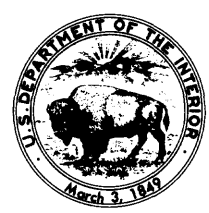
WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN SOUTH DAKOTA

Compiled by E. F. LeRoux and E. M. Decker

U.S. GEOLOGICAL SURVEY

Open-File Report 83-754



July 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

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PROJECT STATUS SUMMARY

July 1, 1983

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INTRODUCTION

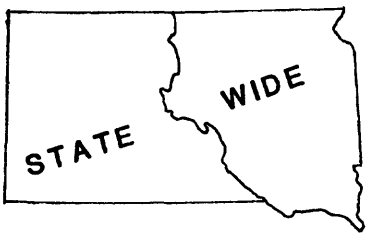
The overall mission of the U.S. Geological Survey's water resources program is to provide the hydrologic information and understanding needed for the best use and management of the Nation's water resources. For 89 years, the U.S. Geological Survey has studied the occurrence, quantity, quality, distribution, and movement of the surface and underground water that compose the Nation's water resources. As the principal Federal water-data agency, the Geological Survey collects and disseminates about 70 percent of the water data currently being used by numerous State, local, private, and other Federal agencies to develop and manage our water resources. This nationwide program, which is carried out through the Water Resources Division's 43 District (State) offices and 4 Regional offices, includes the collection, analysis, and dissemination of hydrologic data and water-use information, areal resource appraisals and other interpretive studies, and research projects. Much of this work is a cooperative effort in which planning and financial support are shared by State and local governments and other Federal agencies.

In South Dakota, various parts of the U.S. Geological Survey program are conducted in cooperation with: South Dakota Department of Water and Natural Resources, Division of Geological Survey, Division of Water Quality, and Division of Water Rights; East Dakota Conservancy Sub-District; Black Hills Conservancy Sub-District; Lower James Conservancy Sub-District; City of Watertown; U.S. Army Corps of Engineers; U.S. Fish and Wildlife Service; U.S. Bureau of Indian Affairs; U.S. Bureau of Reclamation; and U.S. Environmental Protection Agency.

CURRENT PROJECTS

The project descriptions in this section show the location, project number, title, period of the project, cooperating agencies, project leader, purpose of the project, progress, plans, and completed reports.

SURFACE-WATER STATIONS (SD001)



Project leader: John R. Little

Project period: Continuous

Cooperators: South Dakota Department of Water and Natural Resources, East Dakota Conservancy Sub-District, Black Hills Conservancy Sub-District, Lower James Conservancy Sub-District, City of Watertown, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Bureau of Indian Affairs, U.S. Army Corps of Engineers.

Problem: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

Objective: A. 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. B. 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, estuaries, 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.

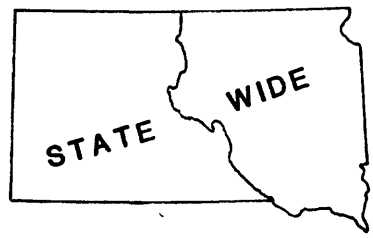
Results last year: Data were collected and published in U.S. Geological Survey Water-Data Report SD-81-1. No significant changes were made in the network. One-hundred twenty active sites.

Plans for 1983: Review the network, consult the cooperators as to their needs and expect to continue on about the same scale as last year. Data will be published in U.S. Geological Survey Water-Data Report SD-82-1, and requests for data will be answered.

Completed reports:

U.S. Geological Survey, 1982, Water resources data for South Dakota, water year 1981: U.S. Geol. Survey water-data report SD-81-1, 357 p.

GROUND-WATER RECORDS
(SD002)



Project leader: John R. Little

Project period: Continuous

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: Long-term water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

Objective: A. 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. B. To provide a data base against which the short-term records acquired in areal studies can be analyzed.

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 for observation of long-term system behavior. This subjective 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.

Results last year: Hydrologic data was collected for bedrock aquifers. All water levels for bedrock aquifers are either in the computer or ready for entry. One open-file report dealing with water levels in the Big Sioux aquifer, Minnehaha County, was prepared. All data collections and storage are up to date. There are 228 active sites.

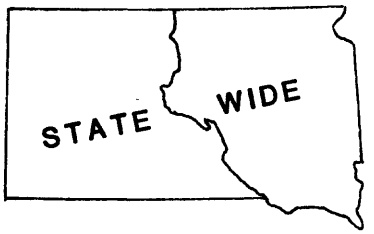
Plans for 1983: Continue collecting water-level data on existing observation wells and establish new observation wells in areas of poor coverage.

Completed reports:

U.S. Geological Survey, 1982, Water resources data for South Dakota, water year 1981: U.S. Geol. Survey water-data report SD-81-1, 357 p.

Winter, D. R., 1983, Records of water levels in the Big Sioux aquifer, Minnehaha County, South Dakota, 1981: U.S. Geol. Survey Open-File Report 82-1020, 25 p.

WATER-QUALITY STATIONS
(SD003)



Project leader: Norman F. Leibbrand

Project period: Continuous

Cooperators: South Dakota Department of Water and Natural Resources, U.S. Army Corps of Engineers, U.S. Bureau of Indian Affairs, U.S. Environmental Protection Agency.

Problem: Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information. For intelligent planning and realistic assessment of the water resource, the chemical and physical quality of the rivers and streams must be defined and monitored.

Objective: 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.

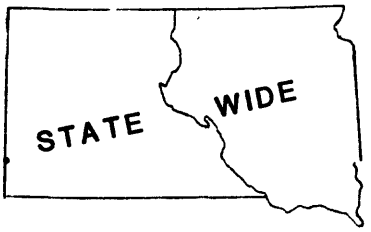
Results last year: Water-quality data were published in the basic data release. There were significant changes in the network, including the dropping of nine stations and the addition of one station. Thirty-one active sites.

Plans for 1983: Simulation of missing records (data) for several stations will be done by regression analysis. Network will continue to be operated.

Completed reports:

U.S. Geological Survey, 1982, Water resources data for South Dakota, water year 1981: U.S. Geol. Survey water-data report SD-81-1, 357 p.

SEDIMENT STATIONS
(SD004)



Project leader: Eugene B. Hoffman

Project period: Continuous

Cooperator: U.S. Army Corps of Engineers.

Problem: Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information. Sediment concentrations and discharges in rivers and streams must be defined and monitored.

Objective: 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 spartial and temporal averages and trends of sediment concentration, sediment discharge, and particle size of sediment being transported by rivers and streams.

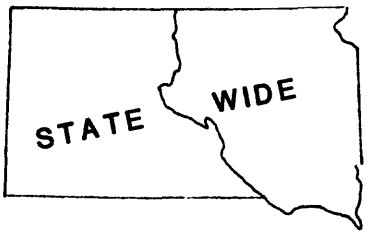
Results last year: Data collected as scheduled and published in U.S. Geological Survey Water-Data Report SD-81-1. One new daily sediment station was added on the White River near Oacoma, SD. Twenty-four active sites.

Plans for 1983: Continue network operation.

Completed reports:

U.S. Geological Survey, 1982, Water resources data for South Dakota, water year 1981: U.S. Geol. Survey water-data report SD-81-1, 357 p.

SOUTH DAKOTA WATER-USE DATA PROGRAM (SD007)



Project leader: Rick D. Benson

Project period: Continuous

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The water requirements in South Dakota for irrigation and energy development have increased considerably in recent years. As a result of the drought in 1976-1977 that affected the economics of the state, a state water plan is being prepared. An important part of the state water plan is a comprehensive statewide water-use assessment. Without adequate data on existing uses of water, predictions for future uses will be inaccurate.

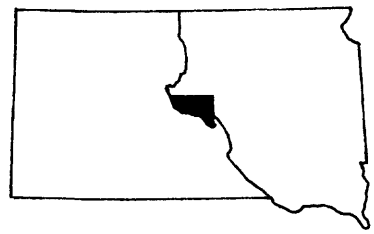
Objective: To develop a statewide water-use data program that will include field collection procedures and computer storage, retrieval, manipulation, and dissemination of water-use data. During the first year of the project, water-use data collection techniques will be developed and evaluated and the requirements for a water-use data handling system will be identified.

Approach: The USGS and the South Dakota Department of Water and Natural Resources will work together in developing a statewide water-use data program. The USGS will provide direction, management, and standards development to meet the national needs. The South Dakota Department of Water and Natural Resources will provide manpower and computer facilities for field collection and processing of water-use data to meet the local needs.

Results last year: The irrigation system questionnaire which will supply information for the national data system is operational. Data for the 1979 irrigation season were obtained from the state of South Dakota and entered onto the National Water-Use Data System (NWUDS). Public water supply system is in design stage.

Plans for 1983: Upon receipt from the state of South Dakota, irrigation system questionnaire data for 1980 will be entered onto the National Water-Use Data System. Work will continue on the development of the public water supply system and a wastewater treatment system.

WATER RESOURCES OF HUGHES COUNTY, SOUTH DAKOTA (SD052)



Project leader: Louis J. Hamilton

Project period: 1979-1983

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: Little is known about the glacial aquifers of Hughes County; however, several extensive and productive aquifers mapped during an earlier U.S. Geological Survey study in Hyde County to the east probably extend into Hughes County. A knowledge of the hydrology of these and other aquifers will be valuable in future land-use planning and in the development of irrigation and rural water systems in the area. Housing developments are beginning in the areas outside the city of Pierre which may lead to the development of rural water systems and the need for additional hydrologic information.

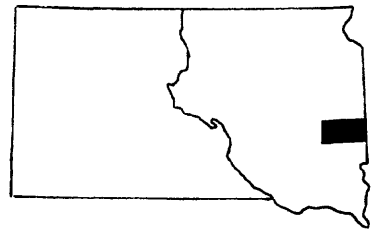
Objective: The objectives of the study are to provide the reliable and up-to-date basic data and analyses needed for water-resources evaluation and for the efficient use of these resources by agriculture, rural water systems, and municipalities. Specifically, the study will concentrate on determining the availability of surface and ground-water resources, the operation of the hydrologic system as it influences availability, the quality of surface and ground water, and the effects on the hydrologic system of developing the water resources. Areas of current or potential hydrologic problems, as related to water use, will be identified.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be collected. A well inventory will be conducted, and a test drilling program will be completed during the first two field seasons. An observation-well network will be established and water samples collected for chemical analysis. Glacial and bedrock aquifers will be delineated and hydrologic characteristics described. Pump tests, using existing wells, will be run whenever feasible. Assistance from outside USGS will consist of a geologic study by the State Geological Survey and extensive test drilling by State drill rigs.

Results last year: Four major glacial outwash aquifers and three major bedrock aquifers were delineated from a canvass of 250 wells and the drilling of 250 test holes to bedrock. Artesian wells flowing as much as 2,000 gallons per minute have been completed in bedrock aquifers of sandstone and limestone at depths of from 980 to 2,600 ft. Glacial aquifers of sand and gravel underlie 130 mi^2 to depths of 390 ft in Hughes County and can yield as much as 900 gpm of very-hard, slightly saline water.

Plans for 1983: Maps and tables summarizing aquifer characteristics will be prepared. A lay-reader report and the final interpretive report for the study will be completed.

WATER RESOURCES OF LAKE AND MOODY COUNTIES, SOUTH DAKOTA (SD053)



Project leader: Donald S. Hansen

Project period: 1979-1983

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: A reconnaissance study, which included part of Moody County, was completed in 1968 but contained little detailed analysis of the Big Sioux aquifer or other glacial aquifers. A knowledge of the hydrology of these aquifers is needed for land-use planning and development of irrigation and rural water systems in the area. The counties are quite heavily populated in the rural areas which should favor the development of rural water systems.

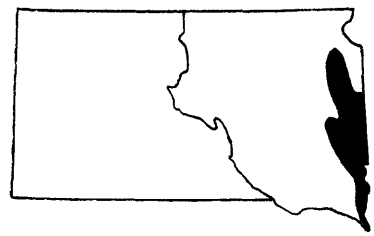
Objective: To provide the reliable and up-to-date basic data and analyses needed for water-resources evaluation and for the efficient use of these resources by agriculture, rural water systems, and municipalities. Specifically, the study will concentrate on determining the availability of surface and ground-water resources, the operation of the hydrologic system as it influences availability, the quality of surface and ground water, and the effects on the hydrologic system of developing the water resources. Areas of current or potential hydrologic problems, as related to water use, will be identified.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be collected. A well inventory will be completed during the first two field seasons. An observation-well network will be established and water samples collected for chemical analysis. Glacial and bedrock aquifers will be delineated and hydrologic characteristics described. Pump tests, using existing wells, will be run whenever feasible. Assistance from outside USGS will consist of a geologic study by the State Geological Survey and extensive test drilling by State drill rigs.

Results last year: Project activities were concerned with collection and interpretation of hydrologic data including test drilling, construction of observation wells, construction of aquifer-thickness, potentiometric, and areal-extent maps, and the measurement of observation wells. A major glacial aquifer was delineated based on data from 120 test holes. The aquifer underlies an area of about 750 mi^2 and is about 250 ft below land surface. Thickness ranges from 10 to 115 ft. The major chemical constituents in water from the aquifer are calcium, sodium, and sulfate. Dissolved solids range from 1,000 to 2,600 mg/L. Water from the aquifer is used primarily for domestic and stock supplies. A first draft of the final interpretive report was begun.

Plans for 1983: Complete data interpretation and final interpretive report.

A GEOCHEMICAL SURVEY OF GROUND WATER IN THE BIG SIOUX AQUIFER IN EASTERN SOUTH DAKOTA (SD057)



Project leader: Norman F. Leibbrand

Project period: 1980-1983

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The Big Sioux aquifer is one of the most heavily developed aquifers within the state of South Dakota. Concern about contamination, health problems, and steady degradation of the chemical quality of the aquifer has prompted local, private and governmental interests as well as government at the state level to propose that a water-quality study of the Big Sioux aquifer be undertaken. The ultimate goal of the study is the development of "best management practices" for future protection of the aquifer and for control programs if relationships can be established between health hazards and water quality.

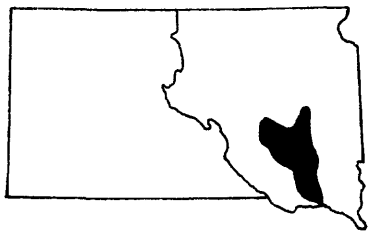
Objective: To define the geochemical variation and chemical character of the ground water in the aquifer. The project is intended to increase hydrologic knowledge through the application of known statistical methods of analysis to a small network of randomly selected sampling sites. Data generated from this project will be used by water managers for development of "best management practices" to preserve the quality of ground water in the aquifer. The data will also be studied by specialists in the health field to determine if relationships exist between water quality and disease.

Approach: Establish a random sampling network and initially select 27 ground-water sources to define geochemical variation in the Big Sioux aquifer. An analysis of variance technique will be used to obtain the geochemical variation and chemical character of the ground water in the aquifer. Statistical testing of the geochemical data will be done to determine whether more sampling sites are needed to adequately define the geochemical variation in the aquifer. The results of the study will be presented in a report describing the geochemical variation and detailing the methods and procedures used in establishing the statistical network.

Results last year: One-hundred forty water samples have been collected from approximately 130 randomly selected sampling areas in the Big Sioux aquifer. The samples have been analyzed for common constituents and several trace metals and are being processed for storage in the National Water Data Storage and Retrieval System (WATSTORE). The data are being subjected to statistical analysis using Statistical Analysis System (SAS) applications.

Plans for 1983: Continue sampling the randomly selected sites, enter the data into WATSTORE, and analyze the data using analysis of variance and correlation coefficients.

SEDIMENT STUDY OF THE JAMES RIVER BASIN BELOW FORESTBURG, SOUTH DAKOTA (SD058)



Project leader: John R. Little

Project period: 1980-1982

Cooperator: Lower James Conservancy Sub-District.

Problem: Improper land use, treatment, and management have allowed erosion and sedimentation to severely damage resources in the area. A large part of this area has inadequate quantities and poor quality domestic water, inadequate waste systems, and few recreation facilities. The Lower James Conservancy Sub-District requested the Soil Conservation Service (SCS) to undertake a soil erosion study in the area. The SCS does not have the equipment or expertise for a sediment study and has requested the U.S. Geological Survey (USGS) to design and conduct a sediment investigation in selected sub-hydrologic basins and on the main stem of the James River in the project area.

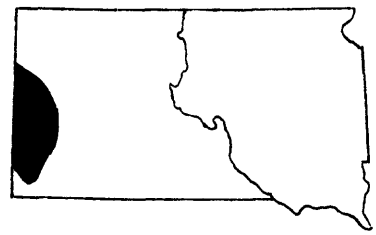
Objective: The responsibility of the USGS will be to quantify sediment delivery to the James River from 4 sub-basins selected jointly with the SCS. Sediment loads and chemical quality of the main-stem James River will be evaluated and quantified at selected sampling sites to aid in identifying other sediment sources. These sites will be used for future evaluations of the effects of the implementation of sediment and erosion control measures. The USGS will prepare interpretive reports which will contain maps and tables of data, data interpretations and descriptions of the hydrologic system with respect to sediment.

Approach: The USGS will establish a network of 7 sediment sampling stations in the Lower James River basin; 4 on selected tributaries and 3 daily stations on the main-stem James River. Automatic sediment samplers and stage recorders will be installed near the mouth of each of the four tributaries. An interpretive report will be prepared by the USGS in which the data will be summarized, suspended sediment loads calculated and annual yields will be calculated for the sub-basins. Sediment loads will be calculated and the chemical quality of main-stem river water will be evaluated and described.

Results last year: A program of sediment-sample collection continued on a network of 3 main-stem and 4 tributary gaging stations in the Lower James River basin.

Plans for 1983: Continue collection of sediment data in Lower James River basin at 3 gaging stations on main stem and at 4 tributary gaging stations. Continue computation and compilation of streamflow and sediment data and prepare interpretive report.

QUALITY AND AVAILABILITY OF GROUND WATER IN THE BLACK HILLS AREA, SOUTH DAKOTA AND WYOMING (SD059)



Project leader: Kathy D. Peter

Project period: 1981-1984

Cooperators: South Dakota Department of Water and Natural Resources, Black Hills Conservancy Sub-District.

Problem: Increasing development in the Black Hills area is placing increased demands on the ground-water system. The data and interpretations at the scale necessary to make specific management decisions are not available. There is concern about the effects of unplugged or improperly plugged uranium test holes, concern about the effect proposed withdrawals from the Madison aquifer will have on streams and aquifers in South Dakota, and concern about the effect of the numerous septic systems on the quality of water in the Minnelusa Formation, the principal aquifer supplying water to the residents in the area.

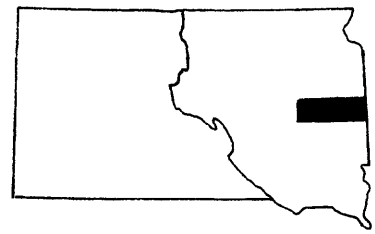
Objective: Evaluate the quality and quantity of ground-water resources of the sedimentary aquifers in the Black Hills area of South Dakota and eastern Wyoming. Evaluate the effects of septic systems on aquifers in the Piedmont Valley area. Develop the data base necessary for application of a digital model(s) to predict the effects of potential stress on the ground-water systems.

Approach: Streamflow and spring discharge data will be obtained as needed to evaluate net aquifer recharge. Water samples from wells in the Piedmont Valley area will be collected and analyzed. Additional wells will be inventoried and evaluated for prospective water-quality and water-level observation networks. The U.S. Geological Survey three-dimensional model will be used to predict the affects of stresses on the system and simulate recharge. Reports on quality and availability of ground water will be prepared.

Results last year: To investigate the extent of areas where the concentration of radium-226 exceeds Environmental Protection Agency (EPA) standards, 29 ground-water samples have been collected for analysis. Ten of the 29 samples are being analyzed for radium-228, the concentration of which may also exceed EPA standards. Preliminary evaluation of observation-well records and the results of well inventories indicate existing development has had little effect on water levels. A digital model of the Black Hills in Wyoming and South Dakota is being prepared to evaluate potential supply based on available information.

Plans for 1983: Water-level and spring discharge measurements will be continued. Water-quality maps will be updated and interpreted. A map showing the orientation of the secondary permeability of the Madison Limestone, based on mapped cave passages, will be prepared. Digital models will be constructed and calibrated.

WATER RESOURCES OF BROOKINGS AND KINGSBURY COUNTIES, SOUTH DAKOTA (SD060)



Project leader: Louis J. Hamilton

Project period: 1981-1986

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The study will help to complete the overall water resources picture in eastern South Dakota. A complete knowledge of the hydrology of the aquifers will be valuable in future land-use planning and in the development of irrigation and rural water systems in the area. Identification of significant new sources of ground water would undoubtedly encourage some changes from dryland to irrigation farming. The counties are quite heavily populated in the rural areas which should favor the development of rural water systems. The recent drought conditions have increased local interest in irrigation development from ground-water sources.

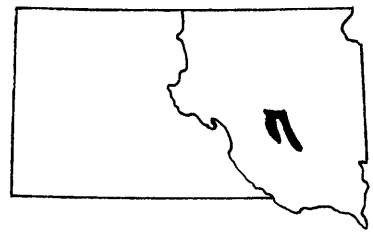
Objective: To provide the reliable and up-to-date basic data and analyses needed for water-resources evaluation and for the efficient use of these resources by agriculture, rural water systems, and municipalities. Specifically, the study will concentrate on determining the availability of surface and ground-water resources, the operation of the hydrologic system as it influences availability, the quality of surface and ground water, and the effects on the hydrologic system of developing the water resources. Areas of current or potential hydrologic problems as related to water use will be identified.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Glacial and bedrock aquifers will be delineated and hydrologic characteristics described. Pump tests, using existing wells, will be run whenever feasible. A geologic study will be made by the State Geological Survey and there will be extensive test drilling by State drill rigs. A preliminary report discussing the major aquifers will be prepared. A final report on the hydrology will be published by the USGS. A report on the geology of the county will be prepared by a State Geological Survey geologist.

Results last year: The study has located three extensive aquifer systems--a shallow glacial-outwash aquifer, buried glacial aquifers at depths ranging from 165 to 500 ft, and the Dakota Sandstone aquifer at depths of from 700 to 1,300 ft. The shallow aquifers are pumped extensively for rural domestic and stock needs, municipalities, and irrigation. Water from the glacial aquifers is very hard, exceeding 1,000 mg/L in some areas. Water from the Dakota aquifer is soft.

Plans for 1983: Test holes to bedrock will be drilled at about 5-mile intervals across the study area. A network of observation wells will be established. An annotated outline will be prepared for the interpretive report on the study.

DIGITAL-MODEL STUDY OF THE GLACIAL AQUIFERS IN A PART OF THE JAMES RIVER BASIN IN EAST-CENTRAL SOUTH DAKOTA (SD064)



Project leader: Patrick J. Emmons

Period of project: 1982-1985

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The drought in South Dakota from 1974-76, the curtailment of the planned Oahe Surface-Water Irrigation Project in 1978, and the near-drought conditions in 1980-81 have caused increased demands on the ground-water resources within many of the heavily agricultural areas of the James River basin. The South Dakota Department of Water and Natural Resources has requested that the U.S. Geological Survey cooperate with them in developing digital models of the aquifer system in part of the James River basin to be used as a basis for establishing a water-use management program.

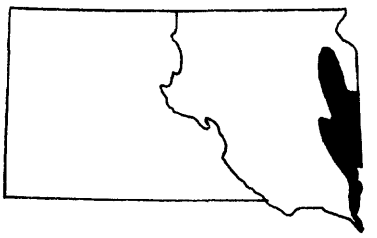
Objective: The purpose of this study is to utilize the modeling expertise of the U.S. Geological Survey to develop and calibrate finite-difference two-dimensional digital models of the ground-water system. The calibrated digital models will be used to determine the long-term yield of the ground-water reservoir and the areal affects on water levels of selected water-use plans. Once developed, water agencies can use the models to help manage future ground-water use and recommend optimum pumping distribution.

Approach: The existing information base includes data and analyses from cooperative countywide water-resources studies in four counties. The study will require hydrologic data collection and some test drilling by the South Dakota Geological Survey, mostly in Beadle and Sanborn Counties. Updating of data will be required in Miner and Hanson Counties. The accepted U.S. Geological Survey digital model will be used and modifications will be made as needed. The model will be used to determine the long-term yield of the glacial aquifer system and to test selected water-use and pumping distribution plans with time.

Results last year: A shallow-glacial aquifer underlies about 650 mi^2 in the study area in Beadle County. It is within 20 ft of land surface over about 20 percent of the area. The areas where the aquifer is close to land surface are the main recharge areas for the aquifer and the water in the aquifer here should have a better quality for most uses than in areas where the aquifer is at greater depths.

Plans for 1983: Hydrologic data will continue to be processed for modeling. Steady-state computer runs will be made to calibrate the model.

WATER RESOURCES OF THE BIG SIOUX RIVER BASIN, SOUTH DAKOTA (SD065)



Project leader: Neil C. Koch

Period of project: 1982-1988

Cooperator: South Dakota Department of Water and Natural Resources.

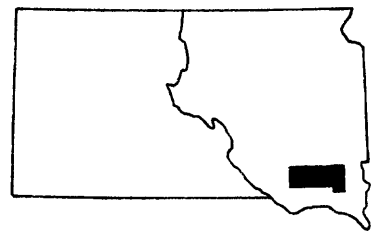
Problem: The Big Sioux River basin of eastern South Dakota represents a sizeable aquifer system of major importance to the economy of South Dakota. Management problems already exist and as development continues the problems continue to increase in number and complexity. Although it is possible to roughly estimate the amount of water in the basin, management is extremely difficult. The aquifers are complex, consisting of many small aquifers that are hydrologically associated with several large aquifers and the Big Sioux River. A comprehensive model study is needed to aid in optimum development of water resources in the basin.

Objective: To provide a scientific basis for evaluation and efficient use of water resources and to explore the possibility of application of a solute transport model to describe rates and directions of movement. Information will be provided on the availability of surface-water and ground-water resources, operation of the hydrologic system, and the effect of water-resources development on the hydrologic system. The study will complete the gathering of all necessary basic data within the basin. This data base will then be used to develop digital models of major aquifers.

Approach: The study will include hydrologic data collection and an extensive test-drilling program by the State Survey. Two-dimensional models of the Big Sioux aquifer will be developed and the feasibility of the application of a solute transport model to describe rates and directions of movement, and concentrations of both naturally occurring and artificially introduced organic and inorganic constituents will be determined. Development alternatives will be tested and analyzed for possible impacts on the hydrologic system. Reports will be prepared summarizing the hydrology and recommending needs for further study and data collection.

Plans for 1983: Inventory wells, install stream gages, and begin test drilling.

WATER RESOURCES OF HUTCHINSON AND TURNER COUNTIES, SOUTH DAKOTA (SD066)



Project leader: Richard J. Lindgren

Period of project: 1982-1987

Cooperator: South Dakota Department of Water and Natural Resources.

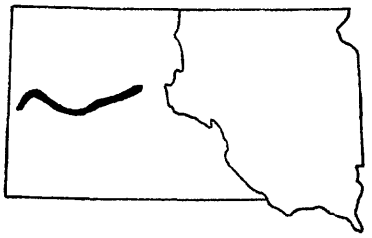
Problem: Several productive aquifers mapped during U.S. Geological Survey studies in adjacent counties probably extend into Hutchinson and Turner Counties. A knowledge of the hydrology of these aquifers will be valuable in future land-use planning and in the development of irrigation and rural water systems. Identification of significant new sources of ground water would undoubtedly encourage some changes from dryland to irrigation farming. Also, the counties are quite heavily populated in rural areas which should favor the development of rural water systems which will benefit by the more detailed knowledge of the ground-water resources resulting from this study.

Objective: Provide the reliable and current basic data and analyses needed for water-resources evaluation for the efficient use of these resources by agriculture, rural water systems, and municipalities. The study will determine the availability of surface and ground water, the operation of the hydrologic system as it influences availability, and the quality of surface and ground water. Current or potential problems related to development of the water resources will be identified. These problems may include declining water levels, decreased natural discharge, and changes in water quality due to induced recharge from materials adjacent to the aquifers.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be collected. A well inventory will be conducted and a test drilling program will be completed during the first two field seasons. An observation-well network will be established and water samples collected for chemical analysis. Glacial and bedrock aquifers will be delineated and hydrologic characteristics described. Pump tests, using existing wells, will be run whenever feasible. There will be a geologic study by the State Survey and extensive test drilling by State drill rigs.

Plans for 1983: Project planning and initial field reconnaissance. Existing basic data will be collected and tabulated. The well canvass (including QW field analysis) will begin and test-drilling and observation-well programs will be planned and initiated.

INVESTIGATION OF HAZARDOUS WASTES ALONG WHITEWOOD CREEK AND THE BELL FOURCHE AND CHEYENNE RIVERS, SOUTH DAKOTA (SD067)



Project leader: Kimball E. Goddard

Period of project: 1982-1984

Cooperator: South Dakota Department of Water and Natural Resources.

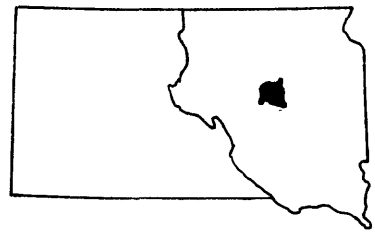
Problem: For approximately 100 years, until the late 1970's, huge volumes of mining and milling wastes were discharged into Whitewood Creek and its tributaries at Lead, South Dakota. The waste material contains non-metallic and metallic minerals associated with the gold and silver deposits at Lead. In addition, mercury and cyanide have been, or are currently being used in the milling processes and may also be present in the wastes. There is evidence that contaminants continue to degrade the surface and ground waters. Of particular concern is the possible contamination of the alluvial aquifers which exist under the streams.

Objective: To define the areal extent and the general physical and chemical characteristics of significant waste deposits. Identify any current downstream movement of the wastes or any resultant leachate in the surface flow of Whitewood Creek and the Belle Fourche and Cheyenne Rivers. Identify any ground-water contamination of the alluvial aquifer caused by leaching of waste deposits along Whitewood Creek and the Belle Fourche and Cheyenne Rivers. Identify and locate past and present contaminant point-sources and determine continuing contribution of present sources.

Approach: Evalute existing reports and maps. Field inspect areas affected by waste deposits and define the chemical, physical, and mineralogic characteristics of the deposits. Obtain background data on surface-water chemistry and sediment concentration. Determine discharge, bottom-material chemistry, and surface-water chemistry profiles. Determine temporal variations in water chemistry and sediment concentration and the variations resulting from high flows. Locate and sample existing wells in the alluvial aquifer. Drill and sample monitoring wells. Locate past and present contaminant point-sources, review monitoring data, and recommend needed changes or additional monitoring sites.

Plans for 1983: Install stream gaging and automatic sampling equipment, inventory wells, and conduct field inspection and identification of waste deposits.

EFFECTS OF IRRIGATION ON GROUND-WATER LEVELS IN SOUTHERN SPINK AND NORTHERN BEADLE COUNTIES, SOUTH DAKOTA (SD068)



Project leader: Neil C. Koch

Period of project: 1982-1983

Cooperator: U.S. Bureau of Reclamation.

Problem: The U.S. Bureau of Reclamation (USBR), the state of South Dakota, and CENDAK Irrigation Project are studying an area in east-central South Dakota to determine its suitability for irrigation. The study consists of evaluating the drainage characteristics of the area and the effect on the water table in the underlying glacial aquifer of recharge from the irrigation water. A hydrologic model of the glacial aquifer has been developed by U.S. Geological Survey (USGS) for part of the area under study and the USBR has asked USGS to use the model to determine potential water-level changes.

Objective: To utilize the hydrologic model developed by USGS to determine the changes in the water table under 4 or 5 levels of recharge. Then, using irrigation wells as a balancing factor, determine the density of wells required to return the water table to acceptable levels for irrigation.

Approach: A ground-water model has been developed by USGS for an area in east-central South Dakota. This model will be used to conduct the study. Recharge values provided by the U.S. Bureau of Reclamation will be entered into the model and discharge wells will be added to determine the density necessary to return the water table to an acceptable level for irrigation. The model can handle any recharge rate but can not deal with conditions outside of the modeled aquifer such as permeability of overlying sediments or perched water tables in sediments overlying the aquifer.

Plans for 1983: Project completed.

EVALUATION OF WITHDRAWAL AND CONSUMPTIVE USE OF GROUND WATER FOR IRRIGATION IN THE JAMES RIVER VALLEY, SOUTH DAKOTA (SD069)

Project leader: Kenneth E. Kolm

Period of project: 1983

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The principal consumptive use of ground water in the James River basin of South Dakota is cropland irrigation. The amount of water used for irrigation can be directly estimated from crop-type and crop-acreage determinations. The U.S. Soil Conservation Service and U.S. Agricultural Stabilization and Conservation Service maintain yearly records of irrigated crops planted in each county. Since this information is volunteered by each landowner, county crop records are generally incomplete. Therefore, an alternative method of crop type and acreage measurement is desirable.

Objective: To determine ground-water-irrigated crop types and estimate crop-acreage in the James River basin using computer image processing and analysis of Landsat imagery, crop-acreage estimates will then be used to estimate consumptive use of ground water. Ground-water withdrawal data collected by the State will also be used in conjunction with the crop-acreage data to estimate the consumptive use of ground water. These estimates will be integrated as both theoretical and actual consumptive usage of ground water into the James River basin aquifer-system model.

Approach: A series of Landsat scenes will be selected and various classification techniques will be used to isolate crop type and estimate crop acreage. An index of theoretical water consumptive usage will be determined from the crop type, crop acreage, and irrigation systems and an index of actual water consumptive usage will be determined from the crop type, crop acreage, and irrigation systems using the ground-water withdrawal data collected by the State. Consumptive use estimates will then be integrated into the James River basin aquifer system model. A report summarizing the results will be prepared.

Plans for 1983: Determine ground-water-irrigated crop types and estimate crop acreage using computer image processing and analysis of Landsat imagery. Estimate consumptive use of ground water. Prepare report summarizing the results of the study.

HYDROLOGIC-DATA PROGRAM

Surface Water

Surface-water discharge (streamflow) and stage (water level) data (table 1) are collected for general hydrologic purposes such as assessment of water resources, areal analyses, determination of long-term trends, research and special studies, or for management and operational purposes. Each year surface-water gaging stations are added and others are terminated; thus, the U.S. Geological Survey has both a current and historical file of hydrologic data. All data collected are stored in the Survey's National Water Data Storage and Retrieval System (WATSTORE) and are available on request to water planners and others involved in making decisions affecting the State's water resources. These data can be retrieved in machine-readable form or in the form of computer-printed tables or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of services or products from WATSTORE can be obtained from the District Chief, U.S. Geological Survey, Water Resources Division in Huron.

Water-quality data are obtained at many of the surface-water stations (table 2) and also at other surface-water sites where discharge and stage are not measured routinely. In addition to monitoring the quality of surface water in South Dakota, some of these stations also are part of a U.S. Geological Survey nationwide network known as the National Stream Quality Accounting Network (NASQAN), which is used to detect nationwide trends in water quality.

Table 1.—Surface-water stations in operation in South Dakota, July 1, 1983

[Classification: B, benchmark or long-term change station; C, current-purpose station; H, hydrologic station to meet objective of defining regional streamflow characteristics; P, principal stream station to meet objective of measuring principal unregulated streams; R, regulated stream station required to meet objective of defining regulated flow; S, stage. Equipment: D, digital water-stage recorder; M, servo-manometer unit; R, graphic water-stage recorder; T, telemark. Cooperation: A, U.S. Army Corps of Engineers; BHC, Black Hills Conservancy Sub-District; BIA, Bureau of Indian Affairs; BR, Bureau of Reclamation; EDC, East Dakota Conservancy Sub-District; F, Federal; FWS, Fish and Wildlife Service; LJC, Lower James Conservancy Sub-District; MRB, Missouri River Basin; NR, Department of Water and Natural Resources; WAT, City of Watertown; WYO, State of Wyoming.]

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06334500	Little Missouri River at Camp Crook	CP	DM	1903 1956	1906	NR
06354860	Spring Creek near Herreid	BH	DM	1962		NR
06355500	North Fork Grand River near White Butte	CR	DM	1945		NR
06356000	South Fork Grand River at Buffalo	BH	DMR	1955		NR
06356500	South Fork Grand River near Cash	C	MR	1945		A
06357500	Grand River at Shadehill	CR	D	1943		BR
06357800	Grand River at Little Eagle	CR	DMT	1958		A
06359500	Moreau River near Faith	CP	DM	1943		A
06360500	Moreau River near Whitehorse	CP	DMRT	1954		A
06395000	Cheyenne River at Edgemont	CP	DR	1903 1928 1946	1906 1933	NR
06400000	Hat Creek near Edgemont	C	R	1905	1906	NR
06400870	Horsehead Creek near Oelrichs	C	DM	1981		NR
06400497	Cascade Springs near Hot Springs	C	DM	1976	1982	NR
06401500	Cheyenne River below Angostura Dam	CR	D	1945		BR

Table 1.—Surface-water stations in operation in South Dakota, July 1, 1983--Continued

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06402000	Fall River at Hot Springs	CR	R	1937		A
06402500	Beaver Creek near Buffalo Gap	BC	D	1937		NR
06403300	French Creek above Fairburn	C	DM	1981		NR
06404000	Battle Creek near Keystone	CH	DM	1945	1947	NR
				1961		
06404989	Grace Coolidge Creek near Game Lodge, near Custer	CH	MR	1976		BHC
06406000	Battle Creek at Hermosa	CH	DM	1949		NR
06408500	Spring Creek near Hermosa	CH	DM	1949		NR
06408700	Rhoads Fork near Rochford	C	DM	1981		NR
06409000	Castle Creek above Deerfield Reservoir, near Hill City	BC	MR	1948		F
06409500	Deerfield Reservoir near Hill City	S	MR	1947		MRB
06410000	Castle Creek below Deerfield Dam	CR	DM	1946		BR
06410500	Rapid Creek above Pactola Reservoir, at Silver City	CR	DR	1953		NR
06411000	Pactola Reservoir near Silver City	S	MR	1956		MRB
06411500	Rapid Creek below Pactola Dam	CR	R	1928	1932	BR
				1946		
06412500	Rapid Creek above Canyon Lake, near Rapid City	CR	MR	1946		NR
06414000	Rapid Creek at Rapid City	CR	DMT	1903	1906	A
				1942		
06418900	Rapid Creek below Sewage Treatment Plant, near Rapid City	C	DM	1981		FNR
06421500	Rapid Creek near Farmingdale	CR	DM	1946		BR
06422500	Boxelder Creek near Nemo	CH	DM	1945	1947	NR
				1966		

Table 1.--Surface-water stations in operation in South Dakota, July 1, 1983--Continued

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06423010	Boxelder Creek near Rapid City	CH	D	1978		NR
06423500	Cheyenne River near Wasta	CR	DM	1914	1915	A
				1928	1932	
				1934		
06425100	Elk Creek near Rapid City	C	DM	1979		NR
06425500	Elk Creek near Elm Springs	CP	DM	1949		NR
06428500	Belle Fourche River at Wyoming-South Dakota State line	CR	D	1946		F
06429905	Sand Creek near Ranch A, near Beulah, Wyoming	C	DM	1976	1982	FWS
06430000	Murray Ditch at Wyoming-South Dakota State line	CR	R	1954		WYO,NR
06430500	Redwater Creek at Wyoming-South Dakota State line	C	D	1929	1931	WYO,NR
				1936	1937	
				1954		
06431500	Spearfish Creek at Spearfish	C	DM	1946		NR
06433000	Redwater River above Belle Fourche	C	DM	1945		NR
06433500	Hay Creek at Belle Fourche	BH	D	1953		A,F
06434500	Inlet Canal near Belle Fourche	CR	D	1945		BR
06436000	Belle Fourche River near Fruitdale	CR	DM	1945		NR
06436150	Whitewood Creek above Lead	C		1983		NR
06436170	Whitewood Creek at Deadwood	C	DM	1981		NR
06436180	Whitewood Creek above Whitewood	C	DMT	1983		NR
06436190	Whitewood Creek near Whitewood	C	DM	1981		NR
06436198	Whitewood Creek above Vale	C	DMT	1983		NR
06436760	Horse Creek above Vale	CH	DM	1962		MRB
06437000	Belle Fourche River near Sturgis	CR	DMT	1945		NR

Table 1.—Surface-water stations in operation in South Dakota, July 1, 1983--Continued

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06438000	Belle Fourche River near Elm Springs	CR	MR	1928 1934	1932	A
06439000	Cherry Creek near Plainview	CP	D	1945		A
06439300	Cheyenne River at Cherry Creek	CR	MRT	1960		A
06440000	Missouri River at Pierre	S	T	1971		A
06441000	Bad River near Midland	CP	DM	1945		A
06441500	Bad River near Fort Pierre	CP	MRT	1928		A
06441590	Missouri River at LaFramboise Island, at Fort Pierre	S	MR			A
06441595	Missouri River at Farm Island, near Pierre	S	MR			A
06442000	Medicine Knoll Creek near Blunt	CH	DM	1950		A,F
06442500	Medicine Creek at Kennebec	CH	DM	1954		A
06442950	Crow Creek near Gann Valley	CH	R	1971		MRB
06443005	Lake Francis Case at Chamberlain	S	R			A
06446000	White River near Oglala	BC	DM	1943		NR
06447000	White River near Kadoka	CP	R	1942		A
06447500	Little White River near Martin	BC	R	1938 1962	1940	NR
06449000	Lake Creek below refuge, near Tuthill	CH	DR	1938 1962	1940	NR
06449100	Little White River near Vetal	CH	DM	1959		MRB
06449300	Little White River above Rosebud	C	DM	1981		BIA
06449400	Rosebud Creek at Rosebud	CP	MR	1974		MRB
06449500	Little White River near Rosebud	CP	DR	1943		NR
06450500	Little White River below White River	CP	DMR	1949		NR
06452000	White River near Oacoma	BC	MRT	1928		A
06452278	Lake Francis Case near Platte	S	MR	1981		A
06453000	Missouri River at Fort Randall Dam	CR	R	1947		F

Table 1.—Surface-water stations in operation in South Dakota, July 1, 1983--Continued

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06453010	Missouri River at Greenwood	S	MDR	1981		A
06453255	Choteau Creek near Avon	HP	DM	1982		BIA
06464100	Keya Paha River near Keyapaha	C	MD	1981		NR
06464500	Keya Paha River at Wewela	BC	DR	1937	1940	NR
				1947		
06466700	Missouri River at Springfield	S	MDR	1981		A
06467500	Missouri River at Yankton	CR	DMRT	1930		F,A
06471000	James River at Columbia	CR	MRT	1945		NR
06471200	Maple River at North Dakota-South Dakota State line	BC	MR	1956		NR
06471500	Elm River at Westport	BC	DM	1945		NR
06473000	James River at Ashton	CR	DM	1945		MRB
06475000	James River near Redfield	CR	DM	1950		MRB
06476000	James River at Huron	CR	D	1928	1932	NR
				1943		
06476500	Sand Creek near Alpena	CH	DM	1950		NR
06477000	James River near Forestburg	CR	DRT	1950		NR
06477500	Firesteel Creek near Mount Vernon	CH	R	1955		NR
06478052	Enemy Creek near Mitchell	C	DMR	1975		MRB
06478053	Pierre Creek near Alexandria	C	DM	1981		LJC
06478320	Plum Creek near Milltown	C	DMR	1981		LJC
06478390	Wolf Creek near Clayton	C	DM	1975		MRB
06478420	Lonetree Creek at Olivet	C	DMR	1981		LJC
06478500	James River near Scotland	CR	DMRT	1928		A
06478513	James River near Yankton	C	DM	1981		LJC
06478514	Beaver Creek near Yankton	C	DMR	1981		LJC
06478515	Missouri River near Gayville	S	DM	1969		A
06478540	Little Vermillion River near Salem	BC	R	1966		F
06478690	West Fork Vermillion River near Parker	CP	DM	1961		NR

Table 1.--Surface-water stations in operation in South Dakota, July 1, 1983--Continued

Station number	Station name	Classification	Gage equipment	Period of record		Cooperation
				Begin	End	
06479000	Vermillion River near Wakonda . . .	CP	DT	1945		A
06479438	Big Sioux River near Watertown . .	BC	DM	1972		EDC,WAT
06479515	Willow Creek near Watertown . . .	H	DM	1971		EDC
06479525	Big Sioux River near Castlewood . .	H	DM	1976		EDC
06479529	Stray Horse Creek near Castlewood	H	DM	1968		MRB
06479640	Hidewood Creek near Estelline . . .	H	DM	1968		MRB
06479980	Medary Creek near Brookings . . .	H	DM	1980		EDC
06480000	Big Sioux River near Brookings . . .	CP	D	1953		NR
06480400	Spring Creek near Flandreau	HP	DM	1982		NR
06480650	Flandreau Creek above Flandreau . .	C	DM	1981		EDC
06481000	Big Sioux River near Dell Rapids . .	CH	DMT	1948		A
06481500	Skunk Creek at Sioux Falls	BC	DMT	1948		A
06482020	Big Sioux River at North Cliff Avenue, at Sioux Falls	CH	DMT	1972		A
06482610	Split Rock Creek at Corson	CH	MD	1970		BR
06482848	Beaver Creek at Canton	HP	DM	1982		NR
06485500	Big Sioux River at Akron, Iowa . . .	CP	DT	1928		F,A
06485696	Brule Creek near Elk Point	HP	DM	1982		NR

Table 2.—Water-quality and sediment stations in operation in South Dakota, July 1, 1983

[Cooperation: A, U.S. Army Corps of Engineers; BIA, Bureau of Indian Affairs; BM, Federal bench-mark station; LJC, Lower James Conservancy Sub-District; MRB, Missouri River Basin; NASQAN, National stream-quality accounting network; NR, Department of Water and Natural Resources; WYO, State of Wyoming.]

Station number	Station name	Cooperation	
		Water quality	Sediment
06357800	Grand River at Little Eagle	NASQAN	NASQAN
06360500	Moreau River near Whitehorse	NASQAN	NASQAN
--------	Coldbrook Reservoir near Hot Springs	A	
06409000	Castle Creek above Deerfield Reservoir, near Hill City	BM	BM
06430500	Redwater Creek at Wyoming-South Dakota State line		WYO
06434500	Inlet Canal near Belle Fourche	MRB	
06436150	Whitewood Creek above Lead	NR	NR
06436180	Whitewood Creek above Whitewood	NR	NR
06436190	Whitewood Creek near Whitewood	NR	NR
06436198	Whitewood Creek above Vale	NR	NR
06436760	Horse Creek above Vale	MRB	
06437000	Belle Fourche River near Sturgis	MRB	
06438000	Belle Fourche River near Elm Springs	NASQAN	NASQAN
06439300	Cheyenne River at Cherry Creek	NASQAN	NASQAN
06440000	Missouri River at Pierre	NASQAN	NASQAN
06441500	Bad River near Fort Pierre	A	A
06449100	Little White River near Vetal	MRB	
06449300	Little White River above Rosebud	BIA	
06449400	Rosebud Creek at Rosebud	MRB	
06452000	White River near Oacoma	NASQAN	NASQAN,A
06453000	Missouri River at Fort Randall Dam	NASQAN	NASQAN
06471000	James River at Columbia	NASQAN	NASQAN
06473000	James River at Ashton	MRB	
06475000	James River near Redfield	MRB	
06476000	James River at Huron	MRB	
06477000	James River near Forestburg		LJC
06478052	Enemy Creek near Mitchell	MRB	LJC
06478320	Plum Creek near Milltown		LJC
06478390	Wolf Creek near Clayton	MRB	
06478420	Lonetree Creek at Olivet		LJC
06478513	James River near Yankton		LJC
06478514	Beaver Creek near Yankton		LJC
06478500	James River near Scotland	NASQAN	NASQAN,LJC
06479529	Strayhorse Creek near Castlewood	MRB	
06479640	Hidewood Creek near Estelline	MRB	
06481000	Big Sioux River near Dell Rapids	MRB	MRB
06485500	Big Sioux River at Akron, Iowa	NASQAN	NASQAN

Ground Water

Water levels in wells, discharge of springs and wells, and water-quality data are key characteristics in monitoring ground-water trends; however, these hydrologic characteristics must be integrated with other observations and ground-water system studies in order to have the fullest meaning and usefulness. In South Dakota, the U.S. Geological Survey makes annual water-level measurements in a number of observation wells (table 3) in the bedrock artesian aquifers. Other wells, which are known as project wells, are used for specific (generally short-term) studies and, although they are not part of the observation-well program, data obtained from them also are available. In addition, the South Dakota Department of Water and Natural Resources maintains and measures more than 1,400 observation wells that are not listed in table 3.

Table 3.—Observation wells in bedrock aquifers in South Dakota, July 1, 1983

[Well number: The wells are numbered according to a system based on the Federal land-surveys of South Dakota. The well number consists of the township number followed by "N", the range number followed by "W", and the section number, followed by a maximum of four upper-case letters that indicate, respectively, the 160-, 40-, 10-, and 2½-acre tract in which the well is located. These letters are assigned in a counter-clockwise direction beginning with "A" in the northeast quarter. A serial number following the last letter is used to distinguish between wells in the same tract. Thus, well 103N65W21ADCC is the well in the SW¼, SW¼, SE¼, NE¼, sec. 21, T. 103 N., R. 65 W.]

County	Well number	Aquifer	Date of first measurement
Aurora	101N66W34BBBC	Dakota Formation	7-19-60
	103N65W21ADCC	-----do-----	7-18-79
	103N65W21CAA	-----do-----	8-20-76
	105N63W33CDBB	-----do-----	7-21-77
	105N64W13DDA	-----do-----	6- 9-61
Beadle	109N61W 6BAAC	-----do-----	10-30-63
	109N64W33ACCD	-----do-----	11- 2-60
	110N62W 9BBAD2	-----do-----	10-16-67
	110N62W 9BBAD3	Greenhorn Limestone	7-16-68
	111N62W13DDDB	Dakota Formation	12-26-76
	113N65W16DDCD	-----do-----	11- 4-63
Bon Homme	92N61W 5DDB	-----do-----	4-12-60
	94N58W 1CCC	-----do-----	10- 5-60
	94N59W 6DABA	-----do-----	7- 7-67
Brookings	109N52W35DDC	-----do-----	4-27-63
	111N52W25DDCC	-----do-----	10- 9-63
Brown	122N60W 8CBBA2	-----do-----	6-21-60
	128N61W 5DCCC	-----do-----	5-26-60
Brule	101N70W 7CBBB	-----do-----	7-12-60
	103N67W25CAD	-----do-----	7-13-60
	104N70W26DCBC	Lakota Formation	3-23-59
	105N68W11CDB	Dakota Formation	7-14-60
Buffalo	106N69W15ABB	-----do-----	7- 7-60
	107N73W 1BBBA	-----do-----	10-13-71
	108N72W12BBCA	-----do-----	9-26-61
	108N73W35DDA2	-----do-----	11- 6-73
	108N73W35DDA3	Inyan Kara Group	7-19-79

Table 3.—Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Butte	8N 2E21CD	Lakota Formation	6- 4-80
	8N 2E23DCCA	Inyan Kara Group	6-10-80
	8N 3E33CCB	Minnelusa Sandstone	6- 4-80
	11N 1E17DCAC	Inyan Kara Group	7- 3-79
	11N 6E23DCB	-----do-----	6- 4-80
Campbell	127N78W 5CDBA	Fall River Formation	5-24-67
	127N78W20DCDD	-----do-----	8-14-62
Charles Mix	94N64W26DBA	Dakota Formation	9-14-60
	96N63W 8CDA	-----do-----	9-14-60
	99N68W31DDDB	-----do-----	3-24-59
Clark	113N56W 5DDDD	-----do-----	- -83
	115N59W15CAAB	-----do-----	3-10-83
	116N59W23DDAA	-----do-----	8-13-76
	119N59W 9CCCA	-----do-----	7-28-60
Clay	92N52W14DBBD	-----do-----	12- 7-70
	93N52W28AAD	-----do-----	6-21-61
	95N51W 7ADA	-----do-----	6-21-61
Codington	116N52W 2CBBC	-----do-----	2- 9-58
Corson	18N25E23DAD	Fox Hills Sandstone	7-15-80
	19N22E 1DB	-----do-----	7-15-80
	20N29E25BBBC	Pierre Shale	7-14-80
	22N18E 4DBAC	Fort Union Formation	7-15-80
	22N19E32CBDA	Ludlow Member of the Lance Formation	7-15-80
	23N17E23ADCB	Fort Union Formation	7-15-80
Custer	3S 7E23DDAC	Lakota Formation	6- 5-80
	3S 7E35DBB	-----do-----	6- 5-80
	3S 8E17BACB	Graneros Shale	5-22-80
	4S 7E 1DAAB	Dakota Formation	6-11-80
	4S 7E28DBBC	Fall River Formation	5-22-80
	5S 6E12DAAD	Sundance Formation	5-22-80
	5S 7E 6CC	-----do-----	6-11-80
	6S 6E15ABDD	Madison Limestone	6-11-80
Davison	104N61W30DAA	Dakota Formation	7-29-60
Dewey	12N22E 2ACC	Fox Hills Sandstone	7-16-80
	12N24E17CBBD	----------	7-15-81
	12N25E12BB	Fox Hills Sandstone	7- 6-80

Table 3.—Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Dewey (Cont.)	13N22E29AD	Pierre Shale	7-16-80
	14N29E36DBDD	----------	5-19-81
	15N30E26CBBB	----------	5-19-81
Douglas	99N64W 3BBA	Codell Sandstone Member of the Carlile Shale	6-12-61
Edmunds	121N68W 3AAAB	Dakota Formation	4-12-66
	121N68W11BCB	-----do-----	8- 9-62
Fall River	7S 1E14BAAC	Sundance Formation	6-12-80
	7S 2E 3ACDD	-----do-----	6-12-80
	7S 5E12CDBB	Minnelusa Sandstone	6-13-80
	7S 6E 1AAAD	Fall River Formation	5-22-80
	8S 2E 8AADD	-----do-----	6-12-80
	8S 2E20DACC	Lakota Formation	6-12-80
	8S 2E36ADBB	Dakota Formation	6-12-80
	8S 2E36ADBC	Fall River Formation	4-11-81
	8S 3E32BDAB	Dakota Formation	6-12-80
Faulk	117N72W15CCCA	Inyan Kara Group	10-12-82
	118N67W16DBCC	Dakota Formation	6-22-60
	119N66W11ABAA	-----do-----	6-23-60
	120N67W15AAAA	-----do-----	11-28-61
Grant	120N48W 2ABBB	Cretaceous sandstone, undifferentiated	7-31-62
	121N47W36BBCB	-----do-----	7-23-76
Gregory	95N65W28	Dakota Formation	6- 1-80
	96N68W29BDCB	-----do-----	7-10-63
Haakon	1N20E14DADB	Madison Limestone	7-23-80
	1N23E24DBAC	Newcastle Sandstone	- -83
	1N23E33CACC	Fall River Formation	- -83
	2N23E 4DA	-----do-----	7- 6-80
	3N23E10BCCA	Newcastle Sandstone	7-15-80
	4N23E35AA	-----do-----	- -83
	6N18E31ABDB	-----do-----	7- 4-80
	6N22E13DC	Lakota Formation	7-23-80
	6N23E31DB	Fall River Formation	7-16-80
	8N23E26ACDA	Madison Limestone	7-23-80
Hamlin	113N55W23BBAB	Dakota Formation	10-10-63

Table 3.--Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Hand	110N67W 7CBBB2	Dakota Formation	5- 5-77
	113N69W 6DDBD	-----do-----	10- 4-62
	116N67W31DDDB	-----do-----	10-10-62
Hanson	104N57W27CCB	-----do-----	6-15-61
	104N58W13DCC	Codell Sandstone Member of the Carlile Shale	6-15-61
Harding	15N 1E13AADD	Fox Hills Formation	5-12-80
	19N 5E30DDA	Hell Creek Formation	7-16-80
Hughes	110N79W 4CAAA	Madison Limestone	5-13-81
	111N74W15BDAD	-----do-----	7-20-76
Hutchinson	99N58W 6CCD	-----do-----	9-20-60
	99N60W 1BBBC	-----do-----	3-27-59
	99N61W 4AAD	-----do-----	9-16-60
Hyde	109N72W32BAA	-----do-----	5- 4-60
	109N73W12BDCB	Sundance Formation and Minnelusa Sandstone	6-24-70
	110N72W 1CDAA	Minnelusa Sandstone	6-24-70
	114N72W19CDD	Dakota Formation	6-24-60
	116N72W18DAAB	Inyan Kara Group	9-14-62
Jackson	1S22E10CCCC	-----do-----	5-17-66
	1S22E19ABA	Fall River Formation	9-12-63
	1S22E28DAAA	Inyan Kara Group	7-22-80
	2S22E28BAD	Dakota Formation	8- -65
	2S22E32ABAD	-----do-----	12-13-55
	2S24E11BDAC	Inyan Kara Group	7-22-80
	2S24E23D	Dakota Formation	8-17-76
	2S24E27CADA	-----do-----	8-18-76
Jerauld	106N67W26CCDB	-----do-----	11- 3-78
	108N63W20DCB	-----do-----	4-27-61
Jones	1S28E36BBDB	Minnelusa Sandstone	7- 9-80
	2N26E31CBD	Dakota Formation	8-28-63
	2N27E17DDD	-----do-----	8-28-63
	2S28E 8ADD	-----do-----	5-17-78
	2S28E 8CBAC	-----do-----	8-18-76
	3S28E 3AAA	Inyan Kara Group	9-13-63

Table 3.—Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Kingsbury	109N57W28AABA	Dakota Formation	6-21-62
	110N58W32CCBC	-----do-----	7-12-76
	111N57W 7AAAA	-----do-----	- -83
	111N58W13AAAA	-----do-----	3-10-83
Lake	107N53W20BBC	-----do-----	7-17-61
	108N53W32BDD2	-----do-----	4-28-67
Lawrence	6N 2E 4BDD	Minnekahta Limestone	6- 4-80
	6N 2E23BBBA	Minnelusa Sandstone	6- 2-80
	6N 4E21DBC	-----do-----	6-10-80
	6N 4E28BBA	Sundance Formation	5-28-80
	7N 1E14CCD	Minnelusa Sandstone	6- 4-80
	7N 1E20AAD	-----do-----	6- 2-80
	7N 1E21BBC	-----do-----	6- 2-80
	7N 1E26ACD	-----do-----	6- 2-80
	7N 1E29BBA	-----do-----	6- 2-80
	7N 1E30BDA2	----------	8-25-80
	7N 2E26BCDA	Minnelusa Sandstone	6- 3-80
	7N 2E32DD	Spearfish Formation	6- 4-80
	7N 3E 7AABA	Minnelusa Sandstone	8-27-62
	7N 4E 2BDBD	Fall River Formation	5-28-80
Lincoln	97N49W33AAAA	Dakota Formation	7- 6-61
	98N50W32AAAA2	-----do-----	8-22-79
Lyman	101N72W35DADA	-----do-----	7-10-63
	103N78W12BBAD	-----do-----	10-21-75
	105N73W21CCBA2	-----do-----	7-18-79
	105N73W27ADAC	-----do-----	7- 9-62
	105N78W 9CABD	-----do-----	8- 6-76
	105N78W14ADD	-----do-----	8-17-76
	106N72W28BDBD	Graneros Shale	7- 8-80
	107N75W17ABB	Newcastle Sandstone	7-10-80
	108N77W21CCAB	Dakota Formation	7-18-63
McPherson	125N66W23ABAA	-----do-----	8- 8-62
	127N66W 5BBBD	-----do-----	8- 8-62
	128N66W 8BAD	Red River Formation	5-22-80
Marshall	127N58W19AABB	Dakota Formation	4-22-65
	127N58W23DAD	-----do-----	7- 1-70
	128N57W 3AABA	-----do-----	7-20-60
	128N59W24CBBB	-----do-----	6- 4-63

Table 3.—Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Meade	3N 6E23DCB	Spearfish Formation	6-29-80
	4N 9E 2ADD	Sundance Formation	5-28-80
	6N 5E19AAAC	Fall River Formation	5-28-80
	6N 5E21DABA	Inyan Kara Group	5-28-80
	6N 5E22DDBC	-----do-----	5-28-80
	7N14E25BDD	Newcastle Sandstone	6-23-80
Mellette	41N26W30DDC	-----do-----	7- 7-80
	41N27W25DBDC	-----do-----	6-27-78
	41N32W28CCD	Arikaree Sandstone	7- 8-80
	42N30W12CB	Dakota Formation	6-11-80
	43N27W 3BDA	-----do-----	5-15-79
	43N27W14ACD	-----do-----	7-25-63
	43N30W 8BBC	-----do-----	7-30-63
	43N30W29A	Inyan Kara Group	7- 8-80
Miner	105N58W31BACC	Dakota Formation	7-30-79
	108N55W22ADBA	-----do-----	6-16-61
Moody	106N48W13BAAC	-----do-----	7-13-61
	107N48W 3DCCC	-----do-----	7-13-61
	107N49W14ABCA	-----do-----	7-13-61
Pennington	1N 7E14CBB	Spearfish Formation	5-30-80
	1N16E31CDA	Fall River Formation	8-19-70
	2N 8E28BCB	Spearfish Formation	5-22-80
	3S14E28DDA	Dakota Formation	6- 2-80
Perkins	13N14E 9DDA	Fox Hills Sandstone	6-17-80
	20N11E35BBA	Hell Creek Formation	6-18-80
	21N14E23C	Ludlow Member of the Lance Formation	6-18-80
	23N16E20ACAC	Fox Hills Formation	6-17-80
	23N17E31BBB	Ludlow Member of the Lance Formation	6-18-80
Potter	118N76W25AB	Dakota Formation	11-24-74
	120N76W33CDDB	Minnelusa Sandstone	7-24-76
Roberts	126N51W 9CCCA	Dakota Formation	6-20-62
	127N49W29BBBC	-----do-----	6-20-62
Sanborn	106N62W30BCBA	-----do-----	10-28-60
Spink	115N65W 4ADDC	-----do-----	3-15-66
	116N62W 5DDCC	-----do-----	3-15-66
	120N63W20DCC2	-----do-----	4-29-64

Table 3.--Observation wells in bedrock aquifers in South Dakota, July 1, 1983--Continued

County	Well number	Aquifer	Date of first measurement
Stanley	3N25E32BC	Inyan Kara Group	6-23-80
	5N27E22CD	Madison Limestone	5-20-81
	6N28E27ABBA	Newcastle Sandstone	6-24-80
	7N26E20B	Fall River Formation	6-25-80
	7N28E18ACB	----------	5-20-81
	109N77W 9CDDA	Dakota Formation	8-21-63
Tripp	99N79W33CC	Upper Cretaceous, undifferentiated	6- 9-80
	100N76W17ABB	Dakota Formation	6- 9-80
	101N74W 8DDCC	Graneros Shale	6- 9-80
	102N74W28CDAA	Dakota Formation	6-19-63
Turner	96N53W36DDDA	-----do-----	7- 7-61
	97N54W 5AB	Niobrara Formation	3-31-66
	99N55W 1CAC	Dakota Formation	6-23-61
Union	93N50W 4DAA	-----do-----	6-30-61
	94N48W 6AAAC	-----do-----	7- 7-61
	95N49W16ACD	-----do-----	7- 7-61
Walworth	123N78W 3BABA	Minnelusa Sandstone and Madison Limestone	7-14-76
	123N78W12BDCC	Dakota Formation	8-15-62
Yankton	93N54W 6CCD	-----do-----	4-28-65
	93N55W 4BBC	-----do-----	10- 6-60
Ziebach	13N18E29BBB	Fox Hills Sandstone	7-22-80
	13N19E36CC	-----do-----	- -80
	13N21E31BDDA	----------	7-15-81
	14N20E 4DBC	Pierre Shale	7-22-80

SELECTED LITERATURE ON WATER RESOURCES

Because the number of publications pertaining to water resources in South Dakota is large, the publications listed below were selected to show the types of information available to those interested in or in need of water facts. Many of these publications are available for inspection at U.S. Geological Survey offices and at large public and university libraries. Also, the U.S. Geological Survey announces all its publications in a monthly report "New Publications of the Geological Survey." Subscriptions to this monthly listing are available free upon request to the U.S. Geological Survey, 329 National Center, Reston, VA 22092. A booklet entitled "Geologic and Water-Supply Reports and Maps for South Dakota," which includes reports on the geology of the State as well as water-resources reports, is available free upon request to the U.S. Geological Survey, 420 National Center, Reston, VA 22092.

USGS Professional Papers.--Professional Papers are sold by the U.S. Geological Survey, Branch of Distribution, 604 South Pickett Street, Alexandria, VA 22304.

P 600-D. Temperature variations of deep flowing wells in South Dakota, by D. G. Adolphson and E. F. LeRoux, in Geological Survey Research 1968, Chap. D, by U.S. Geological Survey, p. D60-D62. 1968.

P 650-B. Effects of reservoir filling on a buried aquifer of glacial origin in Campbell County, South Dakota, by N. C. Koch, in Geological Survey Research 1969, Chap. B, by U.S. Geological Survey, p. B169-B173. 1969.

P 813-B. Summary appraisals of the Nation's ground-water resources--Upper Mississippi Region, by R. M. Bloyd, Jr. 1975.

P 813-K. Summary appraisals of the Nation's ground-water resources--Souris-Red-Rainy Region, by Harold O. Reeder. 1978.

P 813-Q. Summary appraisals of the Nation's ground-water resources--Missouri Basin Region, by O. James Taylor. 1978.

P 877. The Black Hills--Rapid City flood of June 9-10, 1972: A description of the storm and the flood, by F. K. Schwarz, M. S. Peterson, and others. 1975.

P 1015. Proceedings of the first annual William Pecora Memorial Symposium, October 1975, Sioux Falls, South Dakota, by P. W. Woll and W. A. Fischer, editors. 1977.

USGS Water-Supply Papers.--Water-Supply Papers are sold at the above-listed Alexandria, Va., address.

W 1137-A. Missouri River basin floods of April-May 1950 in North and South Dakota, by R. E. Oltman and others. 1951.

W 1260-B. Floods of April 1952 in the Missouri River basin. 1955.

W 1298. Reconnaissance of geology and ground water in the lower Grand River valley, South Dakota, by P. C. Tychsen and R. C. Vorhis, with a section on Chemical quality of the ground water, by E. R. Jochens. 1955.

W 1425. Ground water in the Crow Creek--Sand Lake area, Brown and Marshall Counties, South Dakota, by F. C. Koopman. 1957.

W 1460-G. Ground-water resources of the lower Niobrara River and Ponca Creek basins, Nebraska and South Dakota, by T. G. Newport, with a section on Chemical quality of the water, by R. A. Krieger. 1959.

W 1475-D. Geology and occurrence of ground water at Jewel Cave National Monument, South Dakota, by C. F. Dyer. 1961.

W 1531. Hydrology of the Upper Cheyenne River basin, by R. C. Culler, R. F. Hadley, and S. A. Schumm. 1961.

W 1534. Progress report on wells penetrating artesian aquifers in South Dakota, by R. W. Davis, C. F. Dyer, and J. E. Powell. 1961.

W 1539-T. Geology and ground-water resources of the Lake Dakota plain area, South Dakota, by W. B. Hopkins and L. R. Petri. 1963.

W 1769. Chemical quality of surface waters, and sedimentation in the Grand River drainage basin, North and South Dakota, by C. H. Hembree, R. A. Krieger, and P. R. Jordan. 1964.

W 1800. The role of ground water in the national water situation, by C. L. McGuinness. 1963.

W 1865. Water resources and geology of Mount Rushmore National Memorial, South Dakota, by J. E. Powell, J. J. Norton, and D. G. Adolphson. 1973.

W 2024. Water resources of the Big Sioux River valley near Sioux Falls, South Dakota, by D. G. Jorgensen and E. A. Ackroyd. 1973.

W 2090. Ground-water levels in the United States, 1967-71--north-central States. 1973.

W 2163. Ground-water levels in the United States, 1972-74, north-central States. 1977.

USGS Circulars.--Single copies of circulars still in print are available free from the above-listed Alexandria, Va., address.

C 54. Geology and ground-water hydrology of the Angostura irrigation project, South Dakota, by R. T. Littleton, with a section on Mineral quality of the waters, by H. A. Swenson. 1949.

C 201. Ground-water resources of the Rapid Valley unit, Cheyenne Division, South Dakota, by A. J. Rosier, with a section on Surface waters of Rapid Valley, by L. J. Snell. 1953.

C 270. Chemical quality of water and sedimentation in the Moreau River drainage basin, South Dakota, by B. R. Colby, C. H. Hembree, and E. R. Jochens. 1953.

C 676. Estimated use of water in the United States in 1970, by C. R. Murray and E. B. Reeves. 1972.

C 765. Estimated use of water in the United States in 1975, by C. R. Murray and E. B. Reeves. 1977.

C 1001. Estimated use of water in the United States in 1980, by W. B. Solley, E. B. Chase, and W. B. Mann IV. 1983.

Water-Resources Investigations (WRI) Reports of the U.S. Geological Survey.--Reports in this series are available for inspection at the South Dakota and Reston, Va., offices of the U.S. Geological Survey. Selected reports may be purchased either as microfilm or hard copy from the National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161; the NTIS ordering number is given in parenthesis at the end of the citation. Reports not listing an NTIS ordering number can be purchased from the Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Further information about these reports may be obtained from the District Chief, WRD, Huron.

WRI 35-74. A method for estimating magnitude and frequency of floods in South Dakota, by L. D. Becker. 1974. (PB-239 831/AS)

WRI 80-80. Techniques for estimating flood peaks, volumes, and hydrographs on small streams in South Dakota, by L. D. Becker. 1980. (PB-81 136 145)

WRI 80-100. Appraisal of the water resources of the Big Sioux aquifer, Brookings, Deuel, and Hamlin Counties, South Dakota, by N. C. Koch. 1980. (PB-81 164 584)

WRI 82-31. Magnitude and frequency of floods from selected drainage basins in South Dakota, by L. D. Becker. 1982.

WRI 82-4064. A digital-computer model of the Big Sioux aquifer in Minnehaha County, South Dakota, by N. C. Koch. 1983.

WRI 83-4077. A preliminary assessment of the hydrologic characteristics of the James River in South Dakota, by R. D. Benson. 1983.

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SD-75-1 Water resources data for South Dakota—water year 1975, by U.S. Geological Survey. 1976. (PB-251 861/AS)

SD-76-1 Water resources data for South Dakota—water year 1976, by U.S. Geological Survey. 1977. (PB-266 453/AS)

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USGS Hydrologic Investigations Atlases.--Hydrologic Investigations Atlases (and other maps of areas west of the Mississippi River) are sold by the Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225.

HA-195. Hydrogeology of the glacial drift in the Skunk Creek—Lake Madison drainage basin, southeastern South Dakota, by M. J. Ellis and D. G. Adolphson. 1965.

HA-311. Hydrology of a part of the Big Sioux drainage basin, eastern South Dakota, by M. J. Ellis, D. G. Adolphson, and R. E. West. 1968.

HA-355. Hydrology of the Rosebud Indian Reservation, South Dakota, by M. J. Ellis, J. H. Ficken, and D. G. Adolphson. 1971.

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HA-499. Geohydrology of Crow Creek and Lower Brule Indian Reservations, South Dakota, by L. W. Howells. 1974.

HA-511. Flood of June 9-10, 1972, at Rapid City, South Dakota, by O. J. Larimer. 1973.

HA-585. Geohydrology of the Cheyenne River Indian Reservation, South Dakota, by L. W. Howells. 1979.

HA-644. Geohydrology of the Standing Rock Indian Reservation, North and South Dakota, by L. W. Howells. 1982.

USGS Hydrologic Unit Maps.--Hydrologic Unit Maps are sold at the above-listed Denver address.

U.S. Geological Survey, 1976, Hydrologic unit map--1974 State of South Dakota.

USGS Open-File Reports and Maps.--Open-file reports which may be in manuscript form generally are not reproduced and distributed in quantity. These reports are available for inspection in the Huron, South Dakota, and Reston, Va., offices of the U.S. Geological Survey. Most numbered open-file reports may be purchased from the Open-File Services Section (OFSS), Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Information on the availability of the unnumbered reports may be obtained from the District Chief, USGS, Water Resources Division, Huron, South Dakota.

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83-207. Summary of water withdrawals in the United States, 1950-80, by W. B. Mann IV, W. B. Solley, and E. B. Chase. 1983.

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