STATE OF SOUTH DAKOTA
Richard Kneip, Governor

DEPARTMENT OF NATURAL RESOURCE DEVELOPMENT
Vern W. Butler, Secretary

GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Special Report 58

GROUND-WATER INVESTIGATION FOR THE CITY OF GROTON, SOUTH DAKOTA

by

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INTRODUCTION

Present Investigation

This report contains the results of a special investigation conducted by the South Dakota Geological Survey from June 6 to June 15, 1972, in and around the city of Groton, Brown County, South Dakota. It is the 58th in a continuing series of investigations to assist the cities in South Dakota in locating their future water supplies.

Groton now obtains water from four wells within the city limits. These wells yield water from the Dakota Formation which is at a depth of approximately 1,000 feet below the land surface.

Included in the survey of the Groton area were: (1) geologic mapping of the area, (2) the drilling of 13 auger holes and 2 rotary test holes, (3) a well inventory, and (4) the collection and analyses of 9 water samples.

As a result of this study it was found, within the study area, that the Dakota Formation is the only aquifer that can provide adequate water for city use.

The cooperation of the residents of Groton, especially the city officials, Mayor F. Gravatt, City Auditor H. T. Foss, and Superintendent of Light and Water William D. Johnson, is greatly appreciated. The assistance of the local driller, M. Olson, is also acknowledged.

The project was financed by the South Dakota Geological Survey, Oahe Conservancy Sub-District, and the city of Groton.

Location and Extent of Area

The city of Groton is located in northeast South Dakota in Brown County which is in the Lake Dakota Plain division of the James Basin of the Central Lowlands Physiographic Province (fig. 1). The Groton study area is 20 square miles in size, measuring 4 miles north-south and 5 miles east-west.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Groton area include alluvium and lake sediments (fig. 2). In this area alluvium, consisting of sand and clay, is present along some of the tributaries to Mud Creek.

Lake sediments were deposited in Lake Dakota, a Pleistocene lake of glacial origin. The sediments consist of silt, clay, and very fine sand. The results of test hole drilling in the area indicate that in most locations glacial deposits are present beneath the lake sediments. Glacial deposits are collectively termed drift which is divisible into two broad lithologic groups, till and outwash. Till, commonly called "boulder clay," "blue clay," or "gumbo," consists of unsorted material that ranges from boulder to clay size and was deposited directly by the ice. Outwash is a more homogeneous material, consisting primarily of sand and gravel with minor amounts of silt and clay which was deposited by meltwater issuing from a glacier.

Test holes drilled during the study indicate that the maximum thickness of lake sediment and glacial deposits is 133 feet (test hole 12, app. A; for map location of test holes, see fig. 3).

Subsurface Bedrock

No bedrock is exposed in the study area, but data obtained from limited well logs in the region reveal that Cretaceous stratified sedimentary rocks underlie glacial drift. These deposits in descending order are the Pierre Shale, Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, Dakota Formation, and possibly the Skull Creek and Fall River Formations.

Pierre Shale consists of light- to dark-gray clayey shale and is approximately 50 feet thick. Beneath the Pierre Shale is approximately 110 feet of Niobrara Marl.

The Carlile Shale underlies the Niobrara Marl and consists of light-gray to dark-gray shale interbedded with silt and sand. The approximate thickness of this formation is 250 feet thick.

Greenhorn Limestone is a light-colored, hard limestone. The approximate thickness of this formation is 40 feet.

Graneros Shale underlies the Greenhorn Limestone and is approximately 240 feet thick. The Dakota Formation, also approximately 240 feet thick, is a sequence of alternating sand, sandstone, and shale beds.

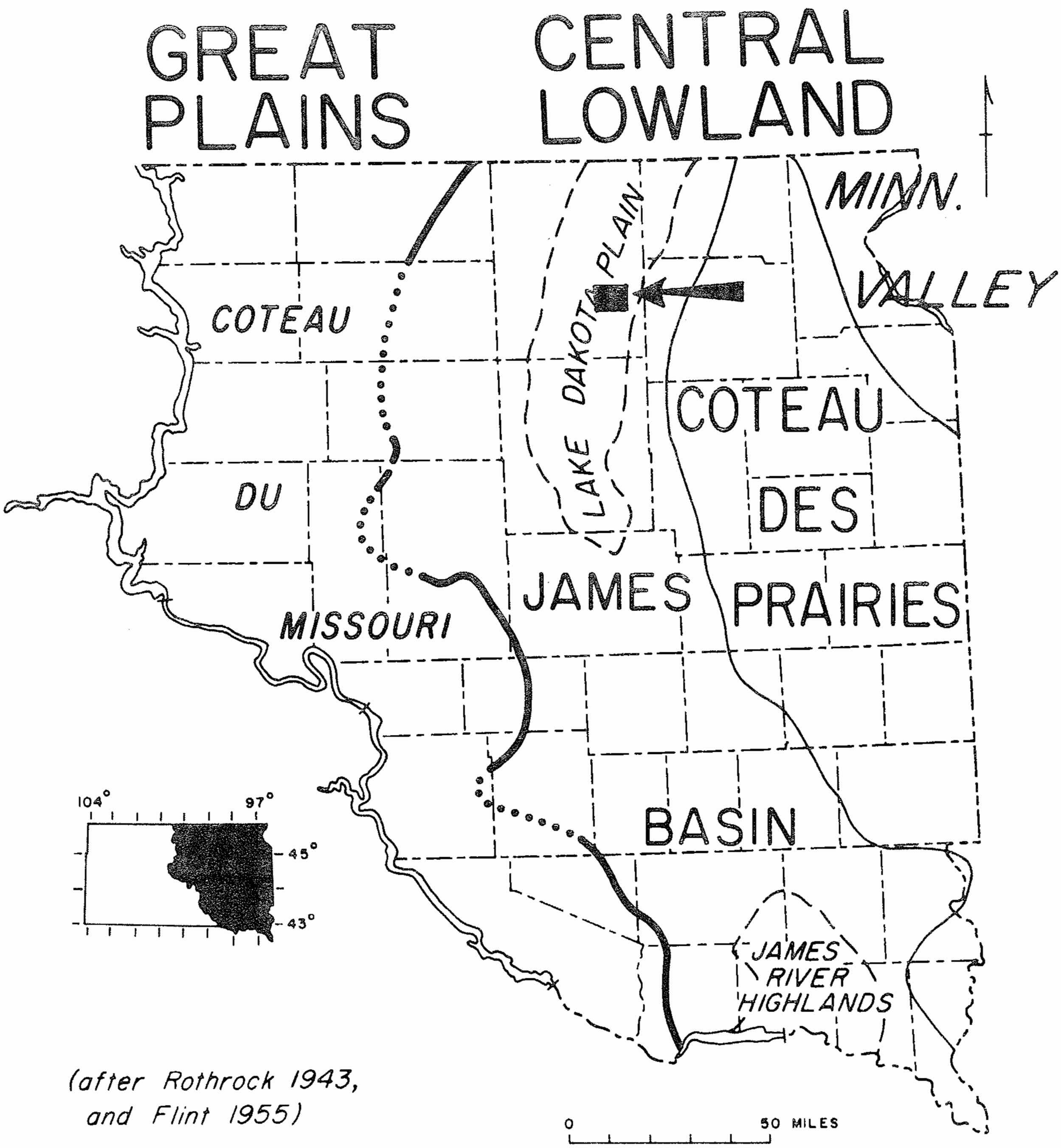
More data are required to determine the presence and thickness of the Skull Creek and Fall River Formations.

Precambrian rocks underlie the above sedimentary rocks.

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Ground water is defined as water contained in the voids or openings within rocks or sediments below the water table. Practically all open spaces in the



■ Groton area

Figure I. Map of eastern South Dakota showing the major physiographic divisions and location of the Groton area.

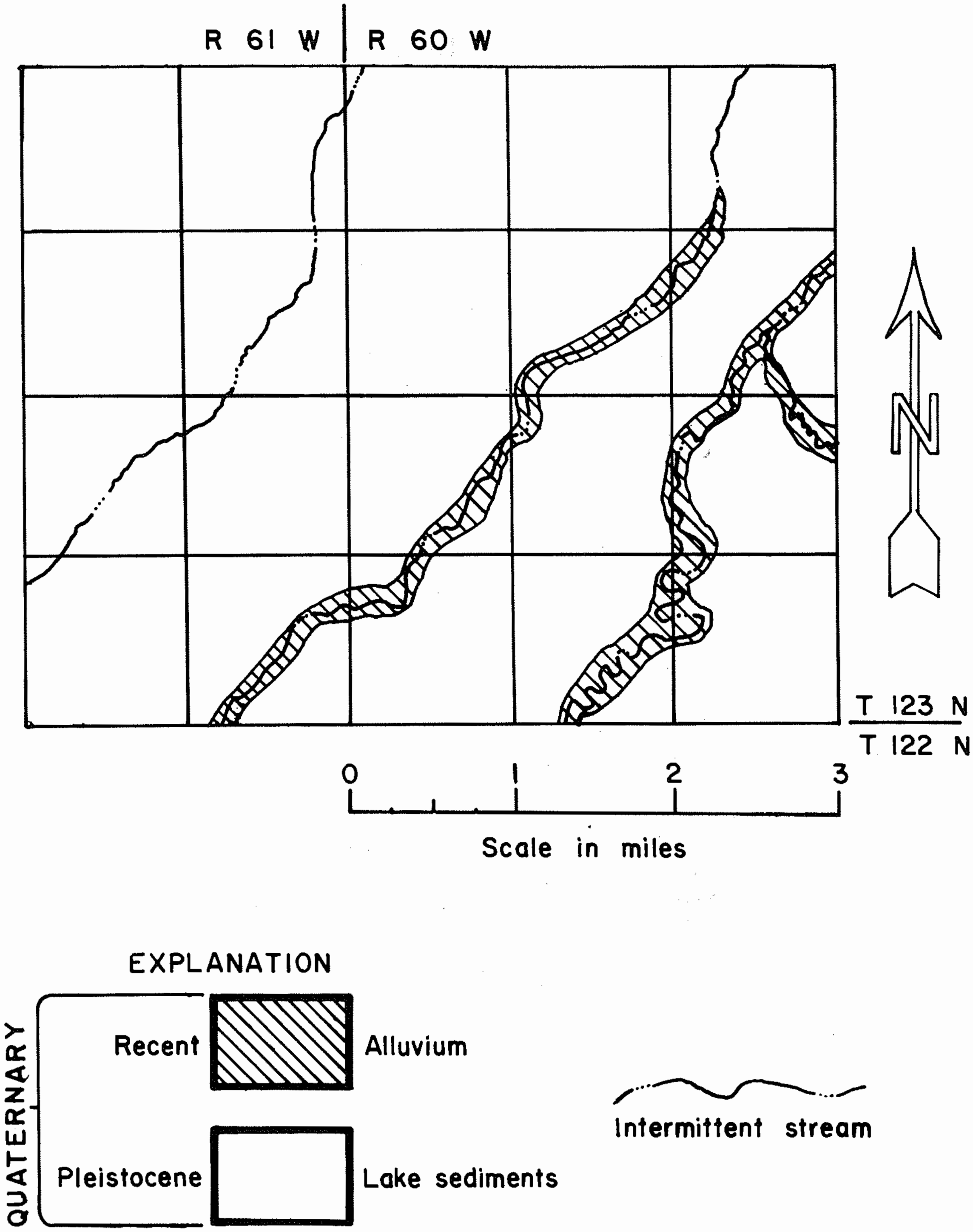


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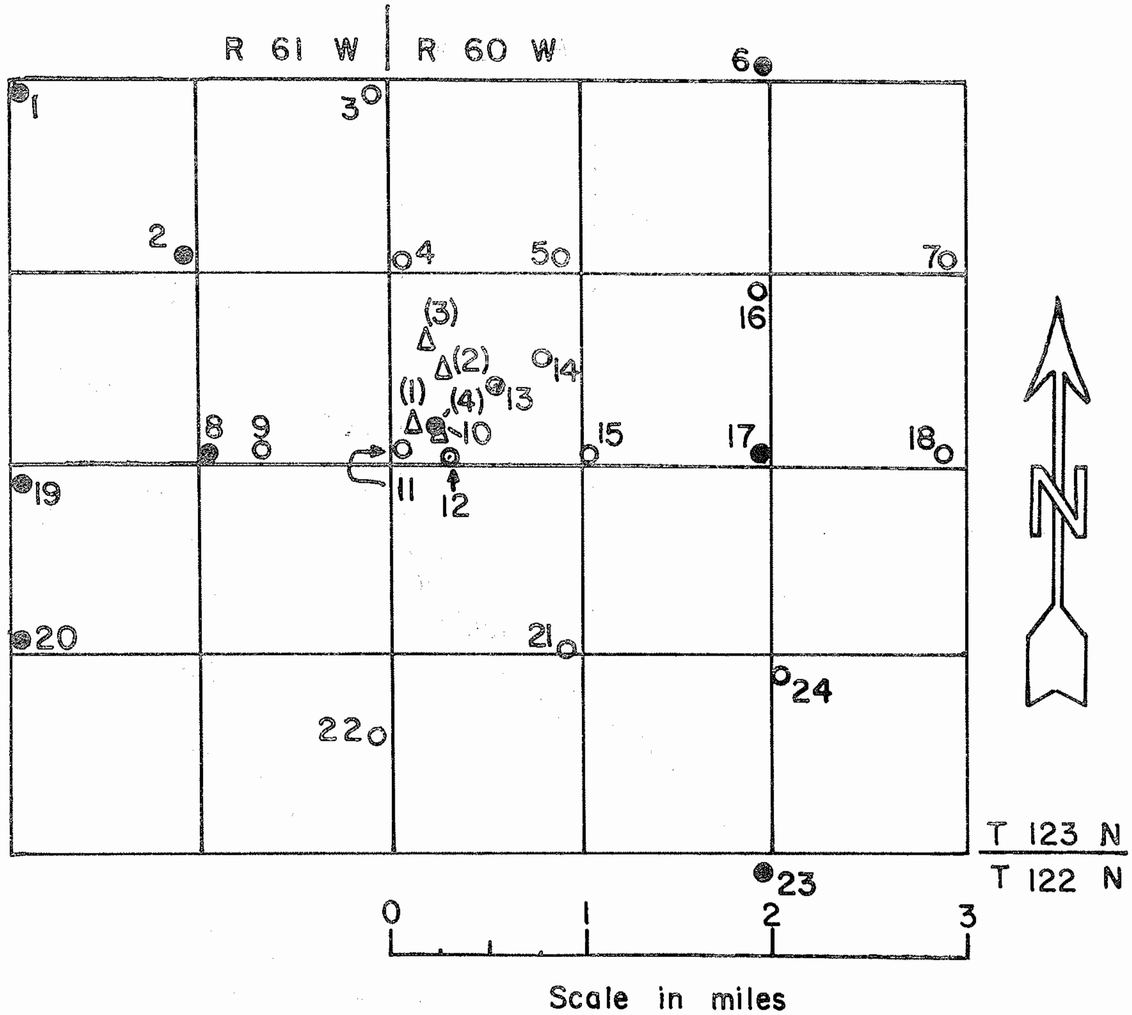
Figure 2. Generalized geologic map of the Groton area.



EXPLANATION

- ●1 Auger test hole, 1971
- ◎5 Auger test hole, 1972
- ○13 Rotary test hole, 1972

Numbers refer to test holes listed in Appendix A.

Δ(1) City well number 1

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Figure 3. Map showing location of rotary and auger test holes and city wells in the Groton area.

rocks that lie below the water table are filled with water; this is called the zone of saturation. The water table is the upper surface of the zone of saturation and is in equilibrium with atmospheric pressure. Water that occurs in the rocks (and soil) that lie above the water table is in the zone of aeration because some of the open spaces in this zone are filled with air; the remaining portion contains water. This water is either held by molecular attraction, returned to the atmosphere by plant use, or is moving downward toward the zone of saturation. Water within the ground above the saturated zone moves downward under the influence of gravity, whereas in the saturated zone it moves in a direction determined by the hydraulic gradient.

Contrary to popular belief, ground water does not occur in "veins" that crisscross the land at random. Instead it can be shown that water is found nearly everywhere beneath the surface, but at varying depths.

Nearly all ground water is derived from precipitation in the form of rain, snow, or ice. This water either evaporates, percolates directly downward to the water table and becomes ground water, or drains off as surface water. Surface water either evaporates, escapes to the ocean by streams, or percolates downward into the rocks.

Recharge is the addition of water to an aquifer (a deposit having structures that permit appreciable water to move through it under ordinary field conditions). Recharge to an aquifer is accomplished in four general ways: (1) by downward percolation of precipitation from the ground surface, (2) by downward percolation from surface bodies of water, (3) by lateral movement of ground water into the area, and (4) by artificial recharge, which takes place from excess irrigation, seepage from canals, and water purposely applied to augment ground-water supplies.

Discharge of ground water from an aquifer is accomplished in four ways: (1) by evaporation and transpiration by plants, (2) by seepage upward or laterally into surface bodies of water, (3) by lateral movement of ground water out of the area, and (4) by pumping from wells, which constitutes the major artificial discharge of ground water.

Porosity of a rock or soil is a measure of contained open pore spaces and is expressed as the percentage of void spaces to the total volume of the rock. Porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of sorting of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) the removal of mineral matter through solution by percolating waters, and (5) the fracturing of the rocks, resulting in joints and other openings. Thus, the size of the material has little or no effect on porosity if all other factors are equal.

Permeability of a rock is its capacity for transmitting a fluid. Water will pass through a material with interconnected pores, but will not pass through material with unconnected pores, even if the latter material has a higher porosity. Therefore, permeability and porosity are not synonymous terms.

Ground Water in Surficial Deposits

Because of minimum thickness and high clay content, alluvial deposits are not capable of yielding large quantities of water in the area. Lake deposits, because of high clay content and very fine sand, likewise cannot produce a large volume of water. Outwash, a highly permeable deposit, may become an aquifer if it has enough thickness and extent, but the study did not reveal an extensive deposit capable of yielding significant water for city use.

Ground Water in Bedrock

The Dakota Formation and the Fall River Formation (if it is present) are the only aquifers capable of producing large quantities of water. The top of the Dakota Formation is approximately 800 feet below the land surface. Water in this formation is under pressure. Artesian wells which have higher hydraulic head than the ground surface yield water to flowing wells in the area.

Quality of Ground Water

Ground water always contains dissolved chemicals. These chemicals are derived from (1) the atmosphere as water vapor condenses and falls, (2) the soil and underlying deposits as the water moves downward to the water table, and (3) the rocks below the water table. In general, the more chemical substances that a water contains, the poorer its quality.

Table 1 shows the chemical quality of water samples collected in the Groton area (for map location, see fig. 4). Sample W-3 was collected from an 80-foot deep well. This well is yielding water from a glacial sand lense. Total solids, manganese, and chloride content is higher than the recommended limits set by the South Dakota Department of Health. All other analyzed chemicals are within the limits. Sulfate in this sample is less than other samples collected in the study area.

Sample W-8 was collected from a well in lake sediments. This sample has very high total solids, sulfate, and hardness. Also, manganese and chloride are higher than the recommended limits.

Samples W-1, W-2, W-4, W-5, W-6, W-7, and W-9 were collected from wells ranging in depth from

Table 1. Chemical Analyses of Water Samples from the Groton Area

Sample	Depth	Parts Per Million											
		Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate Nitrogen	Fluoride	pH	Hardness $CaCO_3$	Total Solids
A	----	----	----	----	250	500[1]	0.3	0.05	10.0	0.9-1.7[2]	----	----	1000[1]
W-1	1200	60		33	116	1175	0.08	0.40	1.07		7.5	286	1768
W-2	1100	118		10	109	1100	1.89	0.58	0.08		7.6	333	2164
W-3	80	103		51	447	300	0.06	0.58	1.28		7.8	466	1732
W-4	1050	37		33	200	1250	0.06	0.30	0.89		7.1	228	2180
W-5	1160	81		21	116	1450	0.08	0.40	1.11		7.9	286	2244
W-6	1000	92		99	120	1200	0.12	0.35	0.05		7.8	633	2196
W-7	1000	116		114	151	1275	0.06	0.30	0.63		7.6	757	2220
W-8	28	552		138	513	2275	0.10	0.40	1.50		7.7	1942	4396
W-9	900 to 1000	27			27	950	0.06	0.51	0.03		8.2	71	2204

A. Drinking Water Standards, U.S. Public Health Service (1962).

Samples W-3 and W-8 were collected from sand lenses in glacial deposits. All other samples were collected from wells yielding water from the Dakota Formation.

[1] Modified for South Dakota by the Department of Health (written communication, Water Sanitation Section, September 24, 1968).

[2] 1.2 is optimum for South Dakota.

All water samples were analyzed by the South Dakota Geological Survey.

The above water samples were not analyzed for sodium and fluoride.

Location of Water Samples
(For map location, see fig. 4)

W-1 SE¼NE¼NE¼NE¼ sec. 14, T. 123 N., R. 61 W., E. G. Mallett.

W-2 SE¼SE¼SE¼SW¼ sec. 14, T. 123 N., R. 61 W., A. Voight.

W-3 SW¼SE¼SW¼ sec. 18, T. 123 N., R. 60 W., M. Olson.

W-4 SW¼SE¼SW¼ sec. 18, T. 123 N., R. 60 W., M. Olson.

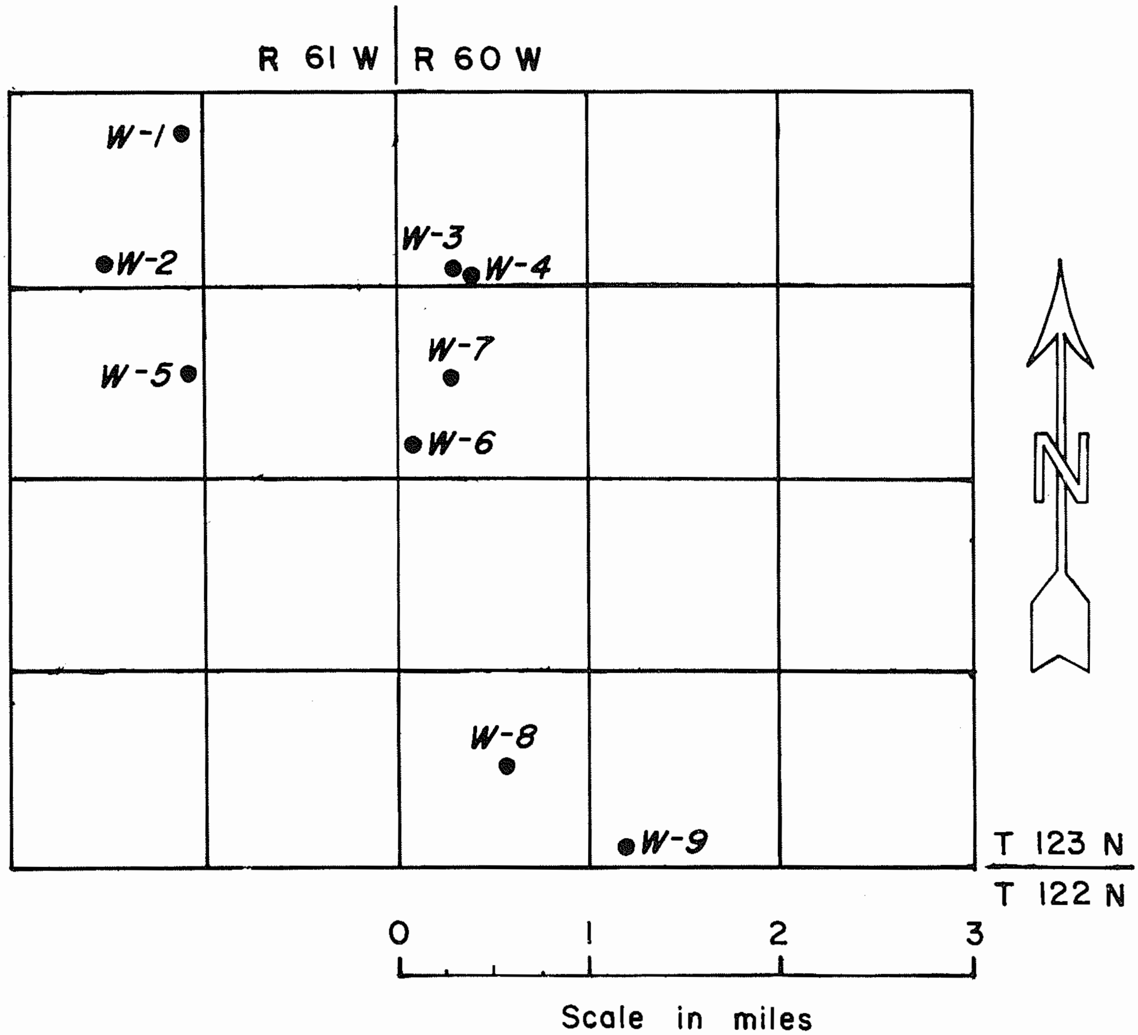
W-5 SE¼SE¼SE¼NE¼ sec. 23, T. 123 N., R. 61 W., B. Anderson.

W-6 SW¼SW¼ sec. 19, T. 123 N., R. 60 W., City of Groton Well No. 1.

W-7 SE¼NW¼ sec. 19, T. 123 N., R. 60 W., City of Groton Well No. 2.

W-8 NW¼NW¼SE¼ sec. 31, T. 123 N., R. 60 W., O. Huffman.

W-9 SW¼SE¼SW¼ sec. 32, T. 123 N., R. 60 W., P. Frommel.



EXPLANATION

● W-7 Location of water samples *(numbers refer to water samples in Table 1).*

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Figure 4. Map showing location of water samples collected in the Groton area.

1,000 to 1,200 feet. The chemical quality of these samples is generally comparable. All samples have high sulfate, total solids, and manganese. Iron content is higher than the recommended limits in sample W-2. The remaining analyzed chemicals are within the limits set by the State of South Dakota. Samples W-6 and W-7 were collected from city wells No. 1 and 2.

Table 2 shows the significance of some physical and chemical properties of drinking water.

CONCLUSIONS AND RECOMMENDATIONS

The Dakota Formation is the only major aquifer in the study area. Small sand lenses in glacial drift are not expected to yield adequate water for city use. With the limited deep hole data, the existence and thickness of the Fall River Formation cannot be determined. Also, it cannot be concluded that the water from wells drilled to depths of 1,000 to 1,200 feet are all from the Dakota Formation or a mixture of the Dakota and Fall River Formations.

If the city should decide to drill additional well(s) into the Dakota Formation, it is recommended that a short pump test be conducted in well No. 3 with the city well No. 2 as an observation well (because of repair on city well No. 1 during the study, the pump test could not be performed). The test should be conducted for approximately 24 hours. The data from the test will provide information on the optimum spacing of future wells. The South Dakota Geological Survey will conduct the test when the city decides to drill an additional well.

Dissolved chemicals from the Dakota Formation are generally high. It is recommended that the city of Groton consult an engineering firm and the Environmental Protection Agency with regard to the cost of water treatment to remove some of these chemicals.

Because most of the water in the study area has high dissolved chemicals, it is also recommended that the town officials consult the Oahe Conservancy Sub-District for information concerning a rural water system. Such a system could provide good quality water from a distant source, or treated water from the city could furnish water for the city and the nearby farms.

Before a permanent well is drilled, the town officials should consult the Division of Water Rights, Deparment of Natural Resource Development, Pierre, South Dakota, to obtain water rights and a permit to drill a municipal well, and the Environmental Protection Agency to determine biological and chemical suitability of the water.

REFERENCES CITED

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Jorgensen, D. G., 1966, Ground-water supply for the city of Lake Norden: S. Dak. Geol. Survey Special Report 34, 27 p., 6 figs.

Rothrock, E. P., 1943, A geology of South Dakota, Part I: The Surface: S. Dak. Geol. Survey Bull. 13, 88 p.

U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service 956, 61 p.

Table 2.--Significance of some chemical and physical properties of drinking water.

Chemical Constituents	Significance	Recommended Limits (ppm)[1]
Calcium (Ca) and Magnesium (Mg)	Cause most of the carbonate hardness and scale-forming properties of water by combining with carbonate and bicarbonate present in the water. Seldom can be tasted except in extreme concentrations.	Ca—None Mg—None
Sodium (Na)	Large amounts in combination with chloride will give water a salty taste. Large amounts will limit water for irrigation and industrial use.	None
Chloride (Cl)	Large amounts in combination with sodium give water a salty taste. Large quantities will also increase corrosiveness of water.	250
Sulfate (SO_4)	Large amounts of sulfate in combination with other ions give a bitter taste to water and may act as a laxative to those not used to drinking it. Sulfates of calcium and magnesium will form hard scale. U. S. Public Health Service recommends 250 ppm maximum concentration.	500[2]
Iron (Fe) and Manganese (Mn)	In excess will stain fabrics, utensils, and fixtures and produce objectionable coloration in the water. Both constituents in excess are particularly objectionable.	Fe—0.3 Mn—0.05
Nitrate Nitrogen (N)	In excess may be injurious when used in infant feeding. The U. S. Public Health Service regards 45 ppm as the safe limit of nitrate (NO_3) or 10 ppm nitrate nitrogen (N).	10
Fluoride (F)	Reduces incidence of tooth decay when optimum fluoride content is present in water consumed by children during period of tooth calcification. Excessive fluoride in water may cause mottling of enamel.	0.9-1.7[3]
pH	A measure of the hydrogen ion concentration; pH of 7.0 indicates a neutral solution, pH values lower than 7.0 indicate acidity, pH values higher than 7.0 indicate alkalinity. Alkalinity tends to aid encrustation and acidity tends to aid corrosion.	None
Hardness	Hardness equivalent to carbonate and bicarbonate is called carbonate hardness. Hardness in excess of this amount is noncarbonate hardness. Hardness in water consumes soap and forms soap curd. Will also cause scale in boilers, water heaters, and pipes. Water containing 0-60 ppm hardness considered soft; 61-120 ppm moderately hard; 121-180 ppm hard, and more than 180 ppm very hard. Good drinking water can be very hard.	None
Total Solids	Total of all dissolved constituents. U. S. Public Health Department recommends 500 ppm maximum concentration. Water containing more than 1000 ppm dissolved solids may have a noticeable taste; it may also be unsuitable for irrigation and certain industrial uses.	1000[2]

Modified from Jorgensen (1966).
[1] (ppm) parts per million.
[2] Modified for South Dakota by the South Dakota Department of Health (written communication, Water Sanitation Section, September 24, 1968).
[3] 1.2 is optimum for South Dakota.

APPENDIX A

Logs of Test Holes in the Groton Area

(For map location, see fig. 3)

Test Hole 1 (Drilled in 1971)
Location: NW¼NW¼NW¼NW¼ sec. 14, T. 123 N., R. 61 W.
Depth to water: 19 feet

0- 2	Soil, brown
2- 10	Silt, yellow
10- 32	Sand, brown, very fine, with clay
32- 39	Sand, gray, very fine, with clay
39- 43	Clay, gravelly, (till?)
43- 49	Clay, gray, (shale?)

* * * *

Test Hole 2 (Drilled in 1971)
Location: SE¼SE¼SE¼SE¼ sec. 14, T. 123 N., R. 61 W.
Depth to water: 21 feet

0- 3	Soil
3- 30	Silt, yellow
30- 55	Silt, gray
55- 83	Clay, gray, compact
83- 89	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 3 (Drilled in 1972)
Location: NE¼NE¼NE¼NE¼ sec. 13, T. 123 N., R. 61 W.
Depth to water: 9? feet

0- 17	Silt, yellowish-brown
17- 20	Silt, gray
20- 36	Sand, dark-gray, very fine, with clay
36- 40	Clay, gray, sandy
40-104	Clay, gray
104-109	Clay, bluish-gray, (shale)

* * * *

Test Hole 4 (Drilled in 1972)
Location: SW¼SW¼SW¼SW¼ sec. 18, T. 123 N., R. 60 W.
Depth to water: 17 feet

0 - 17	Silt, yellowish-brown
17 - 22	Silt, dark-brown
22 - 34	Silt, gray
34 -100?	Clay, gray
100?-130	Clay, compact, (shale)

* * * *

Test Hole 5 (Drilled in 1972)
Location: SE¼SE¼SE¼SE¼ sec. 18, T. 123 N., R. 60 W.
Depth to water: 22 feet

0 - 22	Silt, yellowish-brown
22 - 44	Sand, yellowish-brown, very fine
44 - 60?	Clay, gray
60?- 65	Clay, gravelly, (till)
65 - 74	Clay, gray
74 - 81	Sand, gray, medium, little clay
81 - 93	Clay, gray
93 - 94	Boulder
94 - 97	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 6 (Drilled in 1971)
Location: SE¼SE¼SE¼SE¼ sec. 8, T. 123 N., R. 60 W.
Depth to water: 16 feet

0- 2	Soil
2- 30	Silt, yellow
30- 78	Silt, gray
78- 85	Clay, gray, sandy
85- 87	Gravel, coarse
87- 99	Clay, bluish-gray, (shale)

* * * *

Test Hole 7 (Drilled in 1972)
Location: SE¼SE¼SE¼SE¼ sec. 16, T. 123 N., R. 60 W.
Depth to water: 15 feet

Test Hole 7 -- continued.

0 - 1	Soil, black
1 - 9	Silt, yellowish-brown
9 - 14	Sand, yellowish-brown, very fine, with clay
14 - 17	Clay, yellowish-brown
17 - 19	Sand, yellowish-brown, very fine, much clay
19 - 27	Sand, gray, very fine, much clay
27 - 87?	Clay, gray
87?-118	Clay, bluish-gray, very compact, (shale)

* * * *

Test Hole 8 (Drilled in 1971)
Location: SW¼SW¼SW¼SW¼ sec. 24, T. 123 N., R. 61 W.
Depth to water: 19 feet

0 - 1	Soil, black
1 - 14	Clay, yellowish-brown
14 - 19	Clay, brown, with very fine sand
19 - 60?	Sand, gray, very fine, much clay
60?- 87	Clay, gray, few pebbles, sandy, (till)
87 - 89	Clay, bluish-gray, few pebbles?, (shale?)

* * * *

Test Hole 9 (Drilled in 1972)
Location: SW¼SE¼SE¼SW¼ sec. 24, T. 123 N., R. 61 W.
Depth to water: 15 feet

0- 19	Silt, yellowish-brown
19- 22	Silt, gray
22- 39	Sand, very fine, with clay
39- 42	Sand, more clay
42- 81	Clay, gray
81-109	Clay, compact

* * * *

Test Hole 10 (City Railroad Well) Logs from the USGS file
Location: NW¼SW¼SW¼ sec. 19, T. 123 N., R. 60 W.
Depth to water: not measured

0-105	Clay

Test Hole 10 -- continued.

105-108	Boulders
108-114	Gravel
114-124	Clay
124-140	Gravel, coarse
140-180	Clay
180-540	Shale; contains "hard shells"
540-555	Limestone "cap rock" (Greenhorn)
555-947	Shale
947-986	Sand

* * * *

Test Hole 11 (Drilled in 1972)
Location: NE¼SW¼SW¼SW¼ sec. 19, T. 123 N., R. 60 W.
Depth to water: 17 feet

0- 2	Soil
2- 31	Silt, yellowish-brown
31- 42	Silt, gray
42-125	Clay, gray, pebbly, (till)

* * * *

Test Hole 12 (Rotary test hole drilled in 1972)
Location: NW¼SW¼SE¼SW¼ sec. 19, T. 123 N., R. 60 W.
Depth to water: not measured

0- 25	Clay, yellow
25- 78	Clay, gray
78-101	Clay, pebbly, (till)
101-107	Gravel, very coarse
107-112	Clay, gray, (till)
112-133	Gravel?, much clay, (till?)
133-155	Clay, compact, (shale)

* * * *

Test Hole 13 (Rotary test hole drilled in 1972)
Location: NE¼NE¼NE¼SE¼ sec. 19, T. 123 N., R. 60 W.
Depth to water: not measured

0- 24	Clay, yellow

Test Hole 13 -- continued.

24- 77	Clay, gray
77-110	Clay, dark-gray, (shale, at 85 feet, marl?)

* * * *

Test Hole 14 (Drilled in 1972)
Location: SW¼SW¼SE¼NE¼ sec. 19, T. 123 N., R. 60 W.
Depth to water: 25? feet

0- 15	Silt, yellowish-brown
15- 21	Silt, gray
21- 32	Sand, very fine, much clay
32- 75	Clay, gray, very compact
75- 82	Clay, very gravelly, (till)
82- 85	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 15 (Drilled in 1972)
Location: SW¼SW¼SW¼SW¼ sec. 20, T. 123 N., R. 60 W.
Depth to water: 4 feet

0- 5	Clay, yellowish-brown
5- 10	Clay, black
10- 15	Clay, gray
15- 26	Sand, greenish-brown, very fine, with clay
26- 32	Sand, gray, very fine, with clay
32- 64	Clay, gray
64-116	Clay, gravelly, (till)
116-134	Clay, bluish-gray, (shale)

* * * *

Test Hole 16 (Drilled in 1972)
Location: NE¼NE¼NE¼NE¼ sec. 20, T. 123 N., R. 60 W.
Depth to water: 7 feet

0- 3	Silt, black
3- 6	Sand, white, fine, with clay
6- 17	Sand, brown, very fine
17- 24	Sand, gray, very fine
24- 68	Clay, gray, fairly compact
68-104	Clay, gravelly, (till) very compact beyond 100 feet

* * * *

Test Hole 17 (Drilled in 1971)
Location: SE¼SE¼SE¼SE¼ sec. 20, T. 123 N., R. 60 W.
Depth to water: 19 feet

0- 2	Soil, brown
2- 30	Silt, yellow
30- 71	Silt, gray
71- 79	Clay, gray, compact
79- 86	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 18 (Drilled in 1972)
Location: SE¼SE¼SE¼SE¼ sec. 21, T. 123 N., R. 60 W.
Depth to water: 4 feet

0- 2	Soil, black
2- 5	Clay, brown
5- 6	Clay, gray
6- 19	Sand, fine, brown, much clay
19- 21	Sand, gray, fine, with clay
21- 24	Sand, gray, fine, more clay
24- 95	Clay, gray
95-104	Clay, dark-gray, compact

* * * *

Test Hole 19 (Drilled in 1971)
Location: NW¼NW¼NW¼NW¼ sec. 26, T. 123 N., R. 61 W.
Depth to water: 13 feet

0- 3	Soil, brown
3- 34	Silt, yellow
34- 45	Silt, gray
45- 47	Boulder
47- 62	Clay, bluish-gray
62- 68	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 20 (Drilled in 1971)
Location: SW¼SW¼SW¼SW¼ sec. 26, T. 123 N., R. 61 W.
Depth to water: 18 feet

0- 2	Soil, brown
2- 4	Silt, brown

Test Hole 20 -- continued.

4- 8	Silt, yellow
8- 13	Silt, brown
13- 25	Silt, yellow
25- 50	Silt, gray
50- 66	Clay, gray, fairly compact
66- 84	Clay, bluish-gray, compact, (shale)

* * * *

Test Hole 21 (Drilled in 1972)
Location: SE¼SE¼SE¼SE¼ sec. 30, T. 123 N., R. 60 W.
Depth to water: 17 feet

0- 2	Soil, black
2- 17	Silt, yellowish-brown
17- 25	Sand, brown, very fine, with clay
25- 44	Sand, gray, fine, with clay, more clay beyond 30 feet
44- 80	Clay, gray
80- 97	Clay, gray, boulders, (till) very hard drilling beyond 86 feet

* * * *

Test Hole 22 (Drilled in 1972)
Location: NE¼SE¼SE¼NE¼ sec. 36, T. 123 N., R. 61 W.
Depth to water: 7 feet

0- 2	Gravel, (roadfill)
2- 3	Silt, black
3- 22	Silt, dark-gray
22- 26	Sand, gray, very fine, with clay
26- 31	Clay, gray, with very fine sand
31- 80	Clay, dark-gray
80-102	Clay, gray, more compact
102-119	Clay, bluish-gray, (shale)

* * * *

Test Hole 23 (Drilled in 1971)
Location: NE¼NE¼NE¼NE¼ sec. 5, T. 122 N., R. 60 W.
Depth to water: 10 feet

0- 3	Soil, black
3- 10	Silt, yellow
10- 21	Sand, very fine, much clay
21- 43	Silt, gray
43- 83	Clay, gray, gravelly, (till)
83- 89	Clay, gray, compact, (shale)

* * * *

Test Hole 24 (Drilled in 1972)
Location: NW¼NW¼NW¼NW¼ sec. 33, T. 123 N., R. 60 W.
Depth to water: 8 feet

0- 10	Silt, brown
10- 12	Sand, brown, very fine, much clay
12- 16	Sand, brown, very fine, less clay
16- 26	Sand, gray, very fine with clay, finer sand beyond 20 feet
26- 41	Clay, gray
41- 57	Clay, gray, more compact
57- 58	Clay, gray, with boulders
58- 64	Clay, bluish-gray, (shale)

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APPENDIX B

Well Records in the Groton Area

Source: SD, glacial sand lenses or lake deposits; DF, Dakota Formation

Use: D, domestic; S, stock; OB, observation well

U.S.B.R.: United States Bureau of Reclamation

Well inventory was conducted by the United States Geological Survey and the South Dakota Geological Survey.

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Koehler, W. H.	SE¼SE¼SE¼SW¼ sec. 1, T. 123 N., R. 61 W.	1,100			D,S
Shornack, H.	NW¼NW¼NW¼ sec. 2, T. 123 N., R. 61 W.	1,250		DF	D,S
Ruden, O. E.	SW¼NW¼NW¼NW¼ sec. 3, T. 123 N., R. 61 W.	960		DF	
Wagner, F.	SW¼SW¼SW¼SW¼ sec. 4, T. 123 N., R. 61 W.	900		DF	D,S
Van Riper, C.	SE¼SE¼NE¼SE¼ sec. 6, T. 123 N., R. 61 W.	1,122		DF	
Van Riper, C.	SW¼SW¼SE¼SE¼ sec. 6, T. 123 N., R. 61 W.	960		DF	D,S
Erdman, G.	NW¼NW¼NW¼ sec. 6, T. 123 N., R. 61 W.	960		DF	D,S
Clagenbush, C.	NW¼NE¼NW¼NE¼ sec. 8, T. 123 N., R. 61 W.	1,105		DF	D,S
Siefkes	NE¼NW¼NW¼NW¼ sec. 10, T. 123 N., R. 61 W.	1,100		DF	D,S
Koehler, W.	SE¼SE¼SE¼SE¼ sec. 12, T. 123 N., R. 61 W.	960		DF	D
Quiggle, W.	SE¼SE¼SE¼NW¼ sec. 12, T. 123 N., R. 61 W.	971		DF	D,S
Daringsford, A.	SW¼SE¼SE¼SE¼ sec. 13, T. 123 N., R. 61 W.	1,001		DF	D,S
Voight, A.	SE¼SE¼SE¼SW¼ sec. 14, T. 123 N., R. 61 W.	1,100		DF	D,S
Stanch, E.	NW¼NW¼SW¼NW¼ sec. 14, T. 123 N., R. 61 W.	1,200		DF	D,S
Mallett, E. G.	SE¼NE¼NE¼NE¼ sec. 14, T. 123 N., R. 61 W.	1,200		DF	D,S
Walters, J.	SE¼SE¼SE¼SW¼ sec. 14, T. 123 N., R. 61 W.	32	13	SD	
Johnson, A.	SW¼SW¼SW¼ sec. 15, T. 123 N., R. 61 W.	1,110		DF	D

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Leonhardt, D.	NW¼NW¼NW¼ sec. 15, T. 123 N., R. 61 W.	1,150		DF	D,S
U.S.B.R.	NW¼ sec. 16, T. 123 N., R. 61 W.	120		SD	OB
Lehman, H.	NW¼NE¼SE¼NE¼ sec. 17, T. 123 N., R. 61 W.	1,100		DF	D,S
Lehman, H.	SE¼SW¼NE¼NE¼ sec. 17, T. 123 N., R. 61 W.	1,138		DF	D,S
Lehman, H.	NW¼NE¼SE¼NE¼ sec. 17, T. 123 N., R. 61 W.	25	8	SD	
Trask, F.	NW¼NW¼NW¼NW¼ sec. 18, T. 123 N., R. 61 W.	1,042		DF	D,S
Inglis, K.	NE¼NE¼NE¼SW¼ sec. 18, T. 123 N., R. 61 W.	158		SD	D
Zoellner, I. V.	NW¼NW¼NE¼NW¼ sec. 19, T. 123 N., R. 61 W.	1,150		DF	D,S
Zoellner, R.	SE¼SW¼SW¼SW¼ sec. 19, T. 123 N., R. 61 W.	1,013		DF	D,S
Zoellner, M.	SW¼SW¼SW¼SE¼ sec. 20, T. 123 N., R. 61 W.	1,140		DF	D,S
Heitman, B.	SW¼SE¼SE¼ sec. 21, T. 123 N., R. 61 W.	1,000		DF	D,S
Anderson, O.	SE¼SE¼SE¼NE¼ sec. 23, T. 123 N., R. 61 W.	1,160		DF	D,S
Gillette, I.	NE¼SE¼SE¼SE¼ sec. 24, T. 123 N., R. 61 W.	1,014		DF	D,S
Fliehs, H.	SE¼SW¼SE¼SW¼ sec. 25, T. 123 N., R. 61 W.	1,176		DF	D,S
Wolter, R.	NW¼NE¼NW¼ sec. 26, T. 123 N., R. 61 W.	920		DF	D,S
Zoellner, R.	SW¼NW¼NW¼SW¼ sec. 30, T. 123 N., R. 61 W.	1,242		DF	D,S
Lorenz, A.	NW¼NW¼NW¼SW¼ sec. 31, T. 123 N., R. 61 W.	1,148		DF	D,S
Zoellner, R.	SW¼SE¼SE¼SE¼ sec. 31, T. 123 N., R. 61 W.	1,209		DF	D,S
Zoellner, O.	SW¼SE¼SE¼SE¼ sec. 31, T. 123 N., R. 61 W.	1,127		DF	D,S
Herron, L.	NE¼NE¼SE¼ sec. 32, T. 123 N., R. 61 W.	1,034		DF	D,S
Zoellner, O.	SE¼NW¼NW¼NW¼ sec. 33, T. 123 N., R. 61 W.	1,162		DF	

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Zoellner, O.	SE¼NW¼NW¼NW¼ sec. 33, T. 123 N., R. 61 W.	900		DF	D
U.S.B.R.	SE¼SE¼SE¼SE¼ sec. 33, T. 123 N., R. 61 W.	60		SD	OB
Wing, R.	SE¼SE¼SW¼ sec. 34, T. 123 N., R. 61 W.	1,145		DF	
Larson, N.	NW¼NE¼NE¼ sec. 35, T. 123 N., R. 61 W.	1,100		DF	D,S
Rix, A.	NW¼NW¼SW¼NW¼ sec. 2, T. 123 N., R. 60 W.	900		DF	D,S
Donovan, J.	SE¼NE¼NE¼ sec. 2, T. 123 N., R. 60 W.	880	32	DF	D,S
Rix, E.	SE¼SE¼SE¼SE¼ sec. 2, T. 123 N., R. 60 W.				D,S
U.S.B.R.	NW¼NW¼NW¼NE¼ sec. 2, T. 123 N., R. 60 W.	40	12	SD	OB
Mielke, C.	NW¼NW¼NE¼ sec. 3, T. 123 N., R. 60 W.				D,S
Rohwer, L.	NW¼SW¼SW¼NW¼ sec. 3, T. 123 N., R. 60 W.	1,100		DF	D,S
Richards, R.	SE¼SE¼SW¼SE¼ sec. 5, T. 123 N., R. 60 W.	1,040		DF	
Bission, G.	NW¼SW¼NW¼ sec. 5, T. 123 N., R. 60 W.	900		DF	D,S
U.S.B.R.	NW¼NW¼NW¼SW¼ sec. 5, T. 123 N., R. 60 W.	45	26	SD	OB
Megthaler, E. G.	NE¼SE¼SE¼ sec. 6, T. 123 N., R. 60 W.	987		DF	D,S
Rigg, E.	SW¼SW¼SW¼ sec. 7, T. 123 N., R. 60 W.	972		DF	D,S
Lundman, C.	SW¼SW¼NW¼ sec. 8, T. 123 N., R. 60 W.	1,010		DF	D,S
Adams, F. D.	NW¼ sec. 8, T. 123 N., R. 60 W.	977		DF	
Breitkreutz, R.	NW¼NE¼NW¼ sec. 9, T. 123 N., R. 60 W.	90		SD	
Adams, J.	SW¼SW¼SW¼ sec. 9, T. 123 N., R. 60 W.	935	200	DF	
Breitkreutz, R.	NW¼NW¼NE¼NW¼ sec. 9, T. 123 N., R. 60 W.	1,097		DF	D,S
Breitkreutz, A.	NW¼NW¼NW¼ sec. 9, T. 123 N., R. 60 W.	964		DF	D,S

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Blair, W.	NE¼NE¼NE¼ sec. 11, T. 123 N., R. 60 W.	960		DF	D,S
Blair, W.	NW¼NW¼NW¼ sec. 12, T. 123 N., R. 60 W.	1,024		DF	D,S
Belden, O.	SE¼SW¼SE¼ sec. 13, T. 123 N., R. 60 W.	1,200		DF	D,S
U.S.B.R.	NW¼NE¼NW¼ sec. 13, T. 123 N., R. 60 W.	15			OB
Beldon, O.	NE¼SE¼NE¼ sec. 13, T. 123 N., R. 60 W.	1,100		DF	D,S
Leonhardt, G.	SW¼SW¼NW¼NW¼ sec. 14, T. 123 N., R. 60 W.	1,078		DF	
Clark, H.	NW¼NW¼SW¼ sec. 14, T. 123 N., R. 60 W.	1,100		DF	D,S
Koehler, G.	SW¼SW¼SW¼ sec. 15, T. 123 N., R. 60 W.	1,031		DF	D,S
Messing, E.	SE¼SW¼SW¼SE¼ sec. 15, T. 123 N., R. 60 W.	1,042		DF	D,S
Messing, E.	SE¼SW¼SW¼SE¼ sec. 15, T. 123 N., R. 60 W.	1,275		DF	D,S
Hinkleman, H.	NW¼SW¼SE¼ sec. 17, T. 123 N., R. 60 W.	1,025		DF	D,S
Olson, A.	SW¼SE¼SW¼ sec. 18, T. 123 N., R. 60 W.	850		DF	D
Olson, A.	SW¼SE¼SW¼ sec. 18, T. 123 N., R. 60 W.	1,100		DF	S
Olsen	SW¼SE¼SW¼ sec. 19, T. 123 N., R. 60 W.	80		SD	D,S
Groton City	SW¼SW¼SE¼SW¼ sec. 19, T. 123 N., R. 60 W.	986			D,S
Groton City	SE¼NW¼SW¼SW¼ sec. 19, T. 123 N., R. 60 W.	1,000		DF	D,S
Groton City	NW¼NE¼NW¼SW¼ sec. 19, T. 123 N., R. 60 W.	1,000		DF	D,S
Groton City	NE¼NW¼SW¼ sec. 19, T. 123 N., R. 60 W.	995		DF	D,S
Bonn, J.	SE¼SE¼SW¼ sec. 20, T. 123 N., R. 60 W.	935	233	DF	D,S
Hall, R.	SW¼SE¼ sec. 21, T. 123 N., R. 60 W.	30	20	SD	D
Oliver, R.	NW¼NE¼NE¼ sec. 25, T. 123 N., R. 60 W.	950		DF	D,S

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Oliver, R.	NW¼NE¼NE¼ sec. 25, T. 123 N., R. 60 W.	1,099		DF	D,S
Prunty, E. D.	SW¼SW¼SW¼SE¼ sec. 25, T. 123 N., R. 60 W.	988		DF	D,S
Larson, L.	NW¼NE¼NW¼ sec. 25, T. 123 N., R. 60 W.	1,080		DF	D,S
Rix, A.	NW¼NW¼NE¼ sec. 26, T. 123 N., R. 60 W.	967	14	DF	D,S
U.S.B.R.	NE¼NE¼NE¼NE¼ sec. 26, T. 123 N., R. 60 W.	15			OB
Sperry, M.	SE¼NE¼SE¼ sec. 27, T. 123 N., R. 60 W.	880		DF	D,S
Sperry, K.	SE¼NE¼SE¼ sec. 27, T. 123 N., R. 60 W.	1,052		DF	
Hall, R.	NW¼NW¼NW¼ sec. 28, T. 123 N., R. 60 W.	30		SD	S
Oliver, E.	NW¼NW¼SW¼ sec. 29, T. 123 N., R. 60 W.	893		DF	D,S
Huffman, O.	NW¼NW¼SE¼ sec. 31, T. 123 N., R. 60 W.	28	23	SD	D,S
Frommel, B.	SW¼SE¼SW¼ sec. 32, T. 123 N., R. 60 W.	950		DF	D,S
U.S.B.R.	SE¼SE¼SE¼NE¼ sec. 1 T. 122 N., R. 61 W.	42	9	SD	OB
Lenling, W.	NE¼NE¼NE¼ sec. 2, T. 122 N., R. 61 W.	1,170		DF	
Stange, O.	NE¼NE¼ sec. 4, T. 122 N., R. 61 W.	1,200		DF	
Anderson Bros.	SW¼SW¼NW¼ sec. 4, T. 122 N., R. 61 W.	900	145		
Rose, A.	SE¼SE¼NE¼ sec. 5, T. 122 N., R. 61 W.	940	288	DF	
Zoellner, E.	NE¼SE¼NE¼ sec. 7, T. 122 N., R. 61 W.	1,056		DF	S
Zoellner, E.	NE¼SE¼NE¼ sec. 7, T. 122 N., R. 61 W.	1,198			D,S
Julson, E. D.	NE¼NE¼ sec. 8, T. 122 N., R. 61 W.	900		DF	D,S
Vonwall, V.	SW¼NW¼NW¼NW¼ sec. 8, T. 122 N., R. 61 W.	1,150		DF	D,S
Oliver, E. D.	NE¼SW¼NW¼ sec. 11, T. 122 N., R. 61 W.		9	DF	D,S

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Sundermeser, V.	SE¼SE¼SE¼ sec. 2, T. 122 N., R. 60 W.	1,086		DF	D,S
Strom, C.	SW¼SW¼SE¼SW¼ sec. 3, T. 122 N., R. 60 W.	1,081		DF	D,S
Brendemuehl, G. W.	SW¼NW¼NW¼SW¼ sec. 5, T. 122 N., R. 60 W.	922		DF	D,S
Clocksene, L.	NW¼NW¼SE¼ sec. 6, T. 122 N., R. 60 W.	965		DF	D,S
Edwards, R.	NE¼NE¼NE¼ sec. 7, T. 122 N., R. 60 W.	19	18	SD	
Clocksene, D. D.	NE¼NW¼NW¼SW¼ sec. 8, T. 122 N., R. 60 W.	1,050	20	DF	D,S
U.S.B.R.	SW¼SW¼SW¼SW¼ sec. 10, T. 122 N., R. 60 W.	16			OB
Spencer, G.	NW¼NE¼NW¼ sec. 11, T. 122 N., R. 60 W.	985		DF	