip mines near Gascoyne and Center, North Dakota, and from a potential mine site near Beach, North Dakota. Cores will also be obtained adjacent to each sampling site. Sulfur species present in each phase will be identified and their concentrations determined. Sulfur isotopic ratios of each separable species will be measured. Sulfur-metabolizing microorganisms in each phase will be identified and cultured to determine potential activity and the isotopic fractionation they produce. Isotopic ratios will be used to quantify apparent in situ microbial activities.

REPORT PRODUCTS.--Impact of lignite strip mining on geochemical and microbial controls on the sulfur chemistry of shallow ground water in the Fort Union coal region (planned).

PROJECT TITLE: Evaluation of Effects of Ongoing and Future Mining and Reclamation Activities in Western North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1982 to September 1985

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The purpose of the study is to provide the capability to assess and predict the effects of mining and energy development on the hydrologic system. Specific objectives are (1) to monitor the variations in the quantity and quality of surface and ground water below active energy development sites and (2) to use the data collected to augment and refine predictive models presently available.

APPROACH.--The study includes the operation of five river stream-gaging and water-quality sites, one complete weather station, and three precipitation sites. The U.S. Geological Survey's Precipitation-Runoff Modeling System has been selected as the predictive model. The model has not been completely calibrated for the site where the model was developed; this is one of the five sites to be operated under this project. The plans are to collect enough data at the sites to check verification of the model. The present plans are to collect data for 3 years, but it could depend on runoff conditions.

PROGESS IN 1982.--None. New project.

PLANS IN 1983.--Collection of streamflow, chemical quality, and meterological data will be made. The weaker components of the model will be investigated further.

REPORT PRODUCTS.--The streamflow, chemical quality and water level data will be published annually in the series, "Water Resources Data, North Dakota, Water year 19XX."

Modeling analysis report (planned).

BOARDS AND COMMISSIONS

PROJECT TITLE: Boards and Commissions

LOCATION: Bismarck, North Dakota

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: L. Grady Moore

OBJECTIVES.--Assure impartial Federal representation on the Yellowstone River Compact Commission and the Souris River Board of Control and supply accurate, unbiased information to boards and commissions.

APPROACH.--Chair the meetings and provide administrative support to the Yellowstone River Compact Commission. Act as alternate member for the United States to the Souris River Board of Control. Furnish information requested by members of the Pembima River Engineering Board and the International Souris-Red River Engineering Board.

PROGRESS IN 1982.--The 1981 Annual Report of the Souris River Board of Control was printed and distributed. Meetings of the Board were held January 18, 1982, and May 1, 1982. Information was routinely furnished to parties concerned with Souris River streamflow.

The 1982 Annual Report of the Yellowstone River Compact Commission was printed and distributed. Meetings of the Commission were held April 26, 1982 in Billings, MT, and November 10, 1982 in Billings, MT.

PLANS FOR 1983.--All meetings of the Souris River Board of Control will be attended. The Annual Report for 1982 will be prepared and distributed.

All meetings of the Yellowstone River Compact Commission and the Administration Committee will be attended. The Annual Report for 1983 will be prepared and distributed.