STATE OF SOUTH DAKOTA
Nils Boe, Governor

SOUTH DAKOTA STATE GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Special Report 35

GEOLOGY AND GROUND-WATER RESOURCES AT BRYANT, SOUTH DAKOTA

by
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1966

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INTRODUCTION

Present Investigation

This report contains the results of a special investigation by the South Dakota Geological Survey for the city of Bryant. The investigation was conducted between July 27 and September 10, 1964, at the request of the city and was designed to locate, map, and evaluate all shallow water supplies in and around the city of Bryant, Hamlin County, South Dakota (fig. 1).

The city presently obtains water from two deep artesian wells located within the city limits (fig. 2). The wells are approximately 1,350 feet deep, and each well yields about 55 gallons of water per minute from the sandstones of the Dakota Group. The wells are expensive to maintain; consequently, the city desired to learn more about the shallow ground-water resources in the Bryant area as a possible source of water for future use.

The present investigation consisted of drilling five test holes with the State Geological Survey's auger drill, and 25 test holes with the Survey's rotary drill. A well inventory was conducted along with preliminary geologic mapping, and 25 water samples were collected for chemical analyses. In addition, conductivity readings were taken on 95 water samples to aid in quality of water determination. The results of the survey revealed two areas which should be further investigated for ground-water supplies.

The field work and preparation of this report were performed under the supervision of Lynn S. Hedges, ground-water geologist for the South Dakota Geological Survey. Lloyd Helseth, staff driller, conducted the drilling of the rotary test holes with the assistance of Robert Stach. Robert Schoon, subsurface geologist, aided the survey. Steve Pottratz assisted the author in the field. Ronald Little and Dean Fickbohm drilled the auger holes.

Special acknowledgment is given to Mayor Theodore Ahrens, the City Council, and the residents of the area for their aid and cooperation. The U. S. Geological Survey, Ground-Water Branch, Huron, South Dakota, furnished a conductivity bridge. Mr. Irvin Johnson of Erwin, South Dakota, aided the survey by making available well logs and pumping equipment. Chemical water analyses were made by Nat Lufkin of the State Geological Survey in Vermillion.

Location and Extent of Area

The city of Bryant is located in east-central South Dakota near the west edge of the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The mapped area consists of 72 square miles in parts of Hamlin, Clark, and Kingsbury Counties. The population of Bryant is 522 (1960 census).

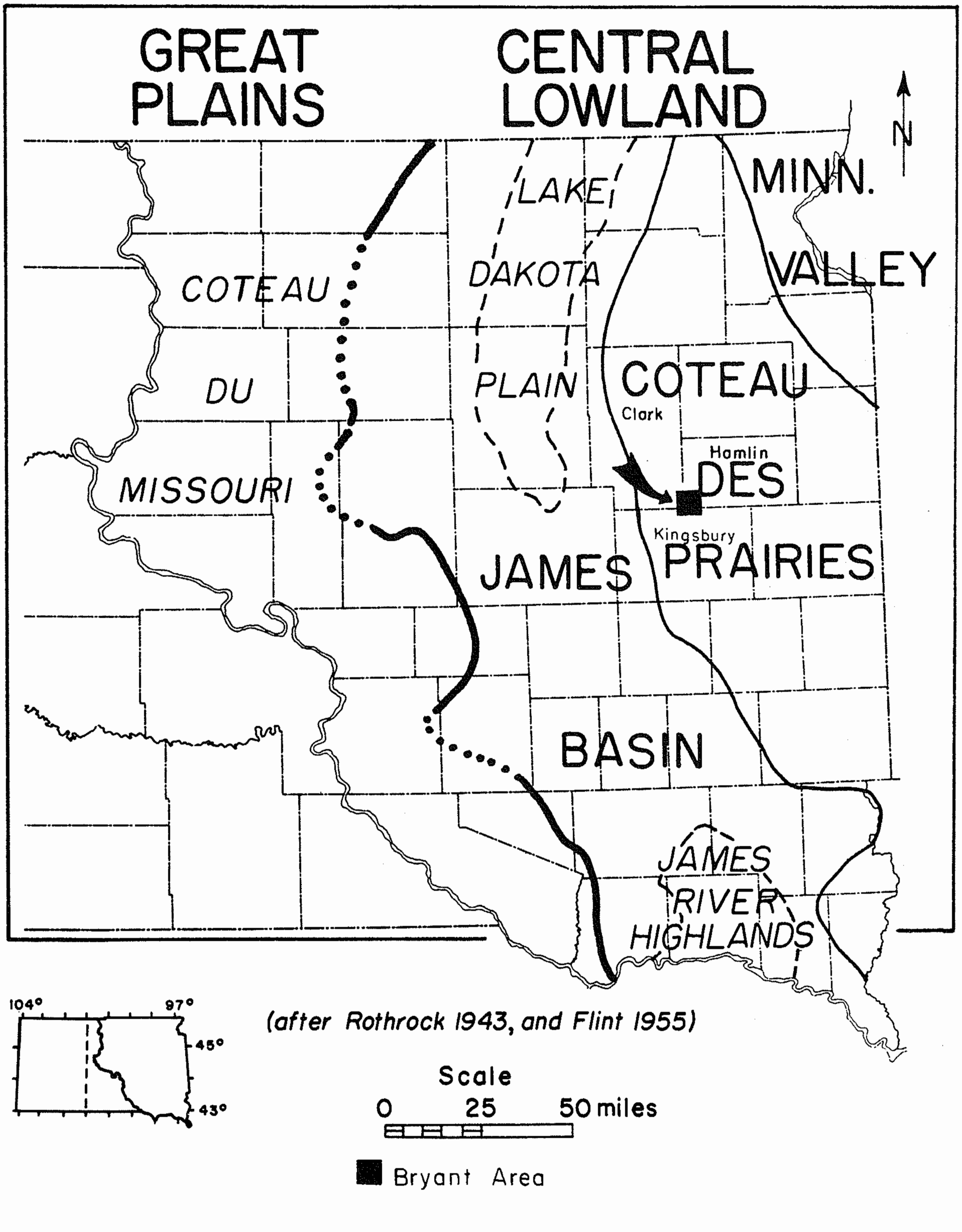

Figure 1. Map Showing Major Physiographic Divisions of Eastern South Dakota and Location of the Bryant Area

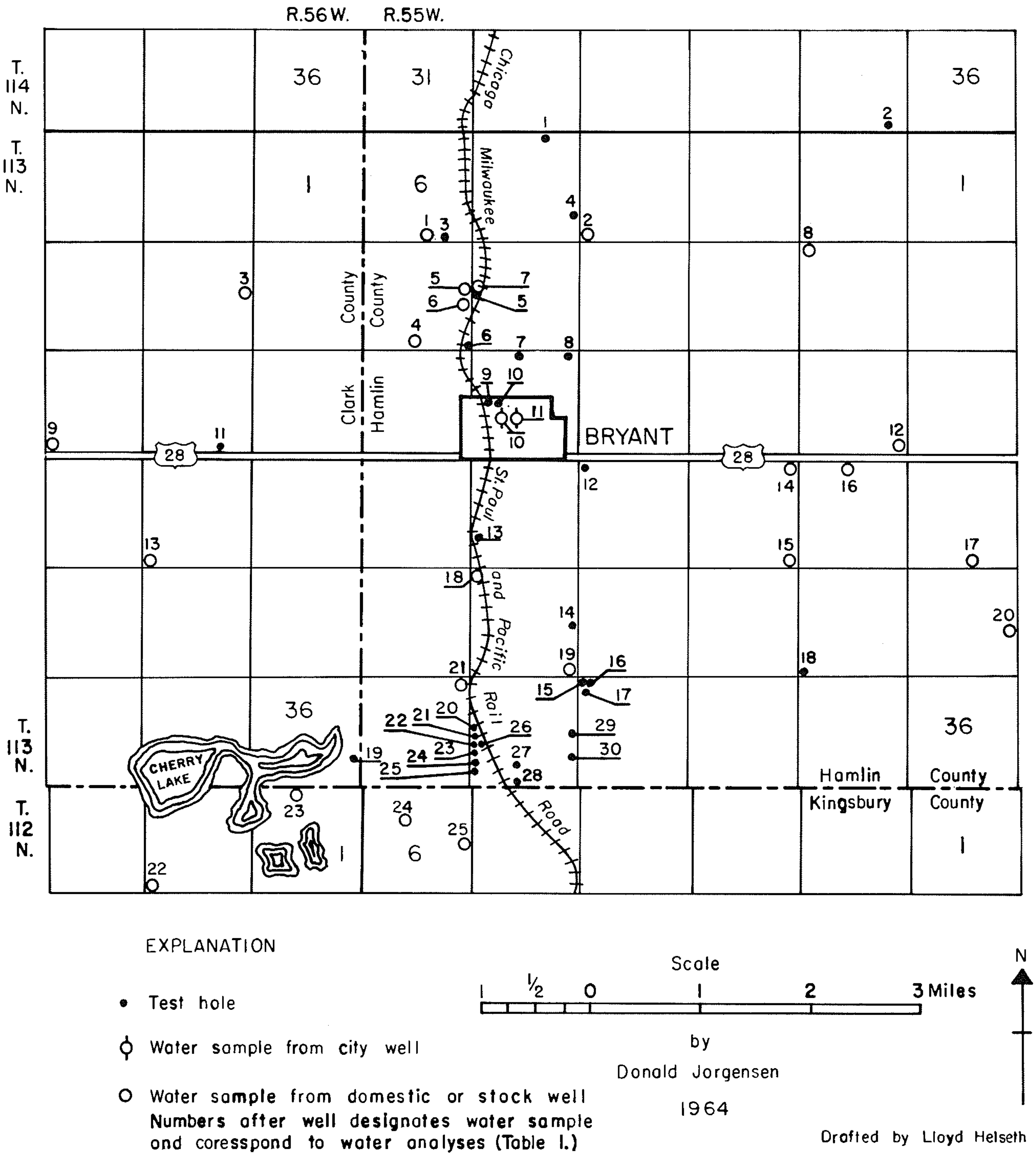

Figure 2. Data Map of the Bryant Area

Climate

The climate is continental temperate, with large daily temperature fluctuations. The average daily temperature is 44.8 degrees F. at Bryant and the average annual precipitation is 20.80 inches at Castlewood, 24 miles northeast. The area is also subject to periods of drought which may greatly affect the ground and surface water levels.

Topography and Drainage

The topography of the area is typical of youthful glacial moraine--rolling hills and valleys with numerous knobs and kettles. There are no major streams controlling the drainage in the area. All the minor drainage terminates in local lakes or depressions.

Well-Numbering System

Wells in this report are numbered in accordance with the U. S. Bureau of Land Management's system of land subdivision. The first numeral of a well designation indicates the township north, the second the range west, and the third the section in which the well is situated. Lower case letters after the section number indicate the well location within the section. The letters a, b, c, d, are assigned in a counterclockwise direction, beginning in the northeast corner of each tract. The first letter denotes the 160-acre tract, the second the 40-acre tract, the third the 10-acre tract, and the fourth the $2\frac{1}{2}$-acre tract. Test Hole 1 (fig. 2), 113-55-5abaa is located in the NE$\frac{1}{4}$NW$\frac{1}{4}$NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 5, T. 113 N., R. 55 W.; the method of designation is shown in Figure 3.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits in the Bryant area consist of late Wisconsin glacial drift and can be subdivided into till, outwash, and lacustrine deposits (fig. 4). Loess (windblown material) and alluvium (stream-deposited material) are present as small isolated patches and were not mapped. The thickness of the drift varies from 300 to 450 feet in the mapped area.

Till consists of clay and silt-size particles irregularly mixed with sand, pebbles, and boulders and was deposited by glacial ice. Till commonly contains small stratified sand lenses that occur randomly at varying depths.

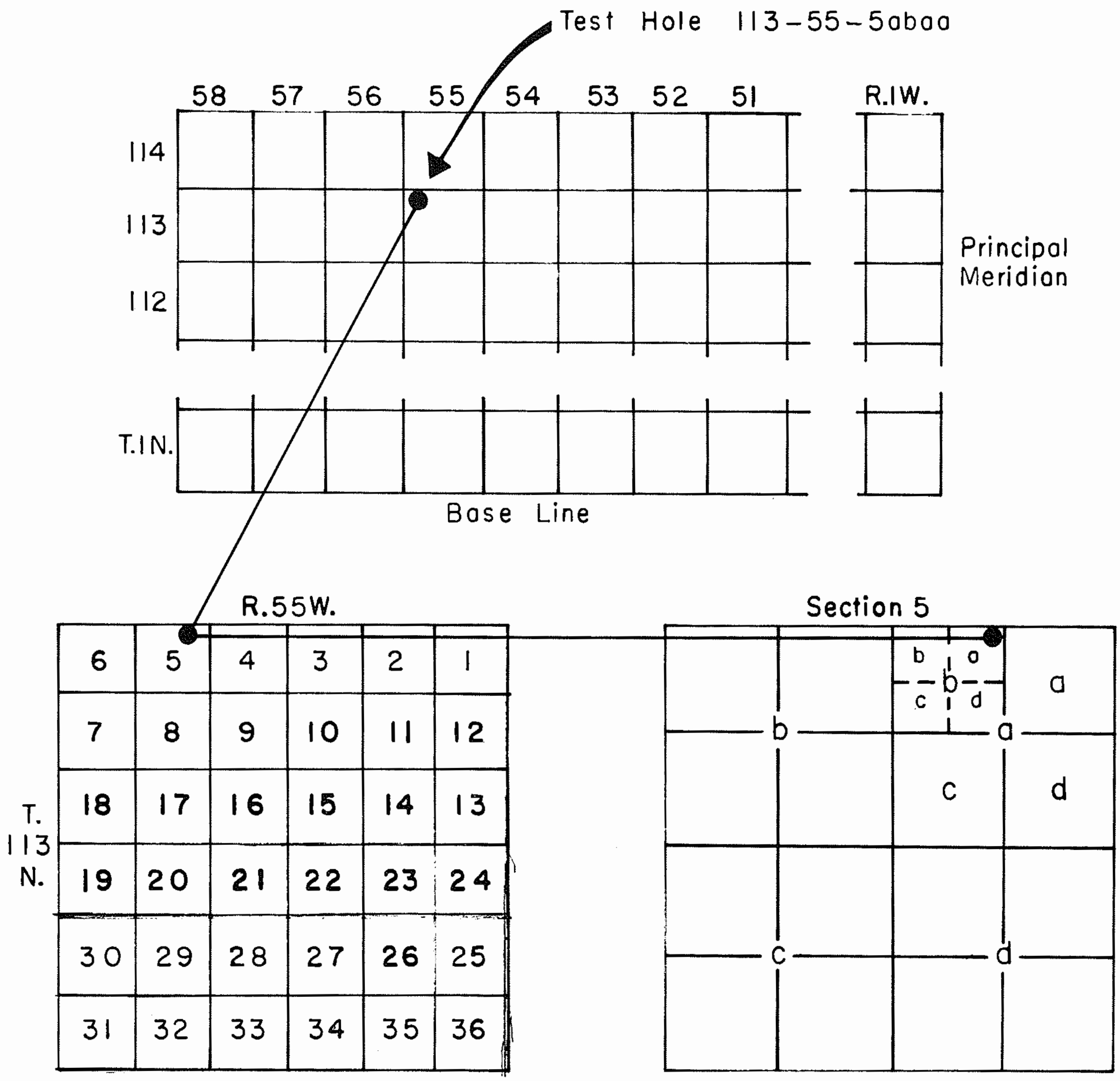

Figure 3. Well-Numbering System

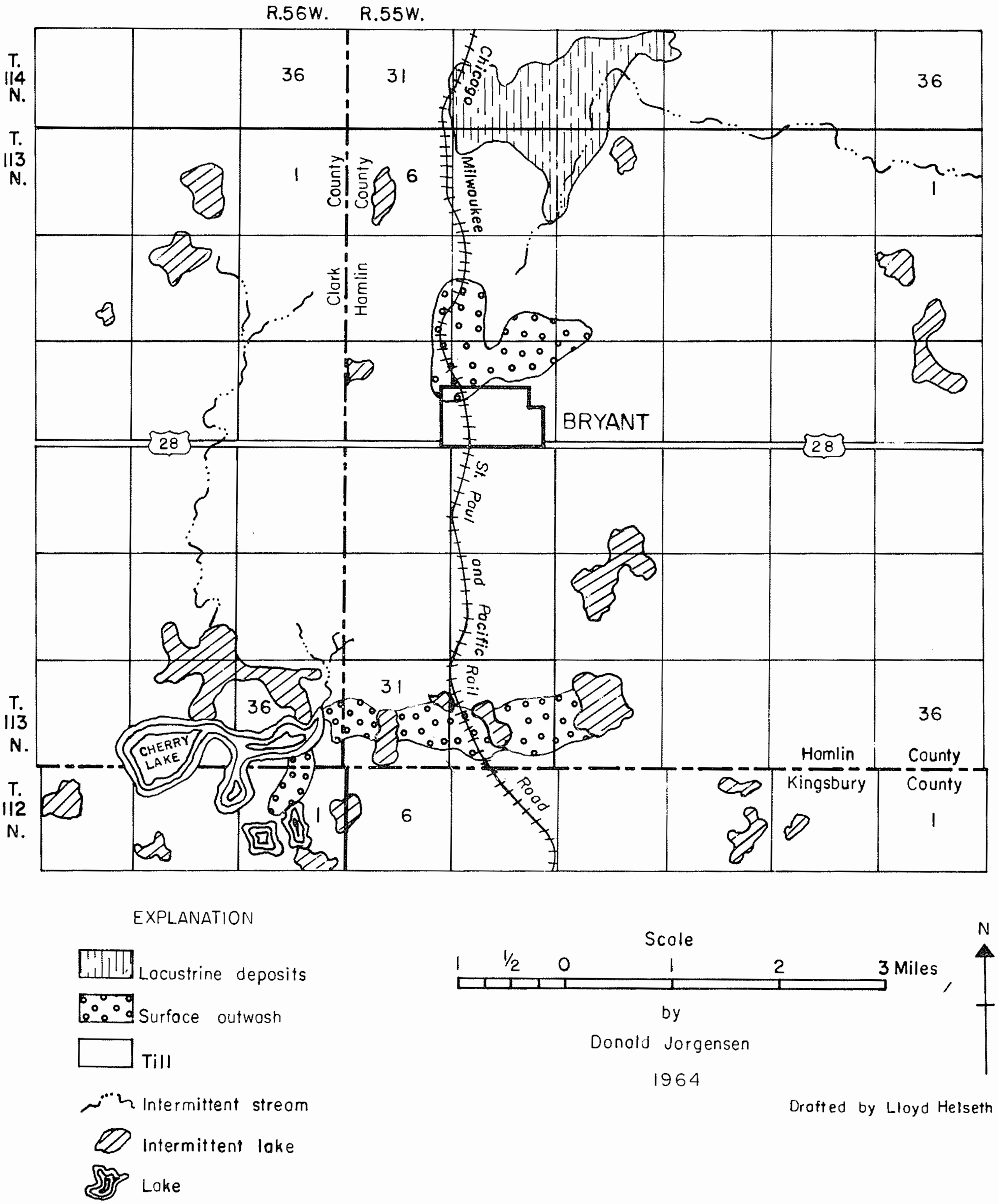

Figure 4. Generalized Geologic Map of Bryant and Vicinity

Outwash consists of stratified sands and gravels which were deposited by glacial meltwater streams. Two surface outwash deposits are shown in Figure 4. One outwash is located adjacent to the northern city limits of Bryant. A second outwash is located $2\frac{1}{2}$ miles south of Bryant (fig. 4). A third outwash is also present $2\frac{1}{2}$ miles south of Bryant beneath the surface outwash (fig. 5). This outwash is termed a "buried" outwash because it has been covered by younger glacial deposits.

A thin sand or gravel deposit sometimes occurs near the base of the glacial drift. This deposit is termed a "basal" sand. A basal sand was found in Test Hole 12 and is also reported to exist in the southeast corner of the mapped area.* Generally the basal sand consists of fine-grained sand and is less than 20 feet thick.

A lacustrine deposit with a surface area of approximately two square miles is located $2\frac{1}{2}$ miles north of Bryant. The lacustrine deposit consists of fine sand layers interbedded with sandy clay layers and attain a thickness of up to 87 feet (Test Hole 1, Appendix A).

Subsurface Bedrock

Beneath the surficial deposits are stratified sedimentary rocks of Cretaceous age. The Cretaceous rocks beneath Bryant in descending order are the Pierre Shale, Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, and Dakota Group.

The Pierre Shale consists of light- to dark-gray clayey bentonitic shale and sandy shale with ironstone concretions. The contact between the glacial deposits and the Pierre Shale is an uneven erosional surface; therefore the thickness of the shale is variable.

The Niobrara Marl consists of a light- to medium-gray shale or marl, which contains numerous microscopic white calcareous specks, and is approximately 140 feet thick.

The Carlile Shale consists of light- to dark-gray bentonitic shale with pyrite concretions, and thin sandstone layers. It is approximately 180 feet thick in the Bryant area.

The Greenhorn Limestone consists of a layer of hard, gray to white limestone containing numerous fossil shell fragments. The limestone layer may be overlain by gray shale with white calcareous specks. The limestone portion is approximately 30 feet thick.

The Graneros Shale is a light- to dark-gray clayey shale, and may contain thin, well-cemented sandstone layers. The thickness of this formation is approximately 160 feet.

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*The existence of the basal sand in the southeast corner of the mapped area was reported to the author by residents of the area and Mr. I. Johnson, well driller.

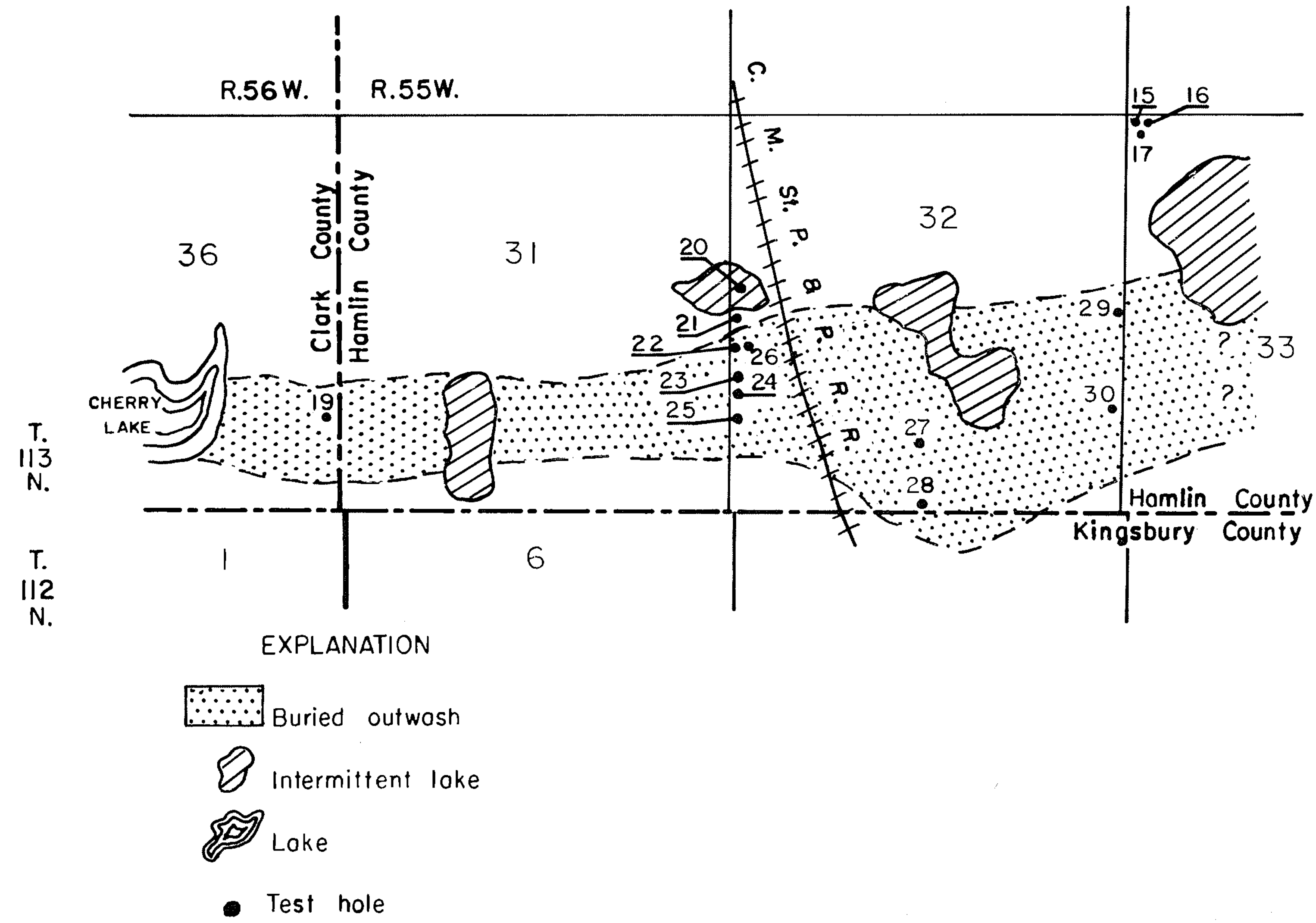

Figure 5. Map Showing Approximate Extent of the Buried Outwash South of Bryant and Location of Test Holes

The Dakota Group consists of a series of alternating sandstone and shale layers. The Dakota Group is of variable thickness and is probably over 100 feet thick in the Bryant area.

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Nearly all ground water is derived from precipitation. Rain or melting snow either percolates downward to the water table or drains off as surface water. Surface water evaporates, escapes to the streams or percolates downward to the ground-water table. In general, the precipitated water that percolates downward reaches the ground-water surface then flows laterally down the hydraulic gradient, and is said to be in transient storage.

Recharge is the addition of water to an aquifer (water-bearing material) and is accomplished in three main ways: (1) direct percolation derived from rain or snow melting on the ground surface; (2) downward percolation from surface bodies of water; and (3) underflow of water in transient storage into the aquifer.

Discharge or removal of ground water is accomplished in four main ways: (1) evaporation and transpiration by plants; (2) seepage upward or laterally into surface bodies of water such as springs; (3) underflow of water in transient storage from the aquifer; and (4) pumping.

The volume of water capable of being stored in a saturated material is equal to the volume of voids or pore spaces within that material. A measurement of the capability of a material to store water is called porosity. Porosity is the ratio of the volume of voids in the material to the rock volume (which includes pore space). The shape and arrangement of grains in a material affect the porosity greatly, but the size of the grains has little effect. Therefore an aquifer composed of well-sorted sand would hold the same amount of water as one composed of well-sorted gravel, provided the particles of sand and of gravel had the same packing and shape. Sands and gravels usually have porosities of 15-40 per cent; whereas, sandstones normally have porosities of 10-25 per cent. The lower porosity of sandstones is due to closer packing and cementation of the grains.

The ratio of the volume of water that will drain from a material by gravity to the volume of the material is called specific yield. Values for specific yields vary from zero for plastic clays to nearly the value of the porosity for coarse sands and gravels.

The rate at which water will drain or pass through a material is a function of the permeability of the aquifer. Water will pass through a material with interconnected pores, but will not pass through a material with unconnected pores even if the latter material has a greater porosity. Therefore, permeability and porosity are not synonymous terms. As an example, till may have a high porosity and still yield little water because of its low permeability.

If an aquifer dips below a confining bed such as shale, the water is no longer under normal water table conditions, but is then under artesian conditions.

An idealized aquifer for a city water supply would be large in areal extent, consist of well-sorted sand or gravel, possess a high permeability, and have adequate recharge. Large sand and gravel deposits are commonly ideal aquifers for a city water supply.

Small water-bearing sand lenses occur at many locations in eastern South Dakota and since they have a lenticular shape should not be considered as "veins". These small lenses will not yield enough water for a city.

Ground Water in Glacial Deposits

Till containing small sand lenses is present at most locations in the mapped area. The till, which has a low permeability, does not yield water readily.

Sand lenses are the source of water for nearly all of the farm wells in the area. A series of thin sand and gravel lenses occur one-half to one mile north of the city at a depth of 90-155 feet. The sand and gravel lenses at the sites drilled probably would not yield an adequate quantity of water for a city well.

A surficial outwash deposit of sand and gravel is present just north of Bryant (fig. 4). This sand and gravel deposit is approximately 15 feet thick. In certain low-lying locations such as the site of the abandoned railroad well north of Bryant, it is completely saturated. This aquifer yields water readily where saturated, but it is unsaturated or only partially saturated at most locations. The saturated portion of the aquifer does not have an adequate volume for use as a city water source.

The surficial outwash $2\frac{1}{2}$ miles south of Bryant is irregularly shaped and limited in width. The sand and gravel deposit is 0-20 feet thick, and is only completely saturated beneath intermittent lakes. The volume of water stored in the fully saturated portions of this outwash is inadequate for use as a city water source.

A "buried" outwash occurs 30-40 feet beneath the surficial outwash south of Bryant. This outwash consists of very fine to very coarse gravels. Some layers of clay may also be present within the deposit. The deposit is more than 30 feet thick in Test Hole 24 (Appendix A). The deposit occurs 45-80 feet below the surface and is not completely saturated. Recharge is probably limited because of the difficulty of water to penetrate the impermeable clay which separates the surface and buried outwash. The buried outwash extends beneath Cherry Lake. If the outwash intersects the lake water or if a permeable hydraulic connection exists between the lake waters and the outwash, then completely saturated areas may exist within the outwash.

A thin sand deposit occurs near or at the base of the glacial drift in the southeast corner of the mapped area. The "basal" sand is quite extensive, but well logs of farm wells in the area indicate that the deposit consists of fine-grained sand less than 20 feet thick. The basal sand encountered in Test Hole 12 is not of adequate thickness to be considered as a city water supply.

The lacustrine deposits 2½ miles north of Bryant may contain up to 43 feet of saturated fine sand. This sand occurs as separate layers up to 12 feet thick, separated by sandy clay layers. The small areal extent of the deposit restricts its storage capacity and it is not known if the fine sand will readily yield large volumes of water.

Ground Water in Subsurface Bedrock

The extensive sandstones of the Dakota Group are the only known bedrock aquifers in the Bryant area from which water is presently produced. The uppermost sandstone occurs at a depth of approximately 1250 feet at Bryant. The sandstone layers have a moderate permeability and yield water at a moderate rate.

The water in the Dakota Group is under artesian pressure; however, the pressure is inadequate in the Bryant area to cause the wells to flow.

Ground-Water Quality

Precipitated water is nearly pure before it reaches the ground. After reaching the ground it comes in contact with many minerals. In general, surface water acquires minerals in solution as it moves to the ocean or to other surface water bodies. The water percolating through the soil towards the water table leaches or washes soil minerals and mineral residues left by plant transpiration and by evaporation. The leaching process is beneficial for future plant growth, but causes deterioration of water quality. After the percolating water reaches the water table it comes in contact with minerals in the aquifer and obtains still more mineral content. Therefore, the mineral content of ground water is dependent on the minerals the water comes in contact with, their solubility in water, and the length of time the water is in contact with them.

Table 1 is a comparison of water analyses from the Bryant area with the drinking water standards established by the U. S. Department of Public Health. These standards are used as an aid in evaluating the mineral content of the water for its suitability as a public water supply.

Chlorides in excess of 250 parts per million (ppm) can be detected by persons with sensitive tastes.

Sulphates in excess of 500 ppm may have a laxative effect when first used for drinking.

Table 1.--Chemical analyses of water samples from the Bryant area.

Sample	Source*	Parts Per Million											
		Calcium	Sodium	Magne-sium	Chlorides	Sulfate	Iron	Manga-nese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
A		---	---	50	250	500**	0.3	0.05	10.0	0.9-1.7***	---	---	1000**
1	SL	132		54	48	111	0.65				7.15	550	866
2	SL	426		180	102	1020	0.40				7.05	1800	2500
3	SL	463		200	72	1020	0.35				7.10	1975	2565
4	SL	451	840	225	142	2682	7.60	1.50	2.9	1.0		2050	4802
5	SL	290	170	89	8	1005	3.30	2.20	1.5	0.4		1092	1928
6	SO	185		94	9	529	0.00				8.4	800	1095
7	SL	285	100	72	4	818	0.20	0.60	1.2	0.4		1009	1674
8	SL	452		146	68	876	0.20				7.10	1725	2360
9	SL	150	100	49	0	550	2.0	0.30	0.9	0.7	7.40	575	1150
10	D	8	****1043	8	442	1228	6.0	0.2	0.0	4.6	8.10	63	3004
11	D	14	****1004	4	421	1226	0.6	0.1	0.0	4.8	8.10	53	2943
12	SL	450		329	230	1655	7.90				7.05	2450	4200
13	SL	155	135	47	0	575	15.60	0.10	1.6	0.9	7.70	579	1258
14	SL	197		78	4	292	0.25				7.55	712	1048
15	SL	381		100	16	827	9.00				7.60	1360	2020
16	D	18	866	1.5	276	1120	0.40		1.8	3.6	7.80	46	2498
17	SL	397		136	20	875	0.10				7.00	1550	3155

(continued on next page)

Table 1.--continued

Sample	Source*	Parts Per Million											
		Calcium	Sodium	Magne-sium	Chlorides	Sulfate	Iron	Manga-nese	Nitrate	Fluoride	pH	Hardness CaCO3	Total Solids
A		---	---	50	250	500**	0.3	0.05	10.0	0.9-1.7***	---	----	1000**
18	SL	229		56	20	633	10.00				7.40	800	1370
19	SL	500		359	72	1460	1.50				6.90	1700	3490
20	SL	414	230	141	12	1546	19.50	5.40	1.1	0.6		1612	2816
21	L	136		36	4	136	2.80				7.40	487	682
22	BS	265		95	72	826	5.00				7.20	1050	1845
23	L	245		119	44	486	0.05				7.30	1160	1570
24	SL	259		60	12	389	1.50				7.10	890	1222
25	SL	464		80	12	878	8.00				7.25	1400	1995

* Source: Dakota Group, D; sand lense, SL; lacustrine, L; surface outwash, SO

** Modified for South Dakota by State Department of Health (written communication, February 5, 1962)

*** Optimum

**** Indicates combined potassium and sodium mineral content in ppm

Samples 4, 5, 7, 9, 13, 16, and 20 were analysed by the State Chemical Laboratory in Vermillion.

Samples 10 and 11 were analysed by State Department of Health at Pierre.

The remaining samples were analysed by the South Dakota Geological Survey in Vermillion.

Location of Water Samples

1 F. Frahm, 113-55-6dc
2 T. Ring, 113-55-4cc
3 R. Warne, 113-56-11ad
4 B. Wiseman, 113-55-7cd
5 J. Anderson, 113-55-7ad
6 C. M. St. Paul & Pac. RR, 113-55-7da
7 B. Hagedorn, 113-55-8bc
8 T. Jensen, 113-55-11bb
9 O. Larsen, 113-56-15cc
10 Bryant City Well (West, 1949)
11 Bryant City Well (East, 1953)
12 D. Braaten, 113-55-14dd
13 W. Johnson, 113-56-23cc
14 E. Everson, 113-55-22aa
15 P. Peterson, 113-55-22dd
16 J. Corey, 113-55-23ba
17 R. Noem, 113-55-24dc
18 R. Christenson, 113-55-29bb
19 M. Peterson, 113-55-29dd
20 K. Anderson, 113-55-25da
21 V. Brown, 113-55-31aa
22 S. Gilbertson, 112-56-2cc
23 H. Boll, 112-56-1b
24 G. Corstorsen, 112-55-6bd
25 J. Vincent, 112-55-6da

Calcium and magnesium have little effect on the taste of water except in very high concentration.

Iron in concentrations of 0.3 ppm will often cause "red water" and precipitate as hydrous iron oxide (rust) after exposure to air.

The pH is an indication of alkalinity or acidity. Water with a pH greater than 7.0 is alkaline and may cause incrustation in water pipes. Water with a pH of less than 7.0 is acidic and may cause corrosion in a water pipe.

Total hardness values of more than 60 parts per million are considered hard by most standards.

Total solids of less than 1000 ppm is desirable. Waters which have total solids greater than 2000 ppm commonly have a disagreeable taste.

Specific conductance in micromohos is a useful indicator of total solids. The total solids can be determined from the specific conductance by:

Dissolved Solids = (F) (Specific Conductance)

Where "F" is a factor which varies for different ground waters but is generally about 0.75.

The quality of water obtained from the sand lenses in the till is variable as shown by the water analyses of samples 1 and 4. Most of these waters are high in magnesium, sulfates, total solids, iron and manganese.

A partial analysis of water taken from the surficial outwash just north of Bryant (sample 6) exceeds the standards for magnesium, sulfates, iron, and total solids.

The two water samples from the lacustrine deposits (samples 21 and 23) are generally of better quality than those from the other glacial deposits. Sample 23 exceeds the standards set for magnesium and total solids. It must be remembered that only two samples were taken from the lacustrine deposits, and this is not a sufficient number on which to make a good comparison.

Water analyses 10, 11, and 16 are representative of the quality that can be expected of water taken from the sandstone of the Dakota Group. Water samples 10 and 11 are from the existing city wells. A comparison of these two analyses with the Public Health Standards shows that the present city supply exceeds the standards in chlorides, sulphates, iron, manganese, fluoride and total solids.

No water samples were obtained from the Pierre Shale, Niobrara Marl, Carlile Shale, Greenhorn Limestone, or the Graneros Shale because no wells in the area obtain water from any of these formations.

CONCLUSIONS AND RECOMMENDATIONS

Two areas that might yield an adequate water supply for the city were located.

The first area is the lacustrine deposits $2\frac{1}{2}$ miles north of town. If further test drilling indicates that the lacustrine sand layers are extensive, then a site should be selected and a test well be installed. The test well is to be used to conduct an aquifer pumping test and to sample the water for quality.

The second area is the buried outwash $2\frac{1}{2}$ miles south of town. Test drilling is needed in the area around Cherry Lake to determine if a hydraulic connection may exist between the lake and the buried outwash. Other additional test drilling is desirable near the test holes previously drilled to determine if a second buried outwash may exist below the known buried outwash. If an extensive saturated outwash can be located in this area, then a test well should be installed. The test well is to be used to conduct a pumping test and for water sampling.

Additional water can be obtained from the sandstones of the Dakota Group, the present city water source. If the present water source is further developed, it is recommended that a pilot bore be drilled to completely penetrate all of the sandstone layers and that water samples be obtained from each layer to determine if any of the sandstone layers possesses a water of better quality than the water the city is presently using. Any new well in the Dakota Group should be drilled at a substantial distance from existing wells to minimize pumping interference.

If additional drilling is conducted, it is recommended that the city officials contact a commercial drilling company licensed by the State of South Dakota to drill the test holes and to install the test well and/or the production well. A pumping test should be conducted for a minimum of 72 hours and water samples should be collected at regular intervals during the test. A consulting engineering firm licensed in South Dakota should be hired to supervise the testing program and to design the well and water system. In addition, the city officials should consult the State Water Resources Commission with regard to obtaining a right to water and a permit to drill a city well, and the State Department of Health with regard to the biological and chemical suitability of the water.

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APPENDIX A

Logs of Test Holes in the Bryant Area

(see figure 2)

Test Hole No. 1
Location: 113-55-5abaa
Type: rotary
Elevation: not measured
Water level: not measured

0- 2	topsoil
2- 10	sand, fine
10- 26	clay, sandy, gray
26- 32	sand, fine, gray
32- 36	clay, very sandy, gray
36- 48	sand, fine to coarse
48- 52	clay, sandy, gray
52- 61	sand, fine
61- 70	clay, very sandy
70- 80	sand, coarse to very coarse with shale and coal fragments
80- 81	clay, sandy, gray
81- 87	sand, coarse, and fine gravel
87-104	clay, sandy, gray
104-110	clay, silty, gray
110-123	clay, very sandy, gray with thin gravel layers
123-150	clay, hard, gray

* * * * *

Test Hole No. 2
Location: 114-55-35ddcd
Type: auger
Elevation: not measured
Water level: (dry hole)

0- 1	topsoil, black
1-14	clay, brown
14-26	clay, dark brown
26-40	clay, gray

* * * * *

Test Hole No. 3
Location: 113-55-6dccc
Type: auger

(continued on next page)

Test Hole No. 3--continued

Elevation: not measured
Water level: not measured

0- 2	topsoil, dark brown
2- 4	clay, light brown
4-24	clay, brown; with very fine sand
24-44	clay, gray

* * * * *

Test Hole No. 4
Location: 113-55-5ddaa
Type: rotary
Elevation: not measured
Water level: not measured

0- 40	clay, buff, sandy
40- 85	clay, buff, sandy and very silty
85-105	silt; and sand, very fine
105-107	gravel, pea size
107-125	clay, gray, sandy

* * * * *

Test Hole No. 5
Location: 113-55-7addd
Type: rotary
Elevation: not measured
Water level: not measured

0- 5	topsoil, black
5- 28	clay, sandy, buff
28- 35	clay, gray
35- 40	clay, sandy, gray
40- 45	sand and gravel
45- 85	clay, gray
85-110	clay, gray; with several 1-2 foot thick sand lenses

* * * * *

Test Hole No. 6
Location: 113-55-7dddd
Type: rotary
Elevation: 1837 feet
Water level: not measured
(continued on next page)

Test Hole No. 6--continued

0- 15	sand, buff; with trace clay
15- 35	clay, sandy
35- 90	clay, greenish-gray
90- 95	sand; and gravel, fine
95-200	clay, sandy, gray
200-205	sand; and gravel, fine
205-256	clay, gray; with sand
256-268	gravel, fine
268-285	clay, buff, sandy
285-290	gravel
290-375	clay, sandy, buff (bottom on impenetrable boulder)

* * * * *

Test Hole No. 7
Location: 113-55-17baab
Type: rotary
Elevation: 1840 feet
Water level: not measured

0- 45	clay, oxidized, buff
45- 85	clay, gray
85- 92	clay, sandy, gray; with thin layers of gravel
92-123	sand, medium to coarse
123-140	sand; with clay layers
140-160	clay, gray; with sand layers
160-165	clay, hard, gray

* * * * *

Test Hole No. 8
Location: 113-55-17aaab
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil
3-15	clay, buff with gravel
15-24	clay, silty, dark
24-35	clay, red; with sand, coarse
35-45	clay, brown; with thin sand layers
45-65	clay, dark brown
65-79	clay, sandy, dark brown (large rock at 79 feet)

* * * * *

Test Hole No. 9
Location: 113-55-17cbaa (80 feet west of Test Hole 10)
Type: 0-85 feet, rotary; 85-120 feet, jet
Elevation: 1838 feet
Water level: not measured

0- 3	topsoil
3- 15	sand; with clay
15- 35	clay, brown; with sand
35- 60	clay, dark gray; with sand
60- 91	clay, medium gray; with sand
91- 93	sand and gravel; with clay
93-100	clay, medium gray; with sand
100-102	sand, medium
102-107	clay, medium gray
107-108	gravel, coarse, angular
108-120	clay, medium gray

* * * * *

Test Hole No. 10
Location: 113-55-17cbaa
Type: rotary
Elevation: 1850 feet
Water level: not measured

0- 15	sand, fine, clayey, buff
15- 90	clay, gray, sandy
90-152	sand, fine to coarse; and clay, gray
152-155	clay, gray

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Test Hole No. 11
Location: 113-56-14dcdc
Type: rotary
Elevation: 1805 feet
Water level: not measured

0- 5	topsoil
5- 10	clay, sandy, buff
10- 22	clay, gray
22- 25	sand; with cobbles
25- 38	clay, gray
38- 47	clay, very sandy, gray
47- 70	clay, gray
70- 78	sand, clean
78-118	clay, silty, gray

(continued on next page)

Test Hole No. 11--continued

118-122	clay, sandy, gray
122-145	clay, gray; with thin sand layers
145-185	clay, buff; with thin sand layers
185-187	gravel, coarse
187-315	clay, hard, buff (bottom on impenetrable rock)

* * * * *

Test Hole No. 12
Location: 113-55-21bbbb
Type: rotary
Elevation: 1840 feet
Water level: not measured

0- 5	clay, buff
5- 18	clay, sandy, buff
18- 30	clay, sandy, gray
30- 60	clay, gray
60- 80	clay, sandy, blue-gray
80- 90	clay, gray
90-138	clay, gray; with alternating thin layers of coarse sand
138-152	clay, gray; with very thin sand layers
152-160	clay, hard, gray
160-180	clay, sandy, buff
180-210	clay, very sandy, buff
210-240	clay, buff
240-250	clay, sandy, soft, buff
250-270	clay, hard, buff
270-290	clay, sandy, gray
290-310	clay, very sandy, gray
310-350	clay, gray
350-377	clay, hard, gray
377-385	sand, fine to coarse
385-407	clay, hard, gray
407-412	shale, dark gray

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Test Hole No. 13
Location: 113-55-20ccbb or cbcc??
Type: rotary
Elevation: 1798 feet
Water level: not measured

0- 3	topsoil

(continued on next page)

Test Hole No. 13--continued

3- 18	sand, clayey, buff
18-205	clay, gray; sand; with thin gravel layers
205-330	clay, buff, sandy
330-400	shale, soft, dark gray

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Test Hole No. 14
Location: 113-55-29addd
Type: rotary
Elevation: not measured
Water level: not measured

0-35	clay, buff; with few thin gravel layers

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Test Hole No. 15
Location: 113-55-33bbbb
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil, buff
3-26	clay; with sand and pebbles
26-44	clay, very sandy, buff
44-46	sand
46-48	clay, gray
48-54	sand, fine to medium
54-86	clay, gray; with thin sand layers

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Test Hole No. 16 and 17
Location: 113-55-33bbbb
Type: rotary
Elevation: not measured
Water level: not measured

0- 2	topsoil, black
2- 4	gray, brown; and silt
4- 6	gravel
6-15	clay, dark brown
15-29	clay, gray

Note: two holes drilled several feet apart; logs identical

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Test Hole No. 18
Location: 113-55-26cccc
Type: auger
Elevation: not measured
Water level: 25 feet

0- 2	topsoil, black
2-10	clay, brown; with large rocks
10-25	clay, dark brown
25-34	clay, brown; with sand, very fine

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Test Hole No. 19
Location: 113-56-36ddaa
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil
3- 7	sand and rocks
7-25	clay, brown
25-34	sand, medium, clean
34-45	clay, medium gray
45-48	sand, coarse; and gravel, fine
48-60	sand, medium to coarse; with fine gravel and with one-foot-thick layers of clay
60-73	sand, coarse; and gravel (hole caving)

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Test Hole No. 20
Location: 113-55-32bccc
Type: auger
Elevation: not measured
Water level: 18 feet

0- 2	topsoil, black
2- 4	clay, brown; and silt
4- 6	gravel
6-15	clay, dark brown
15-29	clay, gray

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Test Hole No. 21
Location: 113-55-32bccc
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil
3-12	clay, buff, light gray
12-18	gravel; with limonite pebbles
18-35	clay, sandy, gray

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Test Hole No. 22
Location: 113-55-32cbbb
Type: auger
Elevation: not measured
Water level: 13 feet

0- 1	topsoil, black
1-10	clay, brown
10-25	clay, dark brown
25-40	clay, gray; with sand

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Test Hole No. 23
Location: 113-55-32cbcc
Type: 0-63, rotary; 63-73, jet; 73-85, rotary
Elevation: 1803 feet
Water level: not measured

0- 6	clay, sandy, buff
6-12	gravel, pea-size
12-67	clay, buff; with thin gravel layers
67-69	sand, coarse; and gravel, fine
69-71	clay, gray
71-73	sand, coarse; and gravel, fine
73-85	sand, coarse; and gravel
	(rocks caving on drill stem at 85 feet)

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Test Hole No. 24
Location: 113-55-32ccbb
Type: rotary
Elevation: 1805 feet
Water level: 72 feet
(continued on next page)

Test Hole No. 24--continued

0- 6	clay, buff, sandy
6-12	gravel, pea-size
12-65	clay, buff; with many gravel layers
65-95	gravel, fine; with cobbles (hole caving, abandoned)

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Test Hole No. 25
Location: 113-55-32ccbc
Type: rotary
Elevation: 1808 feet
Water level: not measured

0- 6	clay, sandy, buff
6-10	gravel
10-61	clay, buff
61-76	sand, coarse; with gravel (rocks caving on drill stem at 76 feet)

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Test Hole No. 26
Location: 113-55-32cbca
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil
3-16	clay, buff
16-23	clay, gray
23-37	clay, gray; with sand and gravel lenses
37-47	clay, gray, sandy
47-57	clay, gray
57-77	gravel
77-80	clay, gray

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Test Hole No. 27
Location: 113-55-32cdaa
Type: not given
Elevation: not measured
Water level: not measured

0- 4	topsoil

(continued on next page)

Test Hole No. 27--continued

4-15	clay, buff, sandy
15-25	clay, gray
25-40	clay, gray, silty
40-48	clay, gray; with thin sand lenses
48-49	gravel
49-58	clay; and silty sand layers
58-62	sand
62-65	clay; and sand layers
65-78	clay, very sandy
78-85	gravel (partially lost circulation)
	(hole walls caving; abandoned hole)

* * * * *

Test Hole No. 28
Location: 113-55-32cddd
Type: rotary
Elevation: not measured
Water level: not measured

0- 2	topsoil
2-18	clay, buff, sandy
18-40	clay, gray
40-75	clay; with fine sand
75-85	sand, coarse; and gravel
	(large impenetrable rocks; abandoned hole)

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Test Hole No. 29
Location: 113-55-32daaa
Type: rotary
Elevation: not measured
Water level: not measured

0- 2	topsoil
2- 8	gravel
8-18	clay, buff, silty
18-38	clay, gray, silty
38-45	sand, fine to coarse; with clay
45-55	clay and sand
55-65	gravel, very coarse
	(hole caving; abandoned hole)

* * * * *

Test Hole No. 30
Location: 113-55-32ddaa
Type: rotary
Elevation: not measured
Water level: not measured

0- 3	topsoil
3- 5	clay, buff
5-22	gravel
22-30	sand, very silty
30-37	clay, gray, sandy
37-50	clay, gray
	(rocks caving in hole; abandoned hole)

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APPENDIX B

Table 2.--Record of wells in the Bryant area.

Geologic source: sl, sand lense; l, lacustrine; so, surface outwash; d, Dakota Group.
Use: S, stock; D, domestic; S,D, stock and domestic.

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
F. Russell	112-55-1a	365	sl	S	5100
E. Johnson	112-55-2d	125	sl	S	2100
J. Hodges	112-55-4a	1463	d	D	
H. Babb	112-55-4d	65	sl	S	2540
D. Martin	112-55-4d	138	sl	S	
J. Ackley	112-55-5b	350	sl	S	3350
G. Carstenson	112-55-6b	160	sl	S	2030
J. Vincent	112-55-6d	360	sl	S	2260
H. Boll	112-56-1b	28	l	S	2390
L. Gilbertson	112-56-1b	400	sl	D	2290
C. Nelson	112-56-2a	1200	d	D	
S. Gilbertson	112-56-2c	420	sl	S	1690
O. Noem	112-56-3d	400	sl	S	3210
I. Gilbertson	112-56-3d	440	sl	S	2200
J. Rasmussen	113-55-1c	300	sl	S	3700
A. Gunderson	113-55-2d	370	sl	S	3100
O. Hall	113-55-3a	250	sl	S	3050
C. Gnat	113-55-3b	100	sl	S	3250
R. Peckenpaugh	113-55-3d	81	sl	S	3500

Table 2.--Records of wells--continued

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
T. Ring	113-55-4c	96	sl	D	3250
Staudy	113-55-5d	87	sl	S	2950
F. Frahm	113-55-6d	28	sl	S,D	1420
J. Anderson	113-55-7a	109	sl	S	2310
F. Frahm	113-55-7b	116	sl	S	
R. Wiseman	113-55-7c	385	sl	S	
Railroad Well N.	113-55-7d	19	so	none	
G. Anderson	113-55-7d	100	sl	S	2530
B. Hagedorn	113-55-8b	55	sl	S	
D. Guse	113-55-8d	95	sl	S	3650
Stauke	113-55-9c	300	sl	S	
B. Peckenpaugh	113-55-10d	181	sl	S	3340
E. Satterness	113-55-11a	60	sl	S	2770
T. Jensen	113-55-11b	76	sl	S	4000
T. Lensin	113-55-13b	387	sl	S	
D. Anderson	113-55-13d	1300	d	D	3250
D. Braaten	113-55-14d	380	sl	S	5260
A. Ladwig	113-55-15c	312	sl	S	
D. Thue	113-55-15d	95	sl	S	
Glennsen	113-55-16d	316	sl	S	3530
H. Sauder	113-55-17a	300	sl	none	
B. Fields	113-55-17d	350	sl	S	

Table 2.--Records of wells--continued

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
H. Richardson	113-55-20c	130	sl	S	2770
B. Fure	113-55-21c	1323	d	S,D	
E. Everson	113-55-22a	280	sl	S	1680
C. Fields	113-55-22c	250	sl	S	
P. Peterson	113-55-22d	87	sl	S	2630
B. Utesch	113-55-23a	400	sl	S	4710
J. Corey	113-55-23b	1320	d	D	3900
Iverson	113-55-24c	400	sl	S	
R. Noem	113-55-24d	100	sl	S	2750
O. Skaglund	113-55-25c	30	sl	D	1720
B. Krull	113-55-25d	87	sl	D	2850
K. Anderson	113-55-25d	95	sl	S	3000
R. Hagelstrom	113-55-26a	96	sl	S	1880
L. Corey	113-55-26c	20	sl(?)	D	2220
C. Fields	113-55-27b	300	sl	S	
H. Gustofson	113-55-27d	85	sl	S	2630
O. Noem	113-55-28a	50	l	S	2040
R. Christianson	113-55-29b	255	sl	S	2040
M. Peterson	113-55-29d	55	sl	S	4010
V. Brown	113-55-31a	22	l	S	1250
J. Corstorsen	113-55-31b	325	sl	S	3870
R. Virchow	113-55-31d	350	sl	S,D	3390

Table 2.--Records of wells--continued

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
L. Haufschild	113-55-32c	1300	d	S	
F. Boldt	113-55-32d	360	sl	S	2012
K. Wiseman	113-55-34b	125	sl	S,D	2290
O. Hursted	113-55-34c	130	sl	S	2130
A. Corey	113-55-34d	100	sl	S	2350
H. Corey	113-55-35b	28	sl	S	4080
C. Babb	113-55-36d	85	sl	S	2220
B. Tiggelaar	113-56-1d	80	sl	S	
L. Griffith	113-56-2b	12	l	S	2690
A. Ladwig	113-56-2d	83	sl	S	3320
R. Warne	113-56-11a	53	sl	S	3005
R. Rumam	113-56-13a	1345	d	S	
E. Layton	113-56-13b	300	sl	S	3250
E. Kays	113-56-14d	97	sl	S	2660
O. Larsen	113-56-15c	220	sl	S	
B. Kerkuliet	113-56-15d	400	sl	S	2600
S. Vorseth	113-56-22d	70	sl	S	3700
C. Ludwig	113-56-23a	87	sl	S	2395
W. Johnson	113-56-23c	190	sl	S	1530
M. Howe	113-56-24a	82	sl	S	
Haube	113-56-24b	240	sl	S	2450

Table 2.--Records of wells--continued

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
O. Eide	113-56-24c	60	sl	S	3560
M. Olsen	113-56-24d	570	sl	S	3090
G. Stesch	113-56-25b	300	sl	S	3500
R. Davidson	113-56-25c	14	l	S	2060
H. Christenson	113-56-25d	90	sl	none	
J. Warne	113-56-27c	400	sl	S	2210
W. Haufle	113-56-27d	300	sl	S	1610
I. Morlder	113-56-27d	480	sl	S	3490
K. Cronkhite	113-56-34d	260	sl	S,D	2300
K. Warne	113-56-34d	427	sl	S	2130
R. Stubbe	113-56-35c	420	sl	S	1610
K. Davidson	113-56-35d	13	l	D	3010
J. Yonker	114-55-25a	300	sl	S	1490
B. Juntunen	114-55-25b	400	sl	S	3950
C. Fedt	114-55-26c	300	sl	S	2540
D. Wemdling	114-55-26d	33	sl	D	2800
N. Horsted	114-55-28d	110	sl	S	2290
N. Noem	114-55-29a	300	sl	S,D	2240
A. Aalser	114-55-29c	365	sl	S	2230
A. Skaglund	114-55-30b	82	sl	S	2770
L. Tackner	114-55-31b	140	sl	S	
N. Staden	114-55-31c	335	sl	S	4570

Table 2.--Records of wells--continued

Name	Location	Depth of Well (ft.)	Geologic Source	Use	Water Conductivity
M. Juntunen	114-55-31d	234	sl	S	3060
C. Gustofson	114-55-32b	16	sl	S	2190
J. Olson	114-55-33a	141	sl	S	2210
E. Kossman	114-55-33b	105	sl	S	
N. Fedt	114-55-34a	370	sl	S	3850
Weeborg	114-55-35a	33	sl	D	2320
R. Sund	114-55-35c	265	sl	S	3650
R. Sour	114-55-36a	380	sl	S	3630
A. Brekke	114-56-25c	70	sl	S	2300
T. Hamre	114-56-27d	165	sl	S	3030
H. Brown	114-56-34d	300	sl	D	2240
A. Tweet	114-56-35d	60	sl	S	1400
C. Skelton	115-55-5a	84	sl	S	2000
G. Dede	116-55-6d	180	sl	S	2580