Geology and Ground-Water Resources Near Berthold, Ward County, North Dakota

By

P. G. RANDICH

Geological Survey

United States Department of the Interior

NORTH DAKOTA GROUND-WATER STUDIES NO. 46

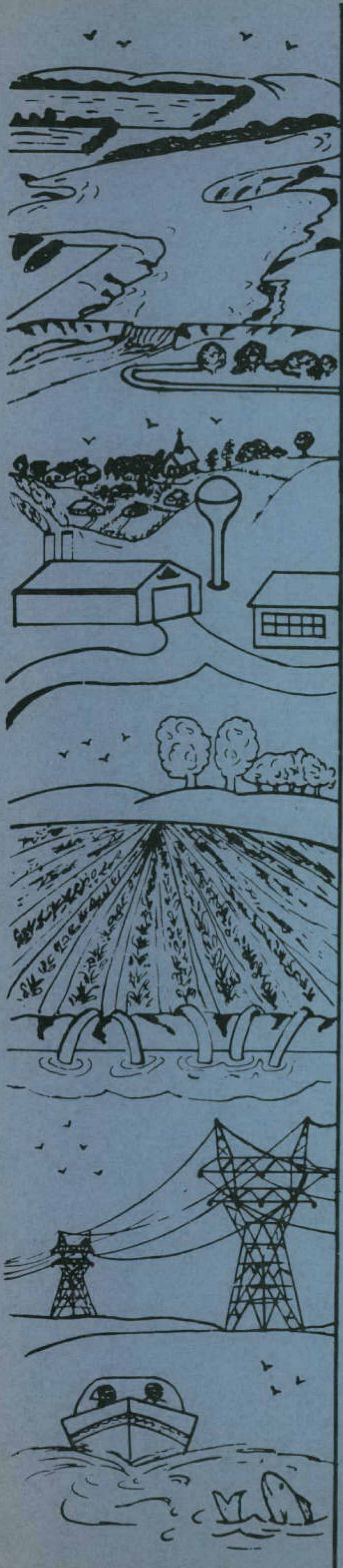
Prepared by the U.S. Geological Survey in cooperation with the North Dakota State Water Commission and the North Dakota Geological Survey

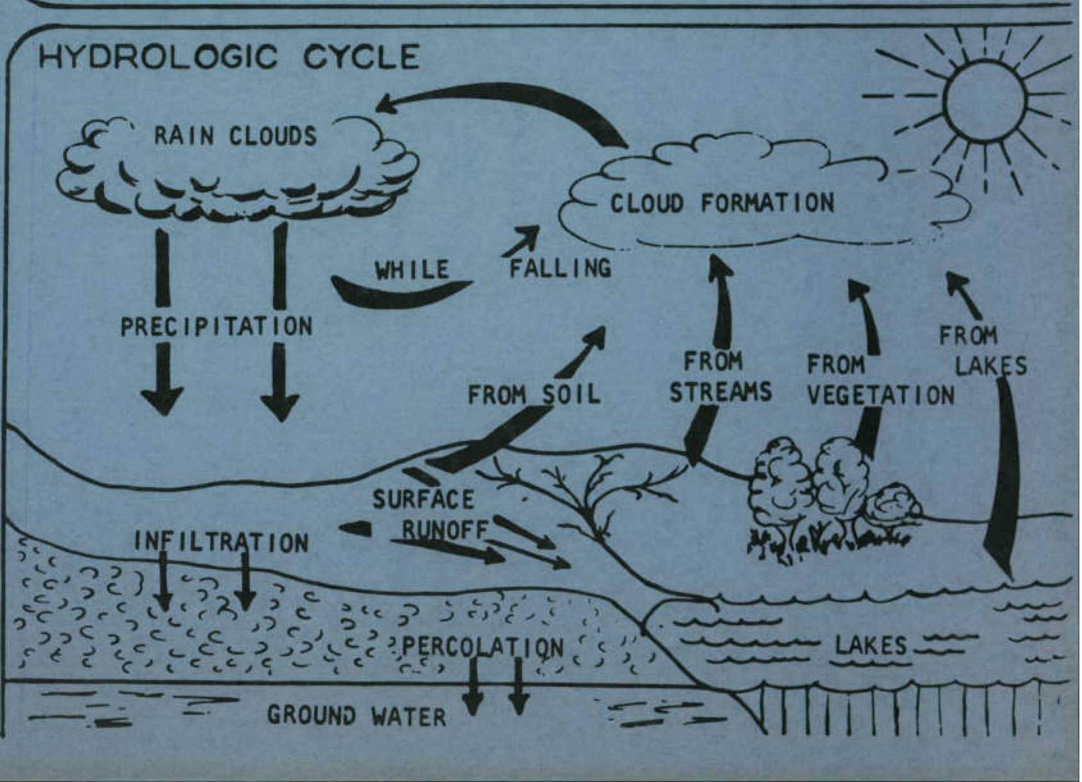
Published by

NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

1301 State Capitol, Bismarck, North Dakota

1963





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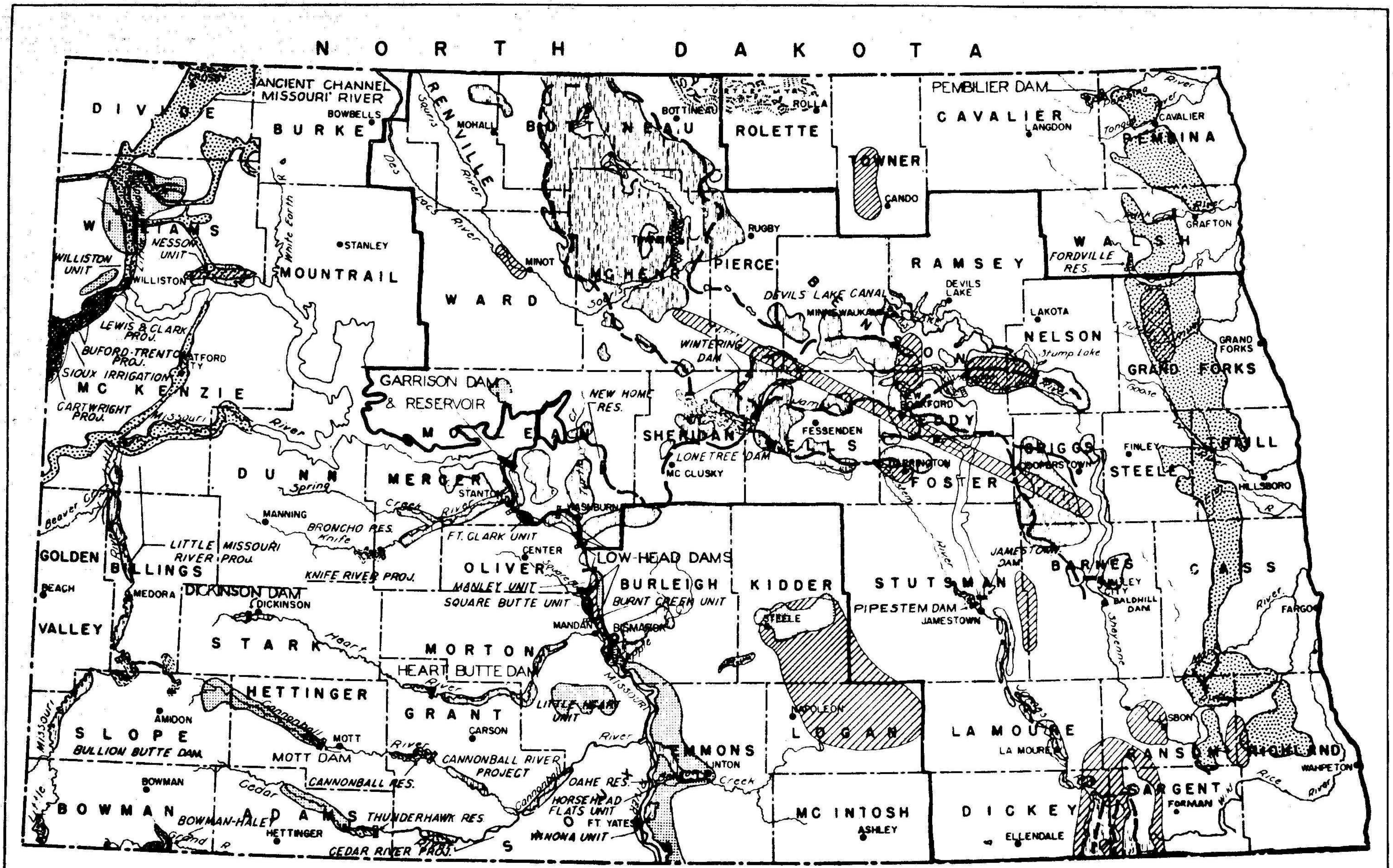
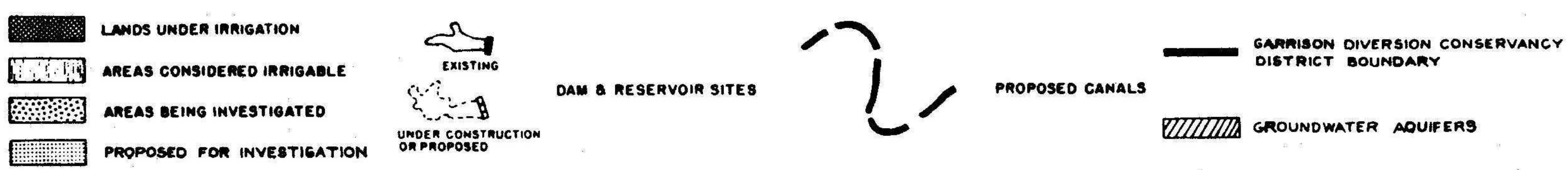


NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN



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WARD COUNTY, NORTH DAKOTA

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By
P. G. Randich

Introduction

As a part of the cooperative program of ground-water investigations in North Dakota, the U.S. Geological Survey, North Dakota State Water Conservation Commission, and North Dakota Geological Survey are making studies of ground-water resources available for municipal use. Investigations are made of small areas surrounding towns that have requested aid from either the North Dakota State Water Conservation Commission or the State Geologist. Also, some county ground-water studies are being made. Reports on the larger investigations may include all or some of the results of previous, smaller municipal water-supply studies.

The present investigation, which began in 1958, was made at the request of the city council of Berthold. It included test drilling and pumping, inventory of selected wells (table 1), water analysis, evaluation of available geologic and hydrologic data, and preparation of this report. The area of investigation consists of 120 square miles in and around Berthold.

The northeastern part of the Berthold area is in the Drift Prairie section of the Central Lowland Province, and the southwestern part is in the Missouri Plateau section of the Great Plains Province. (See fig. 1.) The Drift Prairie is gently rolling or slightly hilly, whereas the Missouri Plateau, which is higher, is hummocky and has a large number of marshes. Short intermittent streams connect marshy areas and drain northeastward. Climatologic records for Berthold are not available, but at the Minot airport, about 20 miles southeast of Berthold, the average annual precipitation is 15.61 inches, and the average annual temperature is 40.5°F., based on a 16-year record by the U.S. Weather Bureau.

The population of Berthold, according to the 1960 census, is 431. Residents of the community depend almost exclusively upon wells for their water supplies. Large-diameter wells range in depth from 9.6 to 80 feet, whereas small-diameter wells generally are more than 300 feet deep. In 1963 the Berthold municipal system was supplied primarily from one well, 570 feet deep.

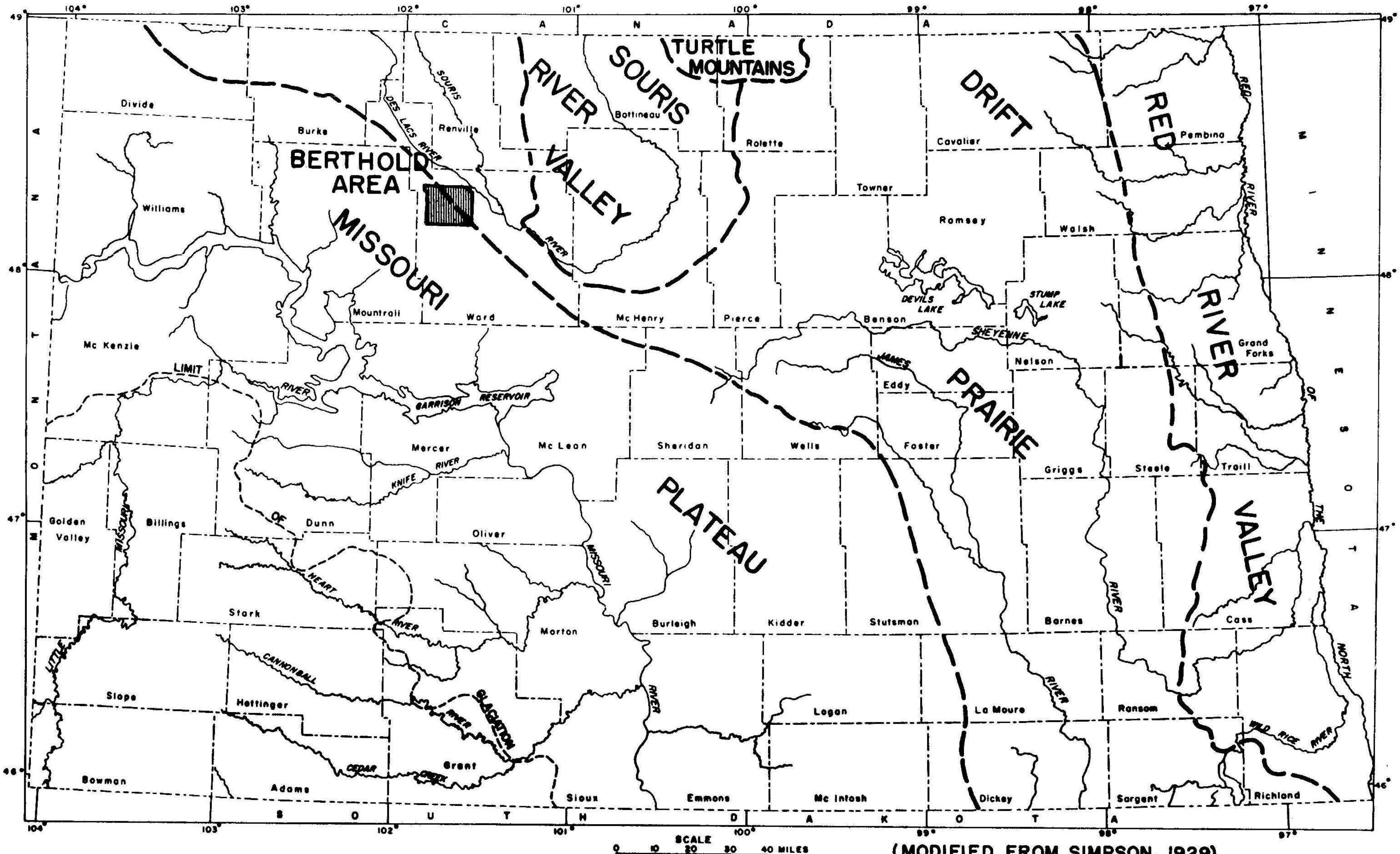

FIGURE 1--MAP SHOWING PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA AND LOCATION OF THE BERTHOLD AREA.

The well-numbering system, illustrated in figure 2, is based on the Federal system of rectangular surveys of public lands. The first numeral denotes the township north of the base line which extends laterally across the middle of Arkansas; the second numeral denotes the range west of the fifth prinicpal meridian; and the third numeral denotes the section in which the well is located. The letters a, b, c, and d designate respectively the northeast, northwest, southwest and southeast quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections (10-acre tracts). Consecutive terminal numerals are added if more than one well, test hole, or spring is shown in a given tract. Thus, a well numbered 156-86-15daa (fig. 2) would be in the NE 1/4 NE 1/4 SE 1/4 sec. 15, T. 156 N., R. 86 W.

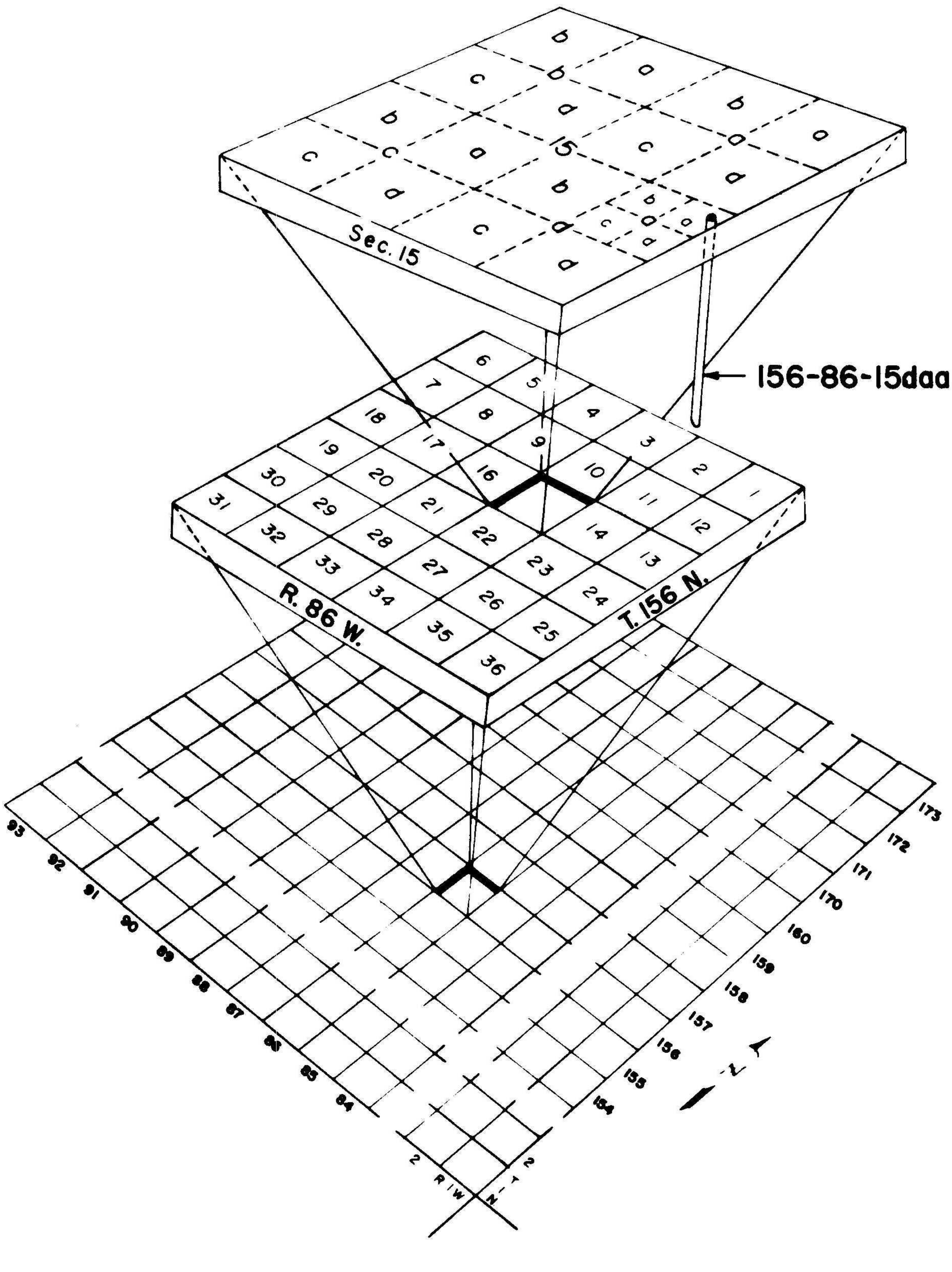

FIGURE 2--SYSTEM OF NUMBERING SPRINGS, WELLS, AND TEST HOLES.

Geology and ground-water resources

Ground water in the Berthold area occurs in Pleistocene glacial drift and sedimentary rocks of Tertiary age. The glacial drift consists of moraines, eskers, and buried-channel deposits. The drift probably was deposited during several stades of the Wisconsin Glaciation. The youngest bedrock in the area, the Fort Union Formation, is composed of clay, shale, sandstone, sand, and lignite of Tertiary age.

Information regarding the geology and hydrology was obtained from 18 test holes and in part from published reports. The locations of the test holes are shown on figure 3, and the logs are given in table 2. The test holes were drilled with a hydraulic-rotary drilling machine owned by the North Dakota State Water Conservation Commission, to depths ranging from 21 to 302 feet; samples were taken of each 5-foot interval.

Pleistocene glacial drift

Ground moraine.--The northeastern and central parts of the Berthold area are covered by ground moraine (fig. 3), consisting of till and stratified sand and gravel deposits. Till is a heterogeneous, unsorted mixture of clay, silt, sand, gravel, and boulders, which is relatively impermeable and yields little or no water to wells. The stratified sand and gravel depsoits yield adequate supplies of water for domestic and stock needs, but only a small number of wells tap the deposits.

NORTH DAKOTA STATE WATER COMMISSION
News Release

October 10, 1963

Water Commission Releases Groundwater Study Report for Berthold Area

Sufficient water of fair quality to supply Berthold's municipal needs is available in that area, according to a report released today by the State Water Commission.

Locations and logs of the 18 test holes drilled, well inventory, quality analyses, along with a map of the area are included in the report. Some 120 square miles are included in the study area located about 20 miles northwest of Minot in Ward County.

A groundwater survey of the entire county is to be started in fiscal year 1964 in cooperation with the recently created Ward County Water Management District.

The State Water Commission, State Geologist, and United States Geological Survey cooperated with the City of Berthold in making the survey.

P. G. Randich, United States Geological Survey, is author of the report, copies of which are available from the Water Commission in Bismarck.

North Dakota State Water Commission

1301 State Capitol
223-8000 Ext 41

Bismarck, North Dakota 58501

LETTER OF TRANSMITTAL

RE: Groundwater Study Reports

We are enclosing a copy of a groundwater study report published by the State Water Conservation Commission because of your interest in such reports released by this office.

Should you desire further information regarding this report, feel free to contact the State Water Conservation Commission office in Bismarck.

Sincerely yours,

Milo W. Hoisveen
Milo W. Hoisveen
Engineer-Secretary

MWH:hs

Mimeo #160

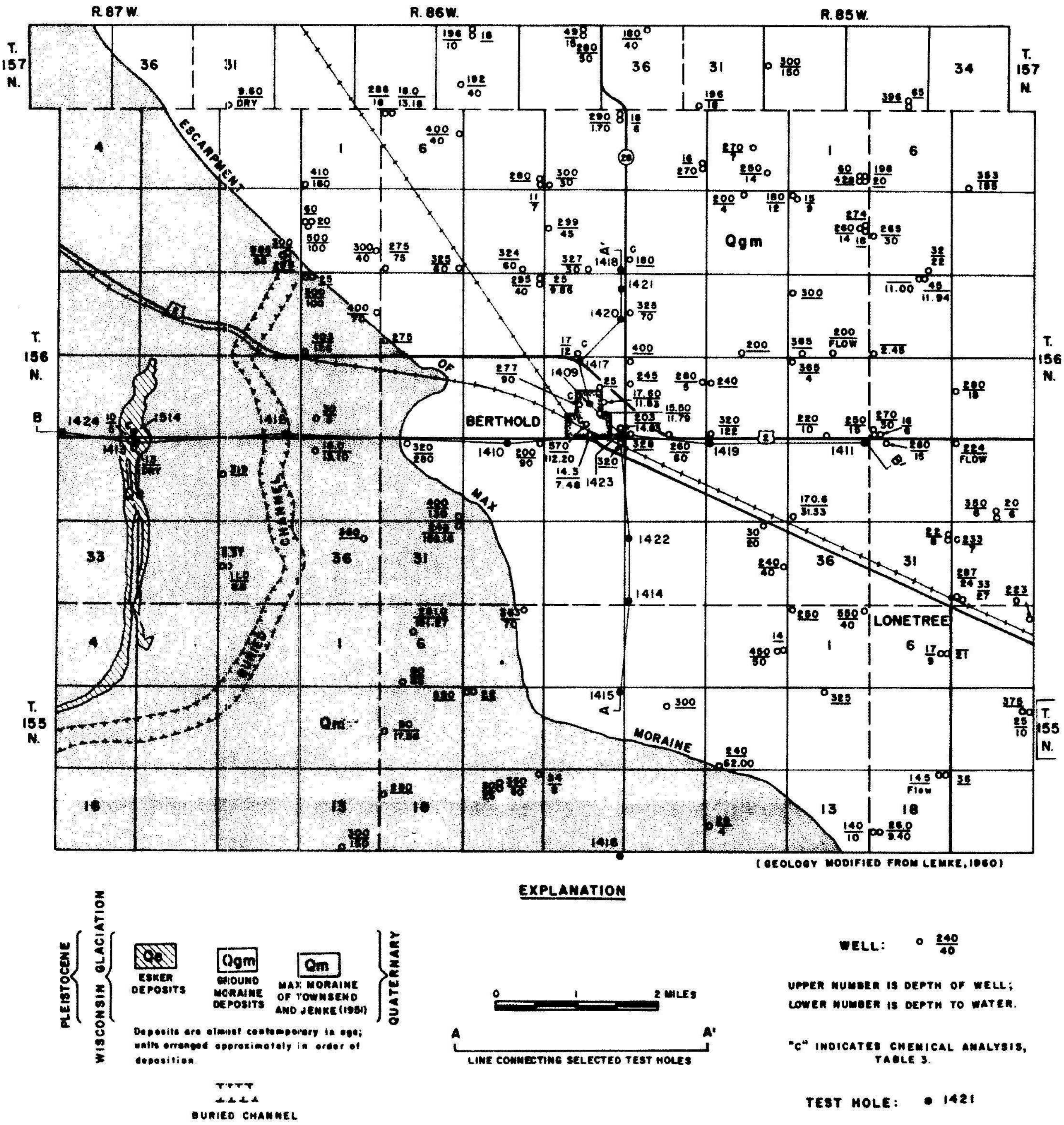

FIGURE 3--MAP OF THE BERTHOLD AREA SHOWING GEOLOGY AND LOCATIONS OF SELECTED WELLS AND TEST HOLES.

In the ground moraine area 13 test holes were drilled, 11 of which penetrated the entire thickness of the drift (table 2). This thickness ranged from 171 to 201 feet. In test hole 1414 (156-86-34ccc), 21 feet of silty gravel is present, between depths of 125 and 146 feet. This gravel was not penetrated in adjacent test holes, so it probably is of small areal extent. In test hole 1418 (156-86-9ddd), there is 131 feet of sand and clayey sand between depths of 65 and 196 feet. This deposit might yield an adequate water supply for the city, however, the clayey sand would probably have less permeability than the clean sand. Additional test drilling would be desirable to obtain more data on its areal extent and thickness at other places. Also, aquifer testing is needed to determine the permeability of the water-bearing sands and the recharge and movement of ground water in the area.

Max moraine.--The southwestern part of the area (fig. 3) is covered by the Max moraine of Townsend and Jenke (1951). It is a deposit consisting predominantly of clayey till, and it differs from the ground moraine in having greater local relief, numerous undrained depressions, and more surficial boulders. Test hole 1424 (156-87-21ccc) in the Max moraine penetrated 48 feet of sand between 88 and 136 feet (fig. 4). A properly developed well in this zone might yield sufficient water for the town or other needs.

Eskers.--Sinuous ridges of ice-contact stratified drift, identified as eskers, overlie the Max moraine in the western part of the area (fig. 3). They consist of mixed sand, gravel, silt, and till and generally stand 10 to 20 feet above the surrounding terrain (Lemke, 1960). Test holes 1413 (156-87-28aaa3) and 1514 (156-87-21ddd) penetrated 12 and 11 feet, respectively, of gravel and sand in these deposits; the eskers are underlain by till (table 2). An analysis of a water sample from test hole 1514 shows that the water is of relatively good chemical quality. Because these deposits are shallow, yields of wells might not be sufficient for a lasting municipal supply.

Buried channel.--A shallow depression extending southwest across the Max moraine was mapped by Lemke (1960). This depression is underlain by a buried channel (fig. 3). In test hole 1412 (156-87-23ddc), 302 feet of till was penetrated, indicating a deep channel in the area; a boulder at 302 feet prevented deeper drilling (table 2). As similar buried channels contain water-bearing sand and gravel in some parts of the State, additional testing may be justified to obtain more data on the channel in the Berthold area.

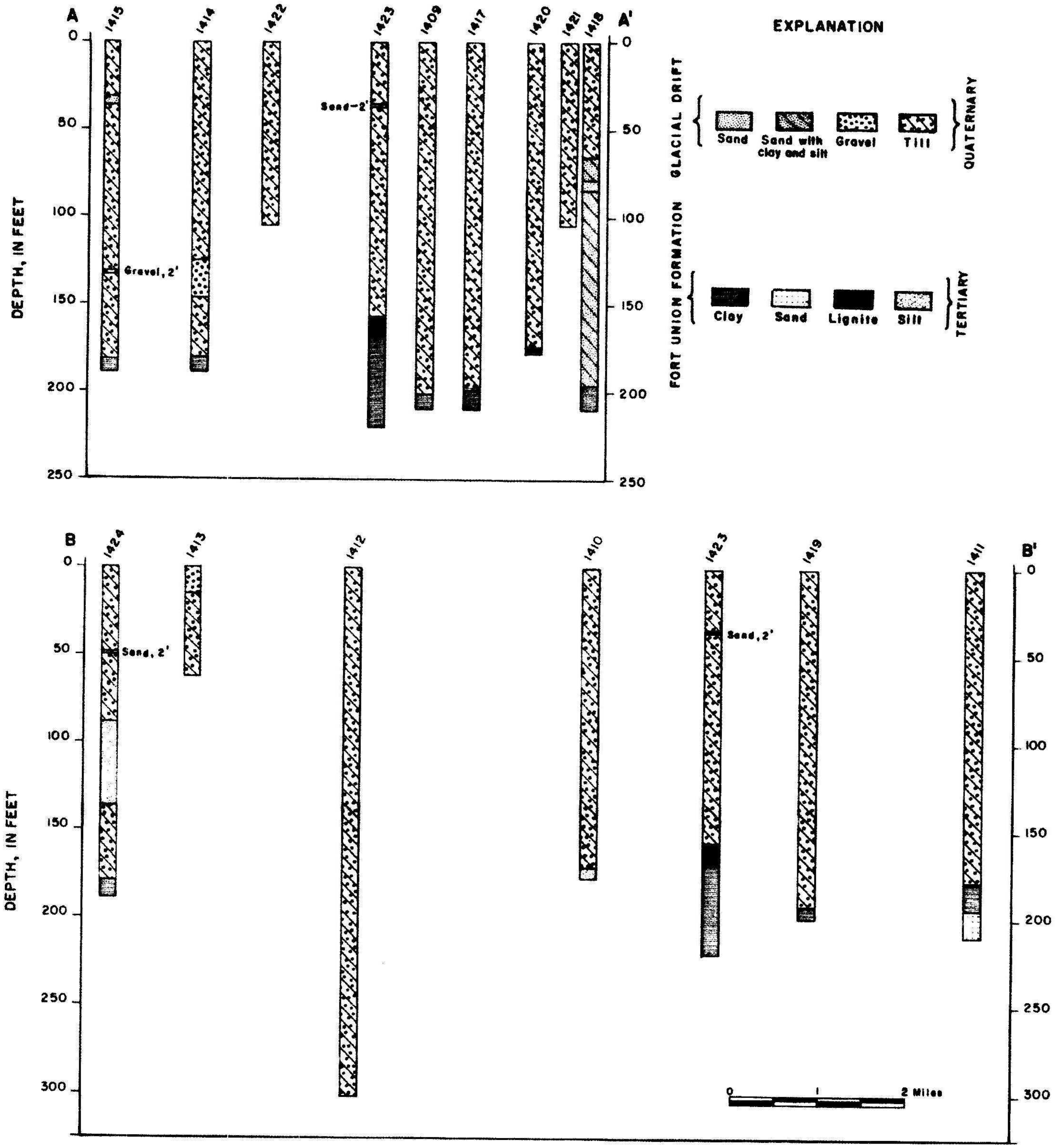

FIGURE 4--GRAPHIC LOGS OF SELECTED TEST HOLES.
(LOCATION OF TEST HOLES SHOWN IN FIGURE 3)

Bedrock

Rocks of Tertiary age underlie the glacial drift in the Berthold area. On the basis of data from 12 test holes, the top of the Tongue River Member (Paleocene) of the Fort Union Formation lies at a depth between 170 and 200 feet (fig. 4). Sand and lignite layers of the Tongue River Member yield water to wells and are the major source of ground water in the area, yielding as much as 30 gpm (gallons per minute).

Wells of various depths derive water from the bedrock. The inconsistency of well depths within comparatively short distances indicates that the bedrock aquifers are discontinuous, probably consisting of lenticular sandy zones or fractured lignite layers.

Analysis of aquifer test

An aquifer test was made at the site of the city well (156-86-21dcb), which is 570 feet deep and taps the Fort Union Formation. The well had not been pumped for 24 hours before the test, which lasted 12 hours and 40 minutes. The water level before pumping was 112.20 feet below the land surface. Owing to the short duration of the test, the lack of data on the thickness of the aquifer, and the lack of records from observation wells, the results were inconclusive. However, valuable information was obtained concerning the productivity of the aquifer and the specific capacity of the well. The drawdown in the well after 12 hours was 20.5 feet, while pumped at 6.4 gpm. Dividing the pumping rate by the drawdown, a specific capacity of about .3 gpm per foot of drawdown is obtained. Assumed to be the same at different rates of discharge, the specific capacity is used to predict drawdown at different pumping rates. Pumping the well for 12 hours at 30 gpm would produce a drawdown of about 100 feet, and the pumping level would be about 212 feet below the land surface.

Source and movement of ground water

Recharge to aquifers in the glacial drift is derived from precipitation and (or) seepage from surface-water bodies. Recharge to bedrock aquifers probably is derived partly from water percolating downward from the glacial-drift aquifer and partly from water moving laterally into the area.

Ground water probably moves through the Fort Union Formation from the southwestern part of the Berthold area to the northeastern part, which is generally lower in altitude. This movement is controlled locally by the bedrock channel, regional slope, and local differences in the transmissibility of the aquifers.

Chemical quality of ground water

The quality of water for public supply and domestic use commonly is evaluated in relation to standards of the U.S. Public Health Service (1962). These standards, in part, are as follows:

Constituent	Maximum concentration (ppm)
Iron (Fe)	0.3
Manganese (Mn)	.05
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	1.7 a/
Nitrate (NO_3)	45
Dissolved solids	500

a/Based on annual average of maximum daily air temperatures at Minot.

Ground water of good quality for general use is difficult to find in the Berthold area (table 3). Water samples were collected and analyzed from 3 private wells, 1 city well (2 samples), 1 school well, and 1 test hole. The analyses show a wide range in total dissolved solids and in the relative proportions of dissolved constituents. The iron content generally exceeds the limit of 0.3 ppm recommended by the U.S. Public Health Service (1962); however, this can be reduced to or below the recommended limit by proper treatment. Recommended maximums of some chemical constituents were exceeded in all but one sample (156-87-21ddd). However, water having more than the recommended maximum for some constituents has been used in North Dakota for many years without apparent ill effects. Water from the Fort Union Formation is primarily a sodium bicarbonate type having a high dissolved-solids content and relatively low hardness. Owing to the high dissolved-solids content, it may have an objectionable taste or color, and treatment is desirable.

Water from the drift differs from that of the Fort Union Formation. Water from the drift well (156-86-16cdd) and from test hole 1514 (156-87-21ddd) is of the magnesium bicarbonate type and very hard. Water from well 156-86-10ccb, which probably is derived from the base of the drift or the upper part of the Fort Union Formation, is of the sodium carbonate plus bicarbonate type and is soft. Recharge is from the overlying glacial material.

Summary of ground-water resources

Most wells in the Berthold area obtain water from bedrock aquifers in the Fort Union Formation, of Paleocene age. The municipal supply for Berthold is obtained from this formation, which yields as much as 30 gpm to properly developed wells. Water from the bedrock contains high concentrations of dissolved solids.

Aquifers consisting mainly of sand deposits in the glacial drift supply water to a few wells in the Berthold area. Test drilling reveals that a relatively large amount of sand and clayey sand is present in the vicinity of test holes 1418 (156-86-9ddd) and 1424 (156-87-21ccc). However, pumping tests are needed to determine aquifer characteristics. A lesser amount is present near the surface in test holes 1413 (156-87-28aaa3) and 1514 (156-87-21ddd), which could supply small amounts of water of good quality for stock and domestic uses. Additional test drilling in a buried channel in the western part of the area may locate deposits of sand and gravel capable of yielding a good water supply.

z

TABLE 1.--Records of

Depth of well and depth to water: Measured depths are given in feet and tenths; reported depths are in feet.

Type of well: Dr, drilled; Du, dug; Dv, driven.

Location No.	Owner or name	Depth of well (feet)	Diameter of well (inches)	Type	Date completed	Depth to water (feet)
155-85						
5aad	A. H. Brooks	223	5	Dr	1925	0
6daa1	Henry Nesham, Jr.	...	4	Dr	....	21
6daa2	..do....	17	36	Du	1918	9
8ada1	George Hennesy	375	4	Dr	1928	.....
8ada2	..do....	25	48	Du	1930	10
18aaa1	Neil Jeffrey	36	36	Dr	....	.....
18aaa2	..do....	145	5	Dr	1910	Flow
18ccb1	..do....	140	5	Dr	....	10
18ccb2	..do....	26.0	24	Dr	1946	9.40
155-86						
1aaa	A. Olson	550	4	Dr	1915	40
1bbb	L. Mann	250	4	Dr	1916	.....
2daa1	Wm. Hennesy	14	22	Du	1910	.....
2daa2	..do....	450	5	Dr	1910	50
5aab	Linster	363	4	Dr	1946	70
6bda	Martha Linster	281.0	3	Dr	1910	191.27
6cdc	..do....	60	24	Dr	1915	25
7cbb	Unknown	80	24	Dr	....	17.56
8bbb1	Engebretson	520	2	Dr	1910	.....
8bbb2	..do....	22	24	Dr	1952	.....
9aaa	Test hole 1415	189	5	Dr	10-58	.....
10abc	Kilbourne	300	..	..	1933	.....
11ccd	E. Kilene	240	3	Dr	1915	62.00
12baa	H. E. Mann	325	6	Dr	1950	.....
14cbc	Ed Fleming	25	48	Du	1910	4
17aaa	Wm. Dokken	34	24	Dr	1952	8
17bad1	Harold Arndt	350	4	Dr	1928	80
17bad2	..do....	50	18	Dr	1955	25
18bcb	Earl Deaver	280	..	Dr	....	.....
21aaa	Test hole 1416	178.5	5	Dr	10-58	.....

wells and test holes

Use of water: D, domestic; Ind, industrial; N, none; S, stock; T, test hole.

Remarks: Chemical analyses are in table 3; logs are in table 2. The terms adequate, inadequate, saline, hard, and soft are water characteristics reported by the owner.

Date of measurement	Use	Aquifer	Remarks
1925	D,S	......	Adequate supply.
....	D	......	..Do....
....	...	......	Inadequate supply.
....	S	......	..Do....
....	D	Sand	Adequate supply; 20 grains hardness.
....	D	......	Adequate supply.
....	S	..do..	..Do....
....	N	......	
9-24-58	D,S	..do..	Adequate supply; 25 grains hardness.
....	D,S	......	Adequate supply; saline.
....	S	......	
....	D	..do..	Adequate supply.
....	D,S	......	Adequate supply; saline.
....	D,S	..do..	..Do....
9-25-58	N	..do..	..Do....
....	D,S	......	..Do....
10-1-58	N	......	
....	D,S	......	..Do....
....	S	..do..	Inadequate supply.
....	T	......	See log.
....	S	......	Adequate supply.
9-24-58	D,S	Clay	..Do....
....	D,S	Sand	..Do....
....	S	..do..	..Do....
....	D,S	..do..	..Do....
....	S	..do..	Adequate supply; saline.
....	D	..do..	Adequate supply; saline; 25 grains hardness.
....	D,S	......	Adequate supply; saline.
....	T	......	See log.

TABLE 1.--Records of wells

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed	Depth to water (feet)
155-87						
13dcc	W. T. Greenup	300	4	Dr	1920	150
156-85						
5ccd	Wendall Schaan	353	1.5	Dr	1955	185
7cbb	Mrs. Peter Olson	265	4	Dr	1925	30
7dcd	Glenard Glein	32	24	Du	1941	22
18abb1	Inga Laumb	45	24	Du	....	11.94
18abb2	..do....	...	..	Du	....	11.00
18ccc	Ollie Otto	...	..	..	....	2.45
19ccc1	Virgil Fegley	250	4	Dr	1957	15
19ccc2	..do....	270	4	Dr	....	30
19ccc3	..do....	16	10	..	....	6
20bcc	Loren Burkhart	280	5	Dr	....	18
29bbb	Jess M. Joiner	224	5	Dr	1911	Flow
29cdd1	Art Soderberg	350	5	Dr	1925	6
29cdd2	..do....	20	6	Dr	1952	6
30bba	Virgil Fegley	280	4	Dr	1912	15
31aad1	Joe Nesham	22	24	Dr	1945	8
31aad2	..do....	233	6	Dr	1914	7
32ccc1	John Sandstrom	287	4	Dr	1917	24
32ccc2	..do....	33	12	Du	1938	27
156-86						
1dda1	Mrs. Hannah Ness	198	5	Dr	9-58	.....
1dda2	..do....	60	..	Dr	....	.....
1dda3	..do....	428	..	Dr	....	.....
1dda4	..do....	20	48	Du	....	.....
2acc	Norman Moger	270	1.25	Dr	1922	7
2d	Harto Moger	250	2	Dr	1926	14
3dad1	Mrs. Edwin Lokken	270	..	Dr	1922	.....
3dad2	..do....	16	36	Du	....	.....
4aaa1	Mrs. Edna Holmen	290	6	Dr	1925	1.70
4aaa2	..do....	18	8	Dr	1947	6
4ccc	Harry Kalenze	300	..	Dr	....	30
5ddd1	Arnst Schwope	11	24	Du	1956	7
5ddd2	..do....	280	4	Dr	1916	.....
6ada	Benhard Larson	400	4	Dr	1928	40
6bbb1	Sam Higgins	286	5	Dr	1916	18
6bbb2	..do....	18.0	4	..	1942	13.18
7ccc	Lydia Heller	275	2.5	Dr	1915	75
7ddd	John M. Stine	325	4	Dr	1915	60

and test holes -- Continued

Date of measurement	Use	Aquifer	Remarks
....	S	Sand	Adequate supply; saline.
....	D,S	..do..	
....	D,S	......	
....	D	Gravel	Inadequate supply.
9-24-58	N	......	
9-24-58	N	......	
9-24-58	...	......	
....	D	..do..	
....	S	......	Trace of soda.
....	D	..do..	Inadequate supply.
....	D,S	......	
....	S	Coal	
....	S	..do..	
....	D	Gravel	Adequate supply.
....	S	Coal	..Do....
....	D	Clay	..Do....
....	S	......	Adequate supply; see chemical analysis.
....	D,S	Coal	Adequate supply.
....	D	Sand	..Do....
....	...	Sand and gravel	
....	S	......	..Do....
....	S	Sand	Abandoned, filled in with sand.
....	D	......	Adequate supply.
....	D,S	Gravel	..Do....
....	D,S	..do..	
....	S	..do..	
....	...	......	
9-23-58	D,S	......	Adequate supply; 9 grains hardness.
....	D	Clay	Adequate supply; 45 grains hardness.
....	...	......	
....	D	Sand	Inadequate supply.
....	D,S	......	Adequate supply.
....	S	..do..	..Do....
....	D	......	..Do....
10-1-58	D	Clay	Adequate supply; 20 grains hardness.
....	..	Sand	Inadequate supply.
....	D	..do..	Adequate supply.

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed	Depth to water (feet)
156-86 (Cont.)						
8dcd	Kenneth Buen	324	4	Dr	1927	60
9bcc	John Allshouse	299	4	Dr	1917	45
9dcc	Harry Kalenze	327	3	Dr	1920	30
9ddd	Test hole 1418	210	5	Dr	10-58	.....
10ccb	Francis Bruels	180	4	Dr	....	.....
11baa	Paul Froxel	200	4	Dr	1923	4
12add1	Raymond Fegley	260	4	Dr	1929	14
12add2	..do....	274	4	Dr	1956	.....
12add3	..do....	18	..	Du	1949	.....
12bbb1	Curtis Churness	180	4	Dr	1946	12
12bbb2	..do....	15	8	Dr	1943	9
13bbc	Lester Lautenschlager	300	..	..	....	.....
13ccd	..do....	365	..	..	....	.....
13dcc	Ralph Rosencrans	200	1.25	Dr	1940	Flow
14cdd	Francis Bruels	200	..	Dr	....	.....
15bcc	Earl Brown	325	2	Dr	1917	70
16aad	Test hole 1421	105	5	Dr	10-58	.....
16cdd	John Allshouse	17	24	Dr	1951	12
16daa	Test hole 1420	178.5	5	Dr	10-58	.....
17aaa1	John Allshouse	15	12	Dr	1928	9.86
17aaa2	..do....	295	5	Dr	1910	40
18ccb	Harold Heller	275	3	Dr	....	.....
21acd	W. H. Gilmore	25	..	Du	....	.....
21baa	Test hole 1417	210	5	Dr	10-58	.....
21caa1	Berthold School	277	3	Dr	....	90
21dba	John Alhas	17.6	36	Du	....	11.83
21dbb	Test hole 1409	210	5	Dr	9-58	.....
21dbd	Walt Kruger	15.5	36	Du	....	11.79
21dcb	City of Berthold	570	3	Dr	....	112.20
21dcc	City stockyard	14.3	48	Du	....	7.48
21ddd1	Terry Abern	20.3	..	Du	....	14.83
21ddd2	Test hole 1423	220.5	5	Dr	10-58	.....
22ada	George Tudahl	280	4	Dr	1923	5
22bbb	William J. Roberts	400	4	Dr	1930	.....
22bcb	Harry Brown	245	..	Dr	....	.....
22ccc	Billy Roberts	328	..	Dr	....	.....
22dcc	Weslie Oil Co.	260	4	Dr	1957	60
23bcb	George Tudahl	240	6	Dr	1925	.....

and test holes -- Continued

Date of measurement	Use	Aquifer	Remarks
....	D,S	......	Adequate supply.
....	D,S	......	..Do....
....	S	......	..Do....
....	T	......	See log.
....	D,S	Drift(?)	See chemical analysis.
....	D,S	Coal	Adequate supply.
....	D,S	Sand	Abandoned.
....	D,S	Gravel	
....	D	Clay	
....	S	......	Adequate supply; 20 grains hardness.
....	D	..do..	Inadequate supply.
....	...	......	Adequate supply.
....	...	......	
....	S	......	
....	...	......	Adequate supply; 25 grains hardness.
....	D	Sand	Adequate supply; 27 grains hardness.
....	T	......	See log.
....	...	Drift	Inadequate supply; see chemical analysis.
....	T	......	See log.
9-23-58	S	Sand	Inadequate supply; 29 grains hardness.
....	D,S	......	Adequate supply.
....	D,S	......	..Do....
....	D	Clay	Inadequate supply.
....	T	......	See log.
....	PS	Sand(?)	See chemical analysis.
9-23-58	N	Clay	
....	T	......	See log.
9-23-58	D	..do..	
....	PS	Sand(?)	Adequate supply; see chemical analysis and aquifer-test data.
9-24-58	S	Clay	
9-23-58	D	..do..	
....	T	......	See log.
....	D,S	......	
....	S	......	
....	S	......	
....	N	......	
....	Ind.	......	
....	D,S	Coal	

TABLE 1.--Records of wells

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed	Depth to water (feet)
156-86 (Cont.)						
23ccc	Leonard Johnson	320	4	Dr	1918	122
24bbb	Lester Lautenschlager	365	4	Dr	1920	4
24cdd	Kenneth Luke	220	4	Dr	1911	10
25aaa	Test hole 1411	210	5	Dr	10-58	.....
25ccc	Unknown	170.6	..	Dr	....	31.33
26bbb	Test hole 1419	199.5	5	Dr	1958	.....
28aaa	Victor Davy	320	3	Dr	1908	.....
29aaa	A. Haugen	200	2	Dr	1915	90
29abb	Test hole 1410	178.5	5	Dr	9-58	.....
30bab	Willard Johnson	320	4	Dr	1918	280
30ddd	Earl Deaver	400	4	Dr	1907	130
31aaa	Robert T. Hagen	245	4	Dr	1920	156.16
34bbc	Test hole 1422	105	5	Dr	10-58	.....
34ccc	Test hole 1414	189	5	Dr	10-58	.....
35aba	Strait	30	18	Dr	1953	20
35daa	..do....	240	4	Dr	1913	40
156-87						
1ccc	Hilman Johnson	410	3	Dr	1918	180
11ddb1	John O. Lee	585	4	Dr	1955	88
11ddb2	..do....	296	3	Dr	1944	.....
11ddb3	..do....	300	..	Dr	1914	.....
12bcc1	Bernhard Wold	500	4	Dr	1915	100
12bcc2	..do....	60	24	Dr	1956	Dry
12bcc3	..do....	20	..	..	1920	.....
12dad	Leon Birdsall	300 0	2	Dr	1912	40
13add	E. J. Burke	400	3	Dr	1915	70
13bbb1	Ralph Birdsall	300	3	Dr	....	100
13bbb2	..do....	25	24	Du	....	.....
13ccc	Don Birdsall	403	2	Dr	1914	126
21ccc	Test hole 1424	189	5	Dr	10-58	.....
21ddd	Test hole 1514	21	5	Dr	10-58	.....
23ddc	Test hole 1412	302	5	Dr	10-58	.....
24cca	DePute	30	24	Dr	1933	6
25bbd	DeBilt	18.0	30	Du	....	13.10
26bcc	Floyd Schwede	319	3	Dr	1918	.....
28aaa1	A. J. Elstoen	10	72	Du	1910	5
28aaa2	..do....	13	60	Du	....	.....
28aaa3	Test hole 1413	63	5	Dr	10-58	.....

and test holes -- Continued

Date of measure-ment	Use	Aquifer	Remarks
....	D,S	.....	Adequate supply
....	D,S	.....	5 grains hardness.
....	D,S	Sand	Adequate supply.
....	T	.....	See log.
9-25-58	N	.....	
....	T	.....	..Do....
....	D,S	.....	
....	D,S	.....	Adequate supply, soft.
....	T	.....	See log.
....	D,S	.....	Inadequate supply.
....	D,S	Gravel	
9-23-58	D,S	Sand	
....	T	.....	See log.
....	T	.....	..Do....
....	D,S	Clay	Inadequate supply.
....	N	Sand	
....	S	.....	Adequate supply.
....	D,S	..do..	
....	N	..do..	
....	N	Coal	
....	S	......	..Do....
....	N	Clay	
....	D	......	..Do....
....	S	......	2 grains hardness.
....	D,S	Coal	Adequate supply.
....	S	Sand	
....	D	......	Inadequate supply.
....	D,S	......	Adequate supply.
....	T	......	See log.
....	T	......	See log; see chemical analysis.
....	T	......	See log.
....	D,S	..do..	Adequate supply.
9-23-58	S	..do..	..Do....
....	S	Coal	
....	D,S	Gravel	..Do....
....	...	Sand	
....	T	......	See log.

TABLE 1.--Records of wells

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed	Depth to water (feet)
156-87 (Cont.)						
35cbb1	Unknown	...	24	Du	....	5.37
35cbb2	..do....	11.0	60	Du	....	8.80
36aac	Ray Johnson	350	4	Dv	....	.....
157-85						
31ccd	Oolav Ronnigen	196	3	Dr	1928	18
32bcc	Theodore Nokleby	300	3	Dr	....	150
33dcd1	Walter Troxel	396	4	Dr	1915	.....
33dcd2	..do....	65	4	Dr	1955	.....
157-86						
31cdd	Unknown	9.6	48	Du	....	Dry
34baa1	Johnnie Furvlie, Jr.	196	4	Dr	1925	10
34baa2	..do....	18	18	Dr	....	.....
34cac	John Stalwick	192	3	Dr	1916	40
35aab1	Sig Ronnigen	280	3	Dr	1917	50
35aab2	..do....	49	12	Dr	1942	15
36abb	Paul Skinningsrud	180	..	Dr	....	40

and test holes -- Continued

Date of measurement	Use	Aquifer	Remarks
10-1-58	N	......	
10-1-58	N	......	
....	S	......	Adequate supply; saline.
....	D,S	......	20 grains hardness.
....	S	Sand	
....	S	..do..	
....	D	..do..	Adequate supply.
10-2-58	N	......	
....	D,S	......	Adequate supply; 20 grains hardness.
....	D	......	Inadequate supply; 25 grains hardness.
....	S	Gravel	Adequate supply; 18 grains hardness.
....	S	Coal	Adequate supply.
....	D	Sand	Inadequate supply.
....	N	......	Adequate supply; 15 grains hardness.

TABLE 2.--Logs of test holes

155-86-9aaa
Test hole 1415

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Till, clayey, yellowish-gray; and fine gravel	18	20
	Till, clayey, gray; fine gravel; and some lignite	11	31
	Sand, fine, silty	5	36
	Till, clayey, gray; fine to coarse gravel; and some lignite	95	131
	Gravel, fine to coarse	2	133
	Till, clayey, gray; and fine to medium gravel	48	181
Fort Union Formation:			
	Clay, silty, light-gray	8	189

155-86-21aaa
Test hole 1416

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till, clayey, yellowish-gray; and fine gravel	11	12
	Till, clayey, gray; and fine to coarse gravel	146	158
Fort Union Formation:			
	Clay, silty, yellowish-gray	20.5	178.5

156-86-9ddd
Test hole 1418

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till, clayey, yellow to yellowish-gray; fine gravel and lignite fragments, oxidized	51	52
	Till, clayey, gray; fine gravel; shale pebbles; and lignite fragments	13	65
	Sand, fine to coarse, silty; large amount of clay	12	77
	Sand, medium to coarse, fairly clean	7	84
	Sand, medium to coarse; and sandy blue clay; large amount of lignite; and shale grains	68	152
	Sand, coarse; and sandy blue clay; lignite; and shale grains	16	168
	Sand, coarse to granule gravel; shale and lignite grains; and sandy blue clay	28	196
Fort Union Formation:			
	Clay, sandy, gray	14	210

156-86-16aad
Test hole 1421

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till, clayey, sandy, yellow; fine gravel, oxidized	12	13
	Till, sandy, mottled yellowish-gray; fine gravel; shale and lignite fragments, oxidized	19	32
	Till, sandy, gray; minor amounts of fine gravel; shale pebbles and lignite fragments	73	105

TABLE 2.--Logs of test holes -- Continued

156-86-16daa
Test hole 1420

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	4	4
	Till, clayey, sandy, yellow to brown; and gravel pebbles, oxidized	9	13
	Till, clayey, gray; gravel and shale pebbles; some lignite fragments	71	84
	Till, clayey, gray; large amount of medium to coarse gravel and some pebbles; shale pebbles; some lignite fragments	21	105
	Till, clayey, gray; fine gravel; shale pebbles; and lignite fragments	69	174
Fort Union Formation:			
	Clay, sandy; large amount of lignite fragments	4.5	178.5

156-86-21baa
Test hole 1417

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Till, clayey, yellowish-gray; and fine gravel	12	14
	Till, clayey, gray; fine to medium gravel; and some lignite	185	199
Fort Union Formation:			
	Clay, silty, light-gray	11	210

TABLE 2.--Logs of test holes -- Continued

156-86-21dbb
Test hole 1409

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	3	3
	Till, clayey, yellow; and a small amount of gravel, slightly oxidized	19	22
	Till, clayey, gray; shale pebbles; and a small amount of gravel	156	178
	Till, clayey, gray; shale pebbles; small amount of gravel; and sand	23	201
Fort Union Formation:			
	Clay, silty, gray	9	210

156-86-21ddd
Test hole 1423

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	3	3
	Till, clayey, yellow; fine gravel, oxidized	8	11
	Till, clayey, sandy, gray; minor amount of fine gravel; shale and lignite fragments	24	35
	Sand, coarse; and granule gravel	2	37
	Till, clayey, sandy, gray; minor amount of fine gravel; shale and lignite fragments	68	105
	Till, clayey, sandy, gray; large amount of coarse sand and granule gravel increasing with depth; shale and lignite fragments	52	157
Fort Union Formation:			
	Lignite	12	169
	Clay, sandy to silty, gray; lignite	51.5	220.5

TABLE 2.--Logs of test holes -- Continued

156-86-25aaa
Test hole 1411

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, silty, black----------------------	2	2
	Till, clayey, yellowish-gray; and fine to medium gravel----------------------	20	22
	Till, clayey, gray; and fine to medium gravel-------------------------------	103	125
	Till, clayey, gray; and gravel containing cobbles--------------------------	37	162
	Till, clayey, gray; and fine to medium gravel-------------------------------	17	179
Fort Union Formation:			
	Clay, sandy, gray; and a few granules of lignite------------------------------	15	194
	Sand, silty; and some lignite-----------	16	210

156-86-26bbb
Test hole 1419

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black----------------------------	2	2
	Till, clayey, yellowish-gray------------	31	33
	Till, clayey, gray; fine to medium gravel; and lignite fragments---------	160	193
Fort Union Formation:			
	Clay, silty, light-gray, variably calcareous------------------------------	6.5	199.5

156-86-29abb
Test hole 1410

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black----------------------------	3	3
	Till, clayey, yellow; and fine gravel---	9	12
	Till, clayey, gray; and fine to medium gravel-------------------------------	159	171
Fort Union Formation:			
	Silt, sandy, light-gray; and some lignite particles-----------------------	7.5	178.5

TABLE 2.--Logs of test holes -- Continued

156-86-34bbc
Test hole 1422

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Till, clayey, grayish-yellow; fine gravel	10	12
	Till, clayey, gray; fine to medium gravel; lignite fragments in lower portion	93	105

156-86-34ccc
Test hole 1414

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Till, clayey, yellowish-gray; fine gravel	19	21
	Till, clayey, gray; fine to coarse gravel; lignite fragments from 71 to 125 feet	104	125
	Gravel, fine, silty; abundant lignite fragments	21	146
	Till, clayey, gray; coarse sand and fine gravel; lignite fragments	34	180
Fort Union Formation:			
	Clay, sandy, gray	9	189

TABLE 2.--Logs of test holes -- Continued

156-87-21ccc
Test hole 1424

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till, clayey, brownish-gray; fine gravel	18	19
	Till, clayey, gray; fine gravel; shale pebbles; and lignite fragments	29	48
	Sand, fine to medium	2	50
	Till, clayey, silty, gray; fine to medium gravel; shale pebbles; and lignite fragments	38	88
	Sand, fine to coarse; large amount of shale pebbles; lignite fragments	48	136
	Till, clayey, light-brownish-gray; minor amount of fine gravel and coarse sand grains; shale pebbles; a few lignite fragments, slightly oxidized	43	179
Fort Union Formation:			
	Clay, silty, light-gray	10	189

156-87-21ddd
Test hole 1514

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Gravel, fine to medium; and abundant medium to coarse sand	11	13
	Till, clayey, gray; and fine to medium gravel	8	21

TABLE 2.--Logs of test holes -- Continued

156-87-23ddc
Test hole 1412

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	2	2
	Till, clayey, yellowish-gray; and fine to coarse gravel	13	15
	Till, clayey, gray; fine to coarse gravel	258	273
	Till, clayey, gray; fine to coarse gravel; and some lignite	29	302

Boulder at 302 feet.

156-87-28aaa3
Test hole 1413

Geologic unit	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, sandy, black	3	3
	Gravel, fine to medium	12	15
	Till, clayey, gray; fine gravel; and some shale and lignite pebbles	48	63

TABLE 3.--Chemical

Geologic source: D, Glacial drift; Tft, Tongue River Member of the Fort Union Formation

(Results in parts per

Location No.	Owner or name	Geologic source	Date of collection	Depth of well (feet)	Temperature (°F)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
156-85										
31aad2	Joe Neshem	Tft	9-24-56	233	46	...	.8	0	32	780
156-86										
10ccb	Francis Bruels	D(?)	9-23-58	180	44	...	4.4	0	18	840
16cdd	John Allhouse	D	9-24-58	17	50	...	5.8	153	260	18
21caal	Berthold School	Tft	9- 7-54	277	..	...	2.5	6	...	.....
21dcb	City of Berthold	Tft	1958	570	..	...	.9	0	32	930
21dcb	..do....	Tft	2- 5-63	570	47	5.8	.9	6	0	1,010
156-87										
21ddd	Test hole 1514	D	4-29-59	21	..	...	.16	136	146	8

analyses of ground water

Analyses by State Laboratories, Bismarck, N. Dak.

million, except as indicated)

Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
6.0	1,290	136	59	163	1.6	.38	.3	1,950	32	92	3,000	8.6
6.5	508	434	775	49	2.0	.78	.3	2,330	18	94	3,580	9.5
3.0	309	0	153	0	.4	....	.4	632	413	3	972	8.0
...	858	163	912	11	...	....	...	2,580	32	..	3,970	8.4
5.8	1,390	261	36	372	.7	.65	.2	2,430	32	94	3,730	8.5
9.0	1,900	48	0	390	1.3	.50	.1	2,610	17	99	3,910	8.2
4.0	207	0	62	16	.5	6.66	0	386	282	2	.....	8.2

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