PREPARED AS PART OF THE PROGRAM OF THE
DEPARTMENT OF THE INTERIOR FOR
DEVELOPMENT OF THE MISSOURI RIVER BASIN

INTRODUCTION

Figure 1.—Index map of North and South Dakota showing location of Standing Rock Indian Reservation.

Figure 2.—Index map of the Standing Rock Indian Reservation.

INTRODUCTION

Effective improvement of economic and social conditions of Indians living on the Standing Rock Indian Reservation has been hampered by lack of adequate and reliable information about the quantity and quality of water supplies available for development. Compounding the problem is the recent filling of Oahe Reservoir (now Lake Oahe), which flooded about 55,000 acres of Indian land, and the consequent relocation of many residents. This report summarizes the results of a water-resources study made at the request of the U.S. Bureau of Indian Affairs. It is intended to provide some of the needed information on water supplies that could be used to alleviate the problems mentioned.

The cooperation and courtesy extended by many farmers, ranchers, and residents of the area contributed greatly to the success of the study. Discussion of the geohydrology of the post-Pierre Shale formations in Sioux County, North Dakota, is based upon information collected by the North Dakota Geological Survey and the North Dakota District of the U.S. Geological Survey, Water Resources Division (Carlson, 1978; Randich, 1978a, b). In North Dakota, other agencies cooperating in the study were the North Dakota State Water Commission and the Sioux County Water Management District.

LOCATION AND SETTING

The Standing Rock Indian Reservation occupies much of Sioux County, North Dakota, and Corson County, South Dakota (figs. 1 and 2). The combined area of the counties is about 3,670 square miles; as the land ownership pattern is complex, all of both counties is included within the area discussed by this report. Thus, for simplicity of discussion, the terms "Standing Rock Indian Reservation" and "Sioux and Corson Counties" are used interchangeably in this report.

The Standing Rock Indian Reservation is in the Missouri Plateau division of the Great Plains physiographic province.

The topography basically is a high rolling upland cut by the deep, meandering trenches of the Missouri River and its two major tributaries in the area, the Grand and Cannonball Rivers. Erosion has cut deeply into the upland to sculpture a badlands type area known locally as "the breaks." An extensive system of terraces extends along the rivers; at least seven terrace levels can be observed in some areas.

Except for part of the rolling upland (all of which is in the area underlain by the Fort Union, Hell Creek, and Fox Hills Formations, see map of surficial geology, figure 5) much of the land is unsuitable for large-scale crop production because of rugged topography or poor soils. The soil and range data (U.S. Bureau of Indian Affairs, 1959; U.S. Soil Conservation Service, unpublished data) indicate that only about 16 percent of the area is arable land (8 percent of Indian land) suitable for production of cultivated crops (including alfalfa and other "tame" hay); about 16 percent is classified as suitable for occasional or limited cultivation; an additional 2 percent is suitable for the production of a crop of wild hay every 2 or 3 years. Thus, much of the area is rangeland, with scattered fields of hayland and cultivated crops that are raised mostly for livestock feed. In 1974 more than 75 percent of the land was used for grazing (90 percent of Indian land), including the more than 1 percent of the report area that is rated as barren wasteland not suited for grazing. Even on the best land,crop production usually is low because of erratic and inadequate rainfall. In 1974, for example, less than 85 percent of the acreage planted in grain was harvested, and of the land that was harvested the average yield per acre was 31 percent (wheat) to 44 percent (corn and barley) below the average of the previous 5 years. Hay yields were about 20 percent below average.

Individual livestock water supplies are fairly small and widely dispersed, a necessity for successful ranching under existing climatic and topographic conditions. The low precipitation, generally low soil fertility, and moderately high relief support a fairly sparse plant growth that must be carefully managed to prevent overgrazing and yet make optimum use of available range resources. The soil and range studies found an average range capacity of 2.1 acres per animal month (the maximum was more than 8 acres), or about 19 acres per animal each grazing season. Rangeland requirements of this magnitude necessitate low livestock population densities, frequent shifting of stock between pastures, or both. Availability of adequate supplies of water close to feeding areas is critical to success in livestock production. Long travel between food and water can result in livestock weight losses rather than weight gains. Thus, to maximize stock production and to make best use of rangeland requires many, dispersed, water supplies. For most ranchers the least expensive way to improve water supplies is to capture and hold spring runoff and occasional summer storm flow by building dams or by excavating dugouts in ephemeral streams and drainageways.

SURFACE-WATER RESOURCES

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The Missouri River and its impoundment, the Oahe Reservoir (Lake Oahe), both in volume and in potential for development vastly overshadow all other sources of surface water available on the reservation (fig. 3). Lake Oahe stores more than 22 million acre-feet. The average annual flow of the Missouri through the area is nearly 16 million acre-feet; compared to this, the average annual surface-water runoff of 0.14 million acre-feet or, even, the average total annual precipitation of 3 million acre-feet are relatively minor. Yet in 1974, surface water sources other than Lake Oahe were far more important to the economy, and for much of the region probably will remain so in the future, because most of the area is suitable only for rangeland and because the cost of distributing Missouri River water for stock use throughout the two counties probably would be prohibitively expensive.

The surface-water hydrology of the area is summarized in the accompanying diagram (fig. 4), which shows the approximate average annual hydrologic budget.

The Missouri River is the only stream that has had a record of continuous flow since the area was first settled, though the Cannonball River has had year-round flow except in years of unusually severe drought. Most local streamflow is from snowmelt and from spring rain. In most years more than 90 percent of the streamflow reaching the Grand, Cannonball, and Missouri Rivers occurs in March, April, May, and June. Runoff from summer storms usually evaporates or is intercepted by stockponds before it reaches the rivers. Springs and seeps are common in spring and early summer except where the Pierre Shale is at or very near the surface, but discharge usually is small. Most springs and seeps dry up by midsummer, although some streams do have more or less permanent natural "water holes"—5 to 100-foot segments that intercept the local water table.

The estimated average annual flows of selected streams are shown in the adjacent table.

Lake Oahe is an almost untapped water resource. Aside from power generation and flow-regulation functions, and considering the use of the reservoir as a water supply only, development by the end of 1974 was negligible. Within the boundaries of the reservation 1,100 acre-feet was diverted for irrigation, less than 250 acre-feet was used for public supplies, and some, probably less than 50 acre-feet, was consumed by livestock. The reservoir also provides outstanding recreational use for fishermen, boaters, and others interested in camping, water sports, and waterfowl hunting.

The severe drought that began in 1973 had, by the summer of 1974, resulted in a water shortage in the two-county area. Many stockponds were nearly dry and some farmers and ranchers had to haul water for their livestock. As a result of such periodic shortages of water, many farmers and ranchers are considering formation of rural water systems to supply water from Lake Oahe for domestic and stock use.

The chemical quality of surface water ranges from very good to very poor, depending upon the water source and the time of year. The system of large reservoirs on the Missouri River has stabilized the quality of the river water to a year-round average of about 450 mg/L (milligrams per liter) of dissolved solids. Tributary streams, stock ponds, and dugouts, however, vary greatly in water quality during the year. Water quality is best in spring during snowmelt and is poorest in late summer or fall when pools and ponds usually have been stagnant for several months.

The water samples analyzed for this report were collected mostly in 1971 and 1972; however, the Grand River has been sampled one or more times each year since 1953 at Shadehill (Perkins County) and since October 1974 at Little Eagle. Single samples from these and other surface-water sources have been analyzed at various times for public agencies and for individuals.

Water in the Grand River is of sodium sulfate type and contains from about 400 to 1,300 mg/L of dissolved solids. Its tributaries have a similar or larger range in dissolved solids but some differ in the proportions of major ions. For example, Firesteel Creek near Isabel (Dewey County) and Willow Creek south of Kaldown contain sodium bicarbonate type water, while a few creeks contain calcium-magnesium sulfate type water. Low dissolved-solids concentration generally is associated with higher rates of flow, though this is not always true.

Daily suspended-sediment concentrations in the Grand River ranged from 124 to 19,000 mg/L during the 1974 water year. Maximum daily load for the period of record is 19,000 mg/L. Water in the tributaries of the Grand commonly is muddy to very muddy.

Water in Cedar Creek and the Cannonball River usually is of sodium sulfate type but during the period of snowmelt and spring rain runoff may be of calcium-magnesium sulfate type. The dissolved-solids content during periods of flow ranges from about 300 to 2,700 mg/L. Low dissolved-solids content generally is associated with higher rates of flow, though this is not always true. Tributaries have a similar or larger range in dissolved solids but some may differ in the proportions of major ions.

Daily suspended-sediment concentrations in Cedar Creek and the Cannonball River (during periods of flow) ranged from about 10 to 7,200 mg/L. Suspended-sediment concentrations usually are highest during periods of high streamflow. Water in tributaries of Cedar Creek and the Cannonball River commonly is muddy to very muddy.

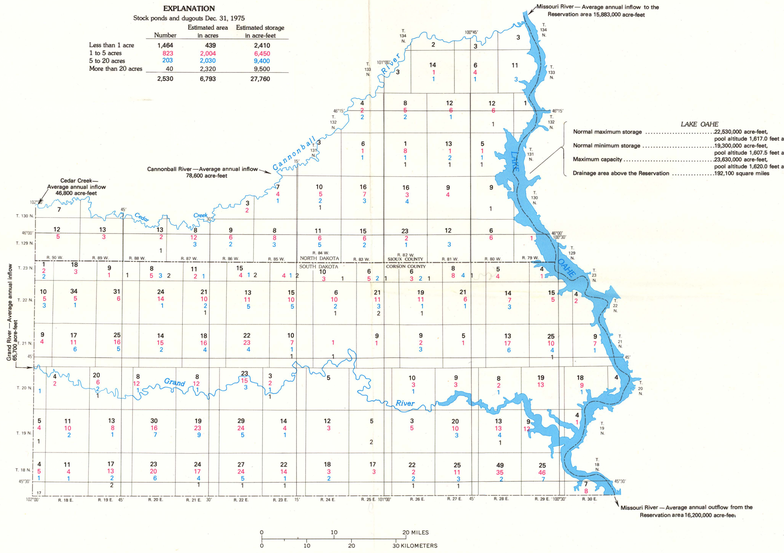

Figure 3—Surface-water-resources.

SURFICIAL GEOLOGY

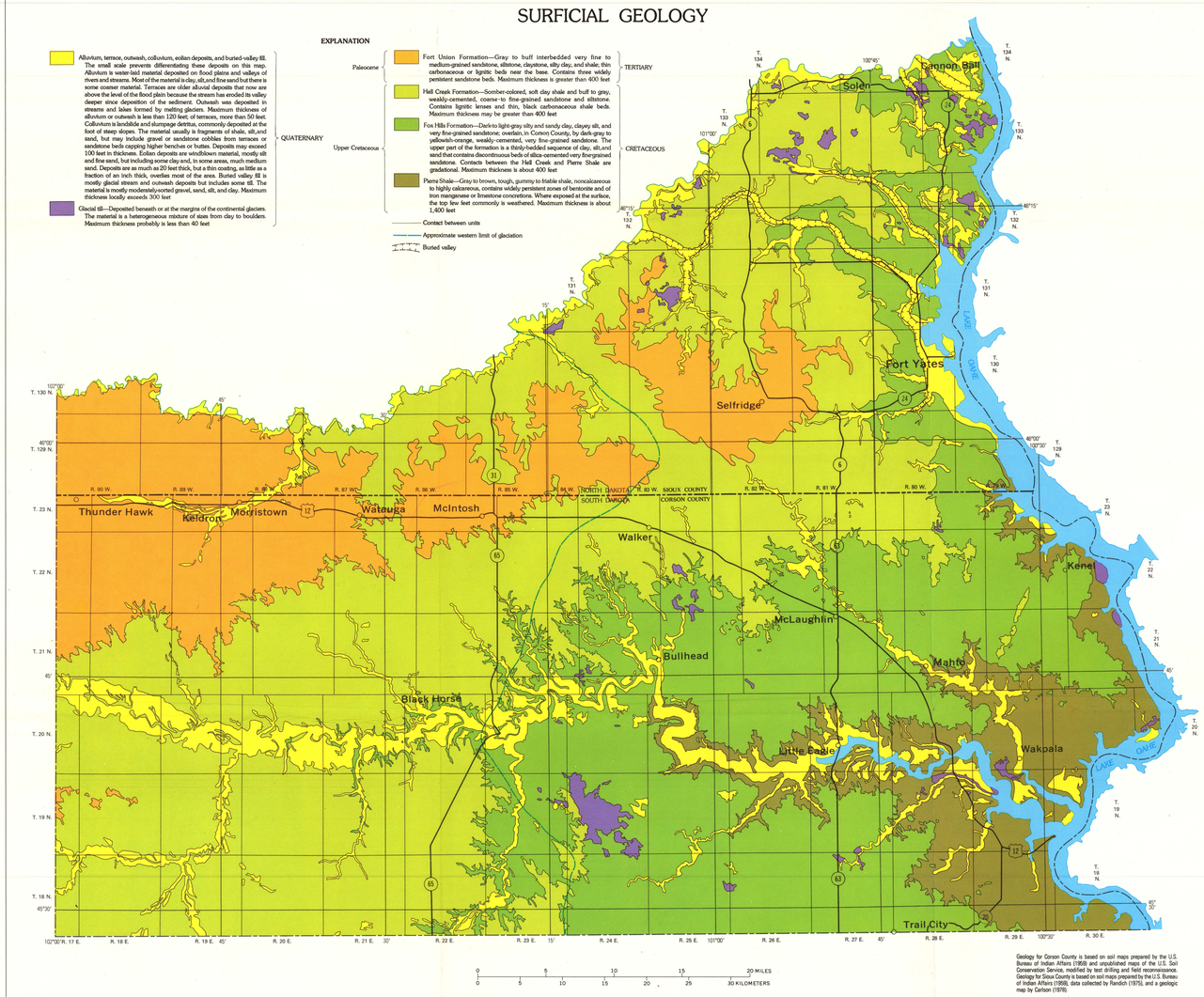

Figure 5.—Surficial geology.

Geology for Corson County is based on soil maps prepared by the U.S. Bureau of Indian Affairs (1968) and unpublished maps of the U.S. Soil Conservation Service, modified by test drilling and field reconnaissance. Geology for Sioux County is based on soil maps prepared by the U.S. Bureau of Indian Affairs (1958), data collected by Randich (1975), and a geologic map by Carlson (1978).

SURFICIAL GEOLOGY

The surface geology (fig. 5), like the topography, has been strongly influenced by continental glaciation and by Pleistocene erosion on a land surface underlain by soft, unconsolidated deposits of continental and marine shale and sandstone. The Standing Rock Indian Reservation is on the western margin of the midwestern area that was invaded by great ice sheets during the last million years. Though at most only 60 percent of the reservation apparently was covered by glacial ice, the effects of the glaciers were pervasive: not only did the ice sheets grind away the land surface in the areas that they invaded, but they also changed the courses of rivers and created a new river—the Missouri. In addition, changes in weather patterns associated with glaciation profoundly influenced streamflow and erosion in the area not reached by the ice sheets.

Formation of the Missouri River modified old drainage patterns and created new ones. Huge volumes of water from melting glaciers enabled the newly created Missouri to cut its channel several hundred feet into the pre-existing land surface. As the Missouri cut its trench deeper, it left remnants of its valley behind as terraces. Tributary streams rapidly cut their channels deeper to keep pace with the Missouri. Large volumes of sandstone, shale, and drift were carried away by erosion and the present "breaks" topography began to develop. The area that most closely resembles the pre-Pleistocene surface probably is in northwestern Corson County near the western boundary of the reservation.

Because the Standing Rock Indian Reservation was on the border of the glaciated region, much of the area is free of glacial deposits and most of the glacial deposits present are thin, discontinuous, and of negligible hydrologic importance.

Prior to the Pleistocene Epoch ("Ice Age") the Fox Hills and Hell Creek Formations covered the entire reservation. The pre-Pleistocene extent of the Fort Union Formation is not known, though deposits of Tertiary age overlay much, possibly all, of the area.

Because the geologic formations exposed at the surface are soft and relatively unconsolidated, and surface relief is high, slumping is common, particularly in the "breaks," and the area is highly susceptible to erosion by wind and water. These conditions contribute to the low agricultural productivity of much of the region.

The Pierre Shale, at or near the surface in about 10 percent of the reservation, is a thick sequence of soft, dark-colored marine shales.

The contact between the Fox Hills Formation and Pierre Shale appears to be transitional throughout the area; thus the lower part of the Fox Hills is sandy shale or shaly (clayey) sand, a relatively impermeable material and a poor source of water. Waage (1968) described the deposits that make up the Fox Hills Formation in this area and detailed the relationships of these deposits to those in overlying and underlying strata. In eastern Corson and Sioux Counties, at the stratigraphic middle part of the Fox Hills is the Timber Lake Member (locally known as the "Timber Lake Sand"), a silty, very fine- to medium-grained sandstone composed of uncemented to poorly cemented quartz and feldspar grains; locally, it may be clayey. The Timber Lake Member abruptly thins and pinches out to the west along a north-south line about 6 miles west of McIntosh. The Timber Lake is missing in southeastern and part of eastern Sioux County because of its removal by Pleistocene and Holocene erosion. Insufficient information is available to determine the exact extent and hydrologic capabilities of the Timber Lake Member in most of eastern Sioux County.

The lower part of the overlying Iron Lightning Member of the Fox Hills Formation is predominantly a thick sequence of thinly interbedded sand, silt, and clay layers ("banded beds") named the "Bullhead lithofacies" by Waage (1968); individual beds range from a fraction of an inch to about 3 inches thick. Bulk composition of the material is more than 50 percent sand. Widely distributed at or near the top of the Fox Hills Formation is a discontinuous sandstone unit which Waage named the "Colgate lithofacies" of the Iron Lightning Member. Earlier investigators in the area had considered the "Colgate" to be a continuous, well-cemented sandstone of member rank. Waage's studies showed it to be a series of lenses of medium to fine sand as much as 60 feet thick; he found as many as three beds of "Colgate sand" at some sites, separated from each other by banded beds of the "Bullhead lithofacies." Although older studies indicated that "Colgate sands" were hard and tightly cemented, such is not the case, except locally, and then mostly at or near areas of outcrop. Where buried beneath the Hell Creek Formation, the "Colgate lithofacies" apparently is a loose and permeable sand.

The predominantly marine Fox Hills Formation grades upward and westward into the predominantly continental Hell Creek Formation. The lower part of the Hell Creek is sandier and siltier than the upper part, though both parts contain zones that are mostly sandy or mostly clayey. However, the upper part contains what apparently is the only continuous sandstone bed in the formation. The upper part of the Hell Creek contains more and thicker carbonaceous or lignitic beds. The lower part of the Hell Creek contains lenses of "Colgate-type sand." The continental Hell Creek Formation grades upward into the basal continental facies of the Fort Union Formation.

The Fort Union Formation of Paleocene age is the topmost bedrock formation found in Sioux and Corson Counties. It underlies about 15 percent of the area. Within the reservation the Fort Union can be divided into three stratigraphic members: a basal, continental, facies called the Ludlow Member; a middle, marine, facies called the Cannonball Member; and an upper, continental, facies called the Tongue River Member. The Ludlow Member is a poorly consolidated sequence of fine-grained sandstone, siltstone, claystone, and shale beds interbedded with lignite and carbonaceous shale beds and lenses. The sandstone and siltstone beds are discontinuous, but one bed is fairly widespread. The Cannonball Member is made up of a sequence of poorly consolidated fine-grained sandstone, siltstone, claystone, and shale beds. The sandstone and siltstone are glauconitic, friable, and noncalcareous. Both sandstone and shale beds may contain round, ovoid, or lenticular concretions ("cannonballs") that have a calcareous matrix and range in size from a few inches to several feet in the longest dimension. The Cannonball Member contains the most continuous and widespread sandstone bed in the Fort Union. The topmost unit, the Tongue River Member, is a poorly-consolidated sequence of interbedded fine-grained sandstone, siltstone, claystone, shale, lignite, and carbonaceous shale beds. At the base of the Tongue River is a fairly widespread bed of sandstone that contains abundant petrified wood, macerated plant fragments, and lignite. Limestone beds up to 4 inches thick are found in the claystone and siltstone beds.

METRIC CONVERSION FACTORS

For the use of readers who may prefer to use metric units rather than inch-pound units, conversion factors for terms used in this report are listed below:

Multiply inch-pound unit	by	to obtain metric unit
foot	0.3048	meter
mile	1.609	kilometer
inch	2.54	centimeter
acre	0.4323	hectare
square mile	2.590	square kilometer
gallon per minute	3.785	liter per minute
acre-foot	1,233.62	cubic meter
gallon	0.003785	cubic meter
to convert °F use relation	[5/9(°F+40)-40]	to obtain °C

Table 1.—Estimated average annual flows in selected streams.

Number shown on Reservation Diagram	Drainage basin	Drainage area (square miles)	Average annual streamflow[1]		
			Acre-feet per square mile	Cubic feet per second	Acre-feet
1	Black Horse Butte Creek	333	23.0	10.6	7,674
2	Cottonwood Creek	76	23.8	2.5	1,810
3	Firesteel Creek	201	24.5	6.8	4,923
4	High Bank Creek	171	25.4	6.0	4,344
5	Snake Creek	63	28.7	2.5	1,810
6	Willow Creek	69	24.1	2.3	1,665
7	Dirt Lodge Creek	130	24.5	4.4	3,185
8	Hump Creek	79	24.7	2.7	1,955
9	Shirk and Iron Dog Creek	120	25.3	4.2	3,041
10	Rock Creek	115	25.8	4.1	2,968
11	Oak Creek	394	29.4	15.6	11,294
12	Hay Creek	124	24.5	4.2	3,041
13	Leaf-on-the-Hill Creek	75	26.1	2.7	1,955
14	Porcupine Creek	271	27.2	10.2	7,384
15	Battle Creek	64	27.2	2.4	1,738

[1]Estimated using the method described by Lamoreux (1970), except that a regression coefficient of 7.19×10^{-3} was used. This modification provides closer agreement between estimated streamflow and measured streamflow (1-35 percent) at the 18 stream-gaging stations used to validate the method for use in the report area.

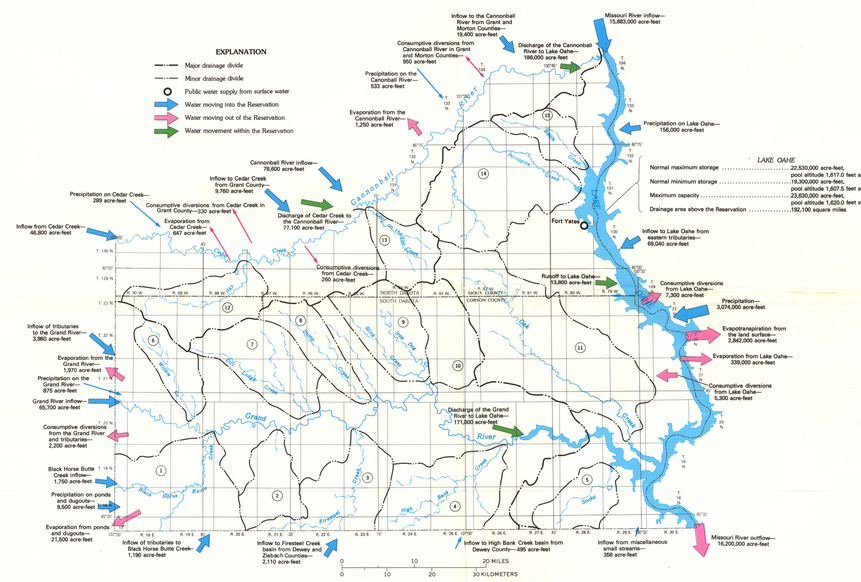

Figure 4.—Diagram showing the approximate average annual hydrologic budget for Standing Rock Indian Reservation. Subsurface outflow and storage changes in the Fort Union, Hell Creek, and Fox Hills Formations are assumed to be too small to be significant. Consumptive diversions shown are those authorized by December 31, 1974. Numbered drainage basins are those for which estimated annual flow is given in the adjacent table.

Base from U.S. Geological Survey
Bismarck, 1954–76, and McIntosh, 1953–76,
1:250,000

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GEOHYDROLOGY OF THE STANDING ROCK INDIAN RESERVATION, NORTH AND SOUTH DAKOTA

By
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1982

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