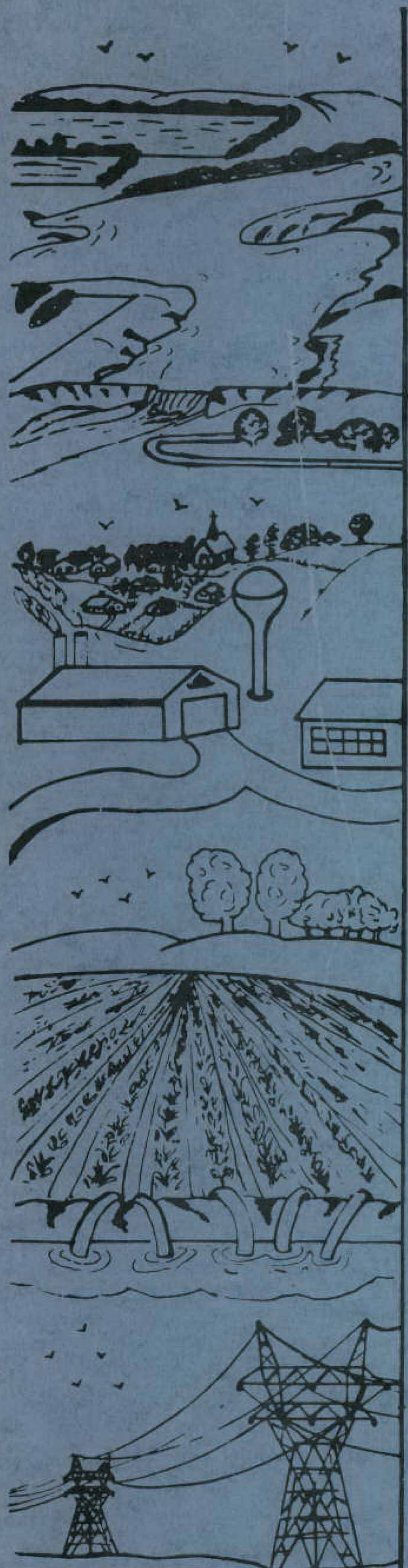


Ground-Water Resources Near Max, McLean and Ward Counties, North Dakota

By

C. A. ARMSTRONG

Geological Survey

United States Department of the Interior

NORTH DAKOTA GROUND-WATER STUDIES NO. 45

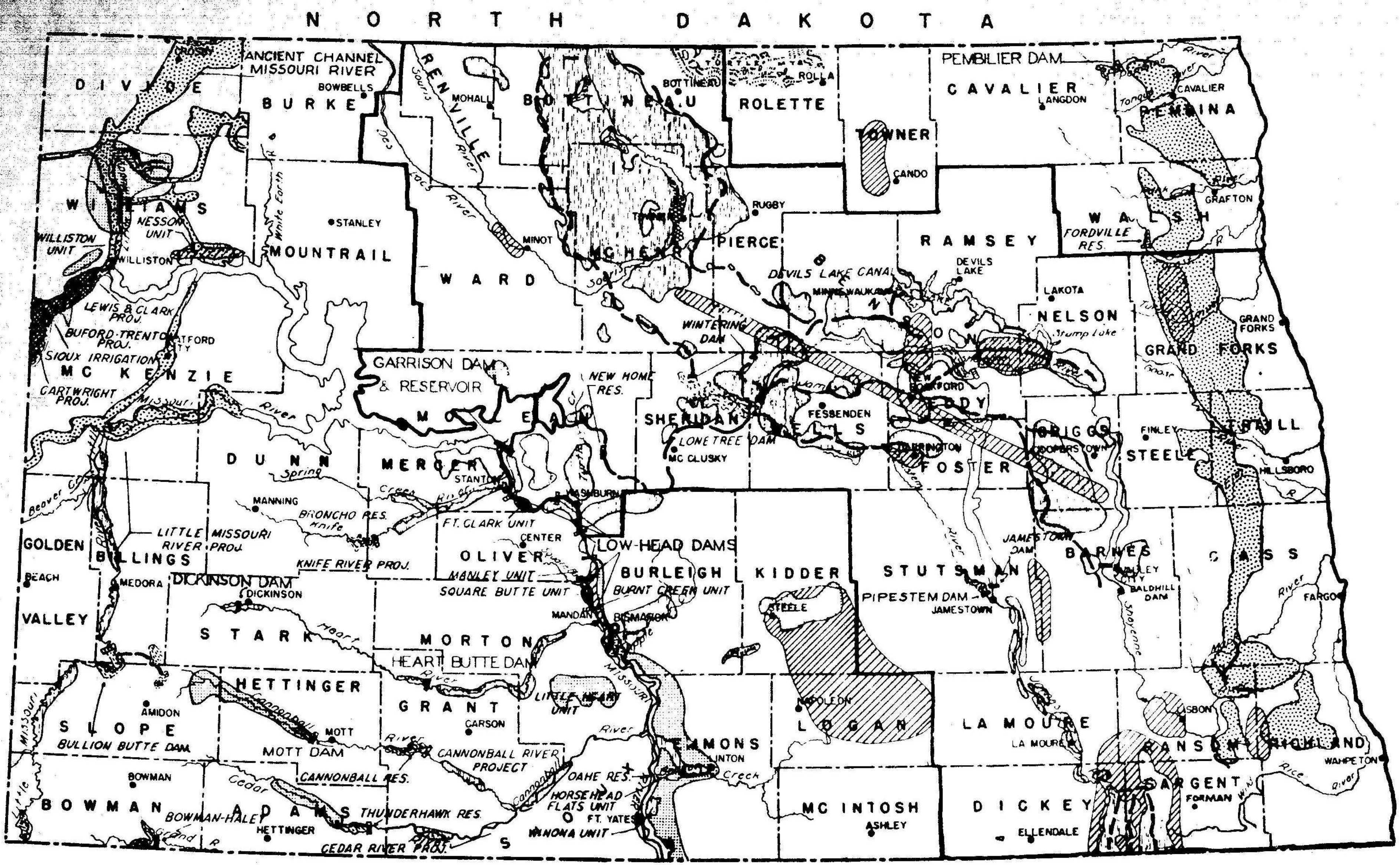
Prepared by the U.S. Geological Survey in cooperation with the North Dakota State Water Commission and the North Dakota Geological Survey

Published by

NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

1301 State Capitol, Bismarck, North Dakota

1963



NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

PROPOSED CANALS

GARRISON DIVERSION CONSERVANCY DISTRICT BOUNDARY

GROUNDWATER AQUIFERS

NORTH DAKOTA STATE WATER COMMISSION

NEWS RELEASE

Water Commission Releases
Groundwater Report for Max Area

November 14, 1963

Areas from which groundwater developments might be made in the Max vicinity are indicated in a report released today by the State Water Commission. Samples of the water located in the aquifers tested show the water to be of inferior quality. Chemical analyses in the report indicate the water is hard and has a relatively high concentration of iron, bicarbonate, and sulfate.

Locations and logs of the 11 test holes drilled, well inventory, quality analyses, along with a map of the area are included in the report. The study area includes 64 square miles primarily in McLean County. Max is 26 miles south of Minot.

The State Water Commission, State Geologist, and the United States Geological Survey cooperated with the City of Max in making the survey. C. A. Armstrong, Bismarck, U. S. Geological Survey, is author of the report, copies of which are available from the Water Commission office in Bismarck.

Distribution
SWC Project #778
SWC File C6-10

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Distribution
SWC Project #778
SWC File C6-10

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

GROUND-WATER RESOURCES NEAR MAX, McLEAN AND WARD COUNTIES, NORTH DAKOTA

By
C. A. Armstrong
Geological Survey
United States Department of the Interior

North Dakota Ground-Water Studies No. 45

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GROUND WATER RESOURCES NEAR MAX, McLEAN AND WARD COUNTIES, NORTH DAKOTA

By
C. A. Armstrong

Introduction

Part of the ground-water investigation program in North Dakota consists of the study of ground-water resources available for municipal development. Ground-water investigations are made of small areas surrounding towns that have requested aid from either the North Dakota State Water Conservation Commission or the North Dakota Geological Survey.

The city council of Max requested the North Dakota State Water Conservation Commission to help locate additional water. As a result of this request an investigation of the geologic and hydrologic conditions of the area surrounding Max was made in the summer of 1958. Max, which is near the Ward County line in the north-central part of McLean County (fig. 1) has a population of about 400 (410 in the 1960 census). It is approximately 26 miles south of Minot, the principal commercial center in the northwestern part of N. Dak.

The city of Max has 3 wells -- a large-diameter dug well 20 feet deep and 2 drilled wells 130 feet deep. The quantity and quality of the ground water from the wells is unsatisfactory for the city's municipal supply.

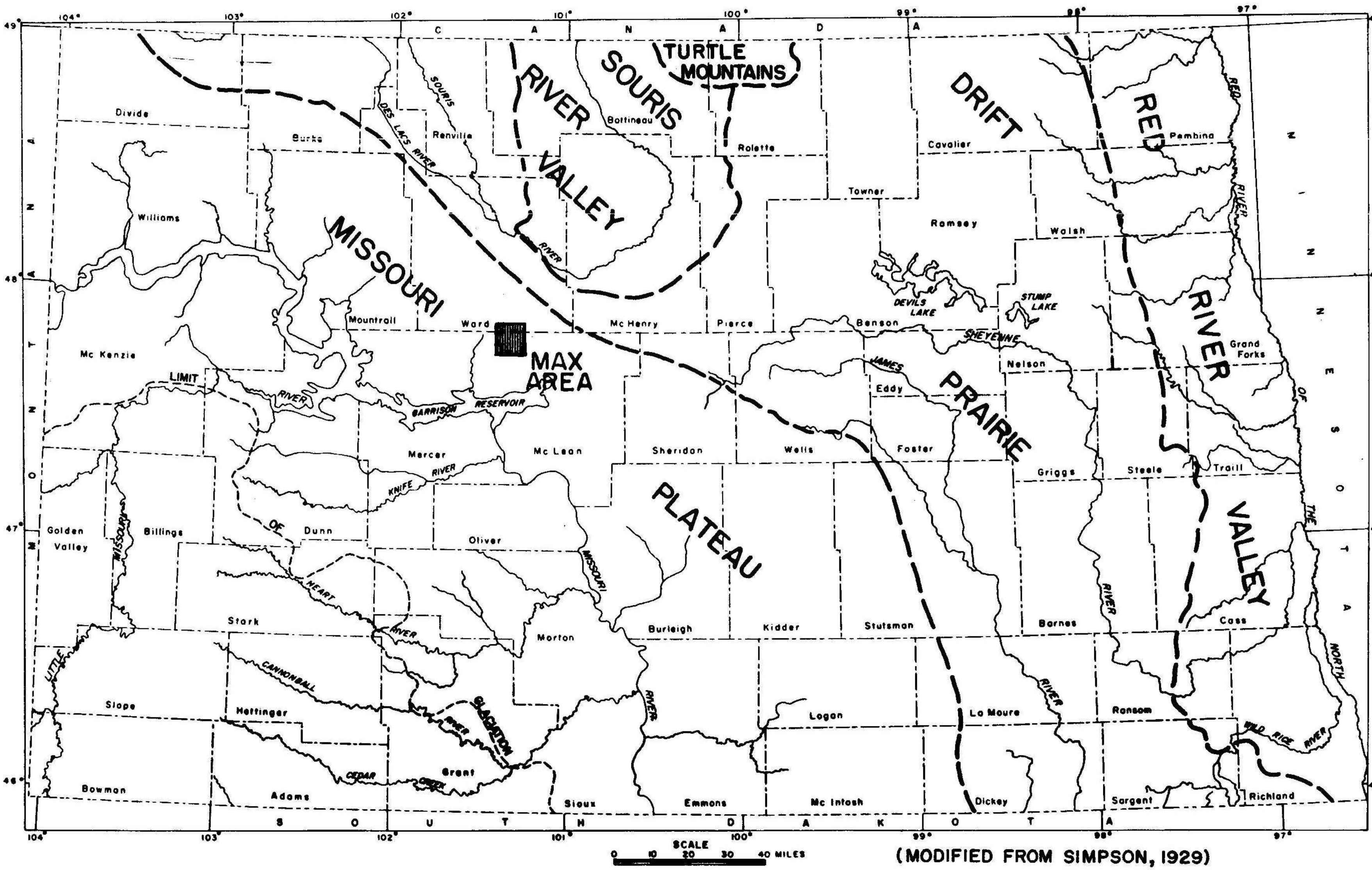

FIGURE I--MAP SHOWING PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA AND LOCATION OF THE MAX AREA.

The area investigated includes 64 square miles of which the larger part is in McLean County and the remainder in Ward County. Max is near the center of the area. The field work for the investigation included a geologic reconnaissance of the area, test drilling, well inventory (table 1), and collection of water samples for chemical analysis. The results of the chemical analyses are shown in table 2.

The average annual precipitation recorded by the United States Weather Bureau (1962, p. 190) for the 33-year period ending December 1961 was 16.79 inches. Most of the precipitation falls as rain during the growing season. The mean annual temperature for the period was 39° F.

Well-Numbering System

The well-numbering system used in this report is illustrated in figure 2 and is based on the location of the well in the federal system of rectangular surveys of the public lands. The first numeral denotes the township north of the base line, the second numeral denotes the range west of the fifth principal 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 tract) as shown in figure 2. Thus well 150-83-15daa is in the NE 1/4 NE 1/4 SE 1/4 sec. 15 T. 150 N., R. 83 W.

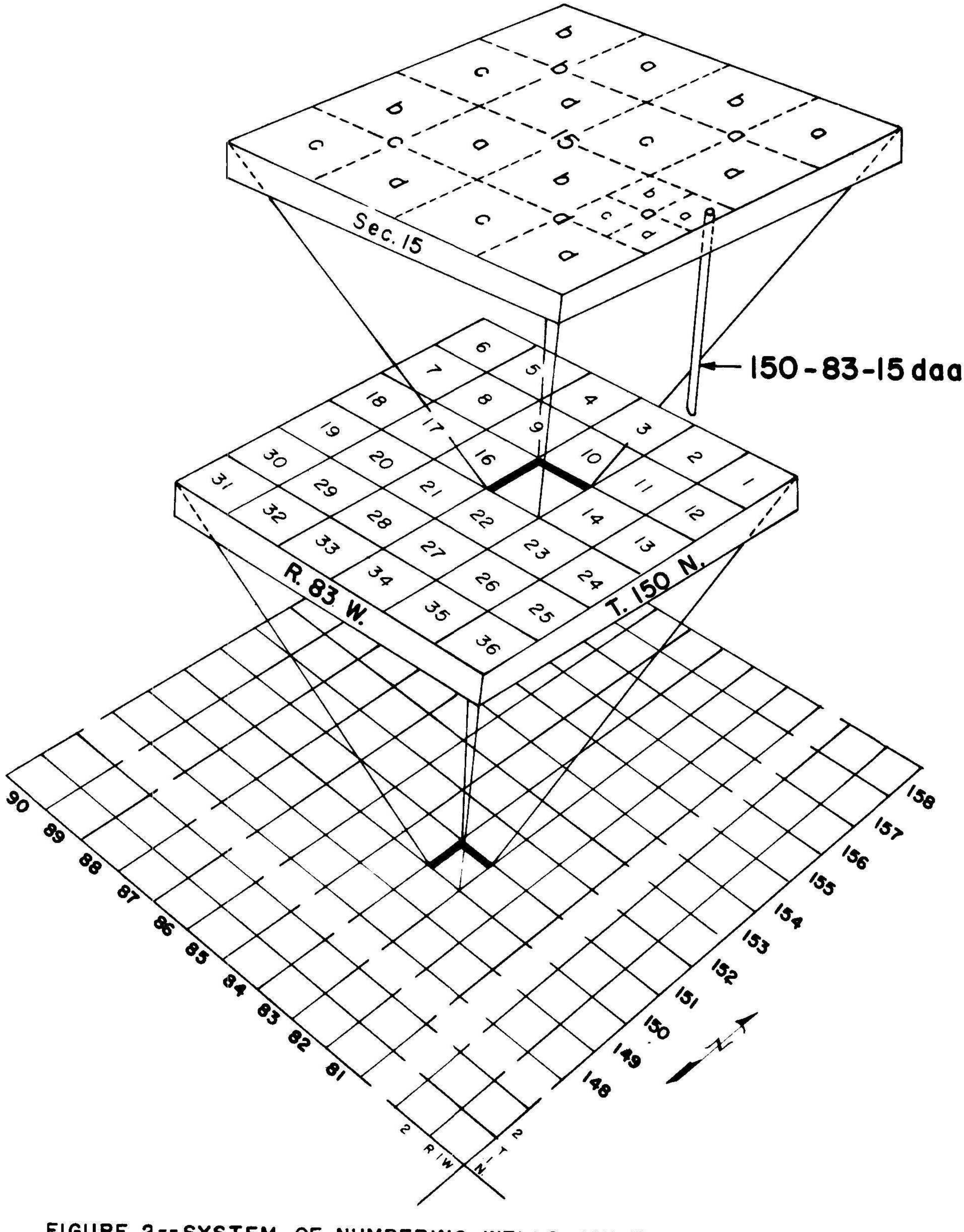

FIGURE 2--SYSTEM OF NUMBERING WELLS AND TEST HOLES.

Geology and Ground Water

Glacial Drift

The report area is in the glaciated part of the Missouri Plateau section of the Great Plains Province (fig. 1) and lies in that part known as the Max moraine. This moraine, 15 to 20 miles wide in the Max area, was formed along the northeast side of the Missouri Plateau apparently as a result of retardation of Pleistocene glaciers by the higher elevation of the plateau. This retardation caused material in and on the glaciers to be deposited in a chaotic profusion of hills and undrained depressions. The measured thickness of the glacial drift penetrated by test holes ranges from 74 feet in test hole 1377 (150-83-10aaa) to more than 220 feet in test hole 1369 (150-83-18aaa). (See table 3.)

Most of the drift is composed of till, a relatively impermeable, heterogeneous mixture of clay, silt, sand, gravel, and boulders that yields little or no water to wells. However, some drift consists of stratified sand and gravel deposits buried within the till, and their capacity to yield water depends on their size and on the amount of replenishment or recharge they receive. If a sand and gravel deposit is completely surrounded by till, it receives recharge slowly; consequently it will not yield large quantities of water for sustained periods. Sand and gravel deposits that are only partly surrounded by till or other impermeable materials, on the other hand, may supply usable quantities of ground water indefinitely. The amount of water that such a deposits will yield depends largely upon its permeability and size.

Figure 3 shows the location of wells and test holes in the Max area. The logs of 4 test holes, 1369, 1370, 1379, and 1380, (table 3) show sand and gravel overlain by till and in most cases underlain by till also. The sand and gravel in holes 1369 and 1370 might be capable of yielding enough water for a small municipal water supply. Further testing will be necessary to determine the quantity and quality of water that is available at these locations. The sand in hole 1379 was fine grained and contained clay; it is probably not a source of enough water for a municipal supply. Gravel was penetrated in the basal 11 feet of the drift in hole 1380. The driller reported that the water level in the hole stood at about the top of the gravel. Unless the gravel deposit is relatively extensive, however, it also is probably inadequate as a source of supply for Max.

Other sources of small ground-water supplies are the ice-contact deposits composed of stratified silt, sand, and gravel that are scattered throughout the area. These deposits commonly form low-rounded to irregular-shaped knolls, but can best be identified by the material in them. The quantity of water that can be obtained from a particular deposit depends on its size; on its permeability; on its storage capacity, which is determined by its porosity; and on the amount of local precipitation and runoff that infiltrates into the deposit. None of the ice-contact deposits in or near Max are large enough to be depended upon for the city's water supply during prolonged periods of drouth when recharge is low, but two local ice-contact deposits are used to supplement the present Max water supply. Well 150-83-16baa1 is 20 feet deep; it was

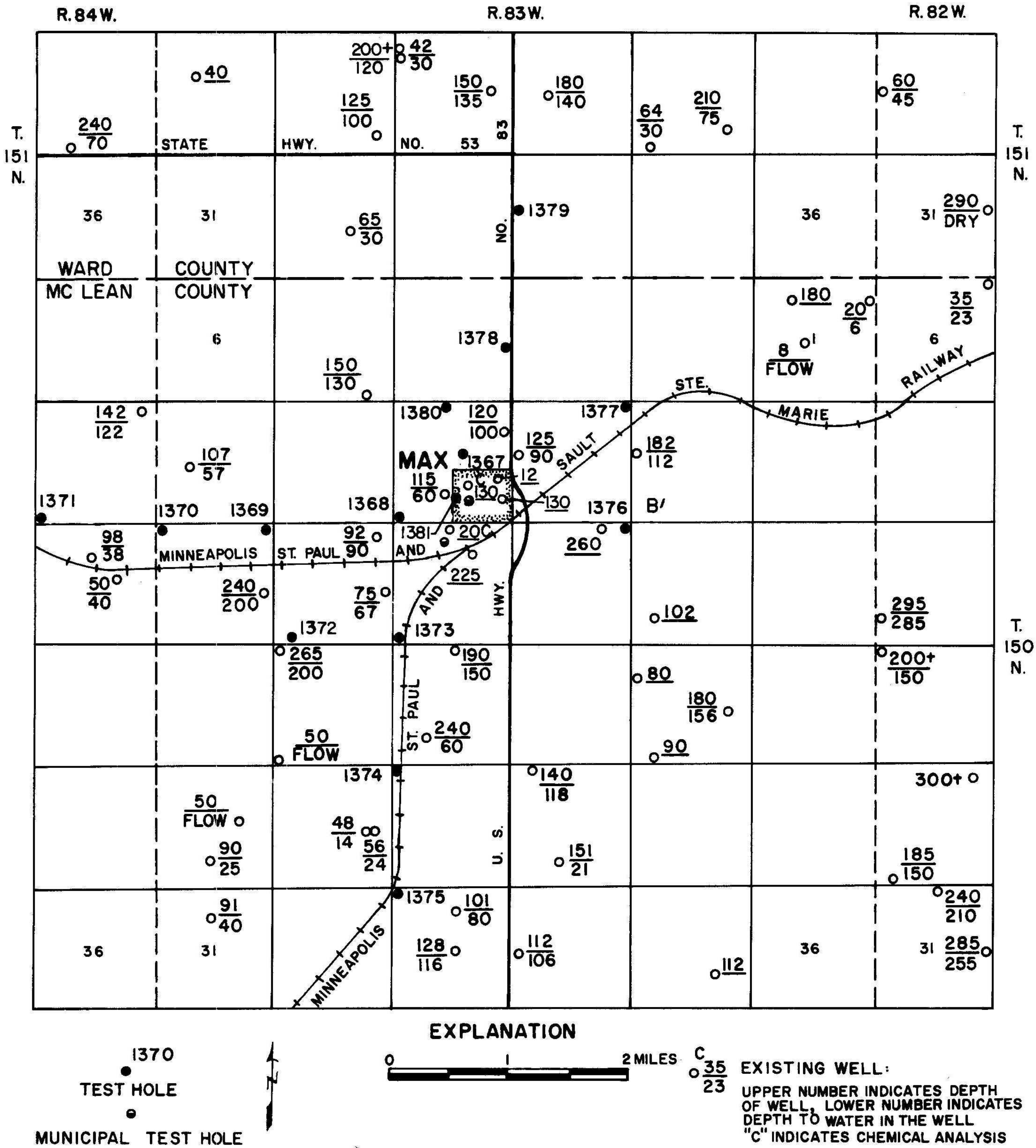

FIGURE 3--MAP OF MAX AREA SHOWING LOCATIONS OF SELECTED WELLS AND TEST HOLES.

dug in an ice-contact deposit consisting of gravel, and it furnishes a part of the city's water supply. Well 150-83-9daa, which is 12 feet deep, was also dug in gravel. It yields only small quantities of water and is not connected to the municipal supply system, but residents of Max carry water from it for culinary use.

Other possible sources of small ground-water supplies are sand and gravel lenses or stringers at the edges of some kettles, which are depressions in the land surface also known as prairie potholes. The sand and gravel deposits were probably formed by the sorting action of melt water from ice blocks that formerly occupied the kettles. The stringers or lenses are generally located only by digging or drilling; because they are not ordinarily exposed and are only a few yards wide; some may be fairly long. Recharge to these shallow aquifers is from local precipitation and runoff. In some deposits the ground water is maintained by water in an adjacent pothole and in some localities water in the potholes may be in part, at least, maintained by water from the shallow aquifers. Generally the deposits yield only a few gallons per minute for relatively short periods, although some of the larger ones may yield small supplies at a nearly steady rate. Wells in such deposits may yield enough water for domestic or stock purposes.

Bedrock Formations

Rocks of the Fort Union Formation of Tertiary age immediately underlie the glacial drift in the Max area. The uppermost beds of this formation are similar to and equivalent to the Tongue River Member as described by Lemke (1960, p. 34). They are composed of gray sandy clay beds interbedded with lignite. In the report area the beds generally dip at a very low angle from the northeast to the southwest. The lack of altitude control as well as the lack of detailed lithologic descriptions in the logs make it difficult and impractical to correlate individual beds within the Tongue River Member. Reported interference between wells in Max that obtain water from lignite beds in the Tongue River Member, however, shows that a degree of hydraulic connection exists, so there is some lateral continuity in the lignite beds at least. Wells yield small supplies from sand beds in a few other parts of the Max area, but the lignite beds are the major sources of water.

The largest part of the Max water supply comes from two drilled wells that tap one of the lignite beds. One well, 150-83-9dda, yields 18 gpm (gallons per minute), which is the maximum reported yield in the report area, and the other well, 150-83-9dba, yields 7 gpm. The yields cannot be sustained indefinitely with both wells pumping simultaneously. During the peak demand for the summer of 1962, 30,000 gallons per day was the maximum quantity of water available. Reports of abandoned wells within the city indicate that perhaps other small-capacity wells could be developed in the bedrock aquifer to supplement the supply, but wide spacing would be necessary to minimize interference between wells.

In parts of North Dakota the Cannonball Member of the Fort Union Formation underlies the Tongue River Member and contains water-producing sand beds, but it has not been identified in the Max area. Simpson (1929, p. 166) gives the log of the Minneapolis, St. Paul, and Sault Ste. Marie Railway well at Max; the well is 2,500 feet deep. Its log shows that shale is present in that part of the section where the Cannonball Member should be. It is probable, therefore, that the sands of this member were not deposited in the Max area. The only water reported in the deep railway well was a "small vein" at 135 feet and another at 250 feet, both of which are in the Tongue River Member. Formations below the Fort Union are either too deep or too impermeable to be considered as practical sources of ground water.

Recharge to both the glacial drift and bedrock aquifers is probably largely from downward seepage of precipitation and runoff on the moraine northeast of Max. Ground water in the Fort Union Formation percolates generally southwestward down the dip of the beds toward the Missouri River valley. This is shown in part by the discharge from springs at some of the lignite outcrops in the escarpment along the northern side of the Missouri River valley.

Quality of Water

Chemical analyses of water samples from 2 wells in the report area are given in table 2. Water from the shallow well (150-83-16baa1) is of better quality than the water from the Fort Union Formation (well 150-83-9dda). In general, the water is probably hard and has a relatively high concentration of iron, bicarbonate, and sulfate.

Summary of Ground-Water Conditions

Wells in the Max area obtain water from either sand and gravel deposits in the glacial drift or from lignite and sand beds in the Tongue River Member of the Fort Union Formation. They supply small amounts of moderately to highly mineralized water for public supply, domestic, and farm use. Ground water occurs in formations older and deeper than the Fort Union Formation, but the formations are too deep or impermeable to be considered as practical sources.

The most promising area for the development of new ground-water supplies is in the vicinity of test holes 1369 and 1370 where probably moderate yields (enough for a small municipal or commercial water supply) can be obtained. Small additional supplies may also be obtained from lignite beds in the Tongue River Member of the Fort Union Formation underlying Max, but widely-spaced wells would be necessary to minimize interference between wells, and the quality of water is apt to be unsatisfactory. Chemical analyses of two ground-water samples suggest that water from the drift is of better quality than water from the Fort Union Formation.

Recharge to shallow aquifers in the drift is derived from water falling on or passing over the surface of the area. Recharge to the bedrock aquifers probably is derived from water percolating downward through the glacial drift in the moraine northeast of Max. The movement of ground water in the bedrock is southwestward toward the Missouri River.

Depth of well and depth to water: Measured depths are given in feet, tenths, and (or) hundredths; reported depths are given in feet.

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

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type
150-82				
6aaa	Matt Semchenko	35	24	Dr
18ccb	Mrs. D. Flitag	295	4	Dr
19bbb	Otto Hauf	200 +	3	Dr
30aa	Mrs. Louis Pede	300 +	4	Dr
30ccd	Wilson Schmidt	185	4	Dr
31abb	Waldo Schmidt	240	4	Dr
31daa	Herman Lange	285	4	Dr
150-83				
1aad	Aleck Bauch	20	36	Du
1bac	Sam Devnich	180	..	Dr
1caa	Mike Zaderaka	8	24	Dr
4daa	Test hole 1378	126	5	Dr
5ddc	M. Philipenkoe	150	6	Dr
7cab	Herbert Biese	107	5	Dr
9acc	Test hole 1367	136	5	Dr
9ada	John Jungling	120	..	Dr
9baa	Test hole 1380	126	5	Dr
9ccc	Test hole 1368	105	5	Dr
9cda	Emil Torno	115	24	Dr
9daa	City of Max	12	48	Du
9dba	....do....	130	..	Dr
9dcb1	Test hole 1381	94	5	Dr
9dcb2	Municipal test hole	500	..	..
9dda	City of Max	130	8	Dr
10aaa	Test hole 1377	84	5	Dr
10bcc	Mrs. Bertha Bevers	125	4	Dr
11bcc	Rudolph Wagner	182	4	Dr
14cca	Andrew Michalenko	102	24	Dr
15aaa	Test hole 1376	105	5	Dr

of wells and test holes

Use of water: D, domestic; P, public supply; S, stock; N, none; T, test hole.

Remarks: Adequate supply means quantity reported sufficient for use indicated.

Date completed	Depth to water below land surface (feet)	Use	Aquifer	Remarks
....	23	D,S	Sand	Adequate supply.
....	285	D,S	......	Adequate supply; alkaline.
....	150	D,S	......	Adequate supply.
....	...	D,S	......	..Do....
....	150	D,S	......	..Do....
1921	210	D,S	"Coal"	..Do....
1918	255	D,S	Sand	Inadequate supply.
....	6	D,S	Gravel	Adequate supply.
....	...	D,S	Sand	..Do....
....	Flow	D,S	..do..	..Do....
9-58	...	T	......	See log.
1918	130	D,S	"Coal"	Adequate supply.
1930	57	S	..do..	..Do....
8-58	...	T	......	See log.
....	100	S	......	Adequate supply; oily film.
9-58	...	T	......	See log.
8-58	...	T	......	..Do....
....	60	D,S	Sand	Adequate supply.
....	...	PS	Gravel	
....	...	PS	"Coal"	Reported yield 7 gpm.
9-58	...	T	......	See log.
1956	...	...	......	..Do....
1954	60	PS	..do..	Reported yield 18 gpm; see chemical analysis.
9-58	...	T	......	See log.
....	90	N	..do..	
....	112	D,S	Gravel	Adequate supply.
....	...	D,S	......	..Do....
9-58	...	T	......	See log.

TABLE 1.--Records of wells

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type
150-83 (Cont.)				
15aab	Clem Haettl	260	6	Dr
16ac	Minneapolis, St. Paul & Sault Ste. Marie Railway	225	..	..
16baa1	City of Max	20	84 x 84	Du
16baa2	Municipal test hole	151	..	Dr
16ccc	Test hole 1373	115.5	5	Dr
17aa	Aleck Vinarckai	92	24	Dr
17ccd	Test hole 1372	115.5	5	Dr
17daa	William Lee	75	24	Dr
18aaa	Test hole 1369	220	5	Dr
18bbb	Test hole 1370	146	5	Dr
18daa	John Wenger	240	4	Dr
20bbb	Ted Wenger	265	3	Dr
20ccc	Carl Schule	50	6	Dr
21abb	Alex Henne	190	5	Dr
21cdb	Merle Lee	240	3	Dr
23bcb	John Finkbiner	80	4	Dr
23ccd	Albert Anderson	90	6	Dr
23dab	Lloyd S. Monson	180	4	Dr
27bba	Emil Bauer	140	6	Dr
27cda	Herbert Songsted	151	4	Dr
28bbb	Test hole 1374	126	5	Dr
29dab1	C. A. Lindquist	48	6	Dr
29dab2	..do....	56	4	Dr
30acd	Mike Kostenko	50	4	Dr
30cda	Gust Oolson	90	4	Dr
31bda	..do....	91	4	Dr
33abc	C. A. Lindquist	101	4	Dr
33bbb	Test hole 1375	147	5	Dr
33dbb	Harry Olson	128	4	Dr
34cbb	Tennes Torgerson	112	4	Dr
35dbd	Victor Zence	112	4	Dr

and test holes -- Continued

Date completed	Depth to water below land surface (feet)	Use	Aquifer	Remarks
....	...	D,S	......	Adequate supply; unfit for irrigation.
....	...	...	......	
....	...	PS	Gravel	See chemical analysis.
1956	...	...	......	See log.
8-58	...	T	......	..Do....
....	90	S	Clay	Inadequate supply.
8-58	...	T	......	See log.
1954	67	D,S	Sand	Inadequate supply.
8-58	...	T	......	See log.
8-58	...	T	......	..Do....
1930	200	D,S	"Coal"	Adequate supply.
1935	200	D,S	..do..	..Do....
....	Flow	S	Gravel	..Do....
1939	150	D,S	Sand	..Do....
1922	60	D,S	..do..	Adequate supply; unfit for drinking.
1939	...	S	......	Inadequate supply.
....	...	D,S	"Coal"	Adequate supply.
1940	156	D,S	..do..	..Do....
1920	118	D,S	......	..Do....
1918	21	S	Sand	..Do....
8-58	...	T	......	See log.
....	14	D,S	Gravel	Adequate supply.
....	24	S	..do..	..Do....
....	Flow	D,S	Sand	..Do....
....	25	D,S	..do..	..Do....
....	40	S	Gravel	Adequate supply; vacant.
....	80	D,S	Sand	Adequate supply.
9-58	...	T	......	See log.
1930	116	D,S	..do..	Inadequate supply.
1913	106	D,S	"Coal"	..Do....
....	...	D,S	..do..	Adequate supply.

TABLE 1.--Records of wells

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type
150-84				
12aa	Jacob Finkheiner	142	4	Dr
12ccc	Test hole 1371	105	5	Dr
13acd	George Day	50	4	Dr
13bda	..do....	98	4	Dr
151-82				
30bcc	Matt Gruzensky	60	4	Dr
31add	Jake Van Winkle	290	4	Dr
151-83				
26ccd	George Fannik	64	3	Dr
26ddb	Jack Fannik	210	4	Dr
27cab	Ed Kabanuck	180	4	Dr
28adc	Fred Strilcov	150	2.5	Dr
28bbc1	John Kabanuck	42	4	Dr
28bbc2	..do....	200 +	4	Dr
29dd	Steve Bokovaa	125	4	Dr
30bdb	Ervin Batke	40	24	Dr
32db	Arnold Schmidt	65	4	Dr
34bcc	Test hole 1379	168	5	Dr
151-84				
25cdc	Ed Sambor	240	4	Dr

and test holes -- Continued

Date completed	Dapth to water below land surface (feet)	Use	Aquifer	Remarks
1940	122	D,S	Sand	Adequate supply.
8-58	...	T	......	See log.
1913	40	D,S	..do..	Inadequate supply.
....	38	D,S	..do..	Adequate supply.
....	45	D,S	..do..	..Do....
....	Dry	D,S	..do..	
....	30	D,S	......	..Do....
1958	75	D,S	..do..	..Do....
....	140	D,S	"Coal"	..Do....
1925	135	D,S	Sand	..Do....
1953	30	D,S	Clay	..Do....
1944	120	D,S	..do..	..Do....
1908	100	S	Sand	Inadequate supply.
1900	...	D,S	Gravel	Adequate supply.
....	30	D,S	Sand	..Do....
9-58	...	T	......	See log.
1955	70	D,S	"Coal"	Adequate supply.

TABLE 2.--Chemical

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

Results in parts per million except as indicated.

Location	Geologic source	Depth of well (feet)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
150-83										
9dda	Tft	130	2-5-63	14	2.4	95	119	371	11	940.0
16baal	D	20	2-5-63	17	0.1	89	62	27	11	435

analyses of ground water

Analyses by State Laboratories, Bismarck, N. Dak.

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
None	778	7.8	0.3	0	0.3	2,008.0	728	52	2,745	6.8
None	187	14	0.2	0.5	0.28	748	478	11	1,057	7.4

TABLE 3.--Logs of test holes

Test hole 1378
150-83-4daa

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	3	3
	Till; clay, yellow to light brown, a few pebbles	40	43
	Till; clay, gray, fine gravel, shale pebbles	69	112
	Gravel, fine to medium	3	115
Fort Union Formation:			
	Clay, sandy, gray	11	126

Test hole 1367
150-83-9acc

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	5	5
	Till; clay, sandy, and pebbly, yellow to brown, oxidized	17	22
	Till; clay, gray, fine gravel, shale pebbles	69	91
	Gravel, fine to medium	1	92
	Till; clay, gray, fine gravel, shale pebbles	37	129
	Lignite	2	131
Fort Union Formation:			
	Shale, gray	5	136

Test hole 1380
150-83-9baa

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Gravel, fine	7	8
	Till, clay, yellow, fine gravel	9	17
	Till; clay, gray, fine to medium gravel, shale pebbles	87	104
	Gravel, fine to medium, slightly indurated	11	115
Fort Union Formation:			
	Clay, sandy, gray, lignite	11	126

TABLE 3.--Logs of test holes -- Continued

Test hole 1368
150-83-9ccc

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black----------------------	2	2
	Till; clay, light-yellow gray, oxidized----------------------	5	7
	Till; clay, grayish-brown, fine to medium gravel, oxidized-----	14	21
	Till; clay, gray, fine to medium gravel, shale pebbles----------	42	63
	Till; clay, gray, fine gravel, shale pebbles-----------------	21	84
	Till; clay, light-yellowish-gray, fine to medium gravel, shale pebbles, oxidized-------------	10	94
Fort Union Formation:			
	Lignite-------------------------	2	96
	Shale, gray---------------------	9	105

Test hole 1381
150-83-9dcb1

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black----------------------	3	3
	Till; clay, light yellowish-gray to yellow, a few coarse sand grains------------------------	18	21
	Till; clay, gray, fine gravel, shale pebbles-----------------	35	56
	Gravel, fine to medium-----------	2	58
	Till; clay, gray, fine gravel, shale pebbles-----------------	10	68
	Till; clay, brownish-gray, fine gravel, shale pebbles----------	18	86
Fort Union Formation:			
	Clay, sandy, gray---------------	8	94

TABLE 3.--Logs of test holes -- Continued

Municipal Test hole
150-83-9dcb2
(Log furnished by C. A. Simpson
and Sons, Bisbee, N. Dak.)

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, gravelly, yellow and rocks (till)	48	48
	Clay, sandy, blue and rocks (till)	39	87
	Rock	2	89
Fort Union Formation:			
	Clay or shale, gray with some coal	23	112
	Clay, yellow	5	117
	Clay, gray with coal slack layers	83.5	200.5
	Rock layer, hard	2.5	203
	Shale, slightly sandy, gray	29	232
	Shale, light-gray	9	241
	Shale, brown, hard with coal particles	7	248
	Shale, gray	26	274
	Shale, brown	4	278
	Shale, light-green	4	282
	Shale, slightly sandy, gray	14	296
	Hard layer	1	297
	Shale, gray with coal and hard layers	12	309
	Coal	6	315
	Shale, gray with few hard layers	60	375
	Coal	3	378
	Shale, gray	11	389
	Shale, brown, rather hard	5	394
	Shale, gray	24	418
	Coal	3	421
	Shale, gray	14	435
	Coal	6	441
	Shale, gray	13	454
	Shale, slightly sandy, gray	9	463
	Shale, gray	29	492
	Shale, sandy, gray	8	500

TABLE 3.--Logs of test holes -- Continued

Test hole 1377
150-83-10aaa

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black-------------------	4	4
	Till; clay, yellowish-gray, fine gravel------------------	18	22
	Till; clay, dense, gray, fine to medium gravel-------------	24	46
	Clay, light-gray---------------	9	55
	Till; clay, gray, fine to medium gravel----------------	19	74
Fort Union Formation:			
	Clay, sandy, gray--------------	10	84

Test hole 1376
150-83-15aaa

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black-------------------	2	2
	Till; clay, yellowish-gray, fine to medium gravel--------	29	31
	Till; clay, gray, fine gravel, shale pebbles----------------	10	41
	Till; clay, yellowish-gray, fine gravel, shale pebbles---	6	47
	Clay, sandy, light-gray--------	6	53
	Till; clay, gray, fine gravel to cobbles-------------------	44	97
Fort Union Formation:			
	Clay, sandy, gray--------------	8	105

TABLE 3.--Logs of test holes -- Continued

Municipal test hole
150-83-16bac2
(Log furnished by C. A. Simpson
and Sons, Bisbee, N. Dak.)

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, brown---------------------	2	2
	Clay, gravelly, yellow----------	3	5
	Sand and gravel, clayey---------	6	11
	Clay, blue, some sandy----------	80	91
	Clay and boulders---------------	2	93
	Clay, very gravelly-------------	24	117
	Clay, gravelly------------------	9	126
Fort Union Formation:			
	Shale, gray with coal flakes----	25	151

Test hole 1373
150-83-16ccc

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black---------------------	1	1
	Till; clay, yellow, slightly oxidized, fine gravel---------	39	40
	Till; clay, brownish-gray, fine gravel, shale pebbles---------	67	107
Fort Union Formation:			
	Clay, sandy, gray---------------	8.5	115.5

TABLE 3.--Logs of test holes -- Continued

Test hole 1372
150-83-17ccd

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	5	5
	Till; clay, yellowish-gray, fine to coarse gravel	11	16
	Till; clay, gray, fine to medium gravel	26	42
	Gravel, coarse	1	43
	Till; clay, gray, fine to medium gravel	56	99
Fort Union Formation:			
	Clay, sandy, gray	16.5	115.5

Test hole 1369
150-83-18aaa

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black----------------------	3	3
	Till; clay, yellow, medium to coarse sand and a few pebbles, oxidized---------------------	19	22
	Till; clay, gray, fine to medium gravel, shale pebbles, lignite fragments------------	68	90
	Till; clay, light-grown, coarse sand and pebbles--------------	30	120
	Gravel, fine to medium, silty, lignite fragments------------	6	126
	Till; clay, gray, fine gravel, shale pebbles-----------------	11	137
	Sand, indurated lenses interbedded with till-------------	8	145
	Till; clay, gray, fine gravel, shale pebbles-----------------	2	147
	Gravel, fine, large concentration of shale granules, lignite fragments--------------------	9	156
	Till; clay, gray, fine gravel, shale pebbles, lignite fragments--------------------	16	172
	Sand, indurated lens------------	2	174
	Till; clay, gray, fine gravel, shale pebbles and lignite fragments--------------------	9	183
	Till; clay, gray, fine gravel consisting largely of shale granules, lignite fragments---	5	188
	Till; clay, gray, fine gravel, shale pebbles, and lignite fragments--------------------	23	211
	Till; clay, sandy, fine gravel, shale and lignite fragments---	9	220

TABLE 3.--Logs of test holes -- Continued

Test hole 1370
150-83-18bbb

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black--------------------	1	1
	Till; clay, yellowish-gray-----	8	9
	Till; clay, yellowish, fine to medium gravel---------------	24	33
	Till; clay, gray, fine to coarse gravel-----------------------	75	108
	Sand, coarse, fine gravel and lignite----------------------	15	123
	Till; clay, gray, lignite fragments--------------------	5	128
Fort Union Formation:			
	Shale, clay, sandy, gray--------	8	136
	Lignite (core)-----------------	10	146

Test hole 1374
150-83-28bbb

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black--------------------	3	3
	Till; clay, yellowish-gray, fine to medium gravel--------------	41	44
	Till; clay, gray, fine to medium gravel-----------------------	40	84
	Till; clay, brownish-gray, fine to medium gravel-------------	37	121
Fort Union Formation:			
	Clay, sandy, gray--------------	5	126

TABLE 3.--Logs of test holes -- Continued

Test hole 1375
150-83-33bbb

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	3	3
	Till; clay, yellowish-gray, fine to medium gravel, slightly oxidized	7	10
	Till; clay, yellow, fine to medium gravel, slightly oxidized	12	22
	Till; clay, gray, a little fine to coarse gravel, shale pebbles	62	84
	Till; clay, light-brown, a little fine to medium gravel, slightly oxidized	18	102
	Sand, coarse, and fine gravel, consisting of shale granules	3	105
	Till; clay, gray, fine gravel and shale pebbles	32	137
Fort Union Formation:			
	Clay, sandy, gray	10	147

Test hole 1371
150-84-12ccc

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till; clay, gray, small amount of sand	6	7
	Till; clay, light-yellowish-brown, fine to medium gravel	11	18
	Till; clay, gray, fine to medium gravel, shale pebbles	67	85
Fort Union Formation:			
	Clay, grayish- to greenish-brown, fine to medium sand	20	105

TABLE 3.--Logs of test holes -- Continued

Test hole 1379
151-83-34bcc

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Soil, black	1	1
	Till; clay, yellowish-gray and fine to medium gravel	15	16
	Till; clay, gray, and fine gravel	78	94
	Till; sand and clay	11	105
	Sand, fine, and clay	10	115
Fort Union Formation:			
	Clay, sandy, yellowish-gray	53	168

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