STATE OF SOUTH DAKOTA
Nils Boe, Governor

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

Special Report 42

GROUND-WATER SUPPLY FOR THE CITY OF MITCHELL, SOUTH DAKOTA

by
Assad Barari

Science Center
University of South Dakota
Vermillion, South Dakota
1966

CONTENTS

ILLUSTRATIONS

TABLE

APPENDIXES

INTRODUCTION

Present Investigation

This report contains the results of a special investigation by the South Dakota State Geological Survey from July 13 to August 8 and from August 15 to 18, 1966, in and around the city of Mitchell, Davison County, South Dakota (fig. 1). The purpose of this investigation was to evaluate the ground-water potential in the Mitchell area as a possible supplemental or future water supply.

Mitchell now obtains its water from Lake Mitchell, just north of the city limits (fig. 2). A treatment plant at the lake has a capacity of 6,000,000 gallons per day, which is nearly the quantity of water used during peak consumption.

A survey of ground-water possibilities was conducted in the Mitchell area. Included in this survey was mapping the geology of 85 square miles, a well inventory, the drilling of 47 auger and 4 rotary test holes. Also included was electrical logging of 4 test holes and collection of 30 water samples for analysis. The result of this ground-water survey shows that there is no aquifer in the Mitchell area which could supply the city with the quantity and quality of water desired for a city supply.

The field work and preparation of this report were performed under the supervision of Lynn Hedges, staff ground-water geologist. The cooperation of the residents of Mitchell, especially Frank B. Orthmeyer, City Engineer and E. Lyle Kinport, Assistant City Engineer, was greatly appreciated. Special thanks are due to Allen and Bob Sampson, local drillers, for making their well records available.

Location and Extent of Area

The city of Mitchell is located in central southeastern South Dakota in Davison County, at an altitude of about 1310 feet above sea level, and has a population of 12,555 (1960 census). The city lies within the James Basin, a part of the Central Lowlands physiographic province (fig. 1).

Climate

The climate is characterized by a wide range of temperatures. The average daily temperature is 48 degrees F., and the average annual precipitation is 21.04 inches at the Mitchell weather station 2 miles south-southeast of the city.

Topography and Drainage

The surface is flat to undulating glacial drift plain, with gently rolling swells and swales. The northern part of the area is nearly level to very gently undulating.

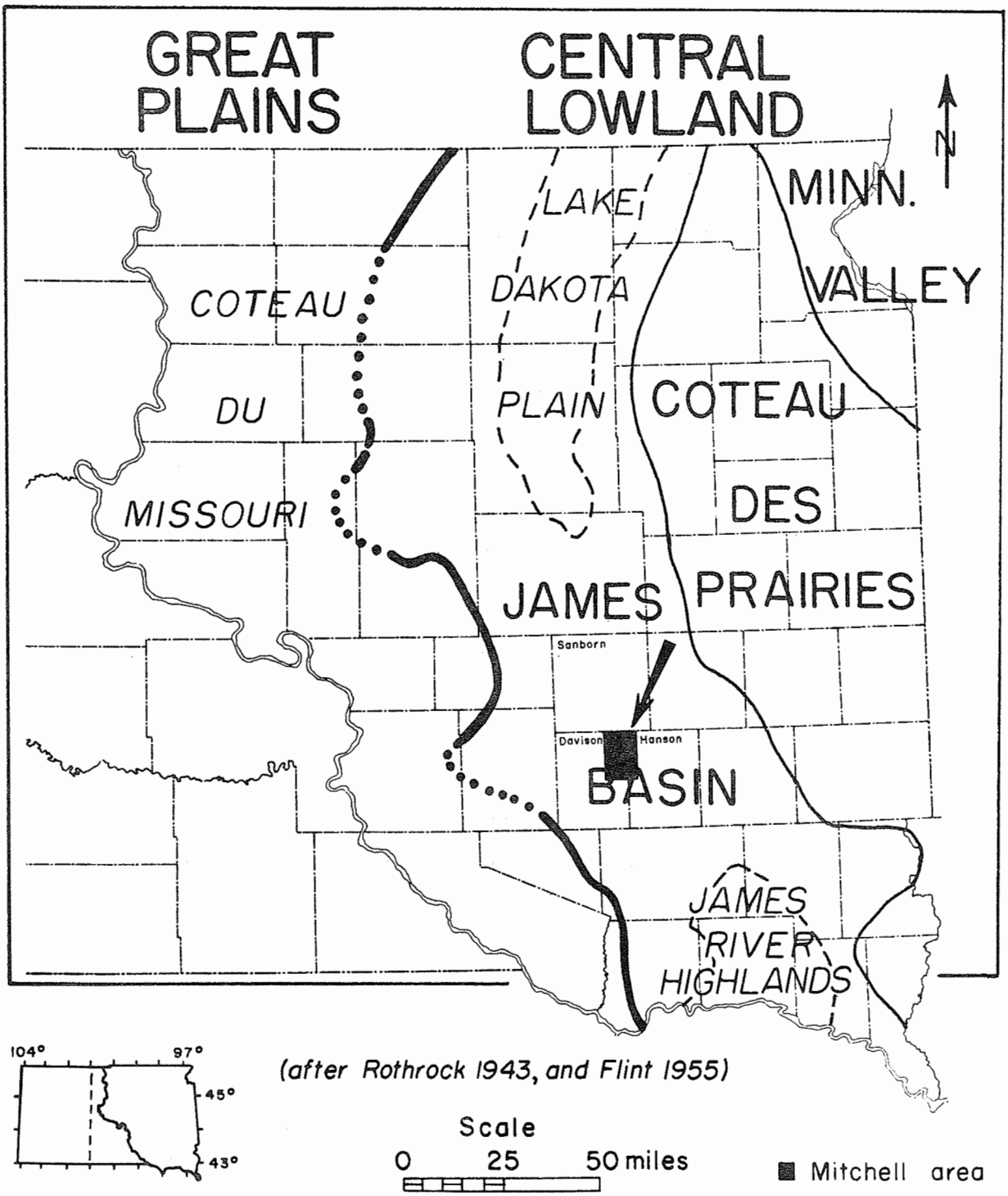


Figure 1. Major physiographic divisions of eastern South Dakota and location of the Mitchell area.

dj

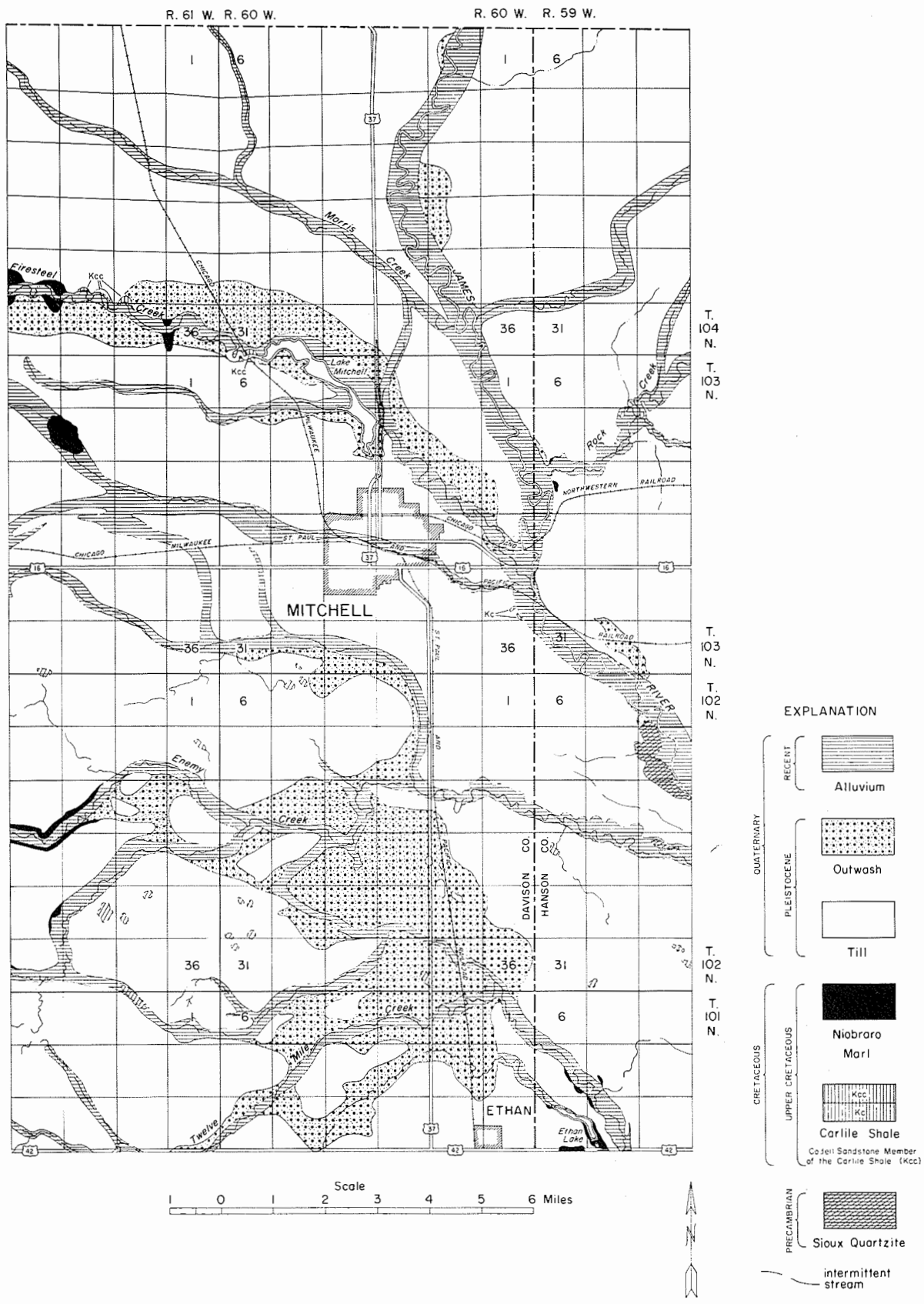


Figure 2. Generalized geologic map of the Mitchell area.

(modified from J. H. Hoff and F. V. Steece, 1960 – H. D. Wang, 1960.
with additional mapping by A. Barari, 1966.)

The area is drained by the James River and its tributaries, which include Firesteel Creek, Enemy Creek, Twelve Mile Creek, Morris Creek, and Rock Creek.

The James River enters the area from the north and leaves Davison County about one mile east of Mitchell. The James River trench has an average width of one-half mile and an average depth of 80 feet.

Data Point Numbering System

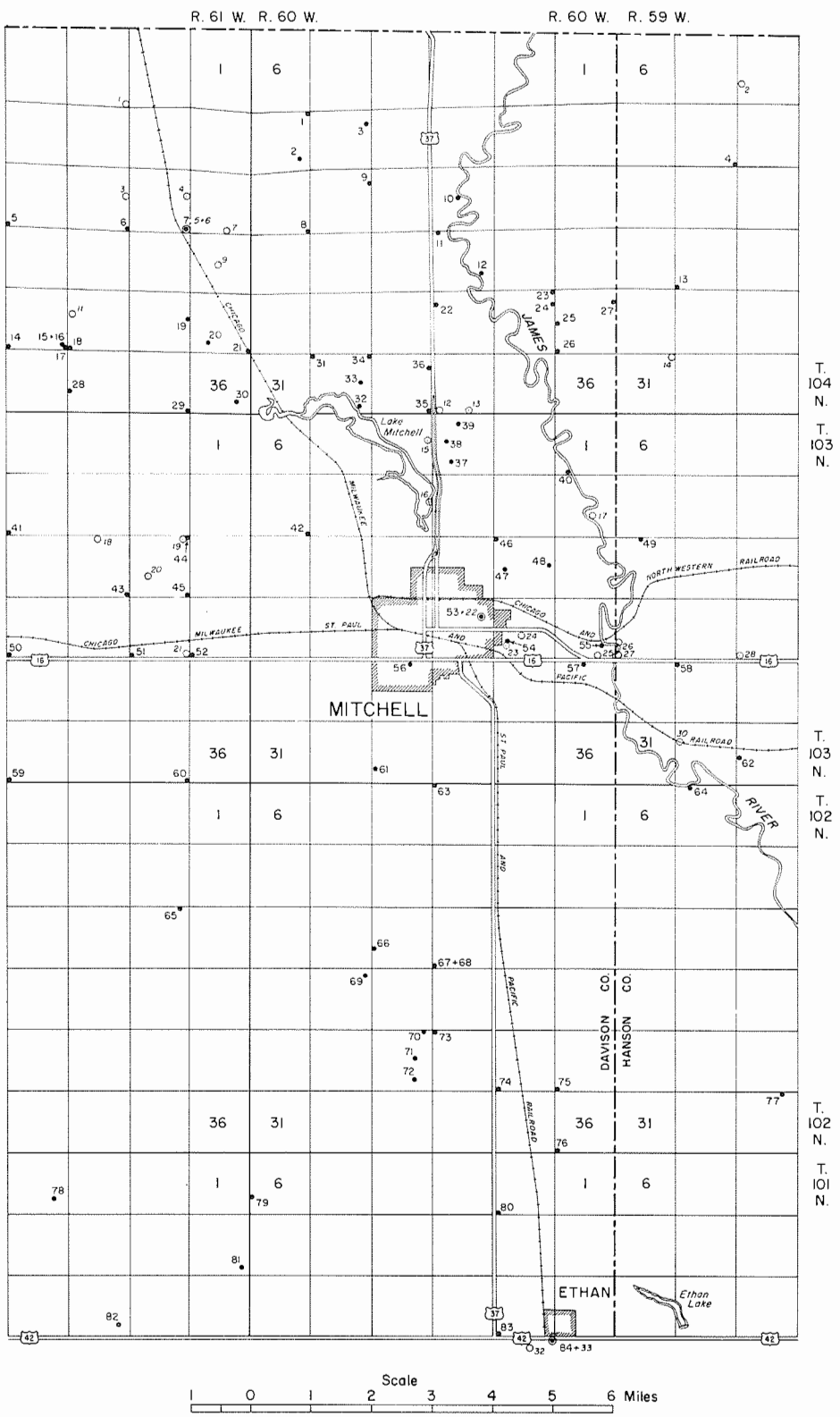
Data-collection points (test holes, wells, and water samples) are located in accordance with the United States Bureau of Land Management's system of land subdivision. The first numeral of a point designation indicates the township, the second the range, and the third the section in which the point is situated. Lowercase letters after the section number indicate location within the section; 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. The letters a, b, c, and d are assigned in a counterclockwise direction, beginning in the northeast corner of each tract. The number of lowercase letters indicates the accuracy of the point location; if the point can be located within a $2\frac{1}{2}$-acre tract, four lowercase letters are shown in the point number. For example, data-collection point 104-61-14dddd (test hole 7, fig. 3) is in the $SE\frac{1}{4}SE\frac{1}{4}SE\frac{1}{4}SE\frac{1}{4}$ sec. 14, T. 104 N., R. 61 W. The method of designation is shown in figure 4.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Mitchell area are mostly the result of glaciation late in the Pleistocene Epoch. The glacial deposits are collectively called drift, and can be divided into till and outwash deposits. Till consists of clay and silt randomly mixed with boulders, pebbles and sand; all were carried and deposited by the ice itself. Glacial till comprises the major portion of the surficial deposits in the Mitchell area (fig. 2). Outwash material was deposited by meltwater streams from the ice and is better sorted, consisting mostly of pebbles and sand with minor amounts of silt and boulders. Outwash material was deposited as small terraces along streams or as outwash plains in low areas adjacent to and between former glacial meltwater channels (fig. 2). The terraces are found mainly on Firesteel Creek and the James River north of Mitchell. The terrace deposits are sand and gravel with various amounts of silt and attain a maximum thickness of 27 feet.

The outwash plain deposits are present four to nine miles south of Mitchell, mainly along Twelve Mile Creek and its tributaries (fig. 2). The outwash plain deposits are mainly sand and silt with some gravel. The maximum thickness of these deposits is 36 feet and the average thickness is about 15 feet.



EXPLANATION

2 Test hole or well, log in Appendix A.

3 Well with water sample; number corresponds to water sample in Table I.

53+22 Test hole with water sample; the first number corresponds to test hole number in Appendix A and the following numbers correspond to water samples in Table I.

Water samples 8, 10, 29, and 31 are outside of study area.

by A. Barari, 1966

drafted by D. W. Johnson

Figure 3. Data map of the Mitchell area.

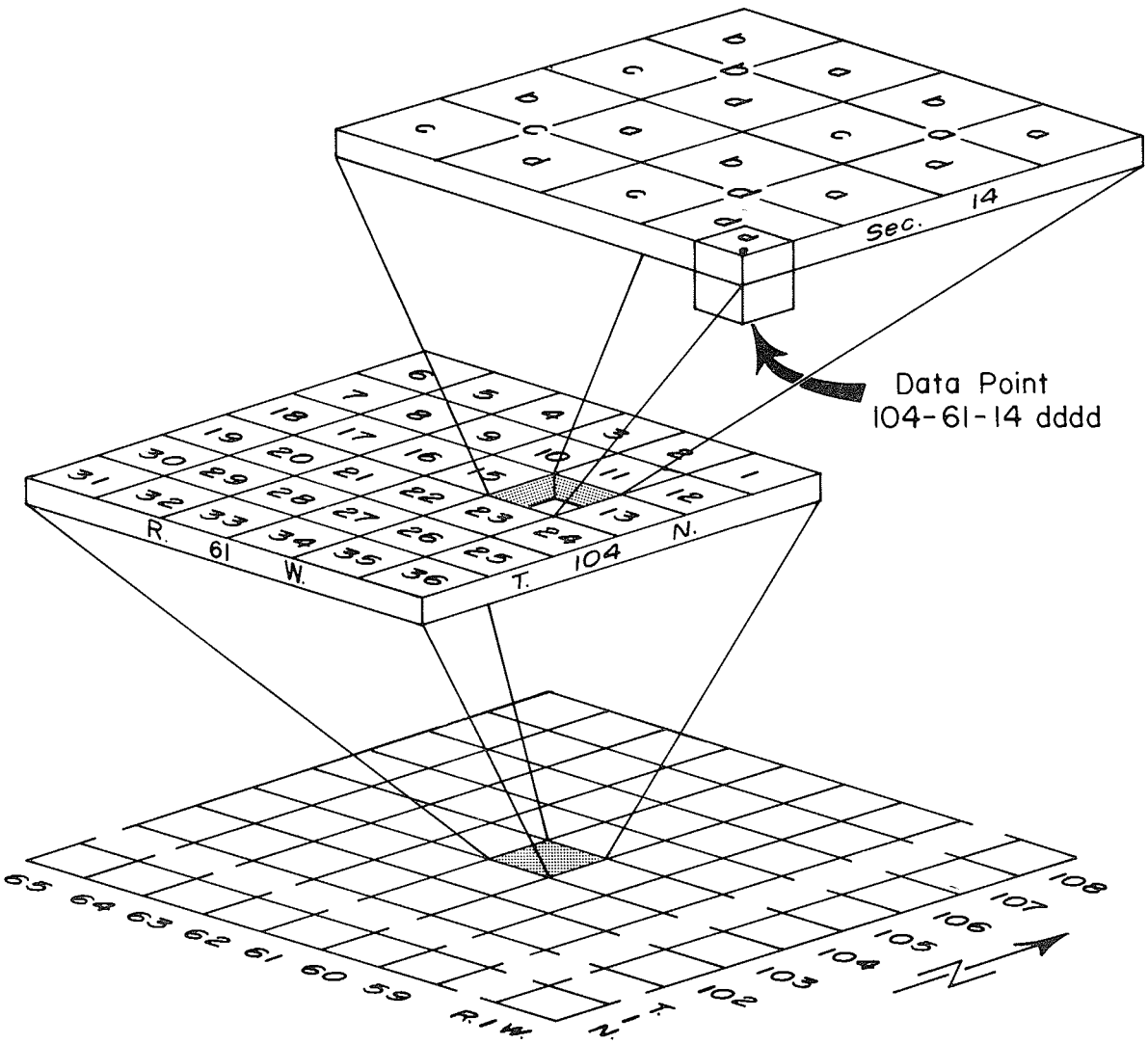


Figure 4. Data point numbering system.

Alluvial material has been deposited by the James River and its tributaries in the Mitchell area (fig. 2). Alluvium consists of silt, clay, and some sand and gravel. The maximum thickness of alluvium penetrated in test drilling was 31 feet.

Exposed Bedrock

The Cretaceous Niobrara Marl crops out in a few locations in the Mitchell area (fig. 2). In this area, the Niobrara is a dark-gray chalk which alternates with layers of gray, shaly marl (Steece and Howells, 1965). The greatest thickness of the Niobrara Marl in the study area was 77 feet in test hole 36 (appendix A).

The Carlile Shale underlies the Niobrara Marl and consists mostly of light-gray to black shale interbedded with silt or sand layers. Locally, the Carlile includes the Codell Sandstone Member near its top. The Codell Sandstone crops out along Firesteel Creek (fig. 2), and the Carlile Shale crops out along the James River two miles southeast of Mitchell (fig. 2). In test hole 7 the Codell is 44 feet thick and consists of brown sandstone and layers of light-gray, medium sand.

The Precambrian Sioux Quartzite crops out along the James River and Enemy Creek where the two streams leave the eastern edge of the study area (fig. 2). The Sioux Quartzite is a hard, massive, pink siliceous quartzite which is bedded and jointed. Where the Sioux Quartzite crops out the younger Cretaceous sediments were probably eroded away.

Subsurface Bedrock

Older stratified rocks of Cretaceous age underlie the Carlile Shale in the Mitchell area. In descending order these are the Greenhorn Limestone, Graneros Shale, and the Dakota Formation.*

The Greenhorn Limestone consists of marl or chalky shale that is locally interbedded with variable thicknesses of hard fragmental limestone (Steece and Howells, 1965). In test hole 54 the Greenhorn Limestone is 13 feet thick.

The Graneros Shale is below the Greenhorn Limestone and above the Dakota Formation. In the Mitchell area the Graneros Shale is a light-gray to dark-gray clay-shale and sandy shale containing some hard layers, probably iron-sulfide or calcium carbonate-cemented sandstone.

The Dakota Formation is a sequence of Cretaceous sand, shale, and coal which is between the Graneros Shale (above) and the Precambrian (below) (Steece and Howells, 1965). The Dakota Formation is missing in the east and southeast parts of the area, reflecting the buried Precambrian Sioux Quartzite highs.

---

*The South Dakota Geological Survey is now using the term Dakota Formation in place of the term Dakota Group of Agnew and Tychsen (1965). For a detailed discussion of this nomenclatural change see Schoon (1965).

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Contrary to popular belief, ground water does not occur in "veins" that crisscross the land at random. Instead it can be shown that water occurs nearly everywhere beneath the surface, but at varying depths. The top of this zone of saturation is known as the water table.

Nearly all ground water is derived from precipitation. Rain or melting snow either 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 to the ground-water table. The permeable rocks (including the soil) that lie above the zone of saturation are in the zone of aeration. Some of the interstices in this zone are also filled with water, but the water is either held in them by molecular attraction or is moving downward toward the zone of saturation. Water within the ground moves downward through the unsaturated zone under the action of gravity, whereas in the saturated zone it moves in a direction determined by the surrounding hydraulic head.

Recharge is the addition of water to an aquifer (formation having structures that permit appreciable water to move through it under ordinary field conditions), and is accomplished in four main ways: (1) downward percolation of precipitation from the ground surface, (2) by downward percolation from surface bodies of water, (3) by lateral underflow of water in transient storage, and (4) by artificial recharge, which occurs 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 main ways: (1) by evaporation and transpiration of plants, (2) by seepage upward or laterally into surface bodies of water, (3) by lateral movement of water in transient storage, and (4) by pumping from the wells which constitutes the major artificial discharge of ground water.

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

The permeability of a rock is its capacity for transmitting a fluid (water). 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 Alluvium

Alluvium is present along the streams in the Mitchell area (fig. 2). Because of the high clay and silt content the alluvium does not readily yield large volumes of water. Locally, domestic wells may yield an adequate supply of water; however, in the study area alluvium would not yield an adequate supply of water for the city of Mitchell.

Ground Water in Glacial Deposits

Till does not yield water readily because of its highly unsorted nature and low permeability. Outwash deposits, because they are better sorted, yield water much more readily than till.

The outwash deposits (fig. 2) generally do not average more than 15 feet in thickness, and are only partially saturated. Locally, the outwash deposits provide an adequate supply for a farm well or small irrigation well, but are not important as a possible city water supply.

Ground Water in Bedrock

The Niobrara Marl and Codell Sandstone Member of the Carlile Shale generally function as a single hydrologic unit in Sanborn County (Steece and Howells, 1965) 8 miles north and is probably true for the Mitchell area. Locally, water from this unit is under artesian pressure. The maximum aggregate thickness of this unit is 121 feet, although the Codell thickness of approximately 40 feet would probably be the maximum thickness for developmental purposes. Test hole 7 (fig. 3) was pumped for several hours at about 100 gallons per minute from the Codell. It should be emphatically stated that this figure is not meant to be an indication of the potential aquifer performance. It is mentioned here only to illustrate that there may be enough potential to justify further investigation as a supplementary or emergency supply.

The Greenhorn Limestone supplies water to some of the artesian wells in the area but does not have a great enough potential for a city supply. Artesian pressure in this aquifer is relatively low.

The sandstones of the Dakota Formation, where they are present, yield water to flowing wells in this area. The driller's log from the Old City Well No. 4 shows that it was getting water from Dakota sand. In the area where the Dakota is present a supplementary water supply is available; however, it is doubtful that its potential greatly exceeds that of the Codell.

The Precambrian Sioux Quartzite yields water to some of the wells from fractures or joints, lenses of porous sand, or deposits of "granite wash" in the west and southern part of the area; however, these supplies are too limited to be considered for municipal use.

Quality of Ground Water

Ground water always contains dissolved chemical substances in various quantities. These substances are derived: (1) from the atmosphere as water vapor condenses and falls, (2) from soil and underlying deposits as the water moves downward to the water table, and (3) from deposits below the water table, where the water is circulating. In general, the more mineral that water contains, the poorer its quality.

Table 1 is a comparison of the quality of water from different sources in the Mitchell area, with the Public Health Standards for drinking water (sample A) and the present city supply (sample 34B) and figure 3 shows the location of the water samples.

The water from the various surface sources (samples 16, 26, 27, and 34) is nearly uniform in quality and is within the recommended limits suggested by the Public Health Department except for the high manganese in sample 26. The water from the various bedrock aquifers, on the other hand, is generally of inferior quality and exceeds the recommended limits in sulfates, total solids, iron, and manganese. In addition, the water is also usually extremely hard and some contains large quantities of calcium.

The water quality in the Niobrara-Codell aquifer varies considerably when compared to the analyses of water from the Dakota Formation. This is probably due to the fact that the Niobrara-Codell aquifer is exposed at the surface and also is in contact with other water-bearing formations where the sediments are pinching out against quartzite ridges. These two situations would allow more interchange of water from various sources, thus causing the erratic analyses from water in this aquifer.

CONCLUSIONS AND RECOMMENDATIONS

From the foregoing information it does not appear that there is an aquifer (or aquifers) in the Mitchell area from which the city could obtain a satisfactory water supply. The glacial outwash deposits are too thin and small in extent to provide an adequate quantity of water for the city. The Niobrara-Codell aquifer may be capable of yielding significant amounts of water; however, a detailed testing program would be required before any estimates of its potential could be made. If this aquifer was found to have a potential it would (1) require several wells to afford even a supplementary supply, (2) require a considerable amount of watermain installation, and (3) produce water inferior in quality to the present supply.

Possible development of the Dakota Formation would be similar to the Niobrara-Codell aquifer except the wells in the Dakota would be deeper and the water quality in general would be inferior to the Niobrara-Codell water.

If the city of Mitchell decides to further investigate the possibility of using water from the Niobrara-Codell or the Dakota aquifers, or both, additional stratigraphic tests would have to be made to determine the thickness, character, and distribution of these aquifers. At least one

Table 1.--Chemical analyses of water samples in the Mitchell area.

Sample	Source	Parts Per Million											
		Calcium	Sodium	Magnesium	Chlorides	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
A		---	---	50	250	500*	0.3	0.05	10.0	0.9-1.7**	---	----	1000*
3	CN	50		13	145	768	None				7.6	180	1870
4	CN	74		18	200	720	0.05				7.4	260	1980?
5	CN	179	3	47	3	408	4.92	0.04	.42	0.8	7.6	640	972
6	CN	149	38	67	6	472	.83	.18	.08	.4	7.8	649	1070
7	CN	320		59	122	1200	0.12				7.9	1040	1910
8	CN	33	600	6	219	838	3.43	1.0	.82	1.0	7.9	108	1996
11	CN	442		172	75	1590	2.4				7.0	1800	2420
12	CN	121	96	25	10	114	0.07	0.4	0.90	0.8	7.2	406	790
13	CN	108		37	25	360	0.52				7.1	420	975
15	CN	150		55	20	480	0.48				7.5	600	970
18	CN	120		37	145	722	0.12				7.4	450	1740
19	CN	173		39	Trace	458	2.0				7.5	590	930
20	CN	209		49	20	580	0.23				7.3	720	1180
21	CN	564	83	226	12	1990	None	.50	1.4	.4	7.3	2339	3768
24	CN	240		83	25	780	12+				7.0	940	1320
29	CN	62		21	150	625	0.12				7.3	240	1745
30	CN	330		103	17	1080	Trace				7.1	1250	1605
31	CN	60		15	135	770	0.04				7.9	210	1680?
32	CN	34		11	350	770	Trace				8.2	131	1760

Table 1.--continued

Sample	Source	Parts Per Million											
		Calcium	Sodium	Magnesium	Chlorides	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
1	Kd	80		24	50	1080	2.0				7.7	300	2008
9	Kd	309	156	80	91	1210	38	.20	.1	1.9	6.6	1100	1940
10	Kd	372	158	81	94	1260	4.0	.12	.0	2.2	7.4	1260	2090
17	Kd	362	142	72	81	1266	None	0.02	0.06	2.0	7.6	1198	2206
22	Kd	510	220	135	122	1721	Fe &Al 1.4		Trace			165?	2220
28	Kd	241		67	80	1140					7.6	1125	1740
14	G	380		None	125	1020					7.4	920	1600
25	G or Kd	372	150	1.2	102	1270	None	None	.94	2.0	7.4	1213	2260
2	T-Q	300		56	100	1140					7.2	980	1890
23	q?	91	128	14	34	378	.20	None	0.8	1.0	8.7	284	714
33	G-q	241		129	125	1142					7.8	1130	1915
16	LM	76	65	60	21	294	0.8	None	.26	2.0	7.9	319	658
***	LM A	70	69	34	20	282	0.2	None	0.3	0.3		314	636
34	LM B	14		14	18	213	None	None	0.0	0.9		90	428
26	JR	65	78	28	31	108	0.3	0.2	0.3	0.4	7.8	276	568
27	JR	56		30	33	240	0.12				8.0	260	620

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

** Optimum

*** City supply (LM): Sample A is raw water; sample B is treated water. Source: CN, Codell-Niobrara; Kd, Dakota Sandstone; G, Greenhorn; T, till; q, quartzite wash (granite wash); Q, quartzite; LM, Lake Mitchell; JR, James River.

Location of Water Samples

A. Drinking Water Standards, U. S. Public Health Service, (1962)
1. 104-61-3dddd, C. Johnson, 510 feet deep (flowing)
2. 104-59-4cbc, E. Fiala, 286 feet deep
3. 104-61-15addd, Koepke, 180 feet (?) deep
4. 104-61-14add, R. Jorgenson, 80+ feet deep
5. 104-61-14dddd, length of casing, 120 feet; the sample was taken at start of pumping
6. 104-61-14dddd, length of casing, 120 feet; the sample was taken after pumping for two hours
7. 104-61-13dcc, O. Hoffman, 85 feet deep
8. 104-62-22bbbb, Blendon School, 140 feet deep
9. 104-61-24ca, Chicago, Milwaukee & St. Paul RR (collected and analyzed by U. S. Geological Survey on 4-29-65), 350 feet deep (flowing), water level 30.95' above land surface
10. 104-61-30add, N. Jacobson (collected and analyzed by U. S. Geological Survey on 4-16-65), 344 feet deep (flowing), water level 17.90' above land surface
11. 104-61-27bcc, D. Stehly, 90+ feet deep
12. 104-60-34ccc, D. Hagge, 100+ feet deep
13. 104-60-34dcc, L. Kistler, 100+ feet deep
14. 104-59-31aaa, M. Moe, 200 feet deep
15. 103-60-4add, C. Keuvley, 75 feet deep
16. 103-60-9addd, Lake Mitchell
17. 103-60-12dbc, H. Kippes, 370 feet deep (flowing)
18. 103-61-15baaa, R. Goldammer, 80 feet deep
19. 103-61-14aab, A. Metzger, 90+ feet deep
20. 103-61-14cac, W. A. Rubel, 36 feet deep
21. 103-61-23ddd, S. Houska, 92 feet deep
22. 103-60-22a, City Old Well #4 (from the file in the City Engineer's office), 538 feet deep
23. 103-60-23cca, A. Schultz, 370 feet deep
24. 103-60-23caa, W. Goldammer, 150 feet deep
25. 103-60-24dcd, D. Barber, (old well in the Dakota Formation?), flowing to the James River
26. 103-59-19ccb, James River, collection date 7-16-66
27. 103-59-19ccc, James River, collection date 8-18-66
28. 103-59-21ccc, Kaneb Pipeline Co., 410 feet deep
29. 103-61-31ccc, E. M. Ross, 180 feet deep
30. 103-59-32bcb, Vitteoe Construction Co., 80 feet deep
31. 102-61-6daaa, C. K. Hubbard, 192 feet deep
32. 101-60-23abc, N. Miller, 114 feet deep
33. 101-60-23aaaa, Ethan City, 320 feet deep
34. City supply from Lake Mitchell

pump test should be conducted for each aquifer; more than one test, however, would be desirable. With this additional information it would be possible to estimate the amount of water available for use by the city. The additional testing should also include feasibility and economic studies for water treatment facilities and water distribution costs.

If the city should decide to use ground water as a supplementary supply, it is recommended that a commercial well driller licensed in South Dakota be contracted to do the test drilling and install the new wells. A consulting engineer licensed in South Dakota should be retained to supervise and coordinate all phases of the testing program, the economic and feasibility studies, and the design and installation of all phases of the water system.

In addition, the city officials should consult with the State Water Resources Commission with regard to obtaining water rights and permits to drill, and the State Department of Health with regard to the biological and chemical suitability of the water.

REFERENCES CITED

Agnew, A. F., and Tychsen, P. C., 1965, A guide to the stratigraphy of South Dakota: S. Dak. Geol. Survey Bull. 14, p. 67.

Flint, R. F., 1955, Pleistocene geology of eastern South Dakota: U. S. Geol. Survey Prof. Paper 262.

Hoff, J. H., and Steece, F. V., 1961, Geology of the Mitchell quadrangle, South Dakota: S. Dak. Geol. Survey, map and text.

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

Schoon, R. A., 1965, Dakota formation of South Dakota: S. Dak. Acad. Sci. Proc., v. 44, p. 72-79.

Steece, F. V., and Howells, L. W., 1965, Geology and ground-water supplies in Sanborn County, South Dakota: S. Dak. Geol. Survey Bull. 17, 182 p.

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

Wong, H. D., 1959, Geology of the Alexandria quadrangle, South Dakota: S. Dak. Geol. Survey, map and text.

APPENDIX A

Logs of Test Holes and Wells in the Mitchell Area

(for location see figure 3)

Test Hole No. 1
SDGS Auger
Location: 104-60-7aaaa
Surface elevation: 1289 feet
Depth to water: not measured

0- 24	Till, brownish-tan
24- 29	Till, olive-brown
29-108	Till, dark-gray; reworked Niobrara?
108-112	Chalk (marl); reworked?

* * * *

Well No. 2
Driller's Log
Location: 104-60-7ddba
Surface elevation: 1307 feet
Depth to water: not measured

0- 80	Clay, blue; (till)
80-100	Chalk
100-300	Shale
300-307	Cap rock
307-361	Sandstone and shale

* * * *

Well No. 3
Driller's Log
Location: 104-60-8aadc
Surface elevation: 1305 feet
Depth to water: flowing

0- 30	Till
30- 75	Drift
75- 90	Chalk
90-110	Shale and clay
110-114	Sandstone
114-256	Shale
? -282	Sandstone, flow

* * * *

Test Hole No. 4
SDGS Auger
Location: 104-59-8dddd
Surface elevation: 1312 feet
Depth to water: 29 feet

0- 1	Topsoil
1-23	Till, brownish-tan
23-29	Till, grayish-brown
29-77	Till, dark-gray
77-	Sioux Quartzite

* * * *

Well No. 5
Bureau of Reclamation Observation Well
Location: 104-61-16cccc
Surface elevation: 1309 feet
Depth to water: not measured

0-26	Till
26-30	Sand, silty
30-43	Chalkstone (marl), light-gray
43-46	Chalkstone (marl), some sand
46-85	Sand, yellow, some cemented layers
85-90	Sandstone, very hard

* * * *

Well No. 6
Driller's Log
Location: 104-61-15dddd
Surface elevation: not measured
Depth to water: flowing

0- 30	Clay, yellow; (till)
30-110	Clay?, blue
110-130	Sandstone
130-160	Chalk? (shale)
160-296	Shale
296-300	Sandstone
300-340	Shale, blue
340-350	Sandstone

* * * *

Test Hole No. 7
SDGS Rotary
Location: 104-61-14dddd
Surface elevation: 1300 feet
Depth to water: 33 feet

0- 14	Till, sand and clay
14- 20	Clay, gray, pebbly; till
20- 35	Clay, some thin layers of fine sand and gravel; till
35- 50	Clay, some pebbles; till
50- 88	Chalk, marl; some calcareous layers
88-132	Sandstone and sand layers
132-155	Shale, gray

* * * *

Well No. 8
Bureau of Reclamation Observation Well
Location: 104-60-18dddd
Surface elevation: 1276 feet
Depth to water: not measured

0-30	Till, oxidized
30-53	Till, unoxidized
53-55	Sand, fine to medium
55-70	Sand, dirty, lime cemented, some chalk pebbles
70-80	Sand, fine, medium, silty
80-82	Till?, granitic pebbles
82-85	Chalkstone (marl), white, hard

* * * *

Well No. 9
Driller's Log
Location: 104-60-17aadd
Surface elevation: 1300 feet
Depth to water: flowing

0- 40	Till, yellow
40- 75	Till, blue
75-100	Chalk
100-126	Sand and sandstone
126-290	Shale
290-302	Sandstone
302-400	Shale
400-401	Sandstone, flow

* * * *

Test Hole No. 10
SDGS Auger
Location: 104-60-15bddc
Surface elevation: 1215 feet
Depth to water: 12 feet

0- 1	Topsoil
1-12	Silt, dark-brown
12-28	Gravel, dark-brown, sandy, with clay
28-37	Chalk
37-39	Shale?
39-40	Sand, dark-gray, fine
40-41	Sandstone?, couldn't drill it

* * * *

Well No. 11
Driller's Log
Location: 104-60-22bbba
Surface elevation: 1217.5 feet
Depth to water: 10.7 feet

0- 7	Topsoil
7-20	Clay, gray
20-45	Sand, fine, and gray clay interbedded
45-50	Clay, blue

* * * *

Test Hole No. 12
SDGS Auger
Location: 104-60-22dacc
Surface elevation: 1210 feet
Depth to water: 14 feet

0- 1	Topsoil
1- 4	Silt, blackish-brown
4-14	Till, blackish-brown
14-24	Clay, tan
24-39	Chalk (calcareous clay)
39-44	Chalk? (calcareous clay-marl)

* * * *

Test Hole No. 13
SDGS Auger
Location: 104-59-20cccc
Surface elevation: 1301 feet
Depth to water: dry hole

0- 1	Topsoil
1-14	Till, buff
14-34	Till, gray-brown

* * * *

Test Hole No. 14
SDGS Auger
Location: 104-61-28cccc
Surface elevation: not measured
Depth to water: 14 feet

0-14	Silt, buff
14-29	Clay, chalk?
29-54	Chalk (marl), drilled hard

* * * *

Test Hole No. 15
SDGS Auger
Location: 104-61-28ddda$_1$
Surface elevation: not measured
Depth to water: 9 feet

0- 9	Silt, dark-brown
9-11	Sand, dark-brown, silty
11-14	Chalk (marl)
14-19	Sand, dark-gray, fine to medium
19-23	Sandstone, hard

* * * *

Test Hole No. 16
SDGS Auger
Location: 104-61-28ddda$_2$
Surface elevation: not measured
Depth to water: 9 feet

0- 9	Silt, dark-brown, clayey
9-11	Sand, dark-brown, silty
11-14	Chalk, probably reworked
14-19	Sand, dark-gray, fine to medium
19-23	Sandstone

* * * *

Test Hole No. 17
SDGS Auger
Location: 104-61-28dddd
Surface elevation: not measured
Depth to water: 9 feet

0- 9	Silt
9-11	Sand, dark-brown, silty
11-14	Chalk (marl)
14-19	Sand, dark-gray, fine to medium
19-23	Sandstone, hard

* * * *

Test Hole No. 18
SDGS Auger
Location: 104-61-27cccc
Surface elevation: not measured
Depth to water: 11 feet

0- 1	Topsoil
1-11	Silt, light-gray
11-13	Sand, buff
13-14	Gravel, boulders
14-22	Chalk (marl)
22-	Sandstone

* * * *

Test Hole No. 19
SDGS Auger
Location: 104-61-26addd
Surface elevation: 1310 feet
Depth to water: dry hole

1- 4	Clay, buff
4- 8	Gravel, reddish-brown, fine to medium
8-14	Till, buff
14-19	Till, gray-brown

* * * *

Well No. 20
Driller's Log
Location: 104-61-25cdbc
Surface elevation: 1305 feet
Depth to water: flowing

0- 35	Till
35- 80	Sandstone
80-183	Shale
183-185	Sandstone, flow
185-290	Shale
290-307	Sandstone, strong flow

* * * *

Test Hole No. 21
SDGS Auger
Location: 104-61-25dddd
Surface elevation: 1306 feet
Depth to water: 24 feet

0- 2	Gravel, reddish-tan
2- 6	Sand, medium, highly oxidized
6-24	Till, light-gray
24-29	Till

* * * *

Test Hole No. 22
SDGS Auger
Location: 104-60-27bbcc
Surface elevation: 1235 feet
Depth to water: 6 feet

1- 6	Clay, silt and some sand; alluvium
6- 9	Clay, buff
9-24	Clay, gray-brown
24-29	Chalk?, drilled hard

* * * *

Well No. 23
Driller's Log
Location: 104-60-26aaaa
Surface elevation: 1297 feet
Depth to water: flowing
(continued on next page)

Well No. 23--continued

0- 40	Clay, yellow (till)
40- 80	Clay, blue
80- 97	Sandstone
97-217	Shale, blue
217-224	Sandstone
224-234	Shale
234-235	Sand (lying on rock)

* * * *

Well No. 24
Driller's Log
Location: 104-60-26aad
Surface elevation: 1297 feet
Depth to water: flowing?

0- 80	Drift
80- 95	Sandstone
95-200	Shale
200-207	Sandstone
207-228	Quartzite

* * * *

Test Hole No. 25
SDGS Auger
Location: 104-60-25cbbb
Surface elevation: 1298 feet
Depth to water: dry hole

0- 1	Topsoil
1-14	Till, buff
14-19	Till, olive-brown
19-76	Till, dark-gray (chalk?)
76-	Sandstone

* * * *

Well No. 26
Driller's Log
Location: 104-60-25ccc
Surface elevation: 1302 feet
Depth to water: flowing

0- 80	Till
80- 90	Sandstone
90-250	Shale
250-317	Sandstone

* * * *

Well No. 27
Driller's Log
Location: 104-60-25daad
Surface elevation: 1285 feet
Depth to water: flowing (48 gpm)

0- 36	Clay, yellow (till)
36- 74	Clay, blue
74-115	Shale, blue, with rock at base

* * * *

Well No. 28
Driller's Log
Location: 104-61-34cbcb
Surface elevation: not measured
Depth to water: flowing

0- 14	Drift
14- 28	Chalkstone
28- 36	Sandstone
36-180	Shale
180-200	Sandstone?, flow near bottom
200-312	Shale
312-313	Sandstone

* * * *

Test Hole No. 29
SDGS Auger
Location: 104-61-35dddd
Surface elevation: 1324 feet
Depth to water: dry hole

1-7	Clay, light-brown
7-	Hit rock, couldn't drill
	Moved 2 feet, drilled 4 feet, hit rock again

* * * *

Test Hole No. 30
SDGS Auger
Location: 104-61-36dadb
Surface elevation: 1265 feet
Depth to water: 5 feet
(continued on next page)

Test Hole No. 30--continued

0- 4	Silt, dark-brown
4-14	Silt, dark-brown, some sand
14-31	Chalk
31-34	Sandstone
34-47	Sandstone, and sand
47-	Rock, sandstone (?)

* * * *

Test Hole No. 31
SDGS Auger
Location: 104-60-32bbbb
Surface elevation: 1296 feet
Depth to water: 18 feet

1- 4	Silt, cream-colored
4- 7	Sand, buff
7-18	Clay, buff, (till)
18-19	Sand, buff
19-24	Till, gray-brown

* * * *

Test Hole No. 32
SDGS Auger
Location: 104-60-32ddbb
Surface elevation: 1295 feet
Depth to water: 32 feet

0- 1	Topsoil
1- 6	Silt, buff
6- 8	Gravel, coarse, some sand
8-11	Till, dark gray-brown
11-14	Sand, highly oxidized
14-27	Till, dark-gray
27-29	Sand, gray, coarse, some clay
29-74	Clay, some coarse sand
74-78	Gravel, with boulders
78-84	Chalk, dark-gray, calcareous clay, drilled hard

* * * *

Test Hole No. 33
SDGS Auger
Location: 104-60-32adcd
Surface elevation: 1298 feet
Depth to water: 9 feet

0- 1	Topsoil
1- 4	Sand, buff, fine, with silt
4-14	Gravel and sand, buff
14-44	Till, dark-gray
44-53	Sand and gravel
53-63	Till, dark-gray
63-68	Sand and gravel indication
68	Hit large rock
68-94	Clay, cream-colored, (chalk)

* * * *

Test Hole No. 34
SDGS Auger
Location: 104-60-32aaaa
Surface elevation: 1294 feet
Depth to water: dry hole

0- 2	Topsoil
2-20	Till, brown

* * * *

Test Hole No. 35
SDGS Auger
Location: 104-60-33dddd
Surface elevation: 1284 feet
Depth to water: dry hole

1- 4	Sand, light-yellow, medium to coarse
4- 9	Till, brownish-tan
9-38	Till, dark-gray
38-	Hit rock

* * * *

Test Hole No. 36
SDGS Rotary
Location: 104-60-33aadd
Surface elevation: 1296 feet
Depth to water: not measured
(continued on next page)

Test Hole No. 36--continued

0- 18	Till, brown
18- 40	Till, gray
40- 86	Till, gray; some gravel
86- 93	Gravel, with clay
93-170	Chalk, gray, and marl; hard calcareous layers
170-190	Sandstone and sand layers
190-200	Sand, with clay
200-215	Shale, gray

* * * *

Test Hole No. 37
SDGS Auger
Location: 103-60-3cdbb
Surface elevation: 1270 feet
Depth to water: 16 feet

0- 1	Topsoil
1-13	Sand, with silt and gravel, oxidized
13-21	Clay, sandy, highly oxidized
21-23	Gravel
23-75	Till, gray
75-79	Chalk (marl), grayish-white

* * * *

Test Hole No. 38
SDGS Auger
Location: 103-60-3bcdd
Surface elevation: 1275 feet
Depth to water: 8 feet

0- 4	Sand, cream-colored
4- 8	Sand, buff, fine to medium
8-23	Sand, gray-brown, fine to medium
23-49	Till, dark-gray, with large gravel
49-59	Chalk, cream-colored

* * * *

Test Hole No. 39
SDGS Auger
Location: 103-60-3badc
Surface elevation: 1295 feet
Depth to water: 9 feet
(continued on next page)

Test Hole No. 39--continued

0- 9	Sand, buff
9-20	Sand, light-gray, fine to coarse
20-22	Gravel indication
22-48	Till, dark-gray
48-54	Chalk, (compact calcareous clay)

* * * *

Test Hole No. 40
SDGS Auger
Location: 103-60-1ccdd
Surface elevation: 1210 feet
Depth to water: 1 foot

0- 1	Topsoil
1- 9	Clay, cream-colored, some yellow
9-27	Clay, light- to dark-gray
27-54	Clay, dark- to very dark-gray

* * * *

Well No. 41
Bureau of Reclamation Observation Well
Location: 103-61-9cccc
Surface elevation: 1346 feet
Depth to water: not measured

0- 5	Sand, silty, fine, oxidized
5-15	Till, oxidized
15-35	Chalk, clayey

* * * *

Well No. 42
Bureau of Reclamation Observation Well
Location: 103-60-7dddd
Surface elevation: 1331 feet
Depth to water: not measured

0 - 45.5	Till, oxidized, clayey silt
45.5- 63	Till, unoxidized, silty clay
63 - 75.5	Sand, fine to medium, some pebbles, partially cemented; probably reworked Codell sand
75.5-120	Sand, fine, some silt, cemented in part; Codell Sandstone
120 -128	Shale, black with thin sand lenses; Carlile Formation

* * * *

Test Hole No. 43
SDGS Auger
Location: 103-61-15dddd
Surface elevation: not measured
Depth to water: 14 feet

0- 1	Topsoil
1-12	Chalk, cream-colored
12-19	Chalk, gray
19-24	Shale, dark-gray to black

* * * *

Well No. 44
Bureau of Reclamation Observation Well
Location: 103-61-14aaaa
Surface elevation: 1338 feet
Depth to water: not measured

0 - 30.5	Till
30.5- 58.0	Chalkstone (marl)
58 -100	Sand, dark-gray to brown, locally cemented
100 -105	Sandstone
105 -118	Shale

* * * *

Test Hole No. 45
SDGS Rotary
Location: 103-61-14dddd
Surface elevation: 1318 feet
Depth to water: not measured

0- 5	Sand, silty
5-25	Chalk (marl), light-gray
25-50	Sandstone, sand, some clay
50-65	Sandstone
65-80	Shale, gray

* * * *

Test Hole No. 46
SDGS Auger
Location: 103-60-14bbbb
Surface elevation: 1249 feet
Depth to water: dry hole

0-1	Topsoil
1-4	Gravel, brown, coarse
4-9	Sand, coarse, with large gravel; hit rock, offset 6 feet, hit rock at 7 feet, abandoned hole

* * * *

Test Hole No. 47
SDGS Auger
Location: 103-60-14cbab
Surface elevation: 1225 feet
Depth to water: 19 feet

0- 1	Topsoil
1-19	Silt, dark-brown
19-31	Sand, light-gray; some fine gravel
31-44	Chalk, dark-gray

* * * *

Test Hole No. 48
SDGS Auger
Location: 103-60-14daaa
Surface elevation: 1280 feet
Depth to water: 19 feet

0- 3	Roadbed
3- 4	Silt, brown
4- 9	Sand, reddish-brown, fine to coarse, some fine gravel
9-14	Sand, reddish-brown, fine to medium
14-19	Gravel, reddish-brown, fine to coarse
19-27	Gravel, gray to dark-brown, fine to coarse
27-44	Clay, with gravel stringers
44-90	Clay, with some fine sand
90-94	Chalk, light- to dark-gray, drilled hard

* * * *

Well No. 49
Driller's Log
Location: 103-59-18ba
Surface elevation: 1230 feet
Depth to water: flowing

0- 44	Clay, black, soft
44- 65	Chalk mixed with shale
65- 90	Clay, blue
90-165	Shale, gray
165-172	Sandstone layers
172-227	Shale, sandy
227-245	Sand
245-	End of sand

* * * *

Test Hole No. 50
SDGS Auger
Location: 103-61-21cccc
Surface elevation: not measured
Depth to water: 29 feet

0- 1	Topsoil
1- 9	Till, light-brown
9-24	Till, olive-brown
24-32	Sand, light-gray
32-33	Gravel indication
33-35	Till, dark-gray
35-37	Gravel and rocks
37-44	Chalk (marl)

* * * *

Test Hole No. 51
SDGS Auger
Location: 103-61-23cccc
Surface elevation: 1355 feet
Depth to water: 12 feet

0- 1	Topsoil
1- 4	Silt, contains clay
4- 9	Till, buff
9-16	Sand, buff, fine to medium
16-24	Till, dark gray-brown
24-34	Chalk (marl)

* * * *

Well No. 52
Driller's Log
Location: 103-61-24cccc
Surface elevation: 1370 feet
Depth to water: around 45 feet

0- 55	Till
55- 64	Sand, coarse
64- 84	Chalk
84-105	Sand and sandstone

* * * *

Well No. 53
Driller's Log
Location: 103-60-22adb City Old Well #4
Surface elevation: 1310 feet
Depth to water: 25 feet

0- 30	Clay, yellow (till)
30- 70	Clay, blue
70-135	Chalk
135-153	Sandstone, water-bearing
153-290	Shale, gray
290-300	Sandstone, hard, dry (limestone?)
300-507	Shale, blue
507-530	Sandstone, water-bearing, containing $2\frac{1}{2}$-feet vein of coal
530-538	Sandstone, hard, dry

* * * *

Test Hole No. 54
SDGS Rotary
Location: 103-60-23cbdd
Surface elevation: 1300 feet
Depth to water: not measured

0- 19	Till, brown
19- 40	Till, gray
40- 51	Till, with thin gravel layers
51-120	Chalk (marl), light-gray
120-150	Sandstone and sand layers
150-280	Shale, some hard layers
280-293	Limestone and chalky shale
293-345	Shale
345-366	Sand, with clay and gravel (?)
366-435	Shale, some thin sand layers

* * * *

Test Hole No. 55
SDGS Auger
Location: 103-60-24ddbb
Surface elevation: 1215 feet
Depth to water: 9 feet

0- 1	Topsoil
1- 9	Clay, blackish-brown
9-19	Clay, buff
19-61	Clay, with some fine to medium sand
61-64	Gravel indication
64-72	Chalk?

* * * *

Well No. 56
Driller's Log
Location: 103-60-28ab
Surface elevation: 1340 feet
Depth to water: not measured

0- 20	Clay, yellow, (till)
20- 40	Clay, blue, with sand
40- 60	Clay, blue?
60- 80	Limestone?, (sandstone?)
80-180	Shale
180-200	Limestone
200-210	Shale
210-220	Quartzite wash
220-240	Quartzite

* * * *

Test Hole No. 57
SDGS Auger
Location: 103-60-25baaa
Surface elevation: 1215 feet
Depth to water: 7 feet

0- 1	Topsoil
1- 4	Clay, blackish-brown
4-14	Clay, buff
14-64	Clay, gray-brown, with fine sand
64-72	Shale
72-73	Shale, drilled hard

* * * *

Test Hole No. 58
SDGS Auger
Location: 103-59-29bbbb
Surface elevation: 1310 feet
Depth to water: 32 feet

0- 4	Silt, buff
4-14	Till, olive to buff
14-32	Till, blue
32-37	Sand, buff
37-80	Till, gray, drilled hard
80-84	Chalk (marl), cream-colored

* * * *

Well No. 59
Bureau of Reclamation Observation Well
Location: 103-61-33cccc
Surface elevation: 1404 feet
Depth to water: not measured

0	-34	Till
34	-37.5	Sand, oxidized
37.5	-45	Till
45	-78	Chalk (marl)

* * * *

Well No. 60
Bureau of Reclamation Observation Well
Location: 103-61-35dddd
Surface elevation: 1353 feet
Depth to water: not measured

0-23	Till, oxidized
23-45	Chalk (marl)

* * * *

Test Hole No. 61
SDGS Auger
Location: 103-60-33ccbb
Surface elevation: 1330 feet
Depth to water: 7 feet

0- 3	Gravel, buff
3- 7	Silt, light-brown
7- 9	Clay, light-brown
9-14	Clay, dark yellow-brown
14-19	Silt, buff, with fine sand
19-29	Clay, buff, some fine sand
29-	Rock, couldn't drill through it

* * * *

Test Hole No. 62
SDGS Auger
Location: 103-59-33cbbb
Surface elevation: 1286 feet
Depth to water: dry hole

0-9	Gravel, very coarse, hit rocks, couldn't drill, offset 6 feet to the north, hit rock at 7 feet and abandoned hole

* * * *

Test Hole No. 63
SDGS Auger
Location: 102-60-3bbbb
Surface elevation: 1320 feet
Depth to water: 7 feet

0- 1	Topsoil
1- 7	Silt, reddish-brown
7-14	Sand, dark-brown, fine to coarse
14-17	Sand, gray, coarse to fine
17-36	Clay with pebbles, dark-gray
36-	Rock

* * * *

Test Hole No. 64
SDGS Auger
Location: 102-59-5bbaa
Surface elevation: 1215 feet
Depth to water: 18 feet

0- 1	Topsoil
1-18	Clay, dark-gray
18-55	Clay, dark-gray, with fine sand
55-56	Rock, very hard
56-68	Chalk, dark-gray
68-74	Shale, dark-gray

* * * *

Well No. 65
Driller's Log
Location: 102-61-14aa
Surface elevation: 1360 feet
Depth to water: flowing

0- 20	Clay, yellow, (till)
20- 60	Chalk
60-120	Sandstone
120-230	Shale, blue
230-232	Cap rock?
232-336	Rock, water-bearing

* * * *

Test Hole No. 66
SDGS Auger
Location: 102-60-16cbcc
Surface elevation: 1330 feet
Depth to water: 7 feet

0- 7	Clay, dark-brown
7-16	Sand, coarse to fine, some clay
16-46	Clay, dark-gray, some pebbles
46-	Rock, couldn't drill through it

* * * *

Test Hole No. 67
SDGS Auger
Location: 102-60-15cccc$_1$
Surface elevation: 1317 feet
Depth to water: 7 feet

0- 1	Topsoil
1- 4	Silt, brownish-tan, some sand
4- 8	Sand, reddish-brown, coarse to fine
8-19	Clay, dark brownish-black, has pebbles in it
19-24	Sand, dark-gray, fine
24-28	Clay, dark-gray to black, has pebbles
28-	Rock, couldn't drill through it

* * * *

Test Hole No. 68
SDGS Auger
Location: 102-60-15cccc$_2$
Surface elevation: 1317 feet
Depth to water: 7 feet

0- 1	Topsoil
1- 4	Silt, buff, some sand
4- 8	Sand, reddish-brown, coarse to fine
8-19	Clay, dark brownish-black, has pebbles in it
19-24	Sand, dark-gray, fine
24-29	Clay, dark-gray, some pebbles
29-	Rock

* * * *

Well No. 69
Driller's Log
Location: 102-60-20aa
Surface elevation: 1340 feet
Depth to water: not measured

0- 30	Clay, yellow, (till)
30- 55	Clay, blue
55- 75	Sandstone
75-195	Cap rock?
195-	Struck pyrites mixed with sandstone and failed to finish the well

* * * *

Well No. 70
Driller's Log
Location: 102-60-28a
Surface elevation: not measured
Depth to water: not measured

0- 2	Topsoil
2- 12	Sand and gravel
12- 21	Till, blue-gray
21- 25	Sand, coarse
25- 44	Till
44- 57	Sand, fine, (Codell?)
57- 65	Sandstone
65-150	Shale
150-152	Rock, hard
152-210	Shale
210-	Sioux Quartzite

* * * *

Well No. 71
Driller's Log
Location: 102-60-28acd
Surface elevation: not measured
Depth to water: not measured

0- 1	Topsoil
1-10	Sand and gravel
10-28	Till
28-36	Sand
36-43	Till
43-57	Sand and sandstone
57-59	Clay, sandy
59-64	Sand, fine
64-70	Bedrock?

* * * *

Well No. 72
Driller's Log
Location: 102-60-28dca
Surface elevation: not measured
Depth to water: not measured

0- 2	Topsoil
2-10	Sand and gravel
10-18	Till, blue-gray
18-26	Sand and gravel
26-28	Till
28-31	Sand
31-32	Till
32-35	Gravel, coarse
35-56	Till
56-66	Sand, fine
66-70	Till
70-75	Niobrara Chalk

* * * *

Test Hole No. 73
SDGS Auger
Location: 102-60-27bbbb
Surface elevation: not measured
Depth to water: 9 feet

0- 4	Sand, dark-brown, coarse
4- 7	Sand, dark-brown, some gravels
7-27	Clay, dark-gray, with pebbles, (till)
27-30	Sand, dark-gray, fine to coarse
30-34	Rock area, last 2 feet drilled harder
34-48	Sand, dark-gray, fine
48-51	Clay, with some sand, and pebbles
51-59	Shale, possibly reworked?

* * * *

Test Hole No. 74
SDGS Auger
Location: 102-60-26cccc
Surface elevation: 1320 feet
Depth to water: 4 feet

0- 4	Sand, yellow, silty
4- 9	Gravel, yellow, fine
9-16	Sand, dark-gray, coarse to fine
16-16½	Quartzite?

* * * *

Test Hole No. 75
SDGS Auger
Location: 102-60-25cccc
Surface elevation: 1311 feet
Depth to water: dry hole

0-3	Large gravel with coarse sand
	Hit large rock at 3 feet, couldn't penetrate

* * * *

Test Hole No. 76
SDGS Auger
Location: 102-60-36cccc
Surface elevation: 1315 feet
Depth to water: 14 feet

0- 1	Topsoil
1- 4	Silt, buff
4-14	Till, buff
14-16	Sand, buff
16-29	Chalk

* * * *

Well No. 77
Driller's Log
Location: 102-59-33abaa
Surface elevation: 1320 feet
Depth to water: not measured

0- 15	Clay, yellow
15- 35	Clay, yellow, sandy
35- 41	Sand, white, fine
41- 43	Clay, blue
43- 55	Sand
55- 57	Clay, blue, hard
57-159	Sand and quartzite wash
159-162	Quartzite, hard, solid

* * * *

Well No. 78
Driller's Log
Location: 101-61-4d
Surface elevation: 1440+ feet
Depth to water: flowing?
(continued on next page)

Well No. 78--continued

0- 40	Clay, yellow, (till)
40-170	Chalk
170-200	Sandstone
200-380	Shale, blue
380-390	Cap rock?
390-430	Shale
430-460	Rock, water-bearing

* * * *

Well No. 79
Driller's Log
Location: 101-60-6c
Surface elevation: 1360-80 feet
Depth to water: flowing

0- 28	Clay, yellow, (till)
28-130	Chalkstone
130-180	Sandstone
180-330	Shale, blue
330-334	Cap rock?
334-366	Shale
366-381	Rock, water-bearing (sandstone)

* * * *

Test Hole No. 80
SDGS Auger
Location: 101-60-2cccc
Surface elevation: 1330 feet
Depth to water: dry hole

Two holes next to each other
At a depth of 7 feet we hit rock
Couldn't penetrate

* * * *

Well No. 81
Driller's Log
Location: 101-61-12dd
Surface elevation: 1400± 20
Depth to water: flowing
(continued on next page)

Well No. 81--continued

0- 30	Clay, yellow
30-125	Chalk
125-205	Sandstone
205-365	Shale, blue
365-374	Cap rock?, (limestone)
374-394	Shale
394-398	Sandstone
398-440	Sandstone below flow

* * * *

Well No. 82
Driller's Log
Location: 101-61-15ddb
Surface elevation: 1400± 20 feet
Depth to water: flowing

0- 30	Clay, yellow, (till)
30-130	Clay, blue
130-180	Chalk
180-265	Sandstone
265-430	Shale, blue
430-444	Cap rock?, (limestone)
444-478	Shale
478-495	Sandstone, water-bearing

* * * *

Test Hole No. 83
SDGS Auger
Location: 101-60-14cccc
Surface elevation: 1345 feet
Depth to water: 14 feet

0- 1	Topsoil
1- 4	Clay, blackish-brown, (till)
4-24	Clay, buff, (till)
24-25	Shale?, dark-gray
25-27	Sand indication
27-50	Shale?, dark-gray
50-56	Shale?, drilled hard, couldn't penetrate

* * * *

Well No. 84
Driller's Log
Location: 101-60-23aaaa Ethan City Well
Surface elevation: 1320 feet
Depth to water: 70 feet

0-150	No samples
150-155	Shale, dark-gray, mixed with fine sand and clay; some fine pyrite
155-165	No samples
165-180	Shale, light-gray, greasy, tends to ball up, with pyrite, some calcite
180-190	No samples
190-265	Shale, dark-gray, flaky, some pyrite, some sand
265-270	Shale, medium-gray, with occasional white specks
270-275	No samples
275-280	Same as above
280-288	No samples
288-290	Limestone (Greenhorn Formation), cream-colored, with numerous broken shells
290-315	No samples
	Sioux Quartzite wash (?) (E-log top 296)
315-320	Sand, fine to coarse, mostly pink quartz, subangular, loose Mixed with some dark shale, limestone, and pyrite

* * * *

APPENDIX B

Well Records in the Mitchell Area

Geologic source: C, Codell; Kd, Dakota Sandstone; G, Greenhorn; N, Niobrara; O, outwash; Q, quartzite; q, quartzite wash (granite wash); T, till
Use: D, domestic; S, stock
Depth: F, flowing

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Geologic Source	Use
Blendon School	104-62-22bbbb	140	36	N,C	D
Johnson, C.	104-61-3dddd	510	F	Kd	D
Hoffmen, O.	104-61-13dcc	85	?	N,C	D,S
Jorgenson, R.	104-61-14add	80+	?	N,C	D,S
Koepke, A.	104-61-15addd	180(?)	?	C?	D
Smith, R.	104-61-28daaa	54	?	N,C	D,S
Stehly, D.	104-61-27bcc	90+	35	N,C?	D,S
Everson, J.	104-60-4add	340	F	Kd	D,S
Cuningham, A. B.	104-60-11ada	274	?	G	D,S
Sibson, L.	104-60-12cccc	210	15	G	D,S
Morrison, W.	104-60-15dac	280	F	G	D,S
Morrison, F.	104-60-23ada	320	?	G	D,S
Thomas, N.	104-60-25bbb	190	25	N,C	D,S
Hagge, D.	104-60-34ccc	100+	?	N,C	D,S
Kistler, L.	104-60-34dcc	100+	80	N,C	D,S
Heiam, W.	104-60-36cab	60	25	N,C	D
Heiam, W.	104-60-36caa	75	40	N,C	D,S

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Geo-logic Source	Use
Heiam, W.	104-60-36dbb	100	70	N,C	D
Fiala, E.	104-59-4cbc	286	?	T,Q	D,S
Green, V.	104-59-5bcb	126	F	T,Q	D,S
Puetz, W.	104-59-6ada	375	F	T,Q	D,S
Ewing, J.	104-59-17cbcc	140	20+	T,Q	D,S
Ewing, W. N.	104-59-19aad	100	?	T,Q	D,S
Ewing, J.	104-59-20bbcc	240	100	T,Q	D,S
Ewing, J.	104-59-29dbb	160	?	T,Q	D,S
Moe, M.	104-59-31aaa	200	7	G	D,S
Brakke, L.	104-59-34cbc	100+	F	T,Q	D,S
Smith, (Mrs.) W.	103-62-2abaa	135	35	N,C	D,S
Pickles & Hillerns	103-61-9dddd	97	?	N,C	D,S
Carcoran, W. J.	103-61-11dacc	72	?	N,C	D,S
Rue, R.	103-61-11addc	100	54	N,C	D,S
Metzger, A.	103-61-14aab	90+	?	N,C	D,S
Rubel, W. A.	103-61-14cac	36	?	N,C	S
Goldammer, R.	103-61-15baaa	80	?	N,C	D,S
Blacksten, D.	103-61-15aad	80	50+	N,C	D,S
Clarke, T.	103-61-21cdc	125	75	N,C	D
Houska, S.	103-61-23ddd	92	?	N,C?	D
Mendenhall, A.	103-61-24ccd	190	?	N,C,Q	D
Wentworth, A.	103-61-24cddd	110	?	N,C	D