WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN SOUTH DAKOTA--FISCAL YEARS 1989-90

Compiled by Ella M. Decker

U.S. GEOLOGICAL SURVEY

Open-File Report 91-91

Huron, South Dakota
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U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

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Federal Center, Bldg. 810
Box 25425
Denver, CO 80225-0425

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric units by the following conversion factors:

Multiply	By	To obtain
acre-foot	1,233	cubic meter
inch	25.40	millimeter
square mile	2.590	square kilometer

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THE U.S. GEOLOGICAL SURVEY

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

Since 1879, the research and fact-finding role of the USGS has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian map-making agency, the primary source of data on the Nation's surface- and ground-water resources, and the employer of the largest number of professional earth scientists. Today programs serve a diversity of needs and users. Programs include:

* Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.

* Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.

* Conducting research on the geologic structure of the Nation.

* Studying the geologic features, structure, processes, and history of the other planets of our solar system.

* Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.

* Developing and producing digital cartographic data bases and products.

* Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.

* Conducting water-resource appraisals in order to describe the consequences of alternative plans for developing land and water resources.

* Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.

* Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.

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

* Studying the hydrologic aspects of global climate change.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation--providing "Earth science in the public service."

THE WATER RESOURCES DIVISION

The mission of the U.S. Geological Survey's Water Resources Division is to provide the hydrologic information and understanding needed for the optimum use and management of the Nation's water resources for the overall benefit of the people of the United States. For more than 110 years, the U.S. Geological Survey has studied the occurrence, quantity, quality, distribution, and movement of the surface and underground water that composes 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 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.

The Geological Survey, through its Office of Water Data Coordination (OWDC), also coordinates the water-data-acquisition activities of other Federal agencies. Information on these Federal activities is made available to all users of water data by means of a national network of assistance centers managed by the Geological Survey's National Water Data Exchange (NAWDEX). In South Dakota, NAWDEX services can be obtained from the District Chief, U.S. Geological Survey, Water Resources Division, Federal Building, Huron, SD 57350. A leaflet explaining NAWDEX services is available from the Assistance Center or from the NAWDEX Program Office, U.S. Geological Survey, 421 National Center, Reston, VA 22092.

HISTORICAL SUMMARY - SOUTH DAKOTA DISTRICT

During 1979, the U.S. Geological Survey observed its 100th anniversary. In South Dakota, the first collection of streamflow data by the U.S. Geological Survey was in 1903. The early records were collected during 1903-06 from Black Hills area streams; data were collected during 1912-20 at sites in the Standing Rock, Rosebud, and Pine Ridge Indian Reservations. During 1928-30, the U.S. Army Corps of Engineers provided financial support for the establishment and operation of 18 gaging stations in the Missouri River basin in South Dakota. One station has been in operation on the Missouri River at Yankton continuously since 1930.

Despite the Survey's early beginning, it was not until October 16, 1944, that the Bismarck District, comprising the states of North Dakota and South Dakota, was created to assess the water resources of the two states with R. E. Marsh as District Engineer. A subdistrict office, with W. M. Littlefield in charge, was established in Pierre to operate the South Dakota stream-gaging stations. The Pierre office was virtually independent of Bismarck, except for major questions of policy. Marsh and Littlefield were the only experienced men in the District, yet it was a period of expansion; in less than three years, the number of stream-gaging stations increased from 28 to 63. A second subdistrict office was later opened in Rapid City to establish and maintain stations on streams and ditches in the Black Hills area.

The next major increase in collection of surface-water records occurred during the mid-1940's as a result of the Pick-Sloan Plan for Missouri Basin development. Most of the stations established during this period were financed by Interior Department Missouri Basin funds and were primarily associated with U.S. Bureau of Reclamation studies.

Numerous unsuccessful attempts had been made by State officials to obtain State funds for cooperation in stream gaging; the Legislature, reflecting the attitude of the citizens, was not water-minded. However, in 1944, the new Governor became convinced that, with the proposed development of the Missouri Basin coming actively into the picture, the State should participate in the inventory of its water resources. Having no specific appropriation for that purpose, he decided that a number of State agencies should contribute from their general funds, and as the work would be done in cooperation with the U.S. Geological Survey, it seemed logical to him that the State Geological Survey should be designated as the cooperating State agency. Accordingly, that agency, the Highway Commission, and the Department of Game and Fish each contributed equal amounts of funding totaling $2,400 for the years 1944 and 1945. By 1958, the cooperative surface-water program with the State Water Resources Commission had grown to $57,000. The network of gaging stations has continued to expand and presently records of daily flow are collected at about 130 sites.

In addition, a cooperative program was begun with the South Dakota Highway Commission in 1955 to determine the magnitude and frequency of floods in South Dakota. It was recognized that hydrologic data for floods from small drainage areas were lacking. Provision was made for establishment of approximately 60 crest-stage gages in 16 areas in the State, mostly on basins of less than 10 square miles.

The State Geologist started a small observation-well program in 1936, and in the fall of 1939, he began cooperation with the USGS for the purpose of enlarging that program; $400 was allotted annually through the fiscal year 1945, when cooperation ceased. At that time, Missouri Basin funds for ground-water investigations became available.

A formal program of ground-water investigation was begun in South Dakota in 1946, with investigations in a proposed unit of the Oahe Irrigation Project. The Oahe Unit studies were begun under the supervision of the District Engineer at Bismarck, North Dakota. A field office was established in Huron on May 13, 1947. This office conducted the ground-water activities while surface-water activities in South Dakota continued to be supervised from the Bismarck office. The early ground-water studies were made in cooperation with the U.S. Bureau of Reclamation (USBR) and were financed by funds appropriated for studies in the Missouri River basin. In addition to the long-range investigations in the Oahe area, several smaller projects were

initiated in cooperation with the USBR between 1946 and 1956. The first ground-water studies utilizing the State-Federal Cooperative Program began in 1955 when the South Dakota State Water Resources Commission entered into a cooperative agreement with the U.S. Geological Survey to investigate the large and wasteful uncontrolled flow from artesian wells throughout the State. In 1958, the South Dakota State Geological Survey entered into a cooperative agreement for a study of ground-water resources, with particular emphasis to be placed upon the determination of ground-water resources primarily in the eastern counties of the State.

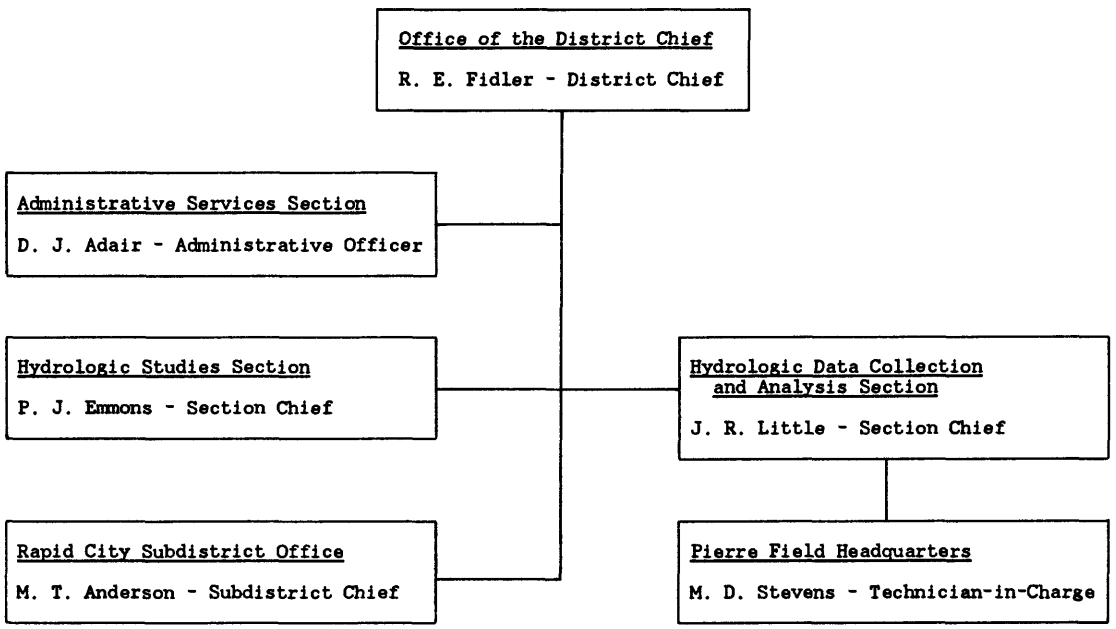
As part of the reorganization of the Water Resources Division in 1966, South Dakota was separated from the Bismarck District and both surface- and ground-water activities were supervised from Huron. John E. Powell was the first District Chief.

During the early years of USGS activity in South Dakota, interest in water quality centered on ground water, and studies of the chemical quality of water were made as integral parts of ground-water investigations. Laboratory work was done either in the Geological Survey Laboratory in Washington, D.C., or was contracted to other laboratories. Because of the need for large amounts of water-quality information in connection with plans for development of the Missouri River basin, the Quality of Water Branch of the U.S. Geological Survey established laboratories in Lincoln, Nebraska, in 1945, which served the South Dakota District for many years. At the present time, one Central Laboratory, located in Arvada, Colorado, provides analytical services for the Geological Survey offices.

Since 1944, more than 100 water-resources studies have been made in South Dakota. These range from reconnaissance-type studies of counties and Indian reservations to research on small-basin runoff and toxic wastes, the quality of water in lakes, the use of remote sensing for defining aquifers, and studies using digital models to describe the ground-water regimen and surface-water hydraulics. During the past 40 years, 184 formal reports describing the studies and results of investigations have been prepared to inform the public and the scientific community.

DISTRICT ORGANIZATION

The South Dakota District of the Water Resources Division consists of two operating sections and one support unit. Water-resources projects conducted by the District are assigned an operating section with the responsibility for a project assigned to a project chief. Personnel are based at the District office in Huron, the Subdistrict office in Rapid City, and the Field Headquarters in Pierre. The District is assisted and advised by research centers, laboratories, technical consultants, and training centers maintained throughout the United States by the Water Resources Division.



Inquiries regarding work of the U.S. Geological Survey, Water Resources Division, in South Dakota may be directed to the following offices:

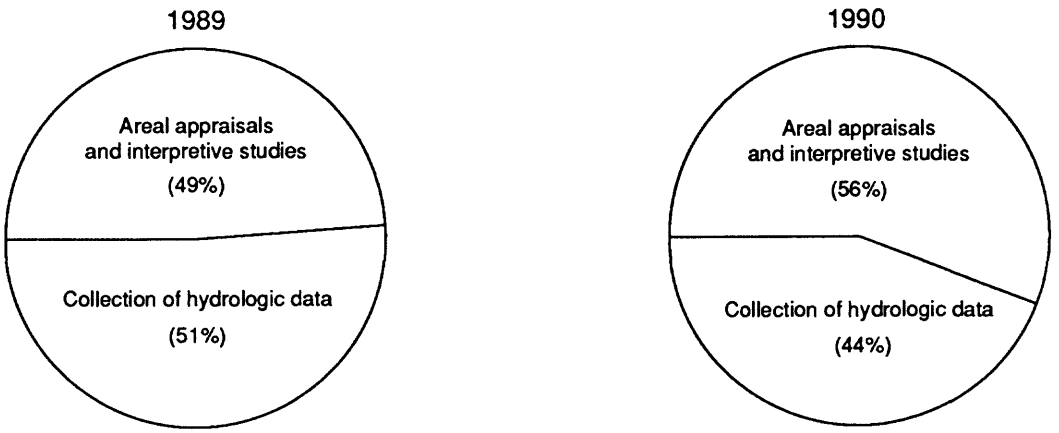
South Dakota District Office
U.S. Geological Survey
Water Resources Division
Room 408, Federal Building
200 4th St. SW
Huron, SD 57350
(605) 353-7176

Rapid City Subdistrict Office
U.S. Geological Survey
Water Resources Division
Federal Building/Courthouse
1608 Mt. View Road
Rapid City, SD 57702
(605) 394-1781

Pierre Field Headquarters
U.S. Geological Survey
Water Resources Division
P.O. Box 220
Pierre, SD 57501
(605) 773-5388

TYPES OF INVESTIGATIONS

The diagram below shows the percentage of water resources investigations in South Dakota for fiscal years 1989 and 1990 in the broad categories of collection of hydrologic data, and areal appraisals and interpretive studies, as a percent of total budget.



The investigations are directed toward obtaining the information needed by managers and planners for the solution or alleviation of water problems in the State.

The investigations are supported by services and (or) funds provided by State and local agencies (table 1), matched on a 50-50 basis by Federal/State cooperative program funds; by funds transferred from other Federal agencies (OFA program); and by funds appropriated directly to the Geological Survey for research, data collection, and special projects (Federal program). In fiscal years 1989 and 1990, the financial support for these programs in South Dakota was about $2,945,000 and $3,066,000, respectively, which was distributed as follows:

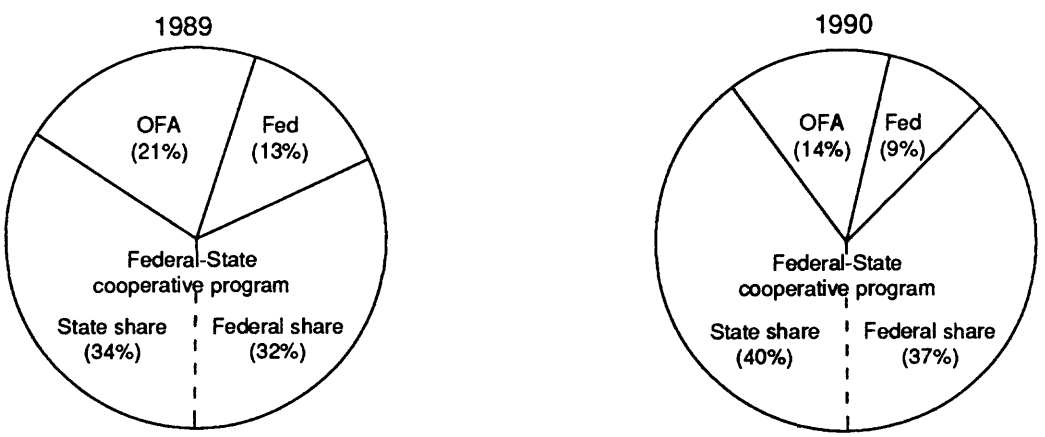


Table 1.--Agencies supporting water-resources investigations in South Dakota during fiscal years 1989-90

State Agencies

South Dakota Department of Transportation
South Dakota Department of Game, Fish & Parks
- Custer State Park Division
- Fish and Wildlife Division

South Dakota Department of Water and Natural Resources
- Division of Water Rights
- Division of Water Quality
- Division of Geological Survey
- Division of Water Resource Management

South Dakota School of Mines & Technology
South Dakota State University

Local Agencies

East Dakota Water Development District
James River Water Development District
Mid-Dakota Water Development District
West Dakota Water Development District

Counties of:	Brookings	Hutchinson	Lincoln	Spink
	Codington	Kingsbury	Minnehaha	Turner
	Custer	Lake	Moody	Union
	Grant	Lawrence		

City of Aberdeen
City of Rapid City
City of Sioux Falls
City of Watertown
Mellette-Todd County Conservation District
North Central RC&D
Oglala Sioux Tribe
Rosebud Sioux Tribe
Sisseton-Wahpeton Sioux Tribe

Federal Agencies

Department of Agriculture
- U.S. Forest Service

Department of the Army
- Corps of Engineers, Omaha District

Department of the Interior
- Bureau of Indian Affairs
- Bureau of Reclamation
- EROS Data Center
- Office of the Secretary
- Fish and Wildlife Service

Tennessee Valley Authority

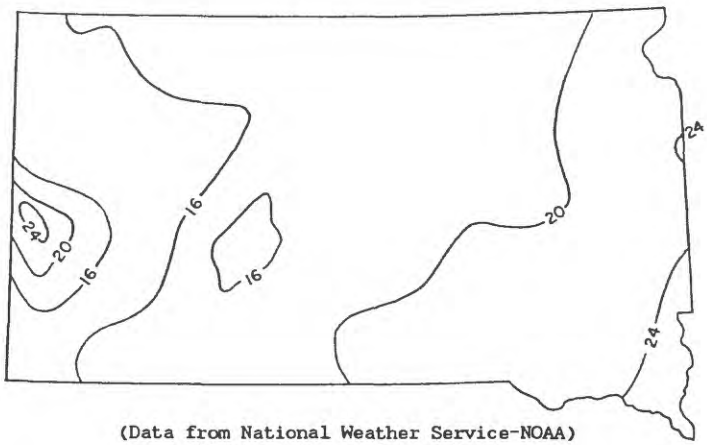
WATER RESOURCES SUMMARY

South Dakota has an average annual precipitation of about 17.6 inches, ranging from slightly less than 16 inches in the northwest to more than 24 inches in the Black Hills and in the southeast (fig. 1). In most years, 75 to 85 percent of the precipitation occurs from April through September. Droughts, especially those of the 1930's, 1950's, 1970's, and 1980's, have been disastrous to agriculture, the State's dominant industry. With the exception of the Missouri River, where 31 million acre-feet of water can be stored in four large reservoirs in South Dakota, streamflow during low flows generally is not dependable for continued irrigation or for municipal or industrial withdrawals (fig. 2).

The large dams on the Missouri River, built under the Pick-Sloan Missouri River Program, provide flood protection and navigation benefits for the basin States downstream. However, the tributary streams in South Dakota are subject to periodic flooding resulting from spring snowmelt and intense summer thunderstorms. The majority of damage is to lands used for agriculture. The U.S. Geological Survey outlines flood-prone areas on topographic maps as part of a nationwide Federal program for managing flood losses. Parts of these topographic maps showing flood-prone urban areas also have been published in urban-area pamphlets. In South Dakota, 311 flood-prone area maps have been completed by the USGS (fig. 3), and 139 urban-area pamphlets have been completed by the Federal Emergency Management Agency through the National Flood Insurance Program. Information on these maps and pamphlets is available on request from the District Chief, U.S. Geological Survey, Huron, South Dakota.

Ground-water constitutes a large and reliable source of water for domestic, industrial, stock, and municipal use. Historically, water from confined (artesian) bedrock aquifers has been important in settlement of the State and in development of its chief industry, agriculture. Although artesian aquifers (from which water flows or can be pumped from moderate depth) underlie nearly all the State, shallow ground water is absent or scarce in much of the State, especially the unglaciated western part. Hence, the availability of artesian water and the development of inexpensive methods of drilling deep wells were of special importance in bringing about early settlement, which otherwise might have been restricted to river valleys where water is available from shallow alluvium. Much of the artesian water is of inferior chemical quality for drinking-water supplies, but it has been used nevertheless.

The other major source of ground water in the State is the glacial drift that underlies South Dakota east of the Missouri River. Several hundred million acre-feet of water, much of it suitable for irrigation, is stored in glacial outwash and alluvium. These deposits are irregular in shape and size, and are scattered throughout the area. Areas in the State where glacial deposits containing large amounts of ground water are known to occur are shown in figure 4. The major glacial-drift aquifers have been mapped as a result of cooperative Federal, State, county, and water-development district water-resources studies.



(Data from National Weather Service-NOAA)
(Contour interval 4 inches)

Figure 1.--Average annual precipitation, in inches.

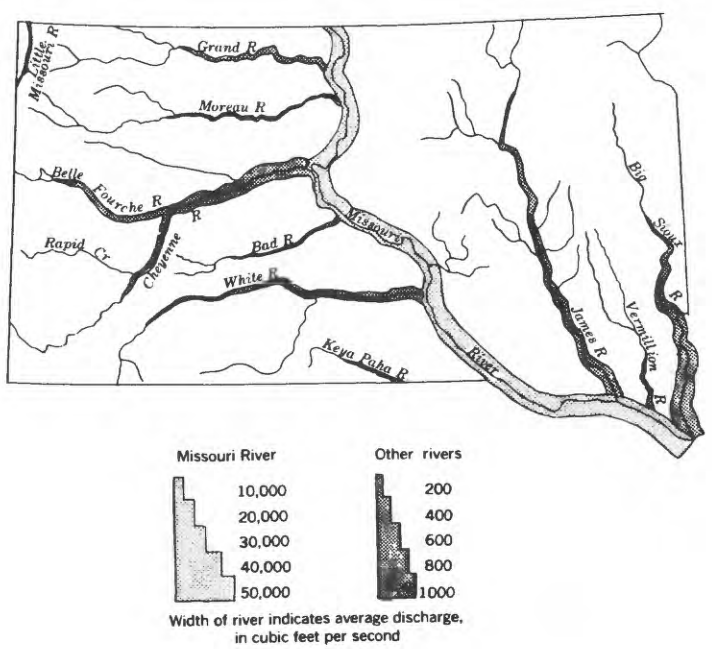


Figure 2.--Average discharge of the principal streams.

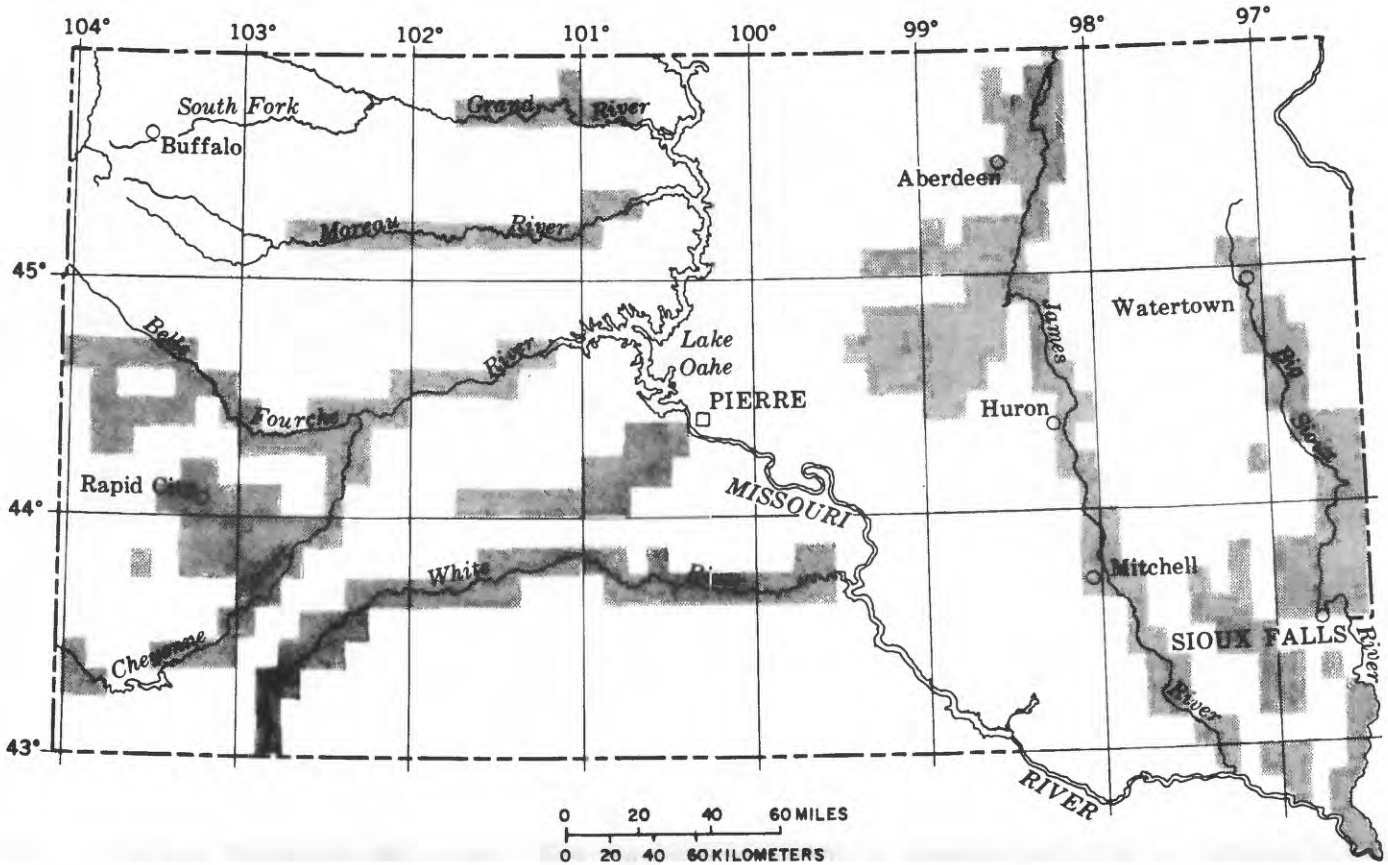


Figure 3.--Flood-prone area maps completed in South Dakota.

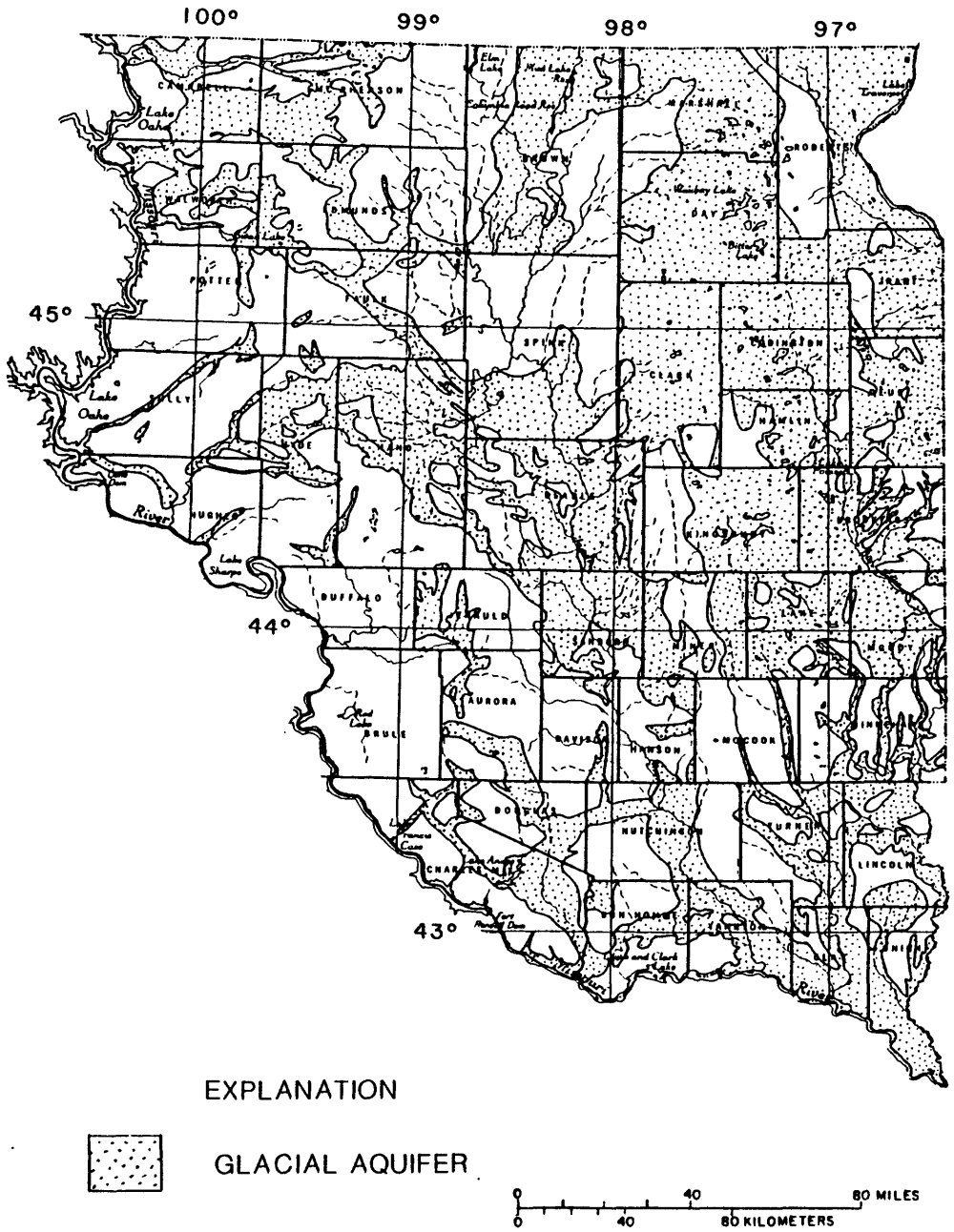


Figure 4.--Major glacial aquifers in eastern South Dakota. (Updated from Bardwell, 1984.)

HYDROLOGIC-DATA PROGRAM

Surface Water

Surface-water discharge (streamflow) and stage (water level) data (table 2, fig. 5) are collected for 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 as the needs and financial resources of the water-data users change. 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 are published annually in the Water Resources Data report or can be furnished in machine-readable form either in raw form or statistically analyzed. 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.

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88

[Classification: B, bench-mark 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; PR, partial-record station. Equipment: D, digital water-stage recorder; M, servo-manometer unit; R, graphic water-stage recorder; T, telemark; P, data-collection platform; CSG, crest-stage gage. Supported by: COE, U.S. Army Corps of Engineers; BIA, Bureau of Indian Affairs; BR, Bureau of Reclamation; ED, East Dakota Water Development District; WD, West Dakota Water Development District; FED, Federal; MRB, Missouri River Basin Program; DWNR, Department of Water and Natural Resources; DOT, Department of Transportation; L, Lawrence County; SC, Stanley County RC&D; WAT, City of Watertown; RC, City of Rapid City; WY, State of Wyoming; BM, Federal bench-mark station; TVA, Tennessee Valley Authority; SWST, Sisseton-Wahpeton Sioux Tribe; GFP, Department of Game, Fish and Parks]

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
05051650	La Belle Creek near Veblen.	H,P	D,M,P	1987		SWST
05289985	Big Coulee near Peever.	H,P	D,M	1987		SWST
06334500	Little Missouri River at Camp Crook . . .	C,P	D,M,T	1903 1956	1906	DWNR
06354860	Spring Creek near Herreid	PR	CSG	1962 1989	1986	DOT
06354882	Oak Creek near Wakpala.	H,P	D,M	1984		BIA
06355500	North Fork Grand River near White Butte .	C,R	D,M	1945		DWNR
06356000	South Fork Grand River at Buffalo	C,H	D,M	1955		DWNR
06356500	South Fork Grand River near Cash.	C,H	D,M	1945		COE
06357000	Shadehill Reservoir at Shadehill.	S		1950		BR
06357800	Grand River at Little Eagle	C,R	D,M,P,T	1958		COE
06359500	Moreau River near Faith	C,H,P	D,M	1943		COE, DWNR
06360500	Moreau River near Whitehorse.	C,H,P	D,M,P,T	1954		COE
06395000	Cheyenne River at Edgemont.	C,H,P	D,P,R	1903 1928 1946	1906 1933	DWNR,TVA
06400000	Hat Creek near Edgemont	C,H,P	D,M	1905 1950	1906	DWNR
06400497	Cascade Springs near Hot Springs.	C	D,M	1976		DWNR
06400875	Horsehead Creek at Oelrichs	C	D,M	1983		DWNR
06401000	Angostura Reservoir near Hot Springs. . .	S		1949		BR
06401500	Cheyenne River below Angostura Dam. . . .	PR, R	D,P	1945		BR
06402000	Fall River at Hot Springs	C,R	D,M	1937		COE

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06402500	Beaver Creek near Buffalo Gap	C,H	D,M	1937		DWNR
06403300	French Creek above Fairburn	C,H	D,M	1981		DWNR
06404000	Battle Creek near Keystone	C	D,M	1945	1947	DWNR
				1961		
06404800	Grace Coolidge Creek near Hayward	C	D,M	1989		DWNR,GFP
06404998	Grace Coolidge Creek near Game Lodge, near Custer	C,H,P	D,M	1976		DWNR,GFP
06405800	Bear Gulch near Hayward	C	D,M	1989		DWNR,GFP
06406000	Battle Creek at Hermosa	C	D,M	1949		DWNR
06406500	Battle Creek below Hermosa	C,H	D,M	1950	1953	DWNR
				1988		
06407900	Spring Creek near Rockerville	C,H	D,M	1985		WD
06408500	Spring Creek near Hermosa	C	D,M	1949		DWNR
06408700	Rhoads Fork near Rochford	C,H	D,M	1981		DWNR
06408860	Rapid Creek near Rochford	C,H	D,M	1988		WD
06409000	Castle Creek above Deerfield Reservoir, near Hill City	B,C	D,M	1948		BM
06409500	Deerfield Reservoir near Hill City	S		1947		BR
06410000	Castle Creek below Deerfield Reservoir	PR,R	D,M,R	1946		BR
06410500	Rapid Creek above Pactola Reservoir, at Silver City	C,R	D,M	1953		DWNR
06411000	Pactola Reservoir near Silver City	S		1956		BR
06411500	Rapid Creek below Pactola Dam	C,R	D	1928	1932	BR
				1946		
06412200	Rapid Creek above Victoria Creek, near Rapid City	C,H	D,M	1988		WD
06412500	Rapid Creek above Canyon Lake, near Rapid City	C,R	D,M,T	1946		DWNR
06412600	Cleghorn Springs main channel at fish hatchery, at Rapid City	H	D	1987		GFP,RC
06412700	Cleghorn Springs south channel at fish hatchery, at Rapid City	H	D	1987		GFP,RC
06412800	Cleghorn Springs north channel at fish hatchery, at Rapid City	H	D	1987		GFP,RC
06412900	Rapid Creek below Cleghorn Springs, at Rapid City	H	D	1987		GFP,RC

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06413200	Rapid Creek below Park Drive, at Rapid City	H	D	1987	1989	GFP,RC
06413300	Leedy Ditch at headgate below Canyon Lake Dam, at Rapid City	H	D	1987	1989	GFP,RC
06413550	Leedy Ditch at mouth, at Rapid City	H	D	1987	1989	GFP,RC
06413570	Rapid Creek above Jackson Boulevard, at Rapid City	C,S	D,T	1987		GFP,RC
06413650	Lime Creek at mouth, at Rapid City	H	D	1987		GFP,RC
06413660	Storybook Ditch at headgate, at Rapid City	H	D	1987	1989	GFP,RC
06413670	Storybook Ditch at mouth, at Rapid City	H	D	1987	1989	GFP,RC
06413700	Rapid Creek above water treatment plant, at Rapid City	H	D,T	1987	1989	GFP,RC
06413800	Deadwood Avenue drain at Rapid City	H	D	1987		GFP,RC
06414000	Rapid Creek at Rapid City	C,R	D,M,T	1903 1942	1906	COE
06418900	Rapid Creek below Sewage Treatment Plant, near Rapid City.	C	D,M,T	1981		DWNR,RC
06421500	Rapid Creek near Farmingdale.	C,R	D,M,T	1946	1989	RC,WD,DWNR
06422000	Rapid Creek at Creston	C	D,M	1929 1989	1932 1990	DWNR,RC
06422500	Boxelder Creek near Nemo.	C,H	D,M	1945 1966	1947	DWNR
06423010	Boxelder Creek near Rapid City.	C	D,M	1978		DWNR
06423500	Cheyenne River near Wasta	C,R	D,M,P,T	1914 1928 1934	1915 1932	COE,DWNR
06425100	Elk Creek near Rapid City	C	D,M	1979		DWNR
06425500	Elk Creek near Elm Springs.	C	D,M	1949		DWNR
06428500	Belle Fourche River at Wyoming-South Dakota State line	C,R	D,P	1946		FED
06429997	Murray Ditch above headgate, at Wyoming-South Dakota State line	C,R	D	1987		DWNR,WY

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06430500	Redwater Creek at Wyoming-South Dakota State line	C,R	D	1929 1936 1954	1931 1937	DWNR,WY
06430770	Spearfish Creek near Lead	C,H	D,M,P	1988		L
06430800	Annie Creek near Lead	C,H	D,M	1988		L
06430850	Little Spearfish Creek near Lead	C,H	D,M	1988		L
06430898	Squaw Creek near Spearfish	C,H	D,M	1988		L
06430900	Spearfish Creek above Spearfish	C,H	D,M	1988		L
06431500	Spearfish Creek at Spearfish.	C	D,M	1946		DWNR
06432020	Spearfish Creek below Spearfish	C,H	D,M	1988		L
06433000	Redwater River above Belle Fourche.	C,R	D,M	1945		DWNR
06433500	Hay Creek at Belle Fourche.	C,R	D	1953		COE,FED
06434500	Inlet Canal near Belle Fourche.	C,R	D,P	1945		BR
06435000	Belle Fourche Reservoir near Belle Fourche	S		1912		BR
06436000	Belle Fourche River near Fruitdale.	C,R	D,M,T	1945		DWNR
06436156	Whitetail Creek at Lead	C	D,M	1988		L
06436170	Whitewood Creek at Deadwood	C	D,M	1981		DWNR
06436180	Whitewood Creek above Whitewood	C	D,M,T	1983		DWNR
06436190	Whitewood Creek near Whitewood.	C	D,M	1981		DWNR
06436198	Whitewood Creek above Vale.	C	D,M,T	1983		DWNR
06436760	Horse Creek above Vale.	C,R	D,M	1962		MRB
06437000	Belle Fourche River near Sturgis.	C,R	D,M,P,T	1945		DWNR
06437020	Bear Butte Creek near Deadwood	C	D,M	1988		L
06437500	Bear Butte Creek near Sturgis	PR	CSG	1988		DOT
06438000	Belle Fourche River near Elm Springs.	C,R	D,M,T	1928 1934	1932	COE
06439000	Cherry Creek near Plainview	C,H,P	D,M	1945		COE
06439300	Cheyenne River at Cherry Creek.	C,R	D,M,P	1960		COE
06439430	Cottonwood Creek near Cherry Creek.	H,P	D,M	1982		BIA
06439960	Chantier Creek near Hayes	PR	CSG	1989		DOT
06439980	Lake Oahe near Pierre	S		1958		COE
06440000	Missouri River at Pierre	S	P	1929 1988	1965	COE

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06440200	South Fork Bad River near Cottonwood	C,H	D,M	1954 1988	1960	FED
06440850	Medicine Creek near Philip	PR	CSG	1989		DOT
06441000	Bad River near Midland.	PR	D,M	1945		COE
06441100	Plum Creek near Hayes	PR	CSG	1989		DOT
06441110	Plum Creek below Hayes	C	D,M	1989		SC
06441400	Willow Creek near Fort Pierre	C	D,M	1989		SC
06441500	Bad River near Fort Pierre.	C,H,P	M,P,R,T	1928		COE
06441590	Missouri River at La Framboise Island, at Pierre	S	D,M,P	1988		COE
06441595	Missouri River at Farm Island, near Pierre	S	D,M,P	1988		COE
06442000	Medicine Knoll Creek near Blunt	H,PR	D,M	1950	1990	COE,FED
06442500	Medicine Creek at Kennebec.	C,H	D,M	1954	1990	COE
06442700	Lake Sharpe near Fort Thompson.	S		1963		COE
06442718	Campbell Creek near Lee's Corner.	H	D,M	1987		BIA
06442900	Elm Creek near Gann Valley.	H	D,M	1987		MRB
06442996	Lake Francis Case (American Creek Bay) at Chamberlain	S	D,M,T	1988		COE
06445685	White River near Nebraska-South Dakota State line.	C,H	D,M	1987		BIA
06445980	White Clay Creek near Oglala.	C,H	D,M	1965 1987	1981	BIA
06446000	White River near Oglala	C	D,M	1943		DWNR
06447000	White River near Kadoka	C,H,P	D,M,R	1942		COE
06447500	Little White River near Martin.	C	D	1938 1962	1940	DWNR
06449000	Lake Creek below refuge, near Tuthill	C,R	D,R	1938 1962	1940	DWNR
06449100	Little White River near Vetal	C	D,M	1959		MRB
06449300	Little White River above Rosebud.	C	D,M	1981		BIA
06449400	Rosebud Creek at Rosebud.	C,P	D,M	1974		MRB
06449500	Little White River near Rosebud	C,P	D,M	1943		DWNR
06450500	Little White River below White River.	C,H,P	D,M,R	1949		DWNR
06452000	White River near Oacoma	C,H	D,M,R	1928		COE
06452278	Lake Francis Case (Ft. Randall Reservoir) near Platte	S	D,M,P	1988		COE

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06452320	Platte Creek near Platte	H	D,M	1988		MRB
06452330	Campbell Creek near Geddes	PR	CSG	1989		DOT
06452500	Lake Francis Case at Pickstown	S		1952		COE
06453007	Missouri River above Greenwood	S	D,M,R,P	1988	1989	COE
06453020	Missouri River below Greenwood	S	D,M,R,P	1989		COE
06453255	Choteau Creek near Avon	H,P	D,M	1982		BIA
06463900	Antelope Creek near Mission	PR	CSG	1963 1989	1970	DOT
06464100	Keya Paha River near Keyapaha	C	D,M	1981		DWNR
06464500	Keya Paha River at Wewela	C,H,P	D,M	1937 1947	1940	DWNR
06466700	Lewis and Clark Lake at Springfield	S	D,M,R,P	1981		COE
06467000	Lewis and Clark Lake near Yankton	S		1955		COE
06467500	Missouri River at Yankton	C,R	D,M,P,T	1930		COE
06471000	James River at Columbia	C,R	M,R,T	1945		DWNR
06471200	Maple River at North Dakota-South Dakota State line	C,H	D,M	1956		DWNR
06471500	Elm River at Westport	C,R	D,M,T	1945		DWNR
06471550	James River below Columbia	H	D,M	1988		BR
06473000	James River at Ashton	C,R	D,M,T	1945		MRB
06473700	Snake Creek near Ashton	H,P	D,M	1955 1984	1969 1989	BR
06473750	Wolf Creek near Ree Heights	H,P	D,M	1959 1984	1981 1989	BR
06474000	Turtle Creek near Tulare	H,P,PR	D,M,CSG	1953 1965 1984	1956 1981	BR,DOT
06474300	Medicine Creek near Zell	H,P	D,M	1959 1984	1981 1989	BR
06475000	James River near Redfield	C,R	D,M	1950		MRB
06476000	James River at Huron	C,R	D	1928 1943	1932	DWNR
06476500	Sand Creek near Alpena	C,H,PR	D,M,CSG	1950		DWNR,DOT
06477000	James River near Forestburg	C,R	D,M,T	1950		DWNR
06477150	Rock Creek near Fulton	PR	CSG	1966 1989	1979	DOT

Table 2.--Surface-water stations in operation in South Dakota, fiscal years 1987-88--Continued

Station number	Station name	Classification	Gage equipment	Period of record (calendar year) Begin	End	Supported by
06477500	Firesteel Creek near Mount Vernon	C,H	D,M	1955		DWNR
06478052	Enemy Creek near Mitchell	PR	CSG	1975 1989	1987	DOT
06478300	Dry Creek near Parkston	PR	CSG	1955 1989	1980	DOT
06478390	Wolf Creek near Clayton	PR	CSG	1975		DOT
06478500	James River near Scotland	C,R	D,M,P,T	1928		COE
06478513	James River near Yankton	C,R	D,M	1981		DWNR
06478515	Missouri River near Gayville	S	D,M,P	1969		COE
06478530	Lake Thompson near Oldham	S	D,M	1988		DWNR
06478535	East Fork Vermillion River near Ramona	C,P	D,M	1986	1989	DWNR
06478540	Little Vermillion River near Salem	B,C,H	D,M	1966		BM
06478690	West Fork Vermillion River near Parker	C,P	D,M	1961		DWNR
06479000	Vermillion River near Wakonda	PR	CGS	1945 1989	1983	DOT
06479010	Vermillion River near Vermillion	C,P	D,M,P	1984		COE
06479215	Big Sioux River near Florence	C,H,P	D,M	1984		ED
06479438	Big Sioux River near Watertown	C,H,P	D,M,P	1972		DWNR,WAT
06479525	Big Sioux River near Castlewood	C,H	D,M	1976		DWNR
06479640	Hidewood Creek near Estelline	PR	CSG	1968 1989	1985	DOT
06479928	Battle Creek near Nunda	H	D,M	1987		ED
06479980	Medary Creek near Brookings	H,P	D,M	1980		ED
06480000	Big Sioux River near Brookings	C,P	D	1953		DWNR
06480400	Spring Creek near Flandreau	H,P	D,M	1982		ED
06480650	Flandreau Creek above Flandreau	H,P	D,M	1981		ED
06481000	Big Sioux River near Dell Rapids	C,P	D,M,T	1948		COE
06481500	Skunk Creek at Sioux Falls	C,P	D,M,T	1948		COE
06482020	Big Sioux River at North Cliff Avenue, at Sioux Falls	C,P	D,M,P,T	1972		COE
06482610	Split Rock Creek at Corson	H,P,PR	M,D,T,CSG	1970		MRB,DOT
06482848	Beaver Creek at Canton	C,PR	D,M,CSG	1982		DWNR,ED,DOT
06485500	Big Sioux River at Akron, Iowa	C,P	D,P	1928		COE
06485696	Brule Creek near Elk Point	H,P	D,M	1982		DWNR

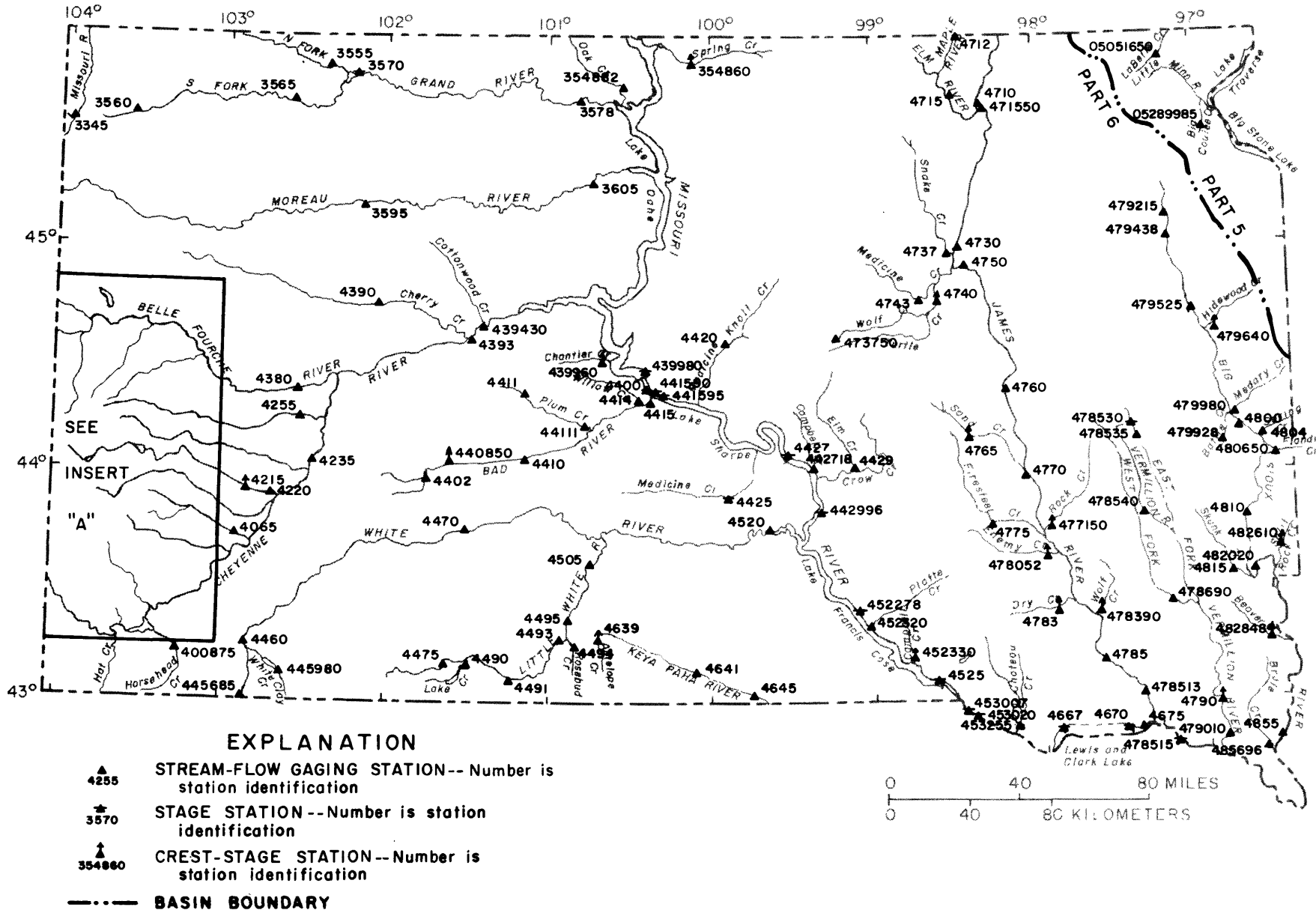


Figure 5.--Location of lake and stream-gaging stations, fiscal years 1989-90.

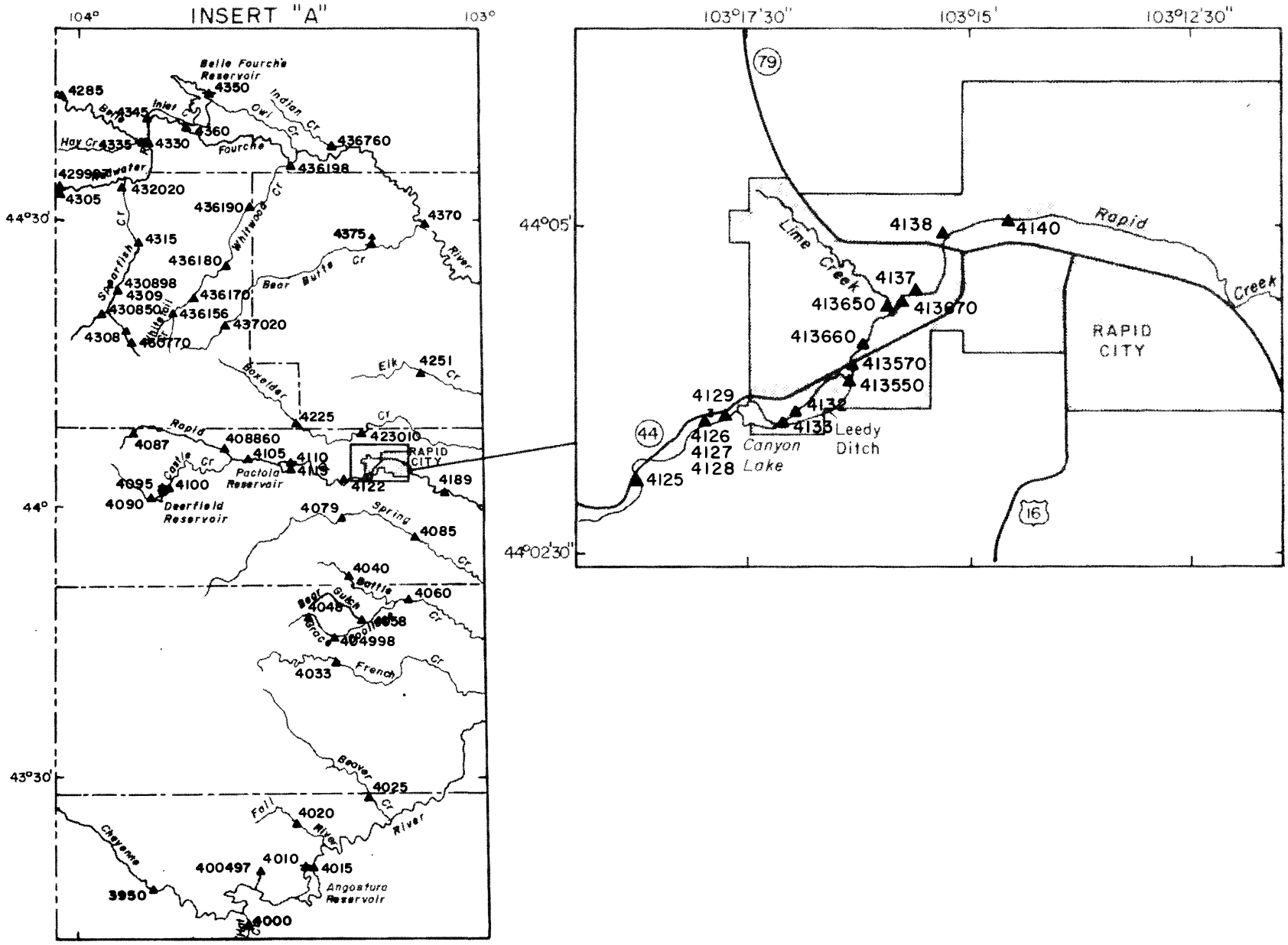


Figure 5.--Location of lake and stream-gaging stations, fiscal years 1989-90--Continued.

Surface-Water Quality

Water-quality data are obtained at many of the surface-water stations (table 3, fig. 6) and occasionally at other surface-water sites where discharge and stage are not measured routinely. Eight of these stations are part of a U.S. Geological Survey nationwide network known as the National Stream Quality Accounting Network (NASQAN), which is used to detect trends in water quality, and one is part of the National Benchmark Network which is used to provide data on stream basins which have little effect from manmade changes to the environment.

Table 3.--Water-quality and sediment stations in operation in South Dakota, fiscal years 1989-90

[Supported by: COE, U.S. Army Corps of Engineers; BIA, Bureau of Indian Affairs; BM, Federal bench-mark station; BR, Bureau of Reclamation; NASQAN, National stream-quality accounting network; MRB, Missouri River Basin Program; SCCD, Stanley County Conservation District; DWNR, Department of Water and Natural Resources; EDWDD, East Dakota Water Development District]

Station number	Station name	Supported by	
		Water quality	Sediment
06357800	Grand River at Little Eagle	NASQAN	NASQAN
06360500	Moreau River near Whitehorse	NASQAN	NASQAN
06409000	Castle Creek above Deerfield Reservoir, near Hill City	BM	BM
06434500	Inlet Canal near Belle Fourche	MRB	
06436180	Whitewood Creek above Whitewood	DWNR	DWNR
06436198	Whitewood Creek above Vale	DWNR	DWNR
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
06440200	South Fork Bad River near Cottonwood	SCCD	SCCD
06441110	Plum Creek below Hayes	SCCD	SCCD
06441400	Willow Creek near Fort Pierre	SCCD	SCCD
06441500	Bad River near Fort Pierre	SCCD	COE,SCCD
06449100	Little White River near Vetal	MRB,BR	MRB,BR
06449300	Little White River above Rosebud	BIA	MRB,BIA
06452000	White River near Oacoma	NASQAN	NASQAN,COE
06452380	Andes Creek near Armour	MRB	MRB
06452383	Lake Andes tributary No. 3 near Armour	MRB	MRB
06452386	Lake Andes tributary No. 2 near Lake Andes	MRB	MRB
06452389	Lake Andes tributary No. 1 near Lake Andes	MRB	MRB
06452390	Lake Andes above Ravinia	MRB	MRB
06452391	Lake Andes near Ravinia	MRB	MRB
06452392	Lake Andes near Lake Andes	MRB	
06452403	Owens Bay near Ravinia	MRB	MRB
06452406	Lake Andes above Lake Andes	MRB	MRB
06453120	Missouri River above Choteau Creek near Verdel, NE	MRB,USBR	
06453200	Choteau Creek near Wagner	MRB	MRB

Table 3.--Water-quality and sediment stations in operation in South Dakota, fiscal years 1989-90--Continued

Station number	Station name	Supported by	
		Water quality	Sediment
06453252	Choteau Creek near Dante.	MRB	MRB
06453300	Choteau Creek below Avon.	MRB	MRB
06453305	Missouri River below Choteau Creek, near Verdel, NE	MRB,USBR	MRB,USBR
06470988	Sand Lake, bay site, near Houghton. . . .	BR	
06470990	Sand Lake, open water site (near Aberdeen), near Columbia.	BR	
06470991	Sand Lake, bay site no. 2, near Houghton.	BR	
06470992	Sand Lake near Columbia	BR	BR
06471000	James River at Columbia	NASQAN,BR	NASQAN,BR
06473000	James River at Ashton	BR	BR
06476000	James River at Huron.	BR	BR
06478500	James River near Scotland	NASQAN,BR	NASQAN,BR
06479928	Battle Creek near Nunda	EDWDD	EDWDD
06485500	Big Sioux River at Akron, Iowa.	NASQAN	NASQAN

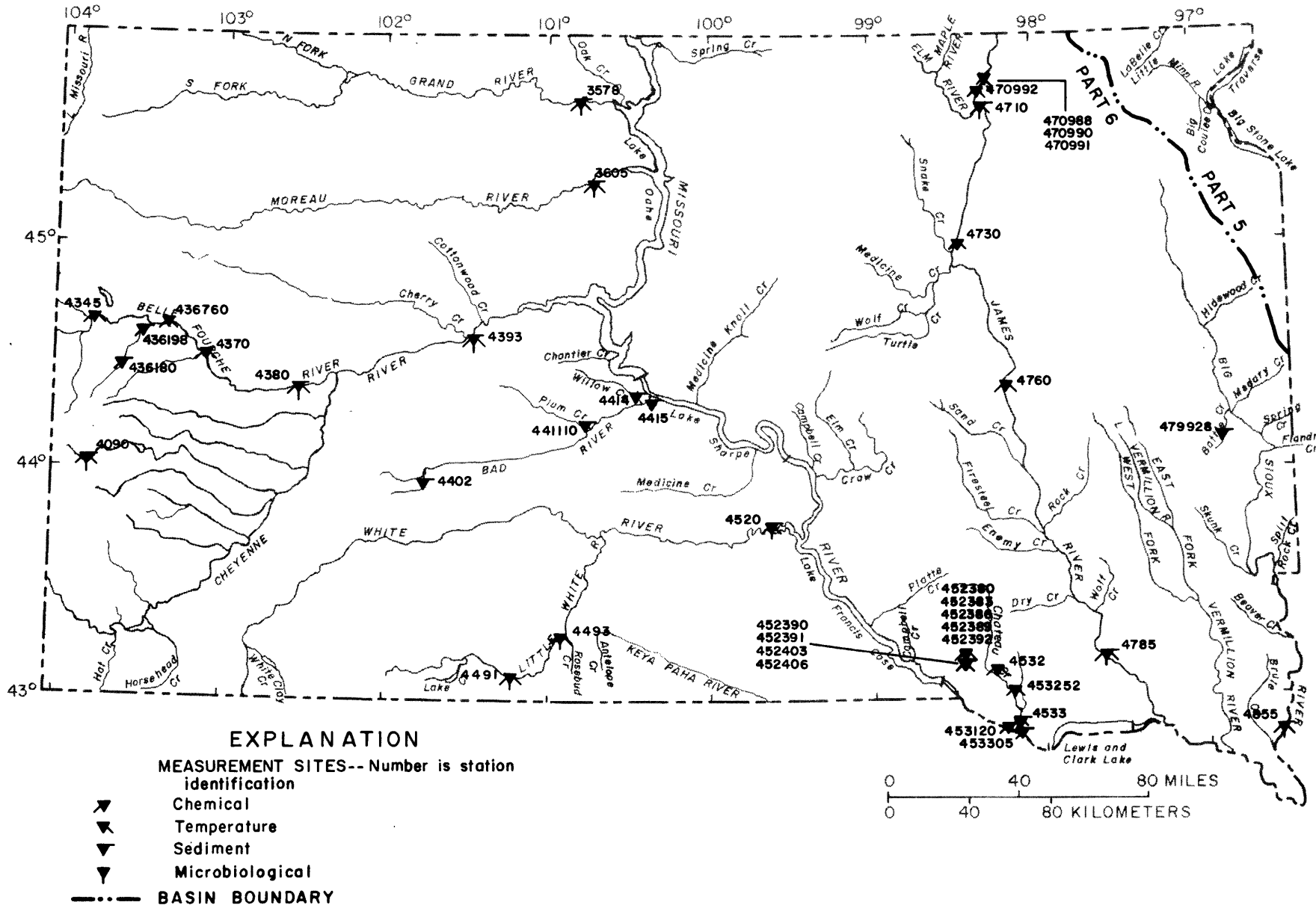


Figure 6.--Location of surface-water-quality stations, fiscal years 1989-90.

Ground Water

Water levels in wells, discharge from 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 4, fig. 7) completed in bedrock artesian aquifers. Other wells, which are known as project wells, are used for specific (generally short-term) interpretive 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 4.

Table 4.--Observation wells in bedrock aquifers in South Dakota, fiscal years 1989-90

[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 uppercase 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	Formation	Date of first measurement
Aurora	101N66W34BBBC	Dakota Formation	7-19-60
	103N65W21ADCC	do.	7-18-79
	103N65W21CAA	do.	8-20-76
	104N63W 6BCCC	Niobrara Formation	4- 1-79
	105N63W33CDBB	Dakota Formation	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
	113N65W16DDCD	Dakota Formation	11- 4-63
Bon Homme	94N58W 1CCC	do.	10- 5-60
Brookings	111N52W25DDCC	do.	10- 9-63
Brown	122N60W 8CBBA2	do.	6-21-60
	128N61W 5DCCC	do.	5-26-60
Brule	104N70W26DCBC	Lakota Formation	3-23-59
	105N68W11CDB	Dakota Formation	7-14-60
Buffalo	107N73W 1BA	do.	11- 6-73
	108N72W12BBCA	do.	9-26-61
	108N73W35DDA3	Inyan Kara Group	7-19-79
Butte	8N 2E21CDBC	Lakota Formation	6- 4-80
	8N 2E23DCCA	Inyan Kara Group	6-10-80
	8N 3E33CCB	Minnelusa Formation	6- 4-80
	11N 1E17DCAC	Inyan Kara Group	7- 3-79
Campbell	127N78W20DCDD	Fall River Formation	8-14-62

Table 4.--Observation wells in bedrock aquifers in South Dakota, fiscal years 1989-90--Continued

County	Well number	Formation	Date of first measurement
Charles Mix	99N68W31DDDB	Dakota Formation	3-24-59
Clark	115N59W15CAAB	do.	3-10-83
	116N59W23DDAA	do.	8-13-76
Clay	93N52W28AAD	do.	6-21-61
	95N51W 7ADA	do.	6-21-61
Corson	18N25E23DAD	Fox Hills Formation	7-15-80
	19N22E 1DB	do.	7-15-80
	20N29E25BBBC	Pierre Shale	7-14-80
	22N18E 4DBAC	Fort Union Formation	7-15-80
Custer	2S 7E34ABBC	Minnelusa Formation	7-27-83
	2S 7E36CBCB	Lakota Formation	6-29-83
	3S 7E23DDAC	do.	6- 5-80
	3S 7E35DBB	do.	6- 5-80
	3S 8E17BACB	Graneros Shale	5-22-80
	3S 8E19BBBB	Morrison Formation	6-28-83
	4S 7E 1DAAB	Dakota Formation	6-11-80
	4S 7E28DBBC	Fall River Formation	5-22-80
	5S 6E12DAAD	Sundance Formation	5-22-80
	6S 6E15ABDD	Madison Group	6-11-80
Davison	102N61W30CAC2	Dakota Formation	6- 2-83
	104N61W30DAA	do.	7-29-60
Dewey	12N22E 7ACC	Fox Hills Formation	7-16-80
	12N25E12BB	do.	7- 6-80
	14N29E36DBDD	Sundance Group	5-19-81
	15N26E12CDB	Dakota Formation	6- 9-82
Edmunds	121N68W 3AAAB	do.	4-12-66
Fall River	7S 2E 3ACDD	Sundance Formation	6-12-80
	7S 2E 3DAAB	do.	7-25-83
	7S 5E12CDBB	Minnelusa Formation	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
Grant	120N48W 2ABBB	Cretaceous sandstone, undifferentiated	7-31-62
	121N47W36BBCB	do.	7-23-76
Haakon	1N23E33CACC	Fall River Formation	- -83
	2N23E 4DA	do.	7- 6-80
	3N23E10BCAA	Newcastle Sandstone	7-15-80
	4N23E35AA	do.	- -83
	6N23E31DB	Fall River Formation	7-16-80
Hamlin	113N55W23BBAB	Dakota Formation	10-10-63
Hand	110N67W 7CBBB2	do.	5- 5-77
	116N67W31DDDB	do.	10-10-62
Hanson	104N58W13DCC	Codell Sandstone Member of the Carlile Shale	6-15-61

Table 4.--Observation wells in bedrock aquifers in South Dakota, fiscal years 1989-90--Continued

County	Well number	Formation	Date of first measurement
Harding	15N 1E13AADD	Fox Hills Formation	5-12-80
	19N 5E30DDA	Hell Creek Formation	7-16-80
Hughes	110N79W 4CAAA	Madison Group	5-13-81
	111N74W15BDAD	Dakota Formation	7-20-76
Hutchinson	99N60W 1BBBC	do.	3-27-59
	99N61W 4AAD	do.	9-16-60
Hyde	109N72W32BAA	do.	5- 4-60
	109N73W12BDCB	Sundance Formation and Minnelusa Formation	6-24-70
	110N72W 1CDAA	Minnelusa Formation	6-24-70
	116N72W18DAAB	Inyan Kara Group	9-14-62
Jackson	1S22E10CCCC	do.	5-17-66
	1S22E19AADA	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
	2S24E23DADD	Dakota Formation	8-17-76
	2S24E27CADA	do.	8-18-76
Jerauld	106N67W26CCDB	do.	11- 3-78
	108N63W20DCB	do.	4-27-61
Jones	1S28E36BBDB	Minnelusa Formation	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
Kingsbury	110N53W10DAAA	do.	8- 2-84
	110N58W32CCBC	do.	7-12-76
	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 Formation	6- 2-80
	6N 2E10BCBB	Spearfish Formation	6-10-80
	6N 4E21DBC	Minnelusa Formation	6-10-80
	7N 1E20AAD	do.	6- 2-80
	7N 1E21BBC	do.	6- 2-80
	7N 1E26ACD	do.	6-20-80
	7N 2E26BCDA	do.	6- 3-80
	7N 2E32DD	Spearfish Formation	6- 4-80
	7N 3E 7AABA	Minnelusa Formation	8-27-62
	7N 4E 2BDBD	Fall River Formation	5-28-80
Lincoln	97N49W33AAAA	Dakota Formation	7- 6-61
	98N49W23DAD	Big Sioux Formation	10-31-86
	98N50W32AAAA2	Dakota Formation	8-22-79
Lyman	101N72W35DADA	do.	7-10-63
	105N73W21CCBA2	do.	7-18-79
	105N78W 9CABD	do.	8- 6-76
	105N78W14ADDA	do.	8-17-76
	108N77W21CCAB	do.	7-18-63
McPherson	125N66W23ABAA	do.	8- 8-62
	127N66W 5BBBD	do.	8- 8-62

Table 4.--Observation wells in bedrock aquifers in South Dakota, fiscal years 1989-90--Continued

County	Well number	Formation	Date of first measurement
Marshall	127N58W19AABB	Dakota Formation	4-22-65
	127N58W23DAD	do.	7- 1-70
	128N59W24CBBB	do.	6- 4-63
Meade	3N 6E15ABBB	Minnelusa Formation	7- 7-84
	4N 6E19AABA	do.	7-10-84
	6N 5E19ADCD	Fall River Formation	5-28-80
	6N 5E22DDBC	Inyan Kara Group	5-28-80
	7N14E25BDD	Newcastle Sandstone	6-23-80
	10N16E 3DB	Fox Hills Formation	6-11-80
Mellette	41N27W25DBDC	do.	6-27-78
	41N32W28CCD	Arikaree Formation	7- 8-80
	43N30W 8BBC	Dakota Formation	7-30-63
	44N31W20BBBB	do.	7- 7-83
Miner	105N58W31BACC	do.	7-30-79
Moody	105N49W35AAAA	Big Sioux Formation	6-26-78
	106N48W13BAAC	Dakota Formation	7-13-61
	107N48W30DCCC	do.	7-13-61
Pennington	1N 7E14CBBD	Spearfish Formation	5-30-80
	1N 7E29DAC	Deadwood Formation	6-10-83
	1N 7E29CAD	do.	6-30-84
	2N 7E17BAAD	Minnelusa Formation	7- 3-84
	2N 8E28BCB	Spearfish Formation	5-22-80
	1S 8E19BBBB	Madison Group	3-13-84
	3S14E22DADA	Lakota Formation	6- 2-80
Perkins	13N14E 9DDA	Fox Hills Formation	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 Formation	7-24-76
Roberts	126N51W 9CCCA	Dakota Formation	6-20-62
	127N49W29BBBC	do.	6-20-62
Sanborn	106N62W30BCBA	do.	10-28-60
Shannon	35N44W17DBCA	Arikaree Formation	10-17-87
	35N44W17DBCA6	Brule Formation	10- 9-87
Spink	115N65W 4ADDC	Dakota Formation	3-15-66
	116N62W 5DDCC	do.	3-15-66
	120N63W20DCC2	do.	4-29-64
Stanley	3N25E32BCDD	Inyan Kara Group	6-23-80
Tripp	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
Union	93N50W 4DAA	do.	6-30-61
	95N49W16ACD	do.	7- 7-61
Yankton	93N55W 4BBC	Dakota Formation	10- 6-60
Ziebach	13N18E29BBB	Fox Hills Formation	7-22-80

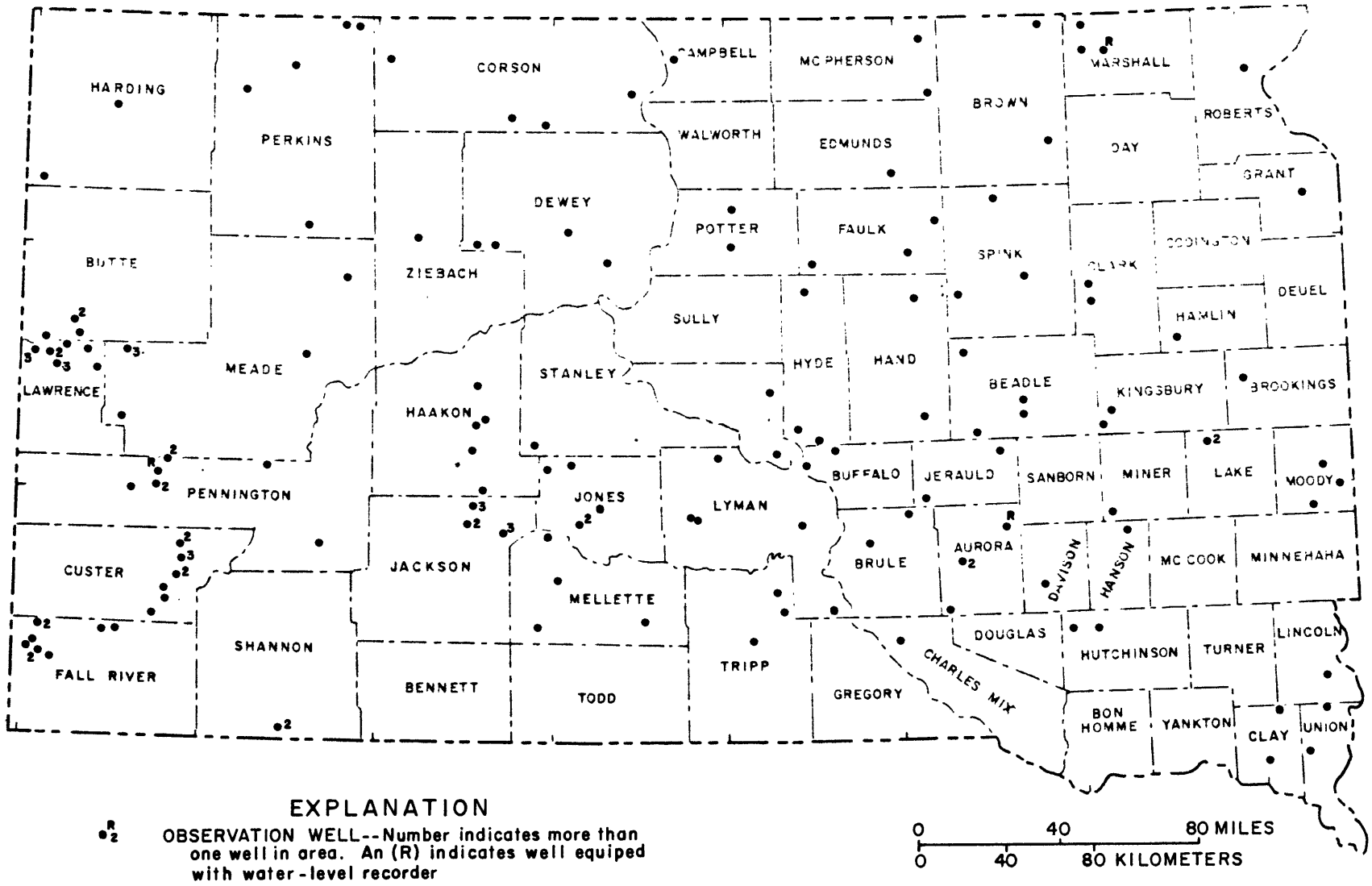
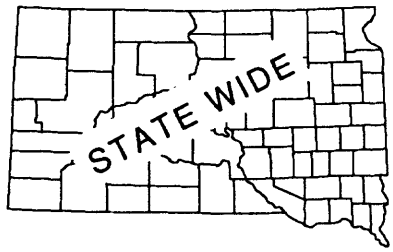


Figure 7.--Location of observation wells in bedrock aquifers, fiscal years 1989-90.

CURRENT PROJECTS

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

SURFACE-WATER STATIONS
(SD001)



Project leader: John R. Little

Project period: Continuous

Cooperators: City of Watertown, City of Rapid City, Sisseton-Wahpeton Sioux Tribe, Belle Fourche Irrigation District, East Dakota Water Development District, West Dakota Water Development District, South Dakota Department of Transportation, South Dakota Department of Water and Natural Resources, U.S. Bureau of Indian Affairs, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Tennessee Valley Authority, Missouri River Basin Program, U.S. Geological Survey (Federal Program).

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: The objectives are to: (1) Collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (a) assessment of water resources, (b) operation of reservoirs or industries, (c) forecasting, (d) disposal of wastes and pollution controls, (e) discharge data to accompany water-quality measurements, (f) compact and legal requirements, and (g) research or special studies. (2) Collect data necessary for analytical studies to define 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 and significant results during fiscal year 1990: The network was decreased by a net of 3 active sites (continuous sites decreased by 22 and other sites increased by 19) at the beginning of FY 1990, bringing the total to 171 active sites. Data were collected and published in U.S. Geological Survey (USGS) Water-Data Report SD-89-1.

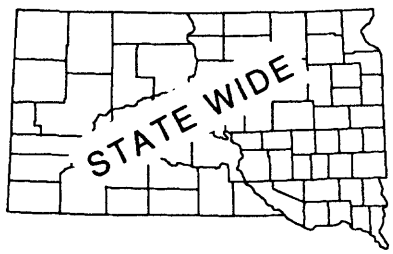
Plans for 1991: The network will be reviewed, in consultation with cooperators as to their needs. Requests for data will be answered. Data will be published in USGS Water-Data Report SD-90-1.

Completed reports:

U.S. Geological Survey, 1989, Water resources data for South Dakota, water year 1988: U.S. Geological Survey Water-Data Report SD-88-1, 304 p.

U.S. Geological Survey, 1990, Water resources data for South Dakota, water year 1989: U.S. Geological Survey Water-Data Report SD-89-1, 383 p.

GROUND-WATER RECORDS
(SD002)



Project leader: John R. Little

Project period: Continuous

Cooperators: City of Sioux Falls, Minnehaha County, West Dakota Development District, South Dakota Department of Water and Natural Resources, U.S. Bureau of Indian Affairs, Missouri River Basin Program, U.S. Geological Survey (Federal Program).

Problem: Long-term water-level records are needed to provide an assessment of the ground-water resource, 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, to detect and define pollution and supply problems, and to provide data for management of the resources.

Objective: The objectives are to: (1) Collect water-level data to provide a long-term data base so that: (a) the general response of the hydrologic system to natural climatic variations and induced stresses is known, and (b) potential problems can be defined early enough to allow proper planning and management; and (2) provide a data base against which short-term records acquired during interpretive studies can be analyzed.

Approach: Evaluation of regional geology allows broad, general definition of aquifer systems and their boundary conditions. With knowledge of the hydrologic properties of aquifers and the stresses on the system, a subjective decision can be made on the most advantageous locations for observation wells to monitor long-term system behavior. This subjective network can be refined as records become available and as detailed areal studies of the ground-water system are completed to more closely define the aquifers, their properties, and the stresses to which they are subjected.

Progress and significant results during fiscal year 1990: Hydrologic data were collected for bedrock aquifers (455 active sites). All water levels for bedrock aquifers have either been prepared for entry, or already entered, into the computer. Data for 30 observation wells were published in U.S. Geological Survey (USGS) Water-Data Report SD-89-1.

Plans for 1991: Water-level data will be collected on existing observation wells and new observation wells will be established in areas of poor coverage. Data will be published in USGS Water-Data Report SD-90-1.

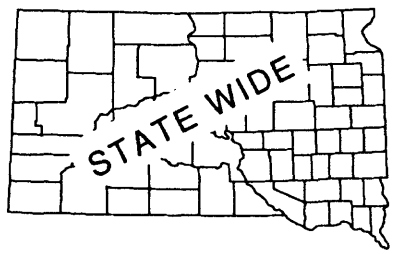
Completed reports:

U.S. Geological Survey, 1989, Water resources data for South Dakota, water year 1988: U.S. Geological Survey Water-Data Report SD-88-1, 304 p.

U.S. Geological Survey, 1990, Water resources data for South Dakota, water year 1989: U.S. Geological Survey Water-Data Report SD-89-1, 383 p.

Neitzert, K.M., and Hansen, D.S., 1990, Records of wells and chemical analyses of ground water in Deuel and Hamlin Counties, South Dakota: U.S. Geological Survey Open-File Report 90-391, 113 p.

WATER-QUALITY STATIONS
(SD003)



Project leader: Donald S. Hansen

Project period: Continuous

Cooperator: City of Rapid City, Rosebud Sioux Tribe, Mellette-Todd Water Quality Advisory Board, West Dakota Water Development District, South Dakota Department of Water and Natural Resources, U.S. Bureau of Indian Affairs, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Missouri River Basin Program, U.S. Geological Survey (Federal Program).

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: The objectives are to: (1) Provide a national bank of water-quality data for broad Federal planning and action programs, and (2) provide data for Federal management of interstate and international waters.

Approach: A network of water-quality stations will be operated to provide average chemical concentrations, loads, and time trends as required by planning and management agencies.

Progress and significant results during fiscal year 1990: Seven bimonthly sites were added to the network at the beginning of FY 1990, bringing the total to 175 active sites. Water-quality data were published in U.S. Geological Survey (USGS) Water-Data Report SD-89-1.

Plans for 1991: The network will be reviewed, in consultation with cooperators as to their needs. Requests for data will be answered. Data will be published in USGS Water-Data Report SD-90-1.

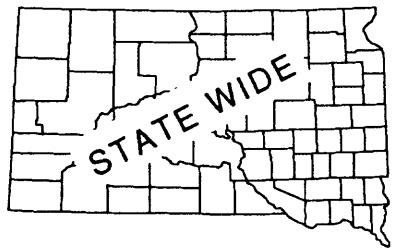
Completed reports:

U.S. Geological Survey, 1989, Water resources data for South Dakota, water year 1988: U.S. Geological Survey Water-Data Report SD-88-1, 304 p.

U.S. Geological Survey, 1990, Water resources data for South Dakota, water year 1989: U.S. Geological Survey Water-Data Report SD-89-1, 383 p.

Sando, S.K., Guttormson, K.G., and Gleich, T.A., 1990, Water resources data collected during water year 1988 at selected James River basin sites in North Dakota and South Dakota: U.S. Geological Survey Open-File Report 90-101, 230 p.

SEDIMENT STATIONS
(SD004)



Project leader: Michael J. Burr

Project period: Continuous

Cooperators: North Central RC&D, East Dakota Water Development District, South Dakota Department of Water and Natural Resources, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Missouri River Basin Program, U.S. Geological Survey (Federal Program).

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: The objectives are to: (1) Provide a national bank of sediment data for use in broad Federal and State planning and action programs, and (2) provide data for Federal management of interstate and international waters.

Approach: A network of sediment stations will be established and operated 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 and significant results during fiscal year 1990: The network was increased by a net of seven sites (from 23 to 30) at the beginning of FY 1990. Sediment data were published in U.S. Geological Survey (USGS) Water-Data Report SD-89-1.

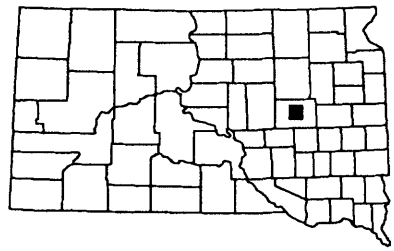
Plans for 1991: Two daily sediment stations (Little White River nr Vetal and Keya Paha River nr Keya Paha) will be added to the network and four stations will be deleted from the network. Requests for data will be answered. Data will be published in USGS Water-Data Report SD-90-1.

Completed reports:

U.S. Geological Survey, 1989, Water resources data for South Dakota, water year 1988: U.S. Geological Survey Water-Data Report SD-88-1, 304 p.

U.S. Geological Survey, 1990, Water resources data for South Dakota, water year 1989: U.S. Geological Survey Water-Data Report SD-89-1, 383 p.

NATIONAL TRENDS NETWORK FOR MONITORING ATMOSPHERIC DEPOSITION (SD005)



Project leader: Steven K. Sando

Project period: Continuous

Cooperator: U.S. Geological Survey (Federal Program).

Problem: A need exists to establish and operate a nationwide long-term monitoring network to detect and measure levels of atmospheric deposition.

Objective: The objectives are to: (1) Collect wet and dry deposition products for analysis of elements and compounds that can contribute to the chemical composition of surface waters, and (2) determine variations in atmospheric deposition that occur on a week to week basis.

Approach: Monitoring stations will be established and operated as part of the National Trends Network. Stations will be maintained, on-site measurements will be made, and samples will be processed and submitted to an analytical laboratory. Data retrievals will be made, verified, and reported.

Progress and significant results during fiscal year 1990: Daily rainfall data for the period November 1983 through September 1989 from the Huron Well Field NADP/NTN Site were entered into the Automated Data Processing System (ADAPS). Weekly collections of precipitation samples for chemical analysis were successfully completed for the entire year, except for a three-week period in July when the motor box on the wet/dry collector was damaged in an electrical storm and had to be replaced. Also, as water-quality data collected at this site became available from the NADP/NTN central data processing unit in Madison, Wisconsin, they were stored in the QW file of the NWIS on the South Dakota District PR1ME computer. Data were published in U.S. Geological Survey (USGS) Water-Data Report SD-89-1.

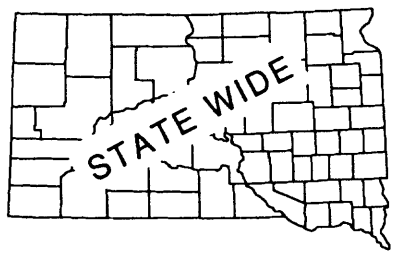
Plans for 1991: Water-quality data and daily rainfall data which are collected will be stored in the South Dakota District PR1ME. Data will be published in USGS Water-Data Report SD-90-1.

Completed reports:

U.S. Geological Survey, 1989, Water resources data for South Dakota, water year 1988: U.S. Geological Survey Water-Data Report SD-88-1, 304 p.

U.S. Geological Survey, 1990, Water resources data for South Dakota, water year 1989: U.S. Geological Survey Water-Data Report SD-89-1, 383 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, U.S. Geological Survey (Federal Program).

Problem: Water requirements for various uses within South Dakota have increased considerably in recent years. A State Water Plan has been developed in order to implement a priority system for all State decisions affecting water-resource development. An important part of the State Water Plan is a comprehensive statewide water-use assessment program.

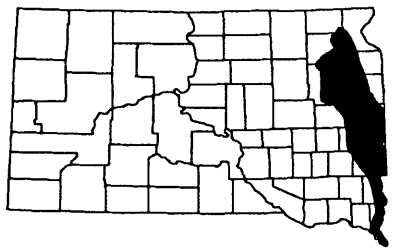
Objective: The main objective is to develop and maintain a statewide water-use data program that will include field-collection procedures and computer storage, retrieval, manipulation, and dissemination of water-use data for 12 categories of water use.

Approach: The U.S. Geological Survey will provide direction, management, and standards development to meet the needs of the National Water-Use Program. The South Dakota Department of Water and Natural Resources will provide annual water-use data to the USGS for categories for which data are available.

Progress and significant results during fiscal year 1990: The project chief coordinated with the South Dakota Department of Water and Natural Resources (DWNR) to develop "water-use questionnaires" for all water uses, in addition to irrigation, which the Department sent out to all permitted water users in South Dakota. Irrigation questionnaire data for 1988 were loaded onto the State Water-Use Data System (SWUDS). Irrigation questionnaire data for 1989 were received from the South Dakota Department of Water and Natural Resources during June 1990; however, the data were not loaded onto SWUDS due to higher priority work.

Plans for 1991: Irrigation questionnaire data for both 1989 and 1990 will be entered onto SWUDS. Questionnaire data for 1990 for other water-use categories will be entered onto SWUDS. Data will be compiled for the report "Estimated use of water in the United States (1990)."

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



Project leader: Donald S. Hansen

Project period: October 1982 to September 1991

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The Big Sioux River basin contains a sizeable aquifer system of major importance to the economy of South Dakota. The aquifer system is complex, consisting of many small aquifers that are hydrologically associated with several large aquifers and with the Big Sioux River. Management problems already exist and, as development continues, the problems continue to increase in number and complexity. Comprehensive model studies are needed to aid in optimum development of water resources in the basin.

Objective: The overall objective is to provide a scientific basis for evaluation and efficient use of water resources within the Big Sioux River basin. Information will be provided on the availability of surface-water and groundwater resources, operation of the hydrologic system, and the effect of water-resources development on the hydrologic system. The study will provide basic data for use in developing digital models of major aquifers.

Approach: The study will include hydrologic data collection and an extensive test-drilling program by the South Dakota Geological Survey. Two-dimensional models of the Big Sioux aquifer will be developed. 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.

Progress and significant results during fiscal year 1990: Revised the Big Sioux aquifer water-quality report, which received Headquarters approval as WRIR 89-4170 on October 16, 1989. Revised draft reports for Water Resources of Lincoln and Union Counties and Water Resources of Minnehaha County. Continued processing of the final draft of the major aquifer report for Codington and Grant Counties. Continued preparation of the Codington and Grant Counties model report. Completed model simulations for the Big Sioux aquifer in Lincoln and Union Counties and completed first draft of the report.

Plans for 1991: Complete reports on: (1) Codington and Grant Counties major aquifer and model reports, (2) Minnehaha County water resources and major aquifer reports, and (3) Lincoln and Union Counties water resources, model, and major aquifer reports.

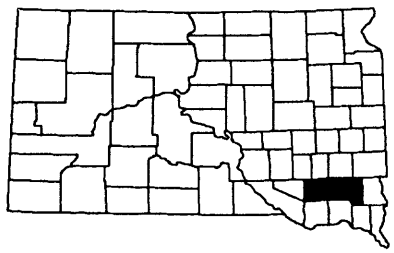
Completed reports:

Hansen, D.S., 1988, Appraisal of the water resources of the Big Sioux aquifer, Moody County, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 87-4057, 38 p.

Hansen, D.S., 1990, Water resources of Codington and Grant Counties, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 89-4147, 47 p.

Ohland, G.L., 1990, Appraisal of the water resources of the Skunk Creek aquifer in Minnehaha County, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 87-4156, 54 p.

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



Project Chief: Richard J. Lindgren

Period of project: October 1982 to September 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 heavily populated in rural areas, which should favor the development of rural water systems that will benefit by the more detailed knowledge of the ground-water resources resulting from this study.

Objective: The major objective is to provide 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.

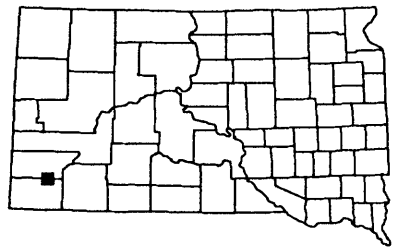
Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be collected. A well inventory will be conducted and a test-drilling program will be completed during the first two field seasons. An observation-well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

Progress and significant results during fiscal year 1990: The final report was revised to accommodate Headquarters comments and was approved on June 11, 1990. Project is complete.

Completed reports:

Lindgren, R.J., and Hansen, D.S., 1990, Water resources of Hutchinson and Turner Counties, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 90-4093, 100 p.

SOUTH DAKOTA SIDE-LOOKING AIRBORNE RADAR STUDY (SD078)



Project leader: Lewis Howells

Period of project: May 1985 to September 1991

Cooperator: U.S. Geological Survey (Federal Program).

Problem: Information on the relationship between the hydraulic conductivity of shale and fracturing of shale is needed for ongoing research and anticipated investigations in South Dakota. Investigation of the hydrology of the Upper Cretaceous shale has been hampered by the complexity of the hydrology, lack of data, and difficulty in applying standard methods. Lineaments, mapped using Landsat and Skylab imagery of South Dakota, may represent fractures and ground-water movement may be related to these lineaments. If the permeability of the shale is fracture controlled, a relationship may be shown for the hydraulic conductivity and linear features in the shale.

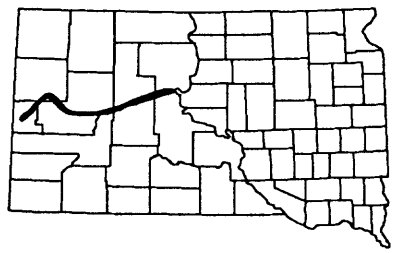
Objective: The major objective is to test the hypothesis that the hydraulic conductivity of the Carlile Shale, of Upper Cretaceous age, in southwestern South Dakota is related to lineaments.

Approach: Existing data consisting of hydraulic conductivity measurements in the Carlile Shale, geophysical surveys by a consulting firm, and similar data collected for Department of Energy will be compiled. In addition, Landsat, thematic mapping, and digital topographic imagery are available from the Earth Resources Observation Satellite (EROS) Data Center. To supplement existing imagery, the area will be mapped as part of the U.S. Geological Survey FY85 Side-Looking Airborne Radar (SLAR) program. The SLAR imagery and data will be combined with existing imagery and data and the linear features mapped, field checked, and compared with known geologic features. Hydraulic conductivities determined from existing data will be analyzed statistically to determine if a relationship exists between hydraulic conductivity and mapped lineaments.

Progress and significant results during fiscal year 1990: The Office of Remote Sensing in the Engineering and Environmental Research Center at South Dakota State University prepared a digital base map of the Provo quadrangle using PC ARC-INFO. In addition, coverages of soils (from the Soil Conservation Service) and lineament data (from Landsat) were built.

Plans for 1991: The Office of Remote Sensing will use image processing software to complete the analyses. A final report will be prepared and provided to the USGS.

SEDIMENT CHEMISTRY - WHITEWOOD CREEK, WEST-CENTRAL SOUTH DAKOTA (SD079)



Project leader: Kimball E. Goddard

Period of project: April 1985 to September 1990

Cooperator: U.S. Geological Survey (Federal Program).

Problem: Arsenic hydrogeochemistry in natural systems is largely undefined due to the complexity of the element's interrelationships with the environment. The transport of arsenic through a river system is dependent upon chemical transformations between ionic species, the sorption of arsenic species on solid materials, and the physical transport of sediment. The Cheyenne River basin, widely contaminated by arsenic-laden mill tailings discharged to a small tributary stream, provides an excellent field site to investigate the processes that control the distribution and movement of arsenic and other trace elements through the environment.

Objective: The objectives are to: (1) Define the mechanisms responsible for the transport of arsenic and trace metals by the surface-water system, (2) describe the occurrence and distribution of arsenic and selected trace metals in water and sediment, and (3) develop and refine appropriate methods for field sampling, sample processing, and laboratory analysis.

Approach: A number of interrelated investigations will be conducted to define the distribution, transport, and fate of sediment and sediment-associated contaminants in the Cheyenne River basin. Laboratory experiments will be used to determine the sorption-desorption characteristics of tailings, alluvium, and suspended sediment. Geomorphologic and geometric measurements of flood-plain deposits will allow definition of sediment-source areas. In-stream sediment and chemistry data will be obtained at sites throughout the basin to determine the transport rates of contaminants.

Progress and significant results during fiscal year 1990: All chapters of the final report, a Water-Supply Paper, were received from the contributing authors and compiled into a draft manuscript. Project is complete except report.

Plans for 1991: Complete review, obtain Director's approval, and publish the Water Supply Paper.

Completed reports:

Goddard, K.E., ed., 1990, U.S. Geological Survey applied research studies of the Cheyenne River system, South Dakota: Description and collation of data, water years 1987-88: U.S. Geological Survey Open-File Report 89-580, 145 p.

WASTE DISPOSAL PLANNING STUDY
(SD080)

MULTISTATE

Project leader: Mark T. Anderson

Period of project: June 1985 to September 1987

Cooperator: U.S. Geological Survey (Federal Program).

Problem: Reports on field studies of active or abandoned low-level nuclear waste-disposal sites all point to a need for careful and comprehensive pre-siting studies of proposed sites. In addition, Nuclear Regulatory Commission (NRC) regulations governing disposal of low-level nuclear waste list a number of disposal-site suitability requirements and site characteristics that must be addressed before a site is accepted for licensing.

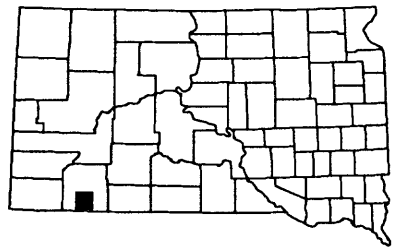
Objective: The major objectives are to: (1) Discuss the nature and disposal of low-level nuclear waste, (2) examine the technical reasons for failure of selected existing disposal sites, and (3) review the literature on hydrologic site characterization.

Approach: The study will be in two phases. The first phase (FY85) will begin with consultation with personnel associated with the Nuclear Waste Hydrology Program to establish guidelines and direction for the study. This will be followed by a review of the literature on the operating practices and hydrologic consequences thereof for a substantial number of existing low-level nuclear waste sites. The second phase (FY86-87) will be a detailed literature review of Earth-science information needed during the site-selection process in order to successfully contain low-level nuclear waste for the long term.

Progress and significant results during fiscal year 1990: Colleague reviews of the draft report were completed, and the report was forwarded to Central Region. Project is complete except report.

Plans for 1991: The report will be forwarded to Central Region and Headquarters for processing. Upon Director's approval, the report will be published.

AVAILABILITY OF WATER FOR IRRIGATION ON THE PINE RIDGE INDIAN RESERVATION NEAR PINE RIDGE, SOUTH DAKOTA (SD083)



Project leader: Earl A. Greene

Period of project: April 1986 to September 1989

Cooperator: Oglala Sioux Tribe.

Problem: The Pine Ridge Indian Reservation is an economically depressed area and determination of the quantity and quality of ground and surface water would greatly enhance economic development. There is a great need to develop industry to decrease massive unemployment on the reservation. The Tribe is looking at agriculture-related industries; however, an adequate water supply is a prerequisite to this industrial development. The economic future of the Pine Ridge Indian Reservation is heavily dependent upon the capacity of underlying aquifers to sustain withdrawals. Irrigation systems have been established but have not operated because of a lack of a sufficient water supply. Knowledge as to the high-yield capabilities of the aquifers is lacking. Previous studies dealt only with geologic mapping or an inventory of existing water development. Information is lacking on the aquifer-yield capabilities or the capacity of the aquifer to sustain withdrawals.

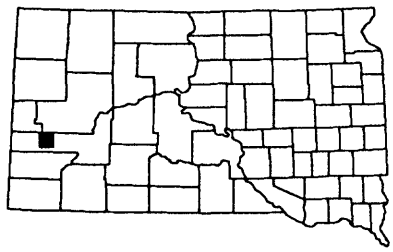
Objective: The major objective is to provide reliable and up-to-date information and analyses needed for water-resources evaluation and for the efficient use of these resources for agriculture, rural-water systems, and municipalities.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be compiled and analyzed. Test drilling will be conducted at selected sites to determine aquifer thickness and sand size. An aquifer test will be conducted where there is a sufficient aquifer thickness to provide a yield of more than 200 gallons per minute. Multiple wells will be considered where yield from a single well is not sufficient for irrigation. Transport of water by pipeline from ground-water sources to existing irrigation systems will be considered.

Progress and significant results during fiscal year 1990: The draft report was forwarded to Central Region. Project is complete except report.

Plans for 1991: The report will be forwarded to Central Region and Headquarters for processing. Upon Director's approval, the report will be published.

NITROGEN GAS IN GROUND WATER, EASTERN BLACK HILLS, SOUTH DAKOTA (SD085)



Project leader: Mark T. Anderson

Project period: October 1986 to September 1991

Cooperators: City of Rapid City, South Dakota Department of Game, Fish and Parks.

Problem: Rapid City secures its municipal water supply primarily from three infiltration galleries along Rapid Creek. Because available surface water is fully appropriated, future water supplies are expected to tap the Madison Limestone aquifer which is known to be hydraulically connected to Rapid Creek. Since several long-term water agreements will be renegotiated within the next five years, the City would like a comprehensive hydrologic budget of Rapid Creek that defines the ground-water/surface-water relationship. Cleghorn Springs water, the mainstay of the City's water supply, is super-saturated with nitrogen gas which is limiting fish production at the South Dakota Game, Fish and Parks Department fish hatchery. The origin and process of nitrogen gas supersaturation is unknown.

Objective: The objectives are to: (1) Develop a hydrologic budget for the Rapid Creek basin from Pactola Reservoir through Rapid City. This will involve: (a) Tracing the sources and relative contributions of water discharged from Cleghorn Springs, and (b) identifying the source of water withdrawn from the infiltration galleries. (2) Study the occurrence of dissolved nitrogen gas and the process of gas supersaturation for ground water of the area. (3) Test the use of nitrogen gas as a tracer of ground water.

Approach: The hydrologic budget between Pactola Reservoir and Rapid City will be estimated by evaluating streamflow records and withdrawal records. The source of water will be determined for each infiltration gallery by use of observation wells, nitrogen gas concentrations, and stable isotopes. The origin and pathways of Cleghorn Springs water will be studied by determining the isotopic signatures at recharge and discharge points of Madison aquifer water. The process of nitrogen gas supersaturation in ground water will be studied by sampling gas concentrations and water temperatures at recharge points of the Madison and along known routes of water movement through the aquifer. Nitrogen gas as a tracer will be evaluated by comparison with the results using stable isotopes.

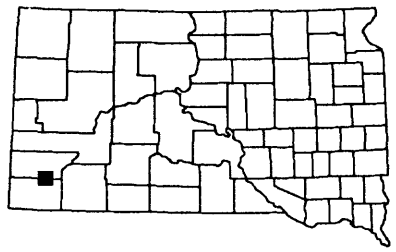
Progress and significant results during fiscal year 1990: Data collection concluded and final analysis of data began. Most of the water-quality and ground-water data have been compiled, with analyses generally complete. An annotated outline of the main report was completed, and preparation of the manuscript began. A draft of an open-file report entitled "Water losses and water gains along Rapid Creek, western South Dakota" was prepared.

Plans for 1991: Drafts of remaining reports are scheduled for completion.

Completed reports:

Driscoll, D.G., and Zogorski, J.S., 1990, Basin characteristics, history of stream gaging, and statistical summary of selected streamflow records for the Rapid Creek basin, western South Dakota: U.S. Geological Survey Open-File Report 90-120, 147 p.

DEPARTMENT OF INTERIOR IRRIGATION DRAINAGE PROGRAM FIELD-SCREENING STUDY OF THE ANGOSTURA UNIT, SOUTH DAKOTA (SD086)



Project leader: Earl A. Greene

Project period: February 1988 to September 1990

Cooperators: Department of the Interior.

Problem: The concentrations of selenium in both surface and ground waters in the western United States have come under careful scrutiny in recent years. This sudden interest in selenium resulted from the large concentrations found in the Kesterson Wildlife Refuge in the lower San Joaquin Valley, California. High egg and chick mortality rates, as well as numerous birth defects in the hatchlings of waterfowl nesting in the refuge, have been correlated with the large selenium concentrations. The Sacramento Bee newspaper published a series of investigative reports in 1985 which implicated 23 sites in nine western states as having significant concentrations of selenium in water, sediment, and plant material. The Angostura Unit was identified as one of those 23 problem sites because selenium concentrations in algae/mud samples (2,128 ppb) were greater than selenium concentrations expected to occur 95 percent of the time in soils of the conterminous United States. The Bee found selenium concentrations in algae (915 ppb) to be slightly less than the concentration considered high for the project area based on preliminary comparisons of selenium concentrations in algae from Volta and Kesterson Wildlife areas, California.

Objective: The major objective is to determine if selenium and other potentially toxic constituents reach concentrations sufficiently high to cause, or have the potential to cause, harmful effects on human health or on fish and wildlife within or immediately downstream from the Angostura Unit.

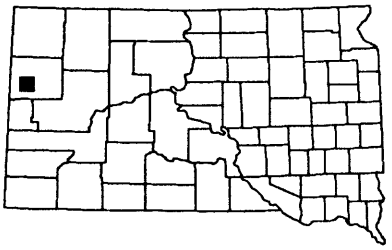
Approach: Samples of geochemical media (water and bottom sediments) will be obtained at 9 sites and biological media (benthic invertebrates and fish) will be obtained at 3 sites within or near the Angostura Unit. Samples will be collected during periods of the year when maximum concentrations could be expected in one or more of the sampled media. These periods are: (1) Late March to early April, the pre-irrigation period when return flows should be at the yearly minimum and game fish are spawning in the Angostura Reservoir; (2) early to mid-June, generally a period of high runoff after pre-crop fertilizers and herbicides have been applied and the crops are established; (3) mid-August to early September, the period when irrigation reaches its maximum and irrigation tailwater comprises the largest proportion of stream discharge; and (4) early November, the period of maximum impact of groundwater return flow. Water and bottom-material samples will be collected by experienced personnel of the U.S. Geological Survey. Benthic invertebrate, fish, and waterfowl sample collection will be conducted by experienced personnel of the U.S. Fish and Wildlife Service.

Progress and significant results during fiscal year 1990: Data analysis and report preparation were accomplished. Project is complete.

Completed report:

Greene, E.A., Sowards, C.L., and Hansmann, E.W., 1990, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Angostura Reclamation Unit, southwestern South Dakota, 1988-89: U.S. Geological Survey Water-Resources Investigations Report 90-4152, 75 p.

DEPARTMENT OF THE INTERIOR IRRIGATION DRAINAGE PROGRAM FIELD-SCREENING STUDY OF THE BELLE FOURCHE PROJECT, SOUTH DAKOTA (SD087)



Project leader: William R. Roddy

Period of project: February 1988 to September 1990

Cooperator: Department of the Interior.

Problem: The concentrations of selenium in both surface and ground waters in the western United States have come under careful scrutiny in recent years. This sudden interest in selenium resulted from the large concentrations found in the Kesterson Wildlife Refuge in the lower San Joaquin Valley, California. High egg and chick mortality rates, as well as numerous birth defects in the hatchlings of waterfowl nesting in the refuge, have been correlated with the large selenium concentrations. The Sacramento Bee newspaper published a series of investigative reports in 1985 which implicated 23 sites in nine western states as having significant concentrations of selenium in water, sediment, and plant material. The Belle Fourche Project was identified as one of those 23 problem sites because dissolved selenium concentrations from Horse Creek (33 ppb) exceeded Environmental Protection Agency criterion for drinking water (10 ppb) and algae/mud samples were greater than would be expected 95 percent of the time from soils in the conterminous United States. It is also not known whether other normally trace elements and pesticide residues are present at elevated concentrations.

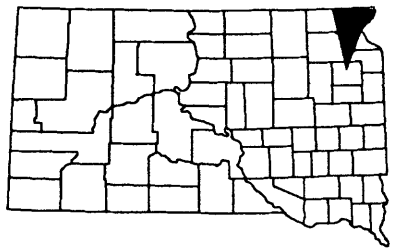
Objective: The major objective is to determine if selenium and other potentially toxic constituents reach concentrations sufficiently high to cause, or have the potential to cause, harmful effects on human health or fish and wildlife within or immediately downstream from the Belle Fourche Project.

Approach: Samples of geochemical media (water and bottom sediments) will be obtained at 10 sites within or near the Belle Fourche Project and at one well-removed background site. Samples of biological media (benthic invertebrates and fish) will be obtained at 3 sites within the project area. Sites and analyses used in the U.S. Geological Survey Surface Water Toxics Program will be used as much as possible. Samples will be collected during periods of the year when maximum concentrations could be expected in one or more of the sampled media. These periods are: (1) Late March to early April, the pre-irrigation period when return flows should be at the yearly minimum and game fish are spawning in Belle Fourche Reservoir; (2) early to mid-June, generally a period of high runoff after pre-crop fertilizers and herbicides have been applied and the crops are established; (3) mid-August to early September, the period when crops are reaching maturity and when irrigation reaches its maximum and irrigation tailwater comprises the largest proportion of stream discharge; and (4) early November, the period of maximum impact of ground-water return flow. Water and bottom-material samples will be collected by experienced personnel of the U.S. Geological Survey. Benthic invertebrate, fish sample, and waterfowl collection will be conducted by experienced personnel of the U.S. Fish and Wildlife Service.

Progress and significant results during fiscal year 1990: Data analysis and report preparation were accomplished. Colleague reviews were completed and the report was being prepared for submission to Central Region at the end of the fiscal year. Project is complete except report.

Plans for 1991: The report will be submitted to Central Region/Headquarters for approval. Subsequent to approval, report will be published.

WATER RESOURCES OF THE LAKE TRAVERSE RESERVATION IN NORTH AND SOUTH DAKOTA (SD088)



Project leader: Lewis W. Howells

Period of project: October 1987 to September 1991

Cooperator: Sisseton-Wahpeton Sioux Tribe.

Problem: Indian-owned trust lands within the Lake Traverse Reservation are scattered through seven counties and two states, mostly in northeastern South Dakota and a small part of southeastern North Dakota. Because land-ownership patterns are complex, attempting to determine the detailed water resources of scattered, individual parcels of trust land or of Indian-owned land would be prohibitively expensive in manpower, time, and money. Therefore, the area to be studied will include the entire 1,595 square miles within the original boundaries of the Lake Traverse Reservation. An appraisal of the water resources of the Lake Traverse Reservation (SD082), to provide detailed, up-to-date information delineating the extent and quality of available water supplies and to identify areas where data are missing, has been completed. Conclusions from that study indicate that, although a significant amount of data are available for surface water and ground water, key pieces of data are missing. Additional gaging stations are needed to monitor streamflow leaving the reservation. An in-depth study of Bitter Lake and Lake Hillebrands could provide insight into hydrogeochemical processes within closed lakes. Data are needed on chloride, sulfate, nutrients, fecal coliform, and fecal streptococcus bacteria, sediment transport, and trace metals in both streams and lakes. Water-level data from aquifers are needed to define areas of recharge and discharge. Additional well logs are needed to define thickness and areal extent of sand and gravel deposits, and delineation of aquifers. Additional data also are needed on the water quality and chemistry of ground water. Economic and social improvement of Indians living on the reservation is hampered by a lack of adequate and reliable information on the quantity and quality of water within the reservation. The need for additional water supplies of good quality is especially critical since new housing development is proceeding on the reservation. This study would provide the necessary foundation for water-resources development within the reservation.

Objective: The major objective is to provide reliable and current basic data and analyses needed for water-resources evaluation in order to facilitate 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.

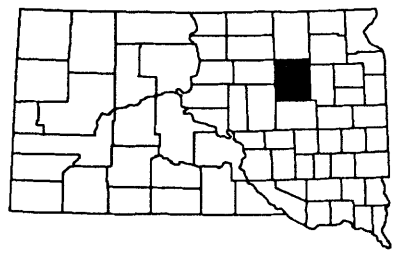
Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. Existing precipitation, streamflow, and well data will be assembled. A well inventory will be conducted and a test-drilling program will be completed during the first two field seasons. An observation-well network will be established and water samples collected for chemical analysis. Glacial and bedrock aquifers will be delineated and hydrologic characteristics described. Aquifer tests will be run wherever feasible. Assistance from outside Water Resources Division will consist of drilling provided by a contract well-drilling company. Oral progress reports will be made to the cooperator during the study period. A preliminary report outlining the major aquifers and discussing their productivity and water quality will be prepared following the last field season. A final report on the hydrology will be published as a Water-Resources Investigations Report.

The project will be funded under a Joint Funding agreement with the Sisseton-Wahpeton Sioux Tribe. Drilling costs will be provided by the U.S. Bureau of Indian Affairs under contract.

Progress and significant results during fiscal year 1990: Analysis of existing precipitation, streamflow, and well data continued. A preliminary geologic map was developed using soil survey data. The well inventory continued and preparation of aquifer maps was continued. Existing observation wells were measured. Fifteen test holes were drilled and three new observation wells were constructed. Nine lakes were sampled for chemical analyses.

Plans for 1991: The well inventory will be completed. Additional test drilling will be done and observation wells will be constructed under the current contract. Additional water samples will be collected for chemical analyses. Analysis of data that have been collected will continue. Report writing will begin.

WATER RESOURCES OF SPINK COUNTY, SOUTH DAKOTA (SD089)



Project leader: Louis J. Hamilton

Period of project: October 1987 to September 1991

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The dryland agricultural economy of Spink County, adversely affected by extended droughts, has been improved by pumping water for irrigation from the James River and from aquifers. However, the James River does not provide a dependable supply, especially during drought periods. In addition, a computer-model appraisal of one aquifer indicates that pumpage may have to be restricted in order to prevent excessive drawdown and decreased yield of wells. Little is known about the glacial-outwash aquifers, even though aquifers which have been mapped in adjacent counties probably extend into Spink County. A knowledge of the hydrology of these aquifers will be valuable in future development of water supplies for municipalities, industry, irrigation, and rural water systems.

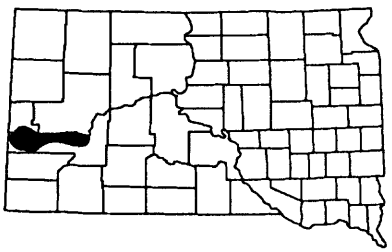
Objective: The major objective is to provide reliable and up-to-date basic data and analyses needed for water-resources evaluation and for efficient use of these resources. Specifically, the study will concentrate on determining the availability of surface- and ground-water resources, the operation of 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 and potential hydrologic problems as related to water use will be identified.

Approach: Water resources will be evaluated using standard geologic and hydrologic techniques. 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 three field seasons. An observation-well network will be established and water samples collected for chemical analysis. Glacial and bedrock aquifers will be delineated and their hydrologic characteristics described. Aquifer tests will be performed wherever feasible. A concurrent geologic study will be made by the South Dakota Geological Survey, with extensive test drilling by State Survey drill rigs. Oral progress reports will be made to the cooperator during the study period. The U.S. Geological Survey will prepare a preliminary report summarizing the major aquifers and discussing their productivity and water quality, followed by a final comprehensive report on the hydrology. A State Survey geologist will prepare a report on the geology of the county.

Progress and significant results during fiscal year 1990: About 100 wells were inventoried and water samples were collected from 30 percent of the wells for field tests of chemical quality. About 30 test holes were drilled to bedrock and 9 observation wells were installed in glacial aquifers and the Niobrara aquifer. Six other shallow observation wells were installed in order to locate, in more detail, recharge areas and estimate the rate of recharge. Water levels were monitored on a monthly basis in 90 wells. The altitudes of measuring points were obtained by running levels from benchmarks to 30 wells in areas of low potentiometric gradients.

Plans for 1991: Available data will be evaluated and incorporated in maps, graphs, and tables. Water samples will be collected from 30 wells for complete chemical analysis. Report writing will be completed.

WATER QUALITY OF SURFACE AND GROUND WATERS OF THE RAPID CREEK BASIN, SOUTH DAKOTA (SD090)



Project leader: Mark T. Anderson

Period of project: January 1988 to September 1991

Cooperator: South Dakota School of Mines and Technology

Problem: The hydrology and quality of water in the Black Hills of South Dakota is highly complex, due in part to the region's size, diverse land and recreational use, climate, geology, karst hydrology, and ground-water/surface-water interactions. Increased development pressures are occurring in the Black Hills due to the renewed interest in surface mining for gold and the expansion of irrigation, housing projects, and recreational activities--especially boating, fishing and snowmobiling. Many of these developmental activities are occurring on or near the recharge zones of regionally important aquifers, such as the Minnelusa and Madison Formations. Concern has been expressed by local authorities and citizens that continued development of the Black Hills may significantly degrade both the quantity and quality of water in the area's surface water (streams and lakes) and ground water (wells and springs).

Objective: The overall objective of this investigation is to provide a comprehensive understanding and documentation of the water quality, both surface and ground water, of the Rapid Creek basin.

Approach: Because of the enormity and complexity of appraising the quality of surface and ground water in the entire Rapid Creek basin, it is proposed that this investigation utilize both the staff of the Water Resources Division (WRD) and the faculty and graduate students of the Civil Engineering Department, South Dakota School of Mines and Technology--a South Dakota funded institution of higher education. The characterization of water quality will be completed by a combination of (1) a comprehensive compilation, review, and evaluation of historical water-quality data; and (2) collection of additional water-quality data, via both field and laboratory analysis. Particular emphasis will be placed on those water resources within the Rapid Creek basin that are known or suspected to have degraded water quality. Examples include (1) Deerfield and Pactola Reservoirs and eutrophication therein; (2) Canyon Lake and recent taste and odor concerns; (3) Rapid Creek alluvium in Rapid City and gasoline contamination thereof; (4) urban runoff in Rapid City and heavy-metal transport and high loadings associated therewith; (5) Minnelusa and Madison aquifers and possible contamination from onsite sewage disposal by residential communities; and (6) occurrence of radon, radium, and other natural radioactive isotopes in surface and ground waters. The major outcome of the study will be a comprehensive, basin-wide assessment of water quality in both the surface and ground waters of the Rapid Creek basin. In addition, more focused water-quality data will be collected at sites where known or suspected contamination is occurring. This latter information will indicate where more intensive, interpretative studies are warranted.

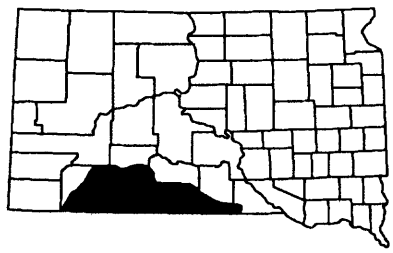
Progress and significant results during fiscal year 1990: Field work was initiated to collect monthly water samples at several locations in Deerfield Reservoir. A draft manuscript was prepared on selenium in the Inyan Kara aquifer. Nitrogen and phosphorus data for Rapid Creek were compiled. A preliminary project plan was developed for an investigation of water quality above Deerfield Reservoir.

Plans for 1991: Obtain Director's approval for several reports, including: (1) Water loss and gain along Rapid Creek; (2) Nitrogen and phosphorus loadings along Rapid Creek from Pactola Dam to Farmingdale; (3) Selenium in the Inyan Kara aquifer; and (4) Radiochemicals in the Deadwood Formation. A draft report on water quality of Deerfield Reservoir will be prepared. A project plan for an investigation of water quality upstream of Deerfield Reservoir will be completed.

Completed reports:

Zogorski, J.S., Zogorski, E.M., and McKallip, T.E., 1990, Sources and summaries of water-quality information for the Rapid Creek basin, western South Dakota: U.S. Geological Survey Open-File Report 90-115, 35 p.

HIGH PLAINS AQUIFER MONITORING, SOUTH DAKOTA (SD091)



Project leader: John R. Little

Period of project: April 1988 to September 1992

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: Based on concerns that have been expressed relative to water-level decline in the High Plains aquifer, Congress has directed the U.S. Geological Survey to investigate the circumstances relating to this decline and to report back to Congress annually.

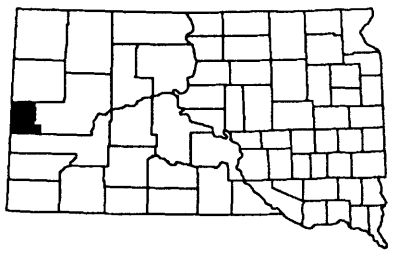
Objective: The objective is to collect and summarize data relative to the changes in water levels, storage, and water quality within the High Plains aquifer in order to meet Congressional directives.

Approach: Existing data will be analyzed and interpreted. New data relative to water levels, storage, and water quality within the High Plains aquifer will be collected, analyzed, and interpreted. Additional data needs will be identified. An annual report will be published.

Progress and significant results during fiscal year 1990: Two continuous recorders were installed on wells located near Pine Ridge. Information and data were provided to the Regional project chief as requested.

Plans for 1991: The current observation-well network will be evaluated to determine if it is satisfactory. Water-level data will be collected and entered into the Ground Water Site Inventory (GWSI) for about 125 observation wells. Information and data will continue to be provided to the Regional project chief as requested.

WATER RESOURCES OF LAWRENCE COUNTY, SOUTH DAKOTA (SD092)



Project leader: Daniel G. Driscoll

Period of project: June 1988 to September 1991

Cooperator: South Dakota Department of Water and Natural Resources, Lawrence County.

Problem: The northern Black Hills area of South Dakota is without a regional hydrology study to characterize and describe fundamental information on quantity and quality of the surface- and ground-water resources. The northern Black Hills area is experiencing an expansion of mining activity, urbanization, and recreational activity. There is concern about the potential for this development to affect the quantity and quality of the surface and ground water. This study needs to address: (1) The lack of baseline information on water quantity and quality; (2) the bedrock aquifers and the ground-water and surface-water interaction; and (3) the lack of available necessary information to predict effects of resource development on the water resources.

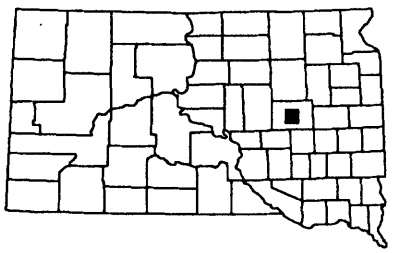
Objective: The objectives are to: (1) Inventory wells completed in the bedrock aquifers, with emphasis on the area south of Spearfish, and to inventory wells completed in the shallow alluvial aquifer along Spearfish Creek. (2) Study the surface waters of the northern Black Hills area, which will involve: (a) an inventory of the springs, lakes, and streams; and (b) the establishment of a long-term streamflow monitoring program at sites where data are lacking and where resource conflicts are anticipated. (3) Determine existing water-quality conditions of both ground waters and surface waters at selected sites.

Approach: A ground-water inventory (Objective 1) will be conducted through the collection and analysis of existing data and by obtaining geophysical logs from wells drilled by others. In general, this objective will be accomplished by inventorying existing wells to obtain information on aquifer locations, extent, depth, thickness, ground-water levels, water quality, character of the aquifer, and locations of potential ground-water movement. An attempt will be made to inventory and catalog all wells within the lithology and geologic structure of the aquifers. It is anticipated that selected wells drilled by mining companies will be available for data collection. The surface-water resources of Lawrence County (Objective 2) will be studied by field inventory and measurement of the lakes, streams, and springs. In addition, a network of precipitation and streamflow gages will be installed to establish a long-term monitoring program. The existing water-quality conditions (Objective 3) will be defined by examining existing data and gathering samples from selected wells and streams.

Progress and significant results during fiscal year 1990: Data from 15 precipitation gaging stations and 8 streamflow gages were published for the first time in water year 1989. Operation of this network continued during water year 1990. Quarterly water-quality sampling continued at four sites, and was scaled back to a semi-annual schedule at nine sites where sufficient background data have been collected. Monitoring of water levels and geophysical logging of new wells in major aquifers continued. A survey of bacteria and nutrient levels in the surface and alluvial waters of Spearfish Creek was conducted. An inventory of discharge and basic water-quality parameters of mapped springs in Lawrence County was conducted. In addition, a study of water-quality effects at historic mining sites was initiated.

Plans for 1991: Collection of basic precipitation, streamflow, water-level, and water-quality data will continue. More attention will be focused on compilation and analysis of incoming data. Work will begin on mapping of spring inventory data, as well as publication of available data and preliminary results.

GROUND-WATER RECHARGE DEMONSTRATION NEAR HURON, SOUTH DAKOTA (SD093)



Project leader: Patrick J. Emmons

Period of project: October 1987 to September 1995

Cooperator: South Dakota Department of Water and Natural Resources.

Problem: The drought in South Dakota from 1974-76 and the near-drought conditions in 1980-81 have resulted in increased demand on the ground-water resources within the James River basin. The South Dakota Department of Water and Natural Resources water-level monitoring program has identified areas in the basin in which a loss of head and subsequent ground-water-level declines have occurred. The city of Huron municipal well field is in one of these areas. The well field currently is being used as a "backup" water supply to the James River, the city's primary water source. Due to anticipated increases in the demand for municipal and industrial water and the uncertainty of the James River, especially during periods of drought, the city may be required to rely more on ground water to meet municipal demands.

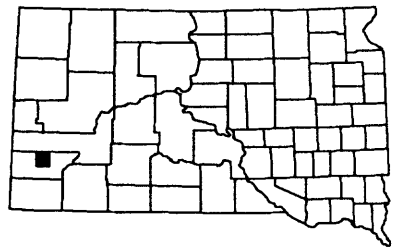
Objective: The general purpose of the study is to demonstrate, at a specific site (city of Huron well field), the artificial recharge potential of the glacial aquifers in eastern South Dakota. The specific objectives are to: (1) Evaluate the use of injection wells to recharge a buried glacial outwash aquifer; (2) determine the rates of artificial recharge using James River water and spring and/or storm runoff; (3) determine the water-level effects of artificial recharge on the aquifer; (4) determine water-quality changes due to introduction of artificial recharge water into the aquifer; and (5) develop an evaluation technique to assess the artificial recharge potential of other areas in South Dakota.

Approach: Because of large variability in the glacial drift over short distances, approximately 70 observation wells will be drilled in the Huron well field areas. These wells will provide additional information on the drift composition, aquifer properties, and allow water levels to be monitored and water samples to be collected. Due to the thickness of the silts and clays overlying the aquifer material, artificial recharge will be conducted using two recharge wells of different diameters. Treated municipal water from the James River will be pumped through the city of Huron's existing pipeline to the city's well field for artificial recharge. Spring runoff and/or storm runoff from an intermittent stream will be used for artificial recharge providing the water can meet the drinking water standards with only minimal onsite treatment. Ground-water and chemical flow models will be used to aid in gaining a better understanding of the ground-water regime before and during artificial recharge. A geochemical model will be developed to aid in gaining a better understanding of the chemical interactions between the recharge and ground waters. The models will be used, in part, to aid in the development of a technique to evaluate the recharge potential of other areas of eastern South Dakota.

Progress and significant results during fiscal year 1990: The Department of Civil Engineering at South Dakota State University was named sponsor of the the project. Hydrologic and geologic data for the artificial recharge area were compiled from files of the City of Huron, South Dakota Geological Survey, Department of Water and Natural Resources, and U.S. Geological Survey. Approximately 50 observation wells were drilled. Twice-monthly water-level monitoring was initiated for about 25 observation wells.

Plans for 1991: An additional 20 observation wells will be drilled and the analysis of drilling data will be completed. A program to collect water-quality samples from selected observation wells and from the City of Huron Water Treatment Plant will be established. The water-level monitoring program will be expanded to include all of the new observation wells. Five data loggers will be installed for continuous monitoring of water-level changes. Flow-transport and chemical modeling will begin. Recharge well specifications will be prepared and the existing pipeline will be modified to convey treated water to the demonstration site.

STREAMFLOW AND WATER-QUALITY EFFECTS OF A LARGE FOREST FIRE IN CUSTER STATE PARK, SOUTH DAKOTA (SD094)



Project leader: Daniel G. Driscoll

Period of project: October 1988 to September 1999

Cooperator: South Dakota Department of Water and Natural Resources, South Dakota Department of Game, Fish and Parks, U.S. Department of Agriculture (Forest Service).

Problem: A forest fire was ignited by lightning within the Galena Creek drainage, Custer County, South Dakota, on July 5, 1988. The pine forest was especially dry after months of below-average precipitation and above-average temperatures, including the hottest June on record in the Black Hills area. As a result, the Galena fire spread rapidly and, in five days, burned 16,788 acres of timber and grassland, primarily within the administrative boundaries of Custer State Park. The Galena fire is unique because it was a large fire concentrated in a watershed with perennial streamflow (14 years of pre-fire streamflow records are available). The majority of the burn occurred within the Grace Coolidge drainage, with portions of French Creek and Spokane Creek drainage also burned. The potential impacts of this fire on the water resources of Custer State Park are particularly important because of the trout fishery in Grace Coolidge Creek and the heavy recreational use of the Park.

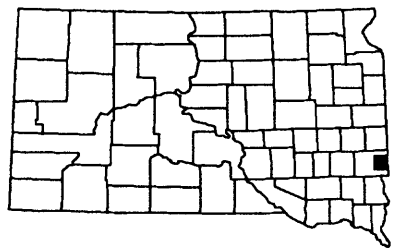
Objective: The specific objectives of this study are to: (1) Determine water quality downstream of the burn area on Grace Coolidge Creek and Bear Gulch, and to compare these data with baseline water-quality data collected upstream of the burn area on Grace Coolidge Creek; (2) determine the erosion and sedimentation effects by study of the channel morphology on Grace Coolidge Creek and Bear Gulch; and (3) determine the changes in watershed hydrology such as annual water yield, peak discharge, time of concentration, and minimum flows.

Approach: Water-quality sampling sites will be established at three sites--one on Grace Coolidge Creek at the USGS gaging station near the Game Lodge (downstream of the burn area), one on Bear Gulch downstream of the burn area, and one on Grace Coolidge Creek upstream of the burn area. Monthly water-quality samples will be collected. Channel morphology changes on Grace Coolidge Creek and on Bear Gulch will be studied by making channel elevation surveys at selected cross sections throughout the course of the study. In addition, some suspended-sediment and bed-load sampling will be accomplished. One of the primary water-quantity objectives is to project the increase in water yield. This will be done by comparing water yield upstream and downstream of the burn areas, as well as documenting the expected decrease in water yield which is expected as reforestation occurs. Pre-burn and post-burn unit hydrograph analyses will be conducted to determine the effects on peak discharges.

Progress and significant results during fiscal year 1990: The water quality and sedimentation portions of this study were finished in 1990. Two theses by M.S. students at South Dakota School of Mines and Technology were produced. These were: "Chemical and biological characteristics of Grace Coolidge and Bear Gulch Creeks after the Galena forest fire in Custer State Park, South Dakota," by Jagadish R. Gundarlahalli; and "Geomorphologic effects of the Galena forest fire in Custer State Park, South Dakota" by Dietrich H. Whitesides.

Plans for 1991: The water yield portion of the project will require additional years of streamflow and precipitation data collection. Results to date indicate a dramatic increase in both stormflow and baseflow. A slow decline in baseflow is expected as revegatation occurs, but this needs to be quantified. It is proposed that the current network of three streamflow gaging stations, three recording precipitation gages, and five nonrecording precipitation observers be maintained through fiscal year 1998.

SPLIT ROCK CREEK AQUIFER STUDY, MINNEHAHA COUNTY, SOUTH DAKOTA (SD095)



Project leader: Donald S. Hansen

Period of project: October 1988 to September 1991

Cooperator: City of Sioux Falls, East Dakota Water Development District.

Problem: The City of Sioux Falls currently obtains the majority of its water supply from the Big Sioux aquifer. Increasing demand for water, in conjunction with drought conditions which have recently occurred, has caused the City to seek additional sources of water. A recent appraisal of the water resources of Minnehaha County identified a potential new source of water in the Split Rock Creek aquifer near Sioux Falls. The extent of Split Rock Creek aquifer in Minnehaha County is about 140 square miles. The aquifer is buried under as much as 337 feet of glacial till and lies on the Precambrian Sioux Quartzite. The thickness of the aquifer is as much as 222 feet, and averages 48 feet.

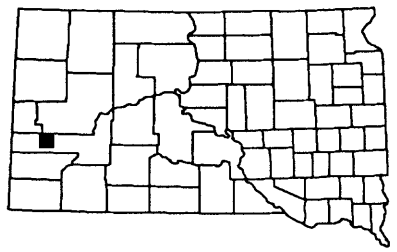
Objective: The objective of the study is to understand the water resources of the Split Rock Creek aquifer in an area of potential development located near Sioux Falls, South Dakota. A model will be developed to evaluate the hydrologic characteristics of the aquifer under various climatic and development conditions.

Approach: The modeling expertise of the U.S. Geological Survey will be used to develop and calibrate a finite-difference two- or three-dimensional digital model of the Split Rock Creek aquifer. The specific approach to be used to achieve the study objective will be: (1) Gather all existing and new hydrologic data from the South Dakota Geological Survey, including aquifer thickness, location, depth to water, saturated thickness, observation well hydrograph and test drilling data; (2) prepare hydrogeologic maps that show the configuration of the potentiometric surface, saturated thickness, and aquifer characteristics; (3) prepare a hydrologic budget that describes the inflow-outflow characteristics of the study area; and (4) develop a digital model using all available hydrologic data to simulate flow in the Split Rock Creek aquifer. The accepted U.S. Geological Survey digital model will be used and modifications will be made as needed. Once the model of the Split Rock Creek aquifer is calibrated under transient conditions, it will be used to evaluate the response of the aquifer system to man-induced stresses such as pumping and natural stresses such as drought. Hypothetical or planned future municipal pumping and other forms of water use proposed by State and local officials can be tested, simply by changing the rates and distribution of the proposed withdrawals in the model.

Progress and significant results during fiscal year 1990: Data entry for the Split Rock Creek aquifer computer model was completed. Steady-state calibration simulations were run and are near completion.

Plans for 1991: Steady-state and transient model calibration simulations will be completed. Hypothetical hydrologic simulations will be conducted. The first draft of the report will be written.

AQUIFER CHARACTERISTICS AND GROUND-WATER FLOW OF THE MADISON LIMESTONE NEAR RAPID CITY, SOUTH DAKOTA (SD097)



Project leader: Earl A. Greene

Period of project: June 1989 to September 1991

Cooperator: City of Rapid City.

Problem: The Black Hills of South Dakota are surrounded by an almost-continuous band of the Madison Limestone exposed at the ground surface. Water enters the Madison from precipitation and from streams that flow across the formation. The Madison is largely undeveloped in the Rapid City area; however, development is eminent, given the demands placed upon water supplies by increasing population and drought. The possibility exists that large-scale development of the Madison in the Rapid City area could increase streamflow losses and adversely affect springflow along Rapid Creek. Therefore, increased knowledge of the Madison Limestone is necessary in order to make prudent management decisions relative to its development.

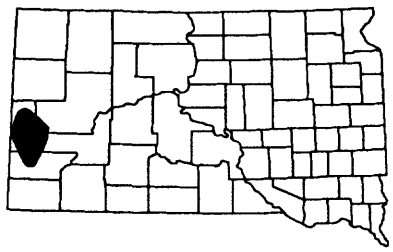
Objective: The objectives of this investigation are: (1) To determine properties of the Madison aquifer including depth, thickness, permeability, and storage in the vicinity of Rapid City; and (2) to study the possible effects of Madison pumping on ground-water flow and surface-water interactions in the Rapid City area.

Approach: Two observation wells will be drilled in locations favorable for performing aquifer tests using two Rapid City production wells as pumping wells. Additional observation wells will be drilled specifically for the purpose of monitoring effects of Madison pumping on ground-water/surface-water interactions. Discharge from springs (Cleghorn, Jackson, and City Springs) will be gaged to examine response to nearby pumping. Borehole geophysical methods will be employed in all observation and production wells to identify the various formations encountered and to estimate the characteristics of the aquifer. Water samples will be drawn from all wells and will be analyzed for a suite of standard constituents. A preliminary numerical simulation model of the Madison aquifer will be built to evaluate aquifer response to recharge and pumping.

Progress and significant results during fiscal year 1990: A detailed plan of study was developed. Observation and production well sites were selected and drilled. Analysis of existing Madison well records and an inventory of existing Minnelusa and Madison wells was completed. All wells suitable for aquifer testing were instrumented.

Plans for 1991: Aquifer-test data will be analyzed to determine the hydraulic properties of the Madison. Construction of the ground-water flow model will begin, including calibration and sensitivity analysis. A draft report will be written.

PARTITIONING OF INORGANIC SOLUTES BETWEEN LIQUID WATER AND ICE IN SMALL STREAMS SUBJECT TO FREEZE-THAW CYCLES, SOUTH DAKOTA (SD098)



Project leader: Kimball E. Goddard

Period of project: January 1990 to September 1992

Cooperator: Lawrence County, West Dakota Water Development District, South Dakota School of Mines and Technology, South Dakota Department of Water and Natural Resources.

Problem: The retention of water in ice crystals has the effect of increasing solute concentrations in the parent solution during periods when ice is forming and decreasing solute concentrations during periods when ice is melting. In the ocean, large lakes, and larger rivers and streams (open systems where the volume of ice formed is not substantial compared to the volume of unfrozen water), solute partitioning does not markedly effect solute concentrations to the extend that environmental criteria or standards are exceeded or causes geochemical changes of unknown significance. An understanding of how solutes partition between liquid water and ice, and an insight as to how this process affects instream solute concentrations, are required for small streams in areas having cold climates where water-quality data are being collected.

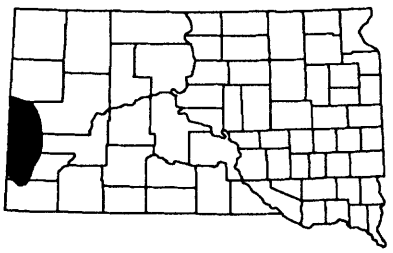
Objective: The research objectives of the investigation are to: (1) Empirically determine partitioning coefficients for selected solutes in liquid water and ice formed in high-quality and polluted streams under various freezing conditions; (2) develop simple mathematical models to relate the heat balance of streams to ice-mass formation/melting and corresponding solute-concentration variation; and (3) examine diurnal variations of solute concentrations caused by freeze-thaw cycles and the possible effect on sample-collection timing and implications for water-quality-standards enforcement.

Approach: Four small streams in South Dakota, each subject to almost complete freezing during the winter, will be intensively investigated. Discharge, specific conductance, water temperature, and air temperature will be monitored continuously on each stream from November through April. Concurrent samples of water and contacting ice will be collected under various hydrologic and weather conditions. Paired samples (liquid water and ice) will be analyzed for major ions and other dissolved constituents depending on solutes known or believed to be in the stream. Paired data will be used to calculate partitioning coefficients when variance is statistically significant. The heat balance of the streams will be calculated from the air-temperature/water-temperature differential, water mass, surface area open to cooling, and turbulence. Models to relate heat balance to ice-mass formation will be used to predict solute-concentration variations.

Progress and significant results during fiscal year 1990: Heated control structures were constructed at three of the four stream sites (the fourth will be constructed before the winter of 1990-91). Water and air temperature recorders were installed at all sites and more complete weather instrumentation (wind speed, solar radiation) was installed at the Rapid Creek heat-balance site. Preliminary observations of discharge and dissolved-solids variations were conducted at the Rapid Creek site during February and March 1990.

Plans for 1991: Full-scale implementation of sample collection will begin about December 1, 1990. Samples of paired water and ice will be collected at all sites under various conditions. Discharge and weather data will be entered into the Automated Data Processing System (ADAPS) as it becomes available. Data interpretation and report writing will begin.

BLACK HILLS HYDROLOGY STUDY,
SOUTH DAKOTA (SD099)



Project Chief: Kimball E. Goddard

Period of project: October 1989 to September 1993

Cooperator: West Dakota Water Development District, South Dakota Department of Water and Natural Resources.

Problem: The Black Hills area of western South Dakota is experiencing an expansion of mining activity, urbanization, and recreation development which could adversely affect the local water resources. In addition, the drought conditions experienced during the late 1980's depleted the supply of water for several Black Hills communities. Water managers in the area lack the hydrologic information needed to adequately assess how resource development and drought will affect the quantity and quality of surface and ground waters.

Objective: The objectives are to: (1) Determine the hydrologic properties of and a water budget for the Madison/Minnelusa aquifer system in and near the Black Hills; (2) define the relationships between precipitation and land use on stream-basin yield and aquifer response for selected basins and aquifers; and (3) compile baseline water-quality information on streams and aquifers and determine temporal changes caused by surface mining, rural development, or other anthropogenic processes.

Approach: Basic hydrologic data (precipitation, stream discharge, water levels, etc.) will be collected through operation of appropriate data-collection networks. A regional network will add a number of new sites to those currently in use. The hydraulic properties of major aquifers will be determined by: (1) Obtaining and compiling existing information, (2) drilling and monitoring observation wells, and (3) conducting aquifer tests. Water-quality samples will be collected from streams, springs, and wells to determine areal and temporal variations in surface and ground-water quality.

Progress and significant results during fiscal year 1990: Five streamflow gaging stations were installed and quarterly water-quality sampling was initiated at these sites. Nine new precipitation gaging sites were established in the southern Black Hills. A study of the effects of historical mining activities was conducted in the northern Black Hills, an inventory of springs was begun in the northern Black Hills, and a clean-up of the Ground Water Site Inventory (GWSI) data base for the Black Hills was initiated.

Plans for 1991: The detailed workplan will be completed. The collection and analysis of hydrologic data will continue. Three additional streamflow stations will be installed. The inventory of springs and the clean-up of the ground-water data base will progress from north to south. The Black Hills area ground-water monitoring program will be reorganized. Construction of a Geographic Information System (GIS) data base will begin and advance planning for the regional ground-water flow model will take place.

PUBLICATIONS OF THE U.S. GEOLOGICAL SURVEY

General Information

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 upon request from the U.S. Geological Survey, 582 National Center, Reston, VA 22092. All publications are for sale unless specifically stated otherwise. Prices, which are subject to change, are not included here. Prepayment is required and information on price and availability should be obtained from listed sales offices before placing an order.

The "U.S. Geological Survey Yearbook" provides a comprehensive description of the Federal Government's largest earth-science agency; copies are available for fiscal years beginning with 1975 and may be purchased at the address where Professional Papers are sold (see below). Summaries of research in progress and results of completed investigations were formerly published each fiscal year in the Professional Paper series "Geological Survey Research" (see under heading "Professional Papers"). This series was discontinued in 1984. A pamphlet entitled "Geologic and Water-Supply Reports and Maps for South Dakota," which lists reports on the geology and water resources of South Dakota, is available upon request to the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 810, Box 25425, Denver, CO 80225.

Water-Resources Information

A monthly summary of the national water situation presented in the "National Water Conditions" (formerly called "Water Resources Review") is available on request to the U.S. Geological Survey, 419 National Center, Reston, VA 22092. Water-resources activity reports (similar to this one) are available for each of the 50 States and Puerto Rico and the Virgin Islands.

Beginning with the 1975 water year, streamflow data, water-quality data for surface and ground water, and ground-water level data for each State are combined and published in the annual series "U.S. Geological Survey Water-Data Reports." See section "U.S. Geological Survey Water-Data Reports available only through NTIS" for listing of these reports.

Records of discharge of streams, and contents (or stage) of lakes and reservoirs were first published in a series of USGS Water-Supply Papers entitled, "Surface Water Supply of the United States." Through September 30, 1960, these Water-Supply Papers were in an annual series and then in a multiyear series for 1961-65 and 1966-70. Records of chemical quality, water temperatures, and suspended sediment were published from 1941 to 1970 in an annual series of Water-Supply Papers entitled, "Quality of Surface Waters of the United States." Records of ground-water levels were published from 1935 to 1974 in a series of Water-Supply Papers entitled, "Ground-water levels in the United States." Water-Supply Papers may be consulted in the libraries of the principal cities in the United States or may be purchased from the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 810, Box 25425, Denver, CO 80225. Pamphlets (mentioned under "General Information") listing the reports for each State by number and title may be obtained on request from that address also.

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 the offices of the Geological Survey in Huron, Rapid City, and Pierre, and at large public and university libraries. The publications are grouped as follows: Publications of the U.S. Geological Survey (USGS); publications of State agencies prepared by or in cooperation with the U.S. Geological Survey; other publications, such as technical journals.

USGS Professional Papers

Professional Papers are sold by the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 810, Box 25425, Denver, CO 80225.

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 Denver, Colo., 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 water, by R. A. Krieger. 1959.

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.

W 2250. National Water Summary 1983, includes State water-issue summaries - South Dakota, p. 209-211. 1984.

W 2275. National Water Summary 1984, includes State summaries of ground-water resources - South Dakota, p. 385-390. 1985.

W 2300. National Water Summary 1985, includes State summaries of surface-water resources - South Dakota, p. 419-424. 1986.

W 2325. National Water Summary 1986, includes State summaries of hydrologic events and ground-water quality - South Dakota, p. 457-464. 1988.

W 2350. National Water Summary 1987, includes State summaries of hydrologic events and water supply and use - South Dakota, p. 459-466. 1990.

USGS Circulars

Single copies of circulars still in print are available free from the above-listed Denver, Colo., 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.

USGS Water-Resources Investigations Reports

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 a NTIS ordering number can be purchased from the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 810, Box 25425, Denver, CO 80225. Further information about these reports may be obtained from the District Chief, WRD, Huron, South Dakota.

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

WRIR 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)

WRIR 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)

WRIR 82-31. Magnitude and frequency of floods from selected drainage basins in South Dakota, by L. D. Becker. 1982 (PB 82-237470)

WRIR 82-4064. A digital-computer model of the Big Sioux aquifer in Minnehaha County, South Dakota, by N. C. Koch. 1982.

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

WRIR 83-4108. Water resources of Hanson and Davison Counties, South Dakota, by D. S. Hansen. 1983.

WRIR 83-4175. A two-dimensional, finite-difference model of the High Plains aquifer in southern South Dakota, by K. E. Kolm and H. L. Case III. 1983.

WRIR 83-4234. Evaluation of the response of the Big Sioux aquifer to extreme drought conditions in Minnehaha County, South Dakota, by N. C. Koch. 1983.

WRIR 84-4030. Water resources of Aurora and Jerauld Counties, South Dakota, by L. J. Hamilton. 1985.

WRIR 84-4069. Water resources of Deuel and Hamlin Counties, South Dakota, by Jack Kume. 1986.

WRIR 84-4078. Appraisal of the water resources of the eastern part of the Tulare aquifer, Beadle, Hand, and Spink Counties, South Dakota, by L. K. Kuiper. 1984.

WRIR 84-4195. Water resources of Hughes County, South Dakota, by L. J. Hamilton. 1986.

WRIR 84-4209. Water resources of Lake and Moody Counties, South Dakota, by D. S. Hansen. 1986.

WRIR 84-4241. Water resources of Yankton County, South Dakota, by E. F. Bugliosi. 1986.

WRIR 84-4312. Simulated artificial recharge in the Big Sioux aquifer in Minnehaha County, South Dakota, by N. C. Koch. 1984.

WRIR 85-4015. Water resources of Walworth County, South Dakota, by Jack Kume and L. W. Howells. 1987.

WRIR 85-4021. Evaluation of techniques for mapping land and crops irrigated by center pivots from computer-enhanced Landsat imagery in part of the James River basin near Huron, South Dakota, by K. E. Kolm. 1985.

WRIR 85-4022. Availability and quality of water from the bedrock aquifers in Rapid City area, South Dakota, by K. D. Peter. 1985.

WRIR 85-4053. Geologic structure and altitude of the top of the Minnelusa Formation, northern Black Hills, South Dakota and Wyoming, and Bear Lodge Mountains, Wyoming, by K. D. Peter, D. P. Kyllonen, and K. R. Mills. 1987.

WRIR 85-4069. Geochemical survey to determine water-quality characteristics of the Big Sioux aquifer in eastern South Dakota, by N. F. Leibbrand. 1985.

WRIR 85-4217. Analysis of flood-flow frequency for selected gaging stations in South Dakota, by R. D. Benson, E. B. Hoffman, and V. J. Wipf. 1985.

WRIR 85-4233. Geologic structure and altitude of the top of the Minnelusa Formation, northeastern Black Hills, South Dakota, by K. D. Peter, D. P. Kyllonen, and K. R. Mills. 1988.

WRIR 86-4035. Water resources of Miner County, South Dakota, by N. C. Koch and S. D. McGarvie. 1988.

WRIR 86-4158. Geohydrology and water quality of the Inyan Kara, Minnelusa, and Madison aquifers of the northern Black Hills, South Dakota and Wyoming, and Bear Lodge Mountains, Wyoming, by D. P. Kyllonen and K. D. Peter. 1987.

WRIR 87-4017. Preliminary assessment of potential well yields and the potential for artificial recharge of the Elm and Middle James aquifers in the Aberdeen area, South Dakota, by P. J. Emmons. 1987.

WRIR 87-4051. Composition, distribution, and hydrologic effects of contaminated sediments resulting from the discharge of gold milling wastes to Whitewood Creek at Lead and Deadwood, South Dakota, by K. E. Goddard. 1989.

WRIR 87-4057. Appraisal of the water resources of the Big Sioux aquifer, Moody County, South Dakota, by D. S. Hansen. 1988.

WRIR 87-4082. A digital simulation of the glacial-aquifer system in Sanborn and parts of Beadle, Miner, Hanson, Davison, and Jerauld Counties, South Dakota, by P. J. Emmons. 1988.

WRIR 87-4156. Appraisal of the water resources of the Skunk Creek aquifer in Minnehaha County, South Dakota, by G. L. Ohland. 1990.

WRIR 87-4208. Analysis of flood-flow frequency, flow duration, and channel-forming flow for the James River in South Dakota, by R. D. Benson. 1988.

WRIR 88-4031. Water-resources appraisal of the Lake Traverse Indian Reservation in South Dakota, by S. J. Lawrence. 1989.

WRIR 88-4185. Water resources of Brookings and Kingsbury Counties, South Dakota, by L. J. Hamilton. 1989.

WRIR 88-4198. A digital simulation of the glacial-aquifer system in the northern three-fourths of Brown County, South Dakota, by P. J. Emmons. 1990.

WRIR 89-4039. Streamflow at selected gaging stations on the James River in North Dakota and South Dakota, 1953-82, with a section on climatology, by G. J. Wiche, R. D. Benson, and D. G. Emerson. 1989.

WRIR 89-4147. Water resources of Codington and Grant Counties, South Dakota, by D. S. Hansen. 1990.

WRIR 90-4093. Water resources of Hutchinson and Turner Counties, South Dakota, by R. J. Lindgren and D. S. Hansen. 1990.

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The water-data reports listed below may be purchased as hard copy or microfiche only from the National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161. They are available for inspection only at the South Dakota and Reston, Va., offices of the U.S. Geological Survey. The PB number in parenthesis is the NTIS ordering number.

Water resources data for South Dakota--water year 1971, Part 1, Surface water records. 1972. (PB-289 442).

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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 U.S. Geological Survey, Map Distribution, Federal Center, Bldg. 810, Box 25286, 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.

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

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USGS Hydrologic Unit Maps

Hydrologic unit maps are sold at the above-listed Denver address.

U.S. Geological Survey, 1978, Hydrologic unit map--1978 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 U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 810, Box 25425, 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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OFR 70-194. A proposed streamflow-data program for South Dakota, by O. J. Larimer. 1970.

OFR 71-228. Approximate optimum yield of the glacial outwash aquifer between Sioux Falls and Dell Rapids, South Dakota, by J. E. Powell and D. G. Jorgensen. 1971.

OFR 75-355. Test drilling at Soldier Creek, Rosebud Indian Reservation, Todd County, South Dakota, by D. G. Adolphson. 1975.

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OFR 81-627. Water levels in bedrock aquifers in South Dakota, by W. L. Bradford. 1981.

OFR 81-924. Records of water levels in unconsolidated deposits in eastern South Dakota, by W. L. Bradford. 1981.

OFR 82-912. Water resources investigations of the U.S. Geological Survey in South Dakota, project status summary, July 1, 1982, by E. F. LeRoux and E. M. Decker. 1982.

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OFR 85-348. Drainage areas in the Big Sioux River basin in eastern South Dakota, by F. D. Amundson, W. L. Bradford, and N. C. Koch. 1985.

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OFR 86-147. Records of wells and chemical analyses of ground water in Brown County, South Dakota, by K. M. Neitzert and N. C. Koch. 1986.

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OFR 87-42. Records of wells and chemical analyses of ground water in Campbell County, South Dakota, by K. M. Neitzert and N. C. Koch. 1987.

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-----1974, Water-supply sites for Wind Cave National Park, Custer County, South Dakota.

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Inquiries about these reports should be addressed to the South Dakota Geological Survey, Science Center, University of South Dakota, Vermillion, SD 57069.

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Reports Pending Publication

In addition to the published reports listed above, the following Water-Resources Investigations Reports and Open-File Reports have been approved and are in various stages of the publication process. Information on the availability of these reports can be obtained by contacting the District Chief, USGS, Water Resources Division, Huron, South Dakota:

WRIR 86-4167. Map showing geologic structure and altitude of the top of the Minnelusa Formation and orientation of mapped cave passages in the Madison Limestone, southern Black Hills, South Dakota, by K. D. Peter, K. R. Mills, and C. L. Loskot.

WRIR 89-4170. Quality of water from surficial-outwash aquifers in the Big Sioux River basin, eastern South Dakota, by S. J. Lawrence.

WSP 2340. Climatological and hydrological factors affected the Lake Thompson chain of lakes in eastern South Dakota, by D. S. Hansen and W. Miller.