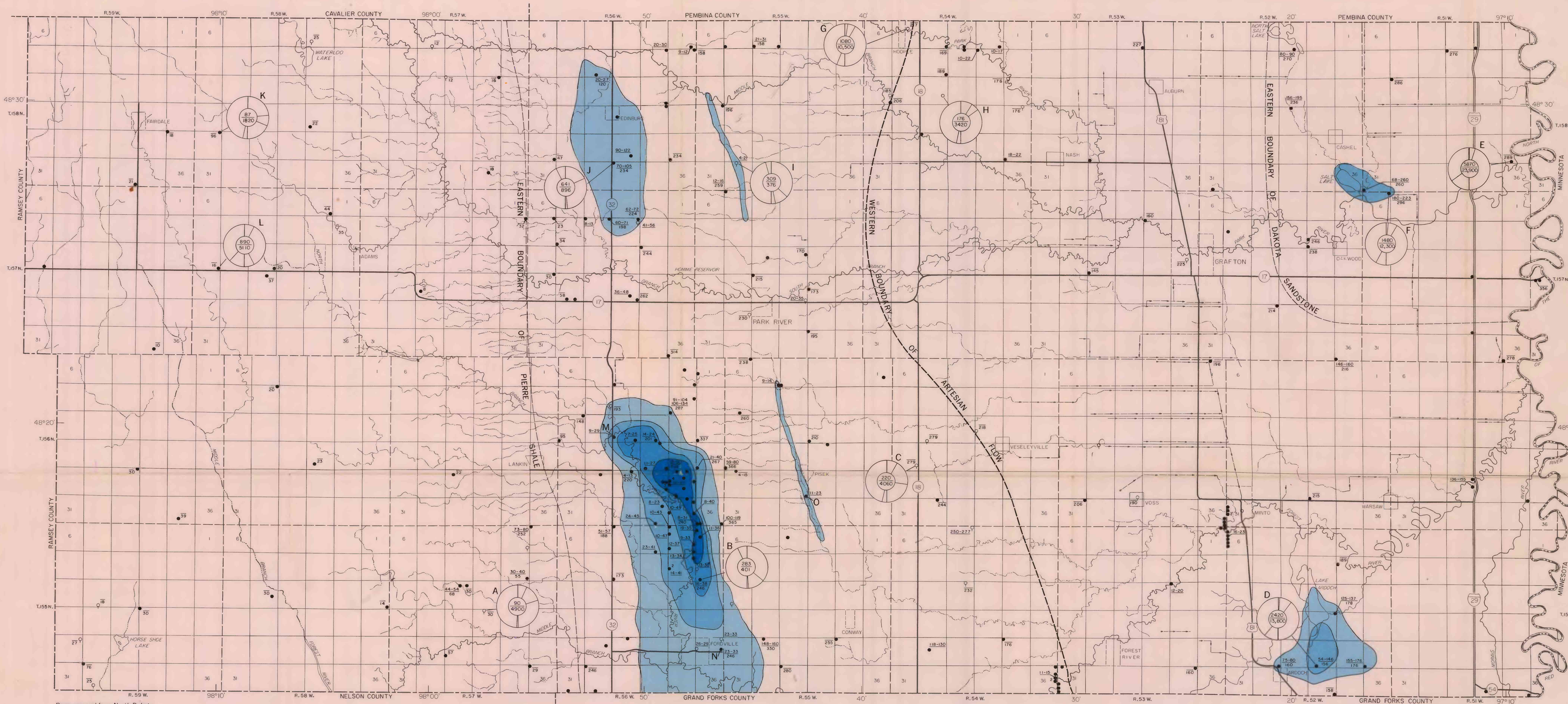
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
NORTH DAKOTA STATE WATER COMMISSION
NORTH DAKOTA GEOLOGICAL SURVEY
WALSH COUNTY BOARD OF COMMISSIONERS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-431



Base prepared from North Dakota Highway Department county highway maps

GROUND-WATER AVAILABILITY MAP

SCALE 1:126 720

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

EXPLANATION

POTENTIAL WELL YIELDS FROM GLACIAL-DRIFT AQUIFERS, IN GALLONS PER MINUTE

More than 500

250-500

50-250

10-50

0-10

POTENTIAL YIELDS FROM BEDROCK AQUIFERS

(See ground-water availability map for detail)

1 to 5 gallons per minute generally available from Pierre Shale (area 1). Moderate to large yields available locally from Dakota Sandstone (areas 1 and 2) and Jurassic(?) and Paleozoic formations (areas 1, 2, and 3)

SELECTED TEST-HOLE AND WELL DATA

Test hole

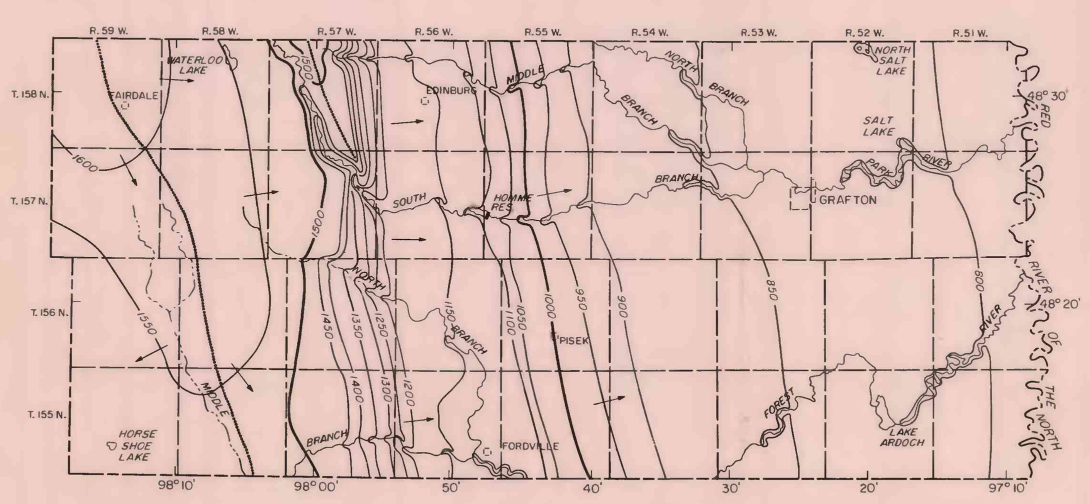
Private well with log

12-16 / 259

Upper numbers indicate aquifer interval, in feet below land surface. Lower number indicates depth to bedrock, in feet below land surface

CHEMICAL COMPOSITION OF DISSOLVED SOLIDS

Letter above circular diagram refers to analysis listed in table of chemical analyses. Number above line at center of circular diagram is carbonate hardness (calcium magnesium hardness as $CaCO_3$), in milligrams per liter; number below line is dissolved solids, in milligrams per liter. The sizes of the segments of each semicircle are proportional to the quantity of each group of anions or cations to the total anions or cations present



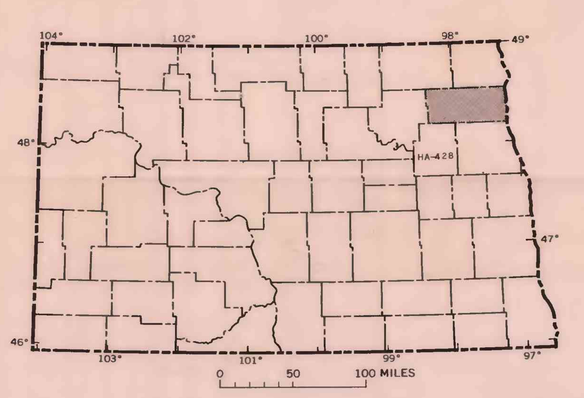
EXPLANATION

Water-table contours
Show elevation of water table. Contour interval 50 feet. Datum is mean sea level

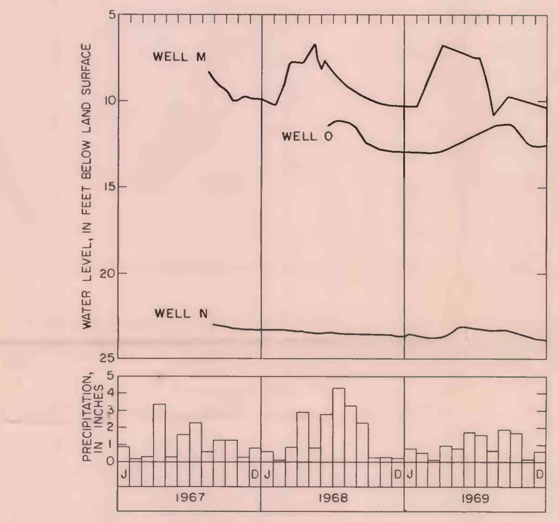
Ground-water divide

Inferred direction of ground-water movement

Map showing elevation of water table in glacial drift and other surficial deposits.



Location of Walsh County (shaded) and location of published atlases in this series by atlas number.



Graphs of selected wells in Walsh County, and precipitation at Grafton.

CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS

Aquifer and formation symbols

Symbol	*Aquifer*
K3PD	Pierre Shale
K1PM	Dakota Sandstone
E	Jurassic(?) and Paleozoic formations
QG02	Beach deposits
QG03	Delta deposits
QG51	Buried sand and gravel

(Analytical results in milligrams per liter)

Well	Depth	Aquifer	Date of collection	Temperature (°C)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Sodium adsorption (SAR)
A	1,042	K1PM	8-18-67	-------	7.0	3.3	21	9.1	1,700	15	676	0	1,010	1,610	2.0	17	4.6	4,900	4,730	90	0	97	7.610	8.2	78
B	35	QG03	5-24-68	6	24	1.8	78	21	19	3.8	297	0	83	6.4	.2	0	.39	401	384	283	39	13	597	8.2	.5
C	295	K1PM	11- 2-67	7	6.8	3.4	49	24	1,370	18	642	0	1,200	1,030	2.5	25	4.1	4,060	4,050	220	0	92	6,210	8.2	40
D	140	QG51	7-15-68	8	19	1.9	584	234	3,840	94	293	0	1,960	6,280	2.5	0	6.1	13,800	13,200	2,420	2,180	77	19,000	7.9	34
E	300	E	8-25-69	7	18	11	1,390	583	6,180	55	85	0	1,650	12,800	.4	0	1.9	23,900	22,700	5,870	5,800	69	34,300	6.9	35
F	203	QG51	8-21-69	7	24	7.4	366	138	3,680	51	361	0	1,390	5,730	.7	0	4.1	12,300	11,600	1,480	1,180	84	18,900	7.8	42
G	322	E	6-14-68	8	16	5.4	245	114	3,610	44	475	0	1,020	5,210	1.9	17	5.0	10,500	10,500	1,080	690	87	16,000	7.3	48
H	246	K1PM	4- 4-68	6	9.7	4.5	46	15	1,190	15	559	19	325	1,350	.2	34	2.9	3,420	3,290	176	0	93	5,410	8.4	39
I	18	QG02	11-20-67	-------	26	.82	88	22	12	2.9	301	0	64	5.3	.3	17	.44	376	387	309	62	8	598	8.0	.3
J	103	QG51	8-21-69	-------	27	3.0	173	51	46	7.6	339	0	444	15	.5	1	.15	896	935	641	363	13	1,280	7.7	.8
K	107	K3PD	7-17-68	6	22	.12	24	6.6	608	9.1	809	10	218	390	.2	2.5	3.6	1,820	1,690	87	0	93	2,720	8.3	28
L	95	K3PD	8-27-68	6	27	.0	224	80	1,320	22	710	0	2,630	390	2.1	18	3.8	5,110	5,070	890	307	76	6,440	7.9	19

INTRODUCTION

This investigation is part of a statewide program to determine the location, extent, and nature of the ground-water reservoirs (aquifers); to evaluate the occurrence and movement of ground water within these aquifers, including the sources and areas of recharge and discharge; to estimate the potential yields of wells tapping the major aquifers; and to determine the chemical quality of the ground water.

Walsh County covers an area of 1,287 square miles in northeastern North Dakota. The study, which began in July 1967, has been made cooperatively by the U.S. Geological Survey, the North Dakota State Water Commission, the North Dakota Geological Survey, and the Walsh County Board of Commissioners. This is an interim report and presents only the major conclusions of the study.

SOURCES OF GROUND-WATER DATA

Many sources of data have been utilized in the preparation of the ground-water availability map. A well inventory has provided data on depth, construction, and productivity of the private and public wells in Walsh County. Test drilling, both private and public, has supplied information as to the thickness and extent of the water-bearing strata that underlie Walsh County. Chemical analyses of water from selected wells have furnished data on the water quality.

The potential yields shown on the ground-water availability map were determined from the thickness and estimated permeability of the water-bearing materials logged at each test hole. Generally, the greater the permeability and thickness of water-bearing materials, the larger the yields. The test-hole logs were examined in detail and permeabilities were assigned on the basis of grain size, apparent sorting, and drilling characteristics of the materials. The test holes were drilled by hydraulic-rotary drilling equipment, which on drilling sand or gravel beds commonly produces samples with less silt and clay and a higher degree of sorting than is actually present in the deposit. In assigning the various permeabilities, allowances were made for this discrepancy. The permeability values were further compared with and adjusted to data obtained from aquifer pumping tests.

OCCURRENCE AND POTENTIAL YIELD OF AQUIFERS

The availability map should be used with the understanding that the estimated yields are for fully penetrating, properly screened and developed wells of adequate diameter. The map is intended as a general guide in the location of major aquifers, not as a map to locate specific wells. Few, if any, aquifers are so uniform in their water-bearing properties that production wells may be drilled in them without preliminary exploratory drilling. If the map is used with this understanding of its limitations, it should serve as a useful tool in the future development of the ground-water resources of Walsh County.

GLACIAL-DRIFT AQUIFERS

Walsh County is almost entirely covered by glacial drift, which may be subdivided into two distinct types. The most common type is till, a nonsorted mixture of clay, silt, sand, gravel, and pebbles. Till was mainly deposited by active glaciers. It has a low permeability, and will normally yield only small quantities of ground water to wells. Glaciofluvial deposits, the least common type, are stratified deposits of sand and gravel that are sorted according to grain size. These materials were deposited by moving water, are normally quite permeable, and form the principal aquifers in Walsh County.

The glacial drift generally ranges in thickness from about 300 feet in the eastern part of the county to about 30 feet in the western part. Locally, along streams in the western part of the county, the glacial drift has been removed by erosion and the underlying bedrock is exposed. Water levels in the glacial drift and other surficial deposits of Walsh County range from an elevation of about 775 feet in the northeastern part of the county to about 1,610 feet at the ground-water divide near Fairdale (see water-table map).

The largest and most productive glacial-drift aquifer in Walsh County is located near the city of Fordville, and is locally known as the Fordville aquifer. The aquifer is part of the Elk Valley delta (Upham, 1895, p. 27) deposits and extends from T. 156 N., R. 56 W. south to the county line. It underlies an area of about 33 square miles. Water-level fluctuations in the Fordville aquifer from August 1967 to December 1969 are shown by the hydrographs for wells M and N. Water-level rises in well M, located about 100 feet from the North Branch of the Forest River near the north end of the Fordville aquifer, are mainly the result of recharge from snowmelt and spring rains. The hydrograph of well N shows that only small water-level fluctuations occur near the discharge area at Fordville.

Several less productive aquifers in Walsh County are associated with various glacial features. The linear beach-ridge aquifers near Pisek and east of Edinburg consist of silt and sand deposits of glacial Lake Agassiz. Test drilling has shown that at these and many other locations the beach deposits have, near the base, a thin water-saturated zone that will supply sufficient water for farm use and domestic supply. Short-term yields from these deposits may be more than 50 gpm (gallons per minute), but long-term yields may be much less. The water-level fluctuations in a beach ridge near Pisek are shown by the hydrograph for well O.

BEDROCK AQUIFERS

Four bedrock units supply water to wells in Walsh County. The areal extent and yields of these units are indicated on the ground-water availability map.

The Pierre Shale underlies the western third of the county, and yields from 1 to 5 gpm from fracture zones in the upper part of the formation.

The Dakota Sandstone underlies all but the northeast corner of the county. Wells tapping the Dakota Sandstone range in depth from about 160 feet in the eastern part of the area to greater than 1,000 feet in the western part. This formation has been reported to yield as much as 500 gpm in Grand Forks County (Kelly and Paulson, 1970), which borders Walsh County on the south. Test drilling indicates that potential yields from the Dakota Sandstone in Walsh County would be quite variable due to the presence of interbedded shale lenses and thinning of the formation toward the east. However, it appears that moderate to large yields would be available at least locally in many parts of the county. Many of the wells developed in the Dakota Sandstone in eastern Walsh County flow at land surface. Artesian flow rates range from 1 gpm to 20 gpm, depending upon well location and construction. Water from the Dakota Sandstone is saline and is generally unsatisfactory for domestic and industrial uses.

The Jurassic(?) and Paleozoic bedrock formations, consisting of siltstone, sandstone, and limestone, underlie the entire county and are directly beneath the glacial deposits in the northeastern part. The limited quantitative hydrologic data available concerning these units indicate that moderate to large yields may be possible at selected sites where fractured or cavernous limestone is present. Water from these units is very saline and is unsatisfactory for most uses.

CHEMICAL QUALITY OF WATER

Wells tapping glacial-drift aquifers in Walsh County yield water with a wide range of chemical quality, as shown by the chemical-analysis symbols on the water-availability map and by the table of selected chemical analyses (analyses B, D, F, I, and J).

Water from the sand and gravel deposits of the Fordville aquifer and from the deposits forming the beach ridges is normally low in dissolved solids (analyses B and I). The chemical quality of water in buried sand and gravel deposits is dependent, to a degree, upon their connection with the underlying bedrock and with the overlying surficial units. Where these buried deposits receive recharge from the surface and have only a limited connection with the bedrock, dissolved solids will be low, as shown by analysis J.

Where the buried sand and gravel deposits have a good hydraulic connection with the underlying bedrock, and ground-water movement is from the bedrock into the sand and gravel deposits, the amount of dissolved solids in the water is dependent upon the degree of mineralization of the water in the bedrock. This effect is illustrated by analyses D and F, where highly mineralized water from the underlying rocks of Jurassic(?) and Paleozoic ages has migrated into the buried sand and gravel deposits.

Water from the Dakota Sandstone in Walsh County (analyses A, C, and H) ranged in dissolved-solids content from 3,420 mg/l (milligrams per liter) to 4,900 mg/l; with a mean value for 23 analyses of 4,500 mg/l.

Water quality from the Pierre Shale (analyses K and L) varies widely within the county depending upon depth and location of the well. The wide range in water quality is due, apparently, to differences in sources of recharge and degree of fracturing within the shale. The mean value of dissolved solids for nine analyses of water from the Pierre Shale was 3,500 mg/l, with a range from 1,820 to 5,110 mg/l.

The most highly mineralized water in Walsh County is produced from wells tapping the rocks of Jurassic(?) and Paleozoic ages. At the present time, little use is made of this water due to the poor quality. Dissolved solids ranged from 10,500 mg/l (analysis G) to 23,900 mg/l (analysis E).

SELECTED REFERENCES

Aronow, Saul, Dennis, P. E., and Akin, P. D., 1953, Geology and ground-water resources of the Michigan City area, Nelson County, North Dakota: North Dakota State Water Comm. Ground-Water Studies, no. 21, 125 p.
Brookhart, J. W., and Powell, J. E., 1961, Reconnaissance of geology and ground water of selected areas in North Dakota: North Dakota State Water Comm. Ground-Water Studies, no. 28, p. 45–52.
Jensen, H. M., and Bradley, Edward, 1962, Ground water near Hoople, Walsh and Pembina Counties, North Dakota: North Dakota State Water Comm. Ground-Water Studies, no. 49, 19 p.
Kelly, T. E., and Paulson, Q. F., 1970, Geology and ground water resources of Grand Forks County; Part III, Ground Water Resources: North Dakota Geol. Survey Bull. 53 and North Dakota State Water Comm. County Ground Water Studies 13, 58 p.
Simpson, H. E., 1929, Geology and ground-water resources of North Dakota: U.S. Geol. Survey Water-Supply Paper 598, 312 p.
Upham, Warren, 1895, The glacial Lake Agassiz: U.S. Geol. Survey Mon. 25, 658 p. [1896].

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1971—W71015

GROUND-WATER RESOURCES OF WALSH COUNTY, NORTHEASTERN NORTH DAKOTA

By
Joe S. Downey

1971

For sale by U. S. Geological Survey, price $1.00