STATE OF SOUTH DAKOTA
Nils Boe, Governor

SOUTH DAKOTA GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Special Report 43

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

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INTRODUCTION

Previous Investigation

Early in September of 1959, a crew from the South Dakota Geological Survey, supervised by Merlin Tipton, conducted a preliminary investigation of water from shallow aquifers in the Viborg area (fig. 1). The work was instigated because of a water shortage in the city of Viborg. From this investigation it was found that: (1) alluvium was present along Turkey Ridge Creek and the small creek south of town, but neither contained a sufficient supply of water; (2) outwash along the Vermillion River constitutes a very good water supply, but the distance from the city is prohibitive; (3) buried sand and gravel northeast of town would be the best water supply for Viborg.

The city was advised to further test this northeastern area from which they are now obtaining their water (fig. 2).

Present Investigation

This report contains the results of a special investigation by the South Dakota Geological Survey from July 18 to August 15, 1966, in and around the city of Viborg, Turner County, South Dakota (fig. 1), for the purpose of assisting the city in outlining their present aquifer and locating, if possible, a source of better quality water.

As mentioned above, Viborg now obtains its water from one well located 1¼ miles northeast of the city. This well is 117 feet deep and produces a sufficient quantity of water which is high in iron, manganese and sulfate content. There are also two deep wells located within the city limits which are used on a standby basis due to their limited production and poor water quality. Another well which is 50 feet deep and located within the city, has the same drawbacks as the other standby wells in town.

A survey of the ground-water possibilities was conducted in a 99-square mile area adjacent to Viborg. The investigation included the preparation of a generalized geologic map, bedrock and buried outwash maps, the drilling of 56 test holes, the collection of 50 water samples for analysis, and a well interview of nearly all the wells within the study area. In addition, 10 electric logs were obtained from test holes.

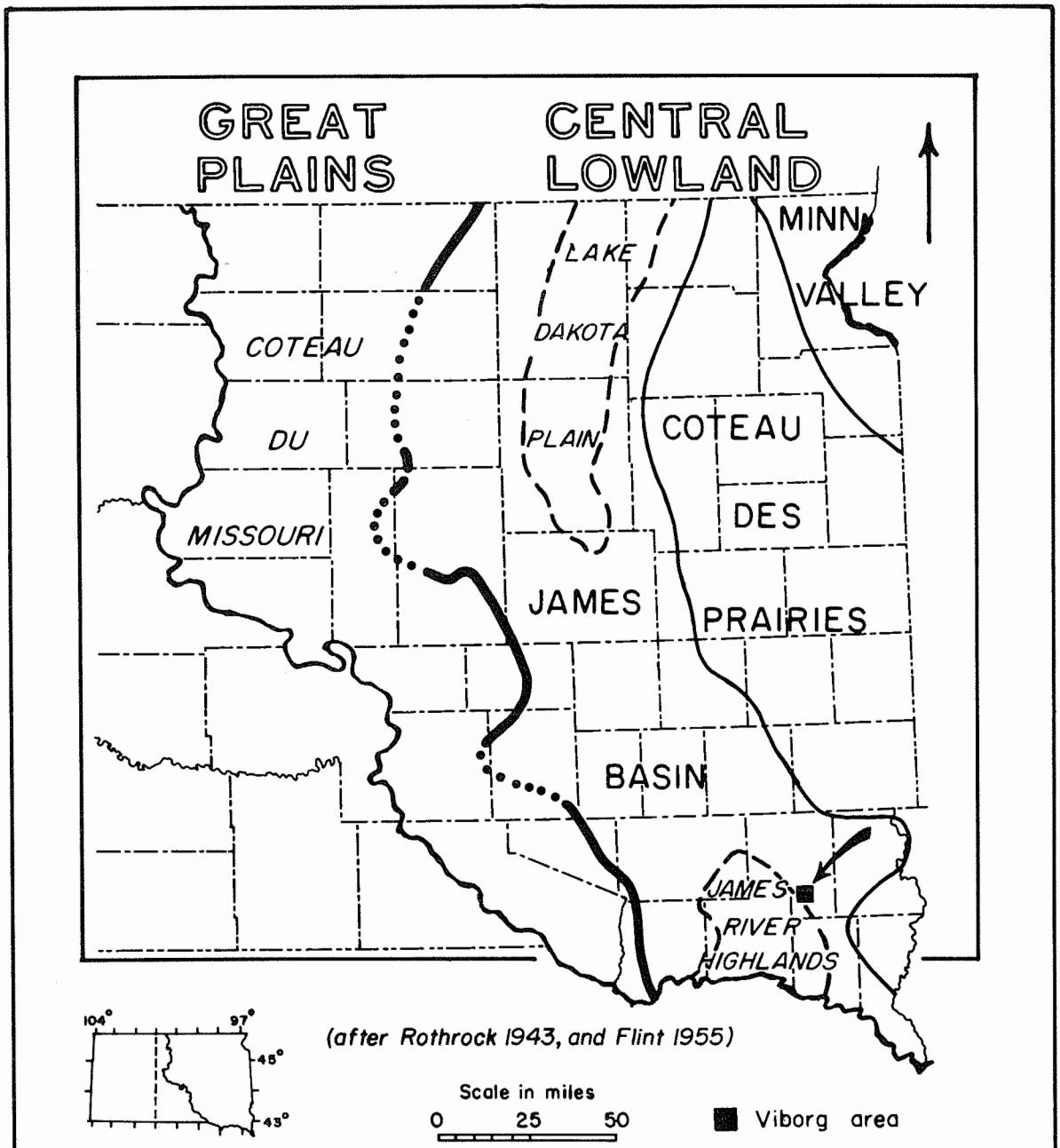
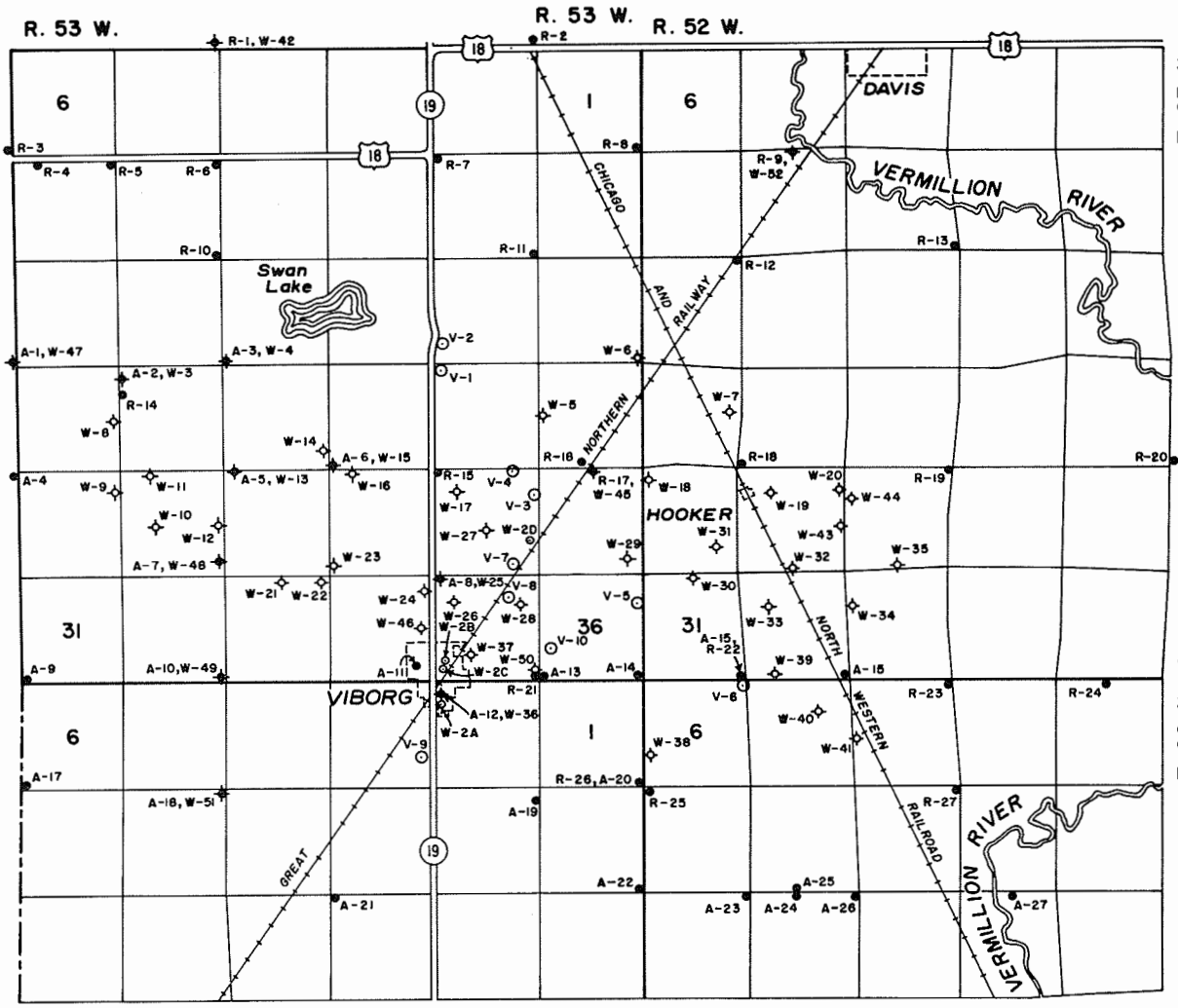


Figure 1. Map showing location of the Viborg area and the major physiographic divisions of eastern South Dakota.



EXPLANATION

R-10 ● Rotary test hole *(see Appendix A for log)*

A-22 ● Auger test hole *(see Appendix B for log)*

A-7, W-48 ✦ Water sample from test hole *(water sample W-3 corresponds to number 3, Table 1)*

W-12 ☆ Water sample from well *(number corresponds to number in Table 1)*

V-3 ⊙ Auger holes from Special Report 3, 1959 *(see Appendix C for log)*

W-28 ⊙ City Well *(number corresponds to number in Table 1)*

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Figure 2. Data map of the Viborg area, showing the locations of test holes and water samples.

As a result of this survey, the boundaries of the several aquifers have been defined (figs. 3, 4, and 5); however, a nearby source of better quality water was not found. The water of the Vermillion River outwash is of better quality than the present supply, but this supply is located 6½ miles northeast of Viborg.

The field work and preparation of this report were performed under the supervision of Lynn S. Hedges and Cleo M. Christensen, ground-water geologists for the South Dakota Geological Survey. The assistance and cooperation of the residents in and around Viborg, especially Mayor Arlo Anderson, is greatly appreciated.

Location and Extent of Area

The city of Viborg is situated in Turner County in southeastern South Dakota. The population, according to the 1960 census, is 699. The area covered in this report is in the James Basin division of the Central Lowland physiographic province except for the extreme southwestern part which lies within the James River Highlands division of the Central Lowland (fig. 1). The study area covers 99-square miles of southeastern Turner County.

Climate

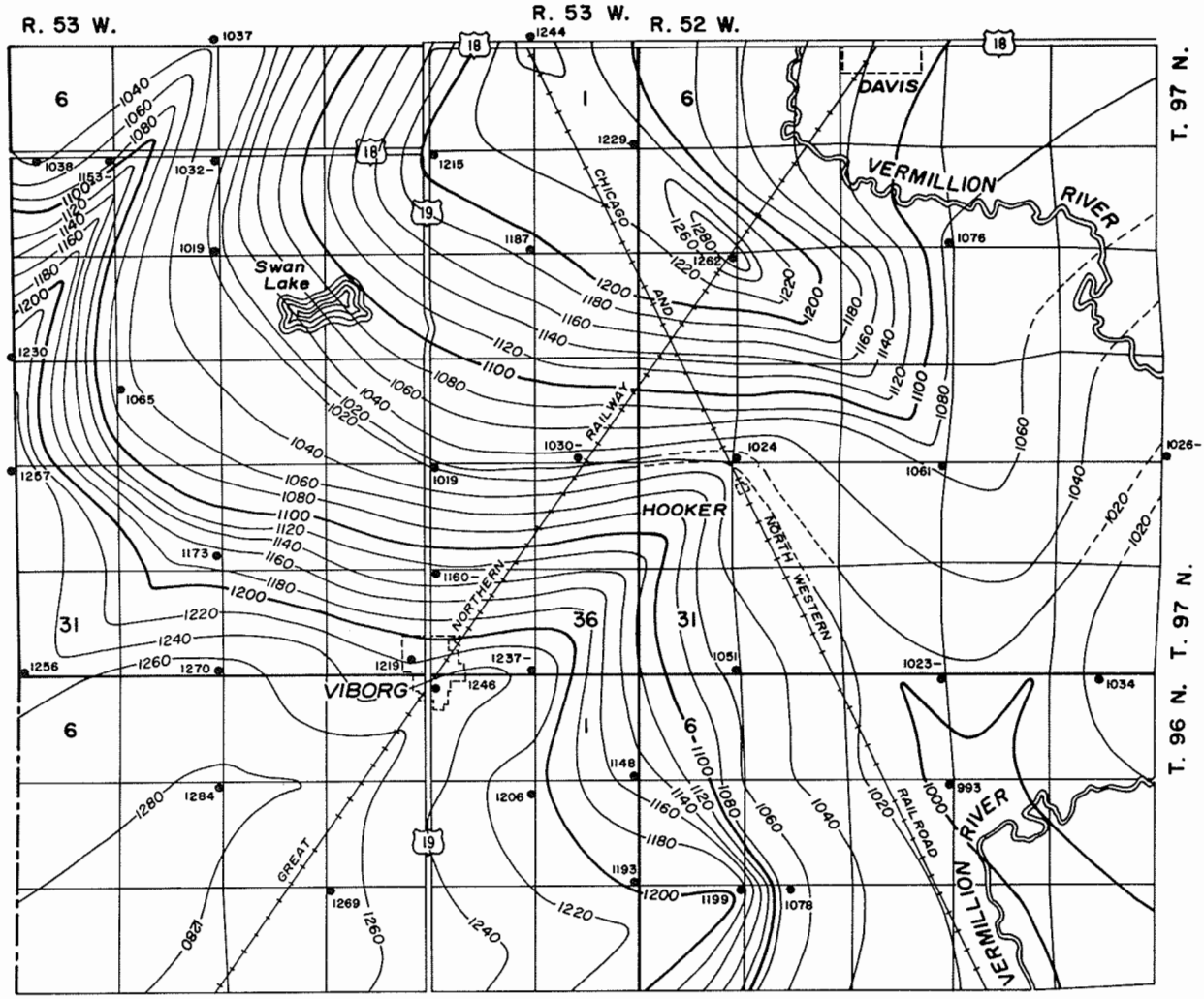
The climate is continental temperate, with large daily and seasonal temperature fluctuations. The average temperature is 47.5 degrees Fahrenheit and the average annual precipitation is 23.6 inches as recorded by the U. S. Weather Bureau station at Marion.

Topography and Drainage

The topography of the area is typical of glacial drift, namely rounded hills and ponds or "potholes." The area is drained to the southeast by Turkey Ridge Creek and its tributaries, which flow into the Vermillion River.

Data-Point Numbering System

Data-collection points (test holes and water samples, fig. 2) are located in accordance with legal land descriptions. The first pair of capital letters and fraction denote the 2½-acre tract; the second pair and fraction denote the 10-acre tract; the third, the 40-acre tract; and the fourth, the 160-acre tract. The first numeral following this is the section number, then the township and finally the range. For example, test hole R-18 is located in the SW¼SW¼SW¼SW¼ sec. 20, T. 97 N., R. 52 W. (fig. 2).



EXPLANATION

1270 Test hole *(number is elevation of bedrock surface above sea level in feet)*

1030– Dash indicates bedrock is below figure stated

1240 1260 Contour lines connecting points of equal elevation on bedrock surface *(contour interval = 20 feet)*

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Figure 3. Map showing configuration of the buried bedrock surface in the Viborg area.

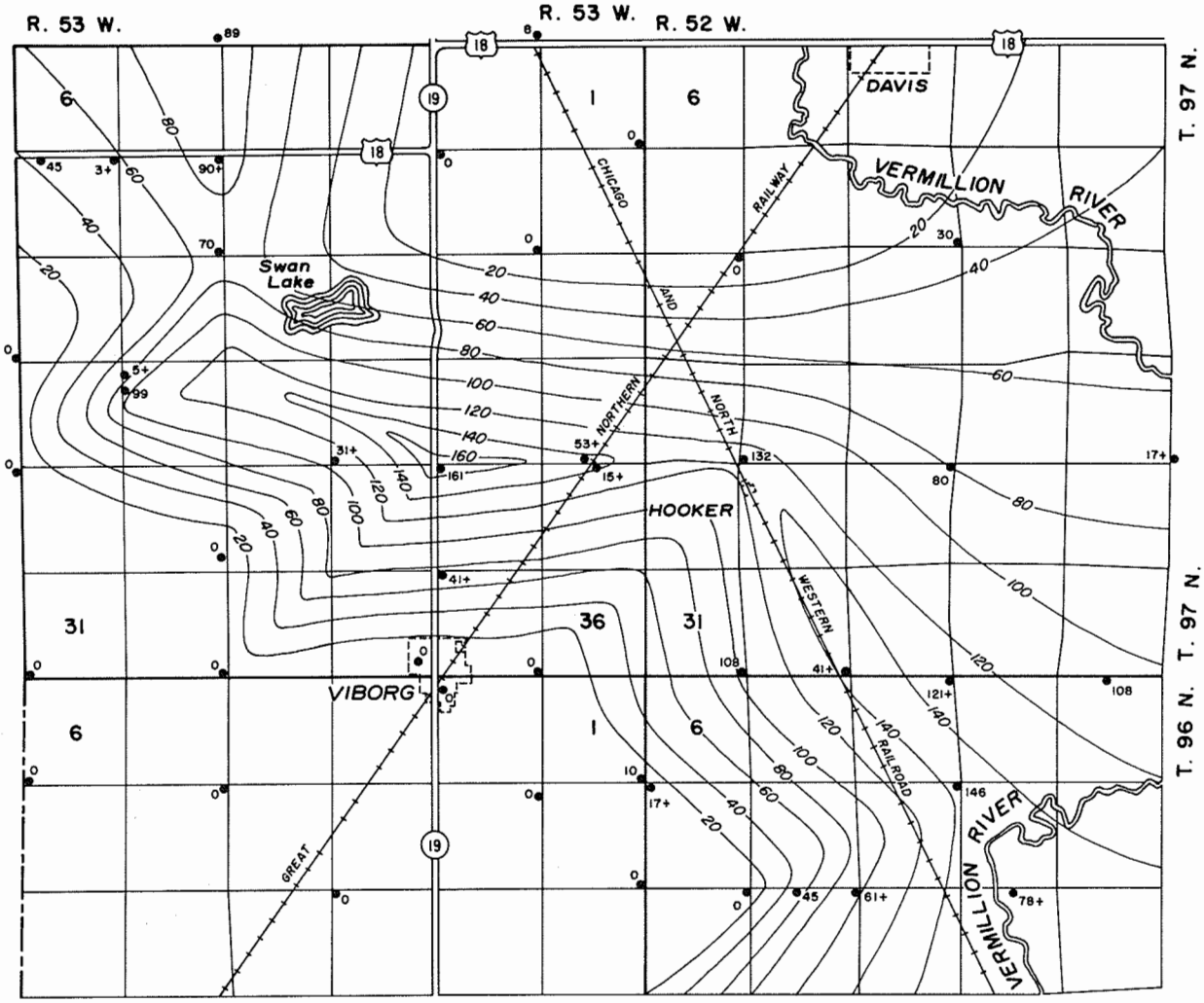

Figure 4. Map showing thickness of the buried outwash sediments in the Viborg area.

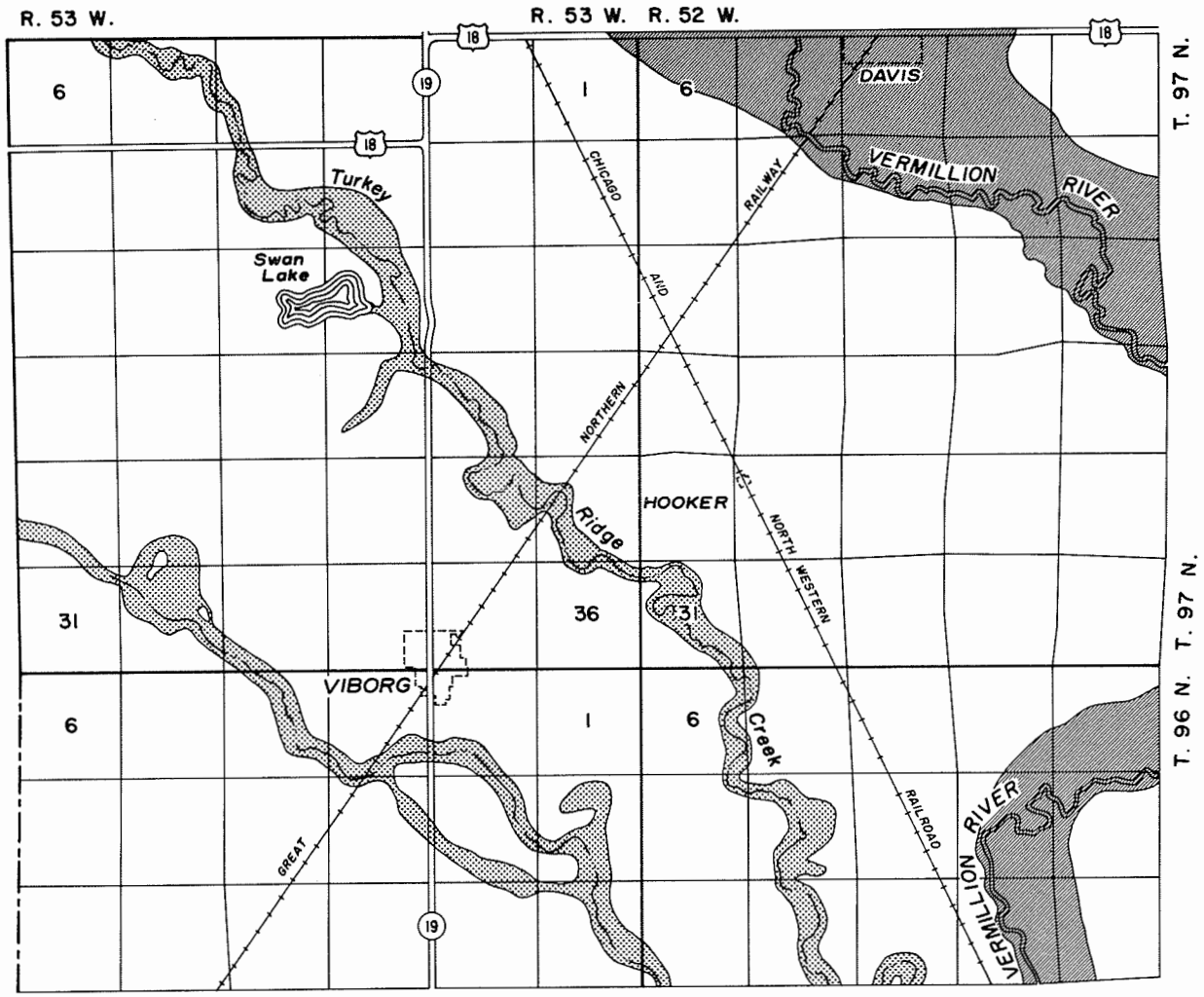

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Figure 5. Generalized geologic map of the Viborg area.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Viborg area are primarily the result of glacial activity late in the Pleistocene Epoch (fig. 5). Glacial deposits, which are collectively termed drift, are divided into till and outwash deposits.

Till consists of clay and silt-sized particles, randomly mixed with boulders, pebbles, and sand, all of which were carried and deposited by the ice itself. The entire Viborg area is covered by till except where overlain by alluvium and outwash along the streams.

Outwash sediments consist chiefly of sand and pebbles with minor amounts of silt and clay, which were deposited by meltwater streams as the glacier wasted. In the immediate Viborg area, very little outwash is present; however, the small stream south of town (fig. 5) may have been a meltwater channel and may contain outwash deposits. Test hole V9 was drilled in this channel but only four feet of saturated sand was penetrated.

Alluvium, which is made up of silt and clay-sized particles with minor amounts of sand and gravel, has been deposited by recent streams since the retreat of the glaciers. Alluvium is present along Turkey Ridge Creek and the small stream south of Viborg.

Subsurface Bedrock

No bedrock is exposed in the Viborg area. Logs of the city's two deep wells indicate that Cretaceous sedimentary rocks underlie the glacial drift. These rocks in descending order are the Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, and the Dakota Formation. Directly beneath the Dakota Formation is the Sioux Quartzite.

The Niobrara Marl is primarily light- to dark-gray calcareous shale which contains numerous white microscopic specks and thin, impure bentonite beds. The Niobrara Marl in the Viborg area varies in thickness from zero to about 160 feet.

The Carlile Shale, which is about 40 feet thick in this area, consists chiefly of gray fissile shale and may contain thin interbedded sands and impure limestone.

The Greenhorn Limestone is about 95 feet thick in the Viborg area, and is composed of light- to dark-gray fragmental limestone and light- to dark-gray chalk and chalky shale. This limestone is dense and easily recognized both in well cuttings and on mechanical well logs.

The Graneros Shale is primarily a siliceous shale and is locally sandy; it is about 160 feet thick in this area.

The Dakota Formation is composed of fine to coarse, friable to cemented sandstone and interbedded shale. This unit is highly variable in thickness throughout the State but is about 170 feet thick in this area.

The Sioux Quartzite is a pink to purple very hard quartzitic sandstone, locally called "granite," "Sioux Falls Granite," or "quartzite."

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Ground water is defined as water contained in the voids or openings of rock or sediments below the water table; therefore, the water table marks the upper surface of the saturated zone of the water-bearing formation. The common belief that ground water occurs in "veins" which crisscross the area in a disconnected maze is a fallacy, for it can be shown that water occurs nearly everywhere beneath the surface. The depth of a water supply depends upon the water table, which is not static but fluctuates, and in general reflects the surface topography. The water table may range from a few feet to many tens of feet beneath the surface, and in the Viborg area it ranges from 7 to 75 feet beneath the land surface.

The amount of water contained in a reservoir rock, called an aquifer, is controlled by the porosity of the rock. Porosity refers to the number of voids in a rock and is expressed as the ratio of pore space to the total volume of rock. Porosity is dependent upon: (1) the shape and arrangement of individual particles, (2) the degree of sorting of the particles, and (3) the degree of cementation and compaction of the particles. Sands and gravels have porosities that usually range from 20 to 40 percent, depending upon the above conditions; whereas, sandstones have porosities of 15 to 25 percent. The lower porosities of sandstones is due to their higher degree of compaction and cementation.

Permeability is the rate at which a fluid under pressure will pass through a material. A material that has a high percentage of interconnected pores has a high permeability, while a material

that is high in porosity but does not have interconnected pores has a low permeability. It can be seen that porosity and permeability are related but are not synonymous.

Nearly all ground water is derived from precipitation. Melting snow or rain either percolates directly downward to the water table and becomes ground water, or drains off as surface water. Surface water either escapes to the ocean by streams, evaporates, or percolates down to the ground-water table. In general, ground water moves laterally down the hydraulic gradient, and is said to be in transient storage.

Recharge is the addition of water to an aquifer, and is accomplished in three ways: (1) by downward percolation of precipitation from the surface of the ground, (2) by downward percolation from surface bodies of water, and (3) by lateral underflow of water in transient storage.

The removal of ground water from an aquifer is called discharge, and is accomplished in four main ways: (1) by evaporation and transpiration by plants, (2) by seepage upward or laterally into surface bodies of water, (3) by lateral underflow of water in transient storage, and (4) by pumping from wells.

Ground Water in Alluvium

Alluvium is present in Turkey Ridge Creek and the small stream south of Viborg (fig. 5), but because of the large amount of silt and clay present in the alluvium, its low permeability, and its limited extent, the alluvium would not readily yield large amounts of water.

Ground Water in Glacial Deposits

As previously stated, glacial deposits are divided into till and outwash. Till, because of its high clay and silt content and its low permeability, generally does not yield water readily. However, outwash is usually a good source of water because of its high porosity and permeability.

In the Viborg area there are two major glacial aquifers, one of which is presently being tapped by city well number 7 (listed as 2D in table 1).

The distribution and saturated thickness of the aquifer or buried outwash from which city well number 7 obtains water is shown in figure 4. It is first encountered at depths ranging from 62 to 195 feet and varies in thickness from 0 to 161 feet. In general but not without exception, the sand and gravel become coarser with depth.

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

Sample	Source[1]	Parts Per Million											
		Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
1.		---	---	50	250	500[2]	0.3	0.05	10.0	0.9 1.7[3]	--	---	1000[2]
2A[4]	Ch	471	53	145	23	1488	5.0	0.3	0.0	1.0	7.2	1784	2628
2B[4]	Ss	152	142	31	72	512	2.2	0.0	0.1	2.9	7.4	512	1114
2C[4]	Ss	179	184	42	106	782	2.1	0.0	0.0	2.4	7.3	624	1418
2D[4]	G	248	51	58	5	573	2.4	0.8	0.0	0.4	7.4	964	1308
3.	S	522		171	15	2280	3.5				6.9	2000	3190
4.	S	532		343	250	3720	0.5				7.0	2750	6700
5.	S	264		64	Tr.	1140	6+					920	1460
6.	S	460		229	0	1645	35+					1940	2460
7.	S	320		102	0	1145	17+					1220	1730
8.	S	368		58	0	818	6+					1160	1420
9.	S	311		110	30	1680	0.75				7.4	1200	1750
10.	S	340		122	Tr.	1200	5				7.2	1350	2250
11.	S	371		49	Tr.	783	4				7.0	1125	1750
12.	S	264		61	Tr.	662	4.5				7.2	900	1520
13.	S	563		245	40	3060	0				7.2	2400	4300
14.	S(?)	260		49	0	541	6				7.2	850	1370
15.	S	400		110	12	1860	0				7.2	1450	2760
16.	S	241		49	20	963	0.75				7.2	800	1868
17.	S	288		39	0	675	0					880	1175

1/ S = sand; Ch = chalk; G = gravel; Ss = sandstone.
2/ Modified for South Dakota by the Department of Health (written communication, March 20, 1968).
3/ Optimum.
4/ Public Water Supply Data, 1961.

Table 1 (cont.)

Sample	Source	Parts Per Million											
		Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
18.	S	300		61	0	957	35+				7.0	1000	1740
19.	S	197		78	8	728	2.8				7.2	810	1108
20.	S	128		107	0	696	5+					760	1135
21.	S	380		103	Tr.	1140	12				7.1	1375	1728
22.	S	372		80	Tr.	1020	12.5				7.1	1250	2046
23.	S	421		158	Tr.	1680	21				7.0	1700	2846
24.	S	382		110	Tr.	1380	6				7.1	1400	2598
25.	S	120		61	0	600	0.12				7.5	550	922
26.	S	351		100	0	985	17+					1300	1790
27.	S	237		75	0	600	1.7					800	1150
28.	S	353		78	0	936	2.0					1200	1740
29.	S	210		97	0	900	20+					1260	1585
30.	S	312		78	0	1140	7.5+					1100	1645
31.	S	337		63	0	816	4.5					1100	1500
32.	S	377		88	0	1125	8.0					1300	1760
33.	S	345		46	0	794	3.5					1050	1570
34.	S	152		58	0	433	0.3					622	935
35.	S	140		36	0	430	1.0					500	827
36.	S	153		5	20	150	0.04				7.6	402	
37.	S	220		59	18	660	0.04				7.1	790	1050
38.	S	350		56	Tr.	890	15+					1100	1475
39.	S	329		70	0	1080	10+					1100	1620

Table 1 (cont.)

Sample	Source	Parts Per Million											
		Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
40.	S	300		76	0	1155	2.6					1060	1610
41.	S	240		58	0	674	5+					840	1205
42.	G	160		25	0	458	Tr.				7.2	500	905
43.	G	193		54	0	455	2.6					700	1055
44.	G	197		680	0	528	3.0					340	1030
45.	G	335		73	Tr.	865	Tr.				7.3	1100	1205
46.	G	411		134	25	1500	8.5				7.1	1573	2460
47.	Ch	523		340	Tr.	2760	0				7.1	2545	3820
48.	Ch	462		275	0	2040	0				7.2	2000	3150
49.	Ch	482		171	0	1680	0				7.0	1900	2700
50.	Ch	400		122	0	1320	0.25				7.1	1500	2310
51.	Ch	562		37	0	1560	0				7.6	1550	2008
52. [5/]	S [6/]	177	24	26	0	404	1.6	0	0.2	0.8		548	966

5/ Analyzed by the State Chemical Laboratory in Vermillion.
6/ Sample from Parker-Centerville Outwash.

Location of Water Samples

(Numbers of water samples correspond to table 1.)

1.	South Dakota Department of Health standards	
2A.	City of Viborg #1	NW¼-2-96-53
2B.	City of Viborg #2	SW¼-35-97-53
2C.	City of Viborg #6	SW¼-35-97-53
2D.	City of Viborg #7	SE¼SW¼NE¼SE¼-26-97-53
3.	Test hole A-2	SW¼NW¼NW¼NW¼-20-97-53
4.	Test hole A-3	SW¼SW¼SW¼SW¼-16-97-53
5.	Skonhoud, Leroy	NW¼NW¼NW¼SW¼-24-97-53
6.	Peterson, James	SE¼SE¼SE¼SE¼-13-97-53
7.	Nygaard, Martin	NW¼NE¼NE¼SE¼-19-97-52
8.	Sorenson, Arnold	NE¼NE¼NE¼SE¼-19-97-53
9.	Flint, Ole	NE¼SW¼NE¼NE¼-30-97-53
10.	Hanson, Leslie	NW¼NE¼NE¼SW¼-29-97-53
11.	Sanborn, Bob	NW¼NW¼NE¼NW¼-29-97-53
12.	Larsen, Duane	NE¼NE¼NE¼SW¼-29-97-53
13.	Test hole A-5	NE¼NW¼NW¼NW¼-28-97-53
14.	Vannorsdel, Paul	NE¼SE¼SE¼SE¼-21-97-53
15.	Test hole A-6	SW¼SW¼SW¼SW¼-22-97-53
16.	Pederson, J. Chris	NE¼NE¼NW¼NW¼-27-97-53
17.	Hansen, Hartig	SE¼NW¼NW¼NW¼-26-97-53
18.	Sorenson, Charles	SW¼NW¼NW¼NW¼-30-97-52
19.	Stotz, Carl	NW¼NW¼SE¼NW¼-29-97-52
20.	Stotz, Donald	SE¼SE¼NE¼NE¼-29-97-52
21.	Nelson, Silas	NW¼NW¼NW¼NE¼-33-97-53

Location of Water Samples (cont.)

22. Peterson, Harvey	NE¼NE¼NE¼NE¼-33-97-53
23. Johnson, Wilbert	NW¼SW¼SW¼SW¼-27-97-53
24. Peterson, Melby	SE¼NE¼NE¼NE¼-34-97-53
25. Test Hole A-8	NW¼NW¼NW¼NW¼-35-97-53
26. Ness, Norman	SE¼SE¼NW¼NW¼-35-97-53
27. Sorenson, Lloyd	SW¼NW¼NW¼SE¼-26-97-53
28. Sorenson, Leonard	SW¼SW¼NE¼NE¼-35-97-53
29. Peterson, Arne	NW¼SE¼SE¼SE¼-25-97-53
30. Cope, T. L.	NW¼NW¼NW¼NE¼-31-97-52
31. Kaarup, Raymond	NE¼NE¼SW¼SE¼-30-97-52
32. Jorgenson, Milton	SE¼SE¼SE¼SW¼-29-97-52
33. Johnson, Murrel	NE¼NE¼SW¼NW¼-32-97-52
34. Austin, Lester	NW¼NW¼SW¼NW¼-33-97-52
35. Orland, Adolf	SE¼SE¼SE¼SW¼-28-97-52
36. Test hole A-12	SW¼NW¼NW¼NW¼-2-96-53
37. Mork, Ken	NW¼NW¼SE¼SW¼-35-97-53
38. Swenson, Simon	NW¼NW¼SW¼SW¼-6-96-52
39. Apland, Noble	SE¼SE¼SW¼SW¼-32-97-52
40. Estergaard, Peter	SE¼SE¼NW¼NE¼-5-96-52
41. Austin, Russell	NW¼NW¼NW¼SW¼-4-96-52
42. Test hole R-1	SE¼SE¼SE¼SE¼-32-98-53
43. Hansen, Harold	NE¼NE¼NE¼SE¼-29-97-52
44. Vasgaard, Clayton	NW¼NW¼SW¼NW¼-28-97-52
45. Test hole R-17	NW¼NE¼NE¼SE¼-34-97-53
46. Paul's Hatchery	NW¼NE¼NE¼SE¼-34-97-53

Location of Water Samples (cont.)

47. Test hole A-1	SE¼SE¼SE¼SE¼-13-97-54
48. Test hole A-7	NE¼SE¼SE¼SE¼-29-97-53
49. Test hole A-10	SE¼SE¼SE¼SE¼-32-97-53
50. Lloyd Frier	SE¼SE¼SE¼SE¼-35-97-53
51. Test hole A-18	NE¼NE¼NE¼NE¼-8-96-53
52. Test hole R-9	NE¼NE¼NE¼NW¼-8-97-52

Ground Water in Bedrock

Some subsurface bedrock formations yield sufficient water for domestic purposes, but in most cases it is of poorer quality than water from surficial deposits. The bedrock formations usually do not yield enough water for large-capacity wells. The Dakota Formation and the Niobrara Marl are the only bedrock aquifers in this area.

Sandstones and sands of the Dakota Formation constitute an aquifer in the Viborg area at a depth of about 720 feet. Information available concerning the two deep city wells indicates that this aquifer is about 170 feet thick and yields approximately 50 gallons of poor quality water per minute (see analyses 2B and 2C, table 1).

The Niobrara Marl yields water to many farm wells in the vicinity and one city well which is 50 feet deep. The top of the marl (locally called chalk) is usually found at a depth of 20 to 60 feet and ranges in thickness from 0 to about 160 feet. This formation can produce as much as 100 gallons of water per minute, but the quality of the water is very bad (see analyses 2A and 47-51, table 1).

Quality of Ground Water

Rain water is nearly pure before it reaches the ground; however, all ground water contains minerals which are obtained from: (1) the atmosphere, (2) the soil and underlying deposits as the water percolates downward to the water table, and (3) deposits below the water table in which the water is circulating. In general, it can be said that the more minerals a water contains the poorer its quality.

Table 1 is a list of water analyses from the Viborg area which was compiled for comparison with the Public Health Standards for drinking water as modified by the South Dakota Department of Health. These samples are grouped according to the aquifer material from which they were obtained; that is, sand, gravel, chalk, or sandstone.

Water samples 3-46 inclusive are from the buried outwash, and all but four exceed the standards in sulfate and total solids, all but nine have excess iron, and all but eight have excess magnesium; none of the samples tested has an excess of chloride.

Water samples 2A and 47-51 inclusive are from chalk wells. All of these samples exceed the standards set for sulfate and total solids; all but one have excess magnesium; none of

these samples has excess chloride; and one exceeds the standards set for iron.

Water samples 2B and 2C, which are from the two deep city wells completed in the Dakota Formation, exceed the Public Health standards in sulfate, iron, total solids, and fluoride content.

Sample 2D is from the newest city well which draws water from the buried outwash northeast of Viborg. This water exceeds the standards in magnesium, sulfate, iron, manganese, and total solids. Although this water is very hard (964 ppm), the use of modern detergents and water-softening agents has reduced the water hardness problem.

All of the above-mentioned water samples are generally of poor quality; however, water sample 52 merits attention. This water exceeds the Public Health drinking water standards only in iron content. This water was obtained from the Parker-Centerville Outwash in the Vermillion River valley (fig. 5) and shows the difference of water quality in this outwash as compared to the buried glacial outwash shown in figure 4. More will be said about this later in the report.

CONCLUSIONS AND RECOMMENDATIONS

From the data collected during this survey it was found that: (1) the boundaries of the aquifer from which the city obtains its present supply of water have been established as shown in figure 4, (2) a source of better quality water was found; however, the minimum distance from the city is 6½ miles northeast of Viborg along the Great Northern railroad tracks. For more detailed information on this outwash refer to Tipton, M. J., 1957, Geology and hydrology of the Parker-Centerville Outwash: S. Dak. Geol. Survey, Report of Investigations No. 82.

Should the city decide to obtain their water from the Parker-Centerville Outwash, a well site should be chosen and a test well installed and test pumped. This test pumping should be conducted by licensed engineers and should be run for a minimum of 72 hours to determine the yield, drawdown, and recovery of the well.

The city officials should consult the State Water Resources Commission with regard to obtaining a water right and permit to drill a city well, and the State Department of Health with regard to biological and chemical suitability of the water.

A consulting engineering firm licensed in the State of South Dakota should be hired to design the well and adjoining water system. It is suggested that the city contract with a commercial drilling company licensed by the State of South Dakota to test drill the area recommended by the engineers.

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APPENDIX A

Logs of Rotary Test Holes in the Viborg Area
(for location see figure 2)

Test Hole R-1
Location: SE¼SE¼SE¼SE¼-32-98-53
Elevation: 1273 feet

0- 20	Clay, brown; chalk fragments
20- 65	Clay, gray, extremely tough
65- 96	Clay, gray, pebbly
96-125	Clay, gray, silty, sandy; gravel layers
125-214	Gravel; few clay layers
214-236	Chalk, calcareous; gray clay
236-245	Shale, calcareous; may be Carlile Shale

* * * *

Test Hole R-2
Location: SE¼SE¼SE¼SE¼-35-98-53
Elevation: 1280 feet

0-28	Clay, brown
28-36	Sand, oxidized
36-65	Chalk

* * * *

Test Hole R-3
Location: SE¼SE¼SE¼SE¼-1-97-54
Elevation: not determined

0-10	Fill
10-28	Clay, brown, greasy; (lake deposit?)
28-35	Clay, gray, silty, sandy

* * * *

Test Hole R-4
Location: NW¼NW¼NE¼NW¼-7-97-53
Elevation: 1278(±) feet

0- 18	Clay, brown
18-195	Clay, gray, silty, becoming more sandy with depth; some gravel layers
195-240	Gravel
240-268	Shale

* * * *

Test Hole R-5
Location: NE¼NE¼NE¼NE¼-7-97-53
Elevation: 1273 feet

0- 3	Topsoil
3- 21	Clay, brown
21- 47	Clay, gray, silty
47- 50	Gravel
50- 80	Clay, gray, silty, sandy; good gravel layers
80-120	Clay, gray, pebbly; hit rock and abandoned hole

* * * *

Test Hole R-6
Location: NE¼NE¼NE¼NE¼-8-97-53
Elevation: 1277 feet

0- 16	Clay, brownish-yellow
16-122	Clay, gray, becoming more pebbly with depth; sand layers from 58 to 65 feet, sandy from 95 to 122 feet
122-140	Sand and gravel; clay layers
140-155	Clay; gravel layers
155-245	Gravel; coal or clay layers; abandoned hole because of caving

* * * *

Test Hole R-7
Location: NW¼NW¼NW¼NW¼-11-97-53
Elevation: 1298 feet

0- 7	Topsoil
7-17	Clay, brown, silty
17-60	Clay, gray
60-82	Rocks; few sand layers
82-95	Chalk

* * * *

Test Hole R-8
Location: SE¼SE¼SE¼SE¼-1-97-53
Elevation: 1277 feet

0-30	Clay, brown
30-40	Clay, gray
40-48	Sand, brown
48-65	Chalk, light-gray

* * * *

Test Hole R-9
Location: NE¼NE¼NE¼NW¼-8-97-52
Elevation: 1245 feet

0- 2	Topsoil
2-28	Sand, coarse
28-50	Clay, gray, silty; pumped hole with air for 4½ hours; produced about 3 gallons per minute

* * * *

Test Hole R-10
Location: SE¼SE¼SE¼SE¼-8-97-53
Elevation: 1274 feet

0- 25	Clay, brown
25- 45	Clay, gray
45- 60	Cobbles, sand layers
60- 85	Clay, gray, silty; gravel layers 1 foot thick
85-110	Clay, gray, silty
110-120	Sand, coarse
120-165	Clay, gray, silty
165-180	Gravel, ¼ to ½ inch diameter
180-185	Clay, gray
185-192	Gravel, ½ to ¾ inch diameter
192-195	Clay, gray
195-255	Gravel, 1 to 1¼ inch diameter
255-	Quartzite(?) could not penetrate

* * * *

Test Hole R-11
Location: SE¼SE¼SE¼SE¼-11-97-53
Elevation: 1282 feet

0- 15	Clay, brown, silty
15- 55	Clay, gray
55- 80	Clay, gray, silty and sandy
80- 95	Sand
95-150	Chalk

* * * *

Test Hole R-12
Location: NE¼NE¼NE¼NE¼-18-97-52
Elevation: 1300 feet

0-38	Clay, brownish-yellow

Test Hole R-12 (cont.)

38-50	Chalk; lost circulation at 43 feet. An attempt was made to bail water from the hole but hole became plugged at 45 feet. About 1 foot of water remained in hole and was bailed out. After about 5 minutes water had again risen to about 1 foot.

* * * *

Test Hole R-13
Location: SE¼SE¼SE¼SE¼-9-97-52
Elevation: 1251 feet

0- 2	Topsoil
2- 18	Clay, brown
18-100	Clay, gray, silty; sand layers increasing with depth
100-125	Gravel
125-130	Clay, gray
130-160	Gravel
160-195	Clay, gray; chalk
195-200	Chalk

* * * *

Test Hole R-14
Location: NW¼NW¼SW¼NW¼-20-97-53
Elevation: 1284 feet

0- 21	Clay, brown
21-120	Clay, gray, silty; gravel layers from 75 to 79 feet
120-219	Gravel
219-275	Shale

* * * *

Test Hole R-15
Location: NW¼NW¼NW¼NW¼-26-97-53
Elevation: 1271 feet

0- 23	Clay, brownish-yellow
23- 91	Clay, gray, pebbly; silty from 80 to 91 feet
91-110	Sand and gravel, very coarse
110-252	Sand and gravel; abundant coal
252-260	Shale

* * * *

Test Hole R-16
Location: SW¼SE¼SE¼SW¼-24-97-53
Elevation: 1265 feet

0- 3	Topsoil
3- 16	Clay, brown
16- 82	Clay, gray; silty from 23 to 82 feet
82- 88	Sand, coarse
88-135	Gravel, 1 to 1¼ inch diameter; abandoned because of caving. Attempt to pump water sample failed.

* * * *

Test Hole R-17
Location: NE¼NE¼NE¼NW¼-25-97-53
Elevation: 1266 feet

0-22	Clay, brownish-yellow
22-65	Clay, gray
65-80	Clay, gray; rocks
80-95	Gravel; pumped hole with air for 5½ hours. Produced about 5 gallons per minute.

* * * *

Test Hole R-18
Location: SW¼SW¼SW¼SW¼-20-97-52
Elevation: 1276 feet

0- 27	Clay, brown, tough; abundant chalk
27- 45	Clay, gray, tough; abundant chalk
45- 52	Sand, silty
52-120	Clay, gray, silty
120-252	Gravel, ¼ to ½ inch diameter; very good in places
252-255	Chalk
255-275	Shale, slightly calcareous

* * * *

Test Hole R-19
Location: NE¼NE¼NE¼NE¼-28-97-52
Elevation: 1266 feet

0- 18	Clay, yellow
18-125	Clay, gray, pebbly; sand layers increasing with depth; gravel layers
125-140	Gravel, silty
140-205	Gravel, coarse; coal
205-215	Chalk, some shale cuttings
215-230	Shale

* * * *

Test Hole R-20
Location: SW¼SW¼SW¼SW¼-24-97-52
Elevation: 1250 feet

0- 32	Clay, brown, silty
32-102	Clay, gray, silty
102-196	Gravel, ¼ to ½ inch diameter; very good in places
196-205	Clay, gray
205-222	Gravel, ¼ to ½ inch diameter
222-224	Boulder; abandoned hole

* * * *

Test Hole R-21
Location: SE¼SE¼SE¼SE¼-35-97-53
Elevation: 1294 feet

0-21	Clay, brown
21-55	Clay, gray, silty
55-65	Chalk

* * * *

Test Hole R-22
Location: SE¼SE¼SE¼SE¼-31-97-52
Elevation: 1226 feet

0- 15	Clay, brown
15- 55	Clay, gray; gravel layers
55- 60	Gravel, poorly sorted
60- 64	Clay, gray
64-167	Gravel, better sorting with depth
167-175	Clay(?), gray; drills tough; no cuttings
175-185	Shale

* * * *

Test Hole R-23
Location: NE¼NE¼NE¼NE¼-4-96-52
Elevation: 1253 feet

0- 19	Clay, brown, silty
19-109	Clay, gray
109-230	Gravel, ¼ to ½ inch diameter
230-	Boulder, abandoned hole

* * * *

Test Hole R-24
Location: NE¼NE¼NE¼NW¼-2-96-52
Elevation: 1244 feet

Test Hole R-24 (cont.)

0- 10	Clay, yellow
10-102	Clay, gray, becoming silty with depth
102-210	Gravel, ¼ to ½ inch diameter
210-240	Shale
240-260	Limestone, Greenhorn(?)

* * * *

Test Hole R-25
Location: NW¼NW¼NW¼NW¼-7-96-52
Elevation: 1282 feet

0-22	Clay, brown; sand layers
22-62	Clay, gray
62-79	Gravel, coarse; hit rock and abandoned hole

* * * *

Test Hole R-26
Location: SE¼SE¼SE¼SE¼-1-96-53
Elevation: 1283 feet

0-29	Clay, brown; rocks
29-66	Clay, gray; gravel layers and rocks
66-95	Gravel, 1 to 1¼ inch diameter

* * * *

Test Hole R-27
Location: NE¼NE¼NE¼NE¼-9-96-52
Elevation: 1247 feet

0- 17	Clay, brown, silty
17-108	Clay, gray
108-254	Gravel
254-270	Shale
270-290	Bentonite; dark-gray limestone(?) chips with white specks; drills hard; possibly Greenhorn Limestone

* * * *

APPENDIX B

Logs of Auger Test Holes in the Viborg Area
(for location see figure 2)

Test Hole A-1
Location: SE¼SE¼SE¼SE¼-13-97-54
Elevation: 1311 feet

0- 2	Topsoil
2-20	Clay, yellow-brown; pebbles
20-45	Clay, gray; pebbles
45-61	Clay, gray; 20% fine sand
61-75	Chalk

* * * *

Test Hole A-2
Location: SW¼NW¼NW¼NW¼-20-97-53
Elevation: 1275 feet

0- 1	Topsoil
1- 15	Clay, yellow-brown; pebbles
15- 55	Clay, gray; pebbles
55-105	Clay, gray; 25% fine sand
105-125	Clay, gray; 35% medium sand
125-135	Clay; 45% medium to coarse sand
135-140	Sand, medium; 35% clay
	Depth to water: 55 feet

* * * *

Test Hole A-3
Location: SW¼SW¼SW¼SW¼-16-97-53
Elevation: 1281 feet

0- 1	Topsoil
1-18	Clay, yellow-brown; pebbles
18-39	Clay, dark-brown; pebbles
39-47	Clay, gray; pebbles
47-50	Clay, gray; pebbles
	Depth to water: 47 feet

* * * *

Test Hole A-4
Location: NE¼NE¼NE¼NE¼-25-97-54
Elevation: 1332 feet

Test Hole A-4 (cont.)

0- 4	Topsoil
4- 7	Clay, dark-brown
7-21	Clay, yellow-brown; pebbles
21-41	Clay, dark-brown; pebbles
41-75	Clay, brown; 35% fine sand
75-85	Chalk
	Depth to water: 41 feet

* * * *

Test Hole A-5
Location: NE¼NW¼NW¼NW¼-28-97-53
Elevation: 1284 feet

0- 2	Topsoil
2-24	Clay, brown; pebbles
24-56	Clay, gray; pebbles
56-80	Clay, gray; 30% fine sand
80-	Large rocks; abandoned hole
	Depth to water: 56 feet

* * * *

Test Hole A-6
Location: SW¼SW¼SW¼SW¼-22-97-53
Elevation: 1276 feet

0- 1	Topsoil
1- 39	Clay, brown; pebbles
39- 56	Clay, gray; pebbles
56- 89	Clay, gray; 15% very fine sand
89-100	Sand, gray, medium coarse; 35% clay
	Depth to water: 56 feet

* * * *

Test Hole A-7
Location: NE¼SE¼SE¼SE¼-29-97-53
Elevation: 1293 feet

0- 2	Topsoil
2- 12	Clay, yellow-brown; pebbles
12- 39	Clay, yellow-brown; pebbles
39-120	Clay, gray; 20% fine sand
120-140	Chalk, gray-black
	Depth to water: 12 feet

* * * *

Test Hole A-8
Location: NW¼NW¼NW¼NW¼-35-97-53
Elevation: 1280 feet

0- 1	Topsoil
1- 21	Clay, brown; pebbles
21- 35	Clay, brown; 10% fine sand
35- 79	Clay, gray; 20% medium sand
79-120	Sand, gray, medium; 30% clay
	Depth to water: 21 feet

* * * *

Test Hole A-9
Location: SW¼SW¼SW¼SW¼-31-97-53
Elevation: 1376 feet

0- 1	Topsoil
1- 34	Clay, brown; pebbles
34- 55	Clay, tan; 10% fine sand
55-120	Clay, gray; 10% fine sand
120-140	Chalk
	Depth to water: 34 feet

* * * *

Test Hole A-10
Location: SE¼SE¼SE¼SE¼-32-97-53
Elevation: 1305 feet

0- 1	Topsoil
1-30	Clay, yellow-brown; pebbles
30-35	Clay, yellow-brown; 15% fine sand
35-60	Chalk
	Depth to water: 30 feet

* * * *

Test Hole A-11
Location: SE¼NW¼SE¼SE¼-34-97-53
Elevation: 1304 feet

0- 1	Topsoil
1-30	Clay, brown; silty; pebbles
30-75	Clay, gray; pebbles
75-85	Clay, gray; 10% fine sand
85-90	Chalk
	Depth to water: 75 feet

* * * *

Test Hole A-12
Location: SW¼NW¼NW¼NW¼-2-96-53
Elevation: 1303 feet

0- 1	Topsoil
1-16	Clay, yellow; pebbles
16-32	Sand, yellow, fine; 10% clay
32-50	Sand, olive-brown, fine; 30% clay
50-57	Sand, gray, fine; 30% clay
57-65	Chalk
	Depth to water: 16 feet

* * * *

Test Hole A-13
Location: SW¼SW¼SW¼SW¼-36-97-53
Elevation: 1295 feet

0- 2	Topsoil
2-22	Clay, brown; pebbles
22-31	Clay, brown; pebbles
31-58	Clay, gray; pebbles
58-	Rock; abandoned hole
	Depth to water: 22 feet

* * * *

Test Hole A-14
Location: SE¼SE¼SE¼SE¼-36-97-53
Elevation: 1268 feet

0- 2	Topsoil
2-29	Clay, brown; pebbles
29-49	Clay, gray; pebbles
49-55	Clay, gray; pebbles
55-	Rock; abandoned hole
	Depth to water: 49 feet

* * * *

Test Hole A-15
Location: SE¼SE¼SE¼SE¼-31-97-52
Elevation: 1226 feet

0- 2	Topsoil
2- 15	Clay, dark-brown; pebbles
15- 44	Clay, brown; 35% fine sand
44- 76	Clay, gray; 35% fine sand
76-115	Sand, gray, coarse to medium; 10% clay
	Depth to water: 15 feet

* * * *

Test Hole A-16
Location: SE¼SE¼SE¼SE¼-32-97-52
Elevation: 1248 feet

0- 2	Topsoil
2- 25	Clay, brown; pebbles
25- 69	Clay, gray; pebbles
69- 99	Clay, gray; 20% fine sand
99-115	Sand, gray, medium; 40% clay
115-140	Sand, gray, medium; 10% clay
	Depth to water: 69 feet

* * * *

Test Hole A-17
Location: SW¼SW¼SW¼SW¼-6-96-53
Elevation: 1437 feet

0- 1	Topsoil
1-40	Clay, brown; pebbles
40-54	Clay, brown; 10% clay
54-75	Clay, gray; 10% clay
	Depth to water: 40 feet

* * * *

Test Hole A-18
Location: NE¼NE¼NE¼NE¼-8-96-53
Elevation: 1323 feet

0- 2	Topsoil
2-21	Clay, brown; pebbles
21-39	Clay, yellow; 10% fine sand
39-50	Chalk, gray
	Depth to water: 21 feet

* * * *

Test Hole A-19
Location: SE¼NE¼NE¼NE¼-11-96-53
Elevation: 1257 feet

0- 1	Topsoil
1-12	Clay, brown; pebbles
12-26	Sand, light-brown, fine to medium; 25% clay
26-51	Clay, gray; 25% fine to medium sand
51-55	Chalk
	Depth to water: 12 feet

* * * *

Test Hole A-20
Location: SE¼SE¼SE¼SE¼-1-96-53
Elevation: 1283 feet

0- 2	Topsoil
2- 7	Clay, brown; many pebbles
7- 39	Clay, brown; pebbles
39- 49	Clay, gray; pebbles
49- 79	Clay, gray; 15% fine sand
79-110	Clay, gray; 30% medium sand
110-125	Clay, gray; 45% coarse sand
125-135	Sand, gray, medium to coarse; 10% clay
135-140	Shale
	Depth to water: 49 feet

* * * *

Test Hole A-21
Location: NW¼NW¼NW¼NW¼-15-96-53
Elevation: 1324 feet

0- 2	Topsoil
2- 6	Clay, yellow
6-45	Clay, brown; pebbles
45-50	Clay, yellow; 10% fine sand
50-55	Clay, gray; 10% fine sand
55-65	Chalk
	Depth to water: 45 feet

* * * *

Test Hole A-22
Location: SE¼SE¼SE¼SE¼-12-96-53
Elevation: 1254 feet

0- 2	Topsoil
2- 7	Clay, brown; pebbles
7-12	Sand, brown; 45% clay
12-21	Sand, brown; 45% clay
21-31	Sand, gray; 45% clay
31-61	Clay, gray; 25% medium sand
61-65	Chalk
	Depth to water: 12 feet

* * * *

Test Hole A-23
Location: NE¼NE¼NE¼NE¼-18-96-52
Elevation: 1244 feet

Test Hole A-23 (cont.)

0- 3	Topsoil
3-12	Clay, dark-brown; small pebbles
12-24	Clay, brown; 25% fine sand
24-45	Sand, brown, fine to medium; 35% clay
45-50	Chalk
	Depth to water: 12 feet

* * * *

Test Hole A-24
Location: NW¼NE¼NE¼NW¼-17-96-52
Elevation: 1211 feet

0- 3	Topsoil
3- 7	Clay, dark-brown; pebbles
7- 14	Clay, dark-brown; pebbles
14- 30	Sand, brown, fine to medium; 15% clay
30- 65	Sand, brown, medium to coarse, trace of clay
65-133	Sand, gray, fine to medium; 15% clay
133-140	Shale
	Depth to water: 7 feet

* * * *

Test Hole A-25
Location: SE¼SE¼SE¼SW¼-8-96-52
Elevation: 1217 feet

0- 1	Topsoil
1- 4	Gravel, coarse; and rocks
4-21	Clay, brown; pebbles
21-35	Clay, gray;pebbles
35-	Hard drilling; unable to go deeper

* * * *

Test Hole A-26
Location: NE¼NE¼NE¼NE¼-17-96-52
Elevation: 1240 feet

0- 2	Topsoil
2- 34	Clay, brown; pebbles
34- 54	Clay, gray; pebbles
54- 79	Clay, gray; 30% fine sand
79-105	Sand, gray, fine; 10% clay
105-140	Sand, gray, fine to medium; 10% clay
	Depth to water: 54 feet

* * * *

Test Hole A-27
Location: NE¼NE¼NE¼NW¼-15-96-52
Elevation: 1204 feet

0- 4	Topsoil
4- 7	Clay, dark-brown; pebbles
7-34	Sand, brown, medium to coarse; 10% clay
34-85	Sand, brown, very coarse; trace of clay
	Depth to water: 7 feet

* * * *

Test Hole A-28 (not shown on figure 2)
Location: NE¼NE¼NE¼NW¼-25-97-52
Elevation: 1223 feet

0- 4	Topsoil
4- 13	Clay, black, pebbly
13- 39	Gravel, brown, medium; mixed with 25% sand and clay
39-140	Sand, brown, medium to coarse; 10% clay
	Depth to water: 13 feet

* * * *

Test Hole A-29 (not shown on figure 2)
Location: NE¼NE¼NE¼NE¼-25-97-52
Elevation: 1222 feet

0- 3	Topsoil
3- 12	Clay, black; pebbles
12- 69	Sand, brown, medium to coarse; 15% clay
69- 90	Sand, gray, fine to medium; 35% clay
90-110	Clay; 35% medium sand
	Depth to water: 12 feet

* * * *

APPENDIX C

Logs of Auger Test Holes in the Viborg Area From Special Report 3, 1959 (for location see figure 2)

Test Hole V1
Location: NW¼NW¼NW¼NW¼-23-97-53

0- 4	Clay, black
4- 9	Sand, brown; clay, wet
9-14	Gravel, clayey
14-19	Clay
19-24	Gravel, clayey
24-39	Clay
	Depth to water: 6½ feet

* * * *

Test Hole V2
Location: SW¼SW¼NW¼SW¼-14-97-53

0- 4	Lime and clay, dry
4-29	Clay, brown, moist
	Depth to water: 7½ feet

* * * *

Test Hole V3
Location: NE¼SE¼SE¼NE¼-26-97-53

0- 4	Clay, black
4-14	Clay, blue
14-19	No sample
19-24	Clay, sandy
24-39	Sand, gravel, and clay
	Depth to water: 4½ feet

* * * *

Test Hole V4
Location: NE¼NW¼NW¼NE¼-26-97-53

0- 9	Clay
9-19	Sand and clay
19-24	Clay
	Depth to water: 4½ feet

* * * *

Test Hole V5
Location: NE¼SE¼SE¼NE¼-36-97-53

0- 4	Clay, black
4-19	Clay, brown
19-39	Clay, blue, gravelly
39-54	Clay, sandy
	Depth to water: 16 feet

* * * *

Test Hole V6
Location NE¼NW¼NW¼NE¼-6-96-52

0- 6	Clay
6- 9	No sample
9-24	Clay, sandy
24-74	Clay
	Depth to water: 11 feet

* * * *

Test Hole V7
Location: NW¼SW¼SW¼SE¼-26-97-53

0- 4	No sample
4- 29	Clay, brown
29- 69	Clay, gray and blue
69- 74	No sample
74- 89	Sand
89-119	Sand and gravel
	Depth to water: 69 feet

* * * *

Test Hole V8
Location: NE¼NE¼SW¼NE¼-35-97-53

0- 29	Clay, moist, brown
29- 64	Clay, blue
64- 69	No sample
69- 84	Sand, some clay
84- 99	Sand, fine to medium
99-119	Sand, coarse; gravel
	Depth to water: 64 feet

* * * *

Test Hole V9
Location: SE¼NE¼NE¼SE¼-3-96-53

0- 4	Silt, brown; clay
4-24	Sand, brown, silty
24-49	Clay, gray
	Depth to water: 20 feet

* * * *

Test Hole V10
Location: NW¼NE¼NE¼SW¼-36-97-53

0- 4	Silt; gravel
4-29	Silt, brown; clay
29-69	Clay, gray and blue
69-74	Sand, fine; clay
74-89	Sand, fine to medium
	Depth to water: 69± feet

* * * *

APPENDIX D

Record of Wells in the Viborg Area

Water use: S, stock; D, domestic; I, irrigation

Name	Location	Depth of Well (ft)	Geologic Source	Use
Jenter, Orville	NW¼NW¼NW¼NE¼-4-96-52	110	sand	S, D
Austin, Russell	NW¼NW¼NW¼SW¼-4-96-52	120	sand	S, D
Rist, Gustav	NE¼NE¼NE¼SE¼-4-96-52	130	sand	S
Estergaard, Peter	SE¼SE¼NW¼NE¼-5-96-52	125	sand	S
Jenter, E. C.	SE¼NE¼NE¼SE¼-5-96-52	90	sand & chalk	S, D
Mark, Donald	NW¼NW¼SW¼NW¼-6-96-52	90	chalk	S, D
Swenson, Timon	NW¼NW¼SW¼SW¼-6-96-52	116	sand	S
Vogue, Arne	NW¼NE¼SW¼NE¼-6-96-52	100	sand	S
Kist, James	SW¼SW¼SW¼SE¼-7-96-52	40	chalk	S
Austin, Ronald	SE¼NE¼NE¼NE¼-8-96-52	120	sand	S
Grace Lutheran Church	SE¼SE¼SE¼NE¼-8-96-52	108	sand	D
Welsh, Warren	NW¼SE¼SE¼SE¼-8-96-52	125	sand	S
Rist Brothers	NW¼NW¼NW¼NE¼-9-96-52	120	sand	S, D
Rist, Clifford	SE¼SE¼NW¼SW¼-9-96-52	120	sand	S, D
Wiese, Ralph	NW¼NW¼NE¼SW¼-16-96-52	108	sand	S, D
Bielau, Otto	SE¼SE¼NW¼NE¼-17-96-52	110	sand	S, D
Andal, Ver Dell	NE¼NE¼NW¼NW¼-17-96-52	80	sand	S, D
Rist, Earl	NE¼SE¼SE¼SW¼-17-96-52	100	chalk	S
Christensen, Delano	SW¼SW¼NW¼NW¼-18-96-52	42	chalk	S
Hansen, Tom	SE¼NE¼NE¼NE¼-1-96-53	75	chalk	S

Name	Location	Depth of Well (ft)	Geologic Source	Use
Peterson, Earl	SW¼SW¼SW¼NW¼-1-96-53	55	chalk	S, D
Sanborn, Don	NE¼NW¼NW¼NE¼-2-96-53	65	chalk	S
Peterson, Ralph	NW¼NW¼NW¼NE¼-2-96-53	65	chalk	S
Flynn, Dale	NE¼NE¼SE¼NW¼-2-96-53	30	chalk	S
Leimback, Helen	NW¼NW¼NW¼SW¼-2-96-53	63	chalk	S
Jaspersen, Nels	NW¼SW¼SW¼SW¼-2-96-53	40	chalk	S
Knudsen, Walter	NW¼NW¼SE¼SE¼-2-96-53	80	chalk	S
Knudsen, Walter	SE¼SE¼SE¼NE¼-3-96-53	40	chalk	S
Oakland, James	NW¼NE¼NE¼NW¼-3-96-53	72	chalk	S
Ness, Larry	SW¼SW¼NE¼SW¼-3-96-53	40	chalk	S
Ward, Bob	NE¼NE¼NE¼SE¼-3-96-53	50	chalk	S, D
Peterson, Herb	SE¼NE¼NE¼NW¼-4-96-53	28	chalk(?)	S
Johnson, Donald	NE¼SW¼SW¼SW¼-4-96-53	32	chalk	S
Jorgensen, Dale	NE¼NE¼NE¼SE¼-4-96-53	25	sand	S, D
Peterson, Palmer	NW¼NW¼NW¼NE¼-5-96-53	32	chalk	S, D
Stortvedt, Peter	SW¼NW¼NW¼NW¼-6-96-53	100	chalk	S
Nelsen, Kenneth	NE¼SW¼SW¼SW¼-6-96-53	100	chalk	S
Johnson, Delbert	NE¼NE¼NW¼SE¼-6-96-53	95	chalk	S
Caryl, Grant	NW¼NW¼NE¼SW¼-7-96-53	84	chalk	S
Johnson, Donald	SE¼NW¼NW¼NE¼-8-96-53	55	chalk	S
Jaspersen, Raymond	NE¼NE¼NE¼NW¼-8-96-53	80	chalk	S
Nelson, Irve	SE¼NW¼NW¼NE¼-9-96-53	25	chalk	S
Ness, Larry	SW¼NW¼NW¼NW¼-10-96-53	40	chalk	S
Mark, Gould	SW¼SW¼SW¼SE¼-10-96-53	60	chalk	S

Name	Location	Depth of Well (ft)	Geologic Source	Use
Larsen, Richard	SE¼NE¼NE¼NE¼-11-96-53	30	chalk	S
Christensen, Reinhart	NW¼NE¼NE¼NW¼-11-96-53	40	chalk	S, D
Simonsen, Soren	NW¼NW¼NW¼NW¼-11-96-53	40	chalk	S
Eckstein Knutson, Karen	SE¼SE¼NW¼SW¼-11-96-53	80	chalk(?)	S
Larsen, Chris	SW¼SW¼SE¼SE¼-11-96-53	30	chalk	S, D
Fikse, Dick	NE¼NE¼NE¼NW¼-12-96-53	24	chalk	S
Nelson, Robert	SW¼NW¼NW¼NW¼-12-96-53	30	chalk	S
Nelson, Ellwood	NW¼NW¼SE¼SE¼-12-96-53	44	chalk	S
De Vries, Darwin	NW¼SW¼SW¼NE¼-13-96-53	24	chalk	S
Christensen, Harry	SW¼SW¼SE¼SE¼-13-96-53	45	chalk	S
Voog, Martin	SE¼NE¼NE¼NE¼-14-96-53	80	chalk	S
Paulsen, Ellwood	NE¼SW¼SW¼SW¼-14-96-53	50	chalk	S
Mark, Nels	SE¼NE¼NE¼NE¼-15-96-53	80	chalk	S
Nielson, Wilfert	SE¼NW¼NW¼NW¼-15-96-53	40	chalk	S
Paulson, Ellwood	NE¼SE¼SE¼SE¼-15-96-53	50	chalk	S
Anderson, Ray	NE¼NE¼SE¼SE¼-16-96-53	60	sand(?)	S
Petersen, Melvin	SW¼SW¼NE¼NW¼-17-96-53	70(?)	chalk	S, D
Hall, Herbert	SE¼SE¼NW¼SE¼-17-96-53	120	sand	S
Jensen, Grant	NE¼NE¼SW¼SW¼-18-96-53	16	sand	S
Olsen, Ruben	NW¼NW¼NE¼SE¼-18-96-53	35	sand	S
Andal, Joe	SE¼SE¼SE¼SE¼-18-96-53	120	chalk	S
Knudsen, Walter	SW¼NW¼NW¼NW¼-22-96-53	23	gravel	S
Petersen, Alfred	NW¼NW¼NW¼NW¼-24-96-53	70	chalk	S

Name	Location	Depth of Well (ft)	Geologic Source	Use
Woolf, J. G.	SW¼SW¼SW¼SW¼-18-97-52	120	sand	S
Nygaard, Martin	SE¼SW¼SW¼NE¼-19-97-52	120	sand	S
Nygaard, Martin	NW¼NE¼NE¼SE¼-19-97-52	120	sand	S
Christensen, Don	SE¼SE¼SE¼NE¼-21-97-52	130	sand	S, D
Hult, Chester	NE¼NE¼SW¼SE¼-22-97-52	85	sand	S, D
Olordson, Noble	NE¼NE¼SW¼NE¼-23-97-52	140	sand	S, D
Knudsen, Berdell	SE¼SE¼SW¼SW¼-23-97-52	100(?)	sand	S, D
Hybertson, Fred	NE¼NE¼NE¼SE¼-23-97-52	110	sand	S, D
Anderson, M.	SW¼SW¼SW¼SW¼-24-97-52	100+	?	S
Hybertson, Henry	SE¼NW¼NW¼NW¼-27-97-52	128	sand	S, D
Vasgaard, Clayton	NW¼NW¼SW¼NW¼-28-97-52	141	gravel	S, D
Orland, Adolf	SE¼SE¼SE¼SW¼-28-97-52	128	sand	S, D
Jorgenson, Milton	SE¼SE¼SE¼SW¼-29-97-52	113	sand	S
Hansen, Harold	NE¼NE¼NE¼SE¼-29-97-52	134	gravel	S, D
Stotz, Carl	NW¼NW¼SE¼NW¼-29-97-52	138	sand	S, D
Stotz, Donald	SE¼SE¼NE¼NE¼-29-97-52	138	sand	S
Kaarup, Raymond	NE¼NE¼SW¼SE¼-30-97-52	110	sand	S
Sorenson, Charles	SW¼NW¼NW¼NW¼-30-97-52	150	sand	S
Cope, T. L.	NW¼NW¼NW¼NE¼-31-97-52	110	sand	S
Apland, Noble	SE¼SE¼SW¼SW¼-32-97-52	111	sand	S
Johnson, Murrel	NE¼NE¼SW¼NW¼-32-97-52	110	sand	S
Austin, Lester	NW¼NW¼SW¼NW¼-33-97-52	112	sand	S, D
Peterson, James	SE¼SE¼SE¼SE¼-13-97-53	100	sand	S
Larsen, M. D.	SE¼SE¼SE¼SE¼-14-97-53	90	chalk(?)	S, D

Name	Location	Depth of Well (ft)	Geologic Source	Use
Neilson, Nanfeldt	SE¼SE¼SW¼SE¼-18-97-53	85+	chalk	S
Sorenson, Arnold	NE¼NE¼NE¼SE¼-19-97-53	72	sand	S
Jacobson, Anton	SE¼SW¼SW¼SW¼-21-97-53	65	chalk	S
Vannorsdel, Paul	NE¼SE¼SE¼SE¼-21-97-53	80	sand(?)	S, D
Paulson, Leland	NE¼NE¼NE¼SE¼-23-97-53	60	chalk	S
Skonhoud, Blanche	NE¼NE¼NE¼NE¼-24-97-53	126	sand(?)	--
Skonhoud, Leroy	NW¼NW¼NW¼SW¼-24-97-53	117	sand	S
Skonhoud, Olie	NE¼NE¼SE¼SE¼-24-97-53	60	sand	S
Peterson, Arne	NW¼SE¼SE¼SE¼-25-97-53	98	sand	S
Ness, Norman	NE¼NE¼NW¼SW¼-26-97-53	60	chalk(?)	S
Hansen, Hartvig	SE¼NW¼NW¼NW¼-26-97-53	125	sand	S
Sorenson, Lloyd	SW¼NW¼NW¼SE¼-26-97-53	105	sand	S
Pederson, J. C.	NE¼NE¼NW¼NW¼-27-97-53	95	sand	S
Johnson, Wilbert	NW¼SW¼SW¼SW¼-27-97-53	86	sand	S
Sanborn, Bob	NW¼NW¼NE¼NW¼-29-97-53	65	sand	S
Hansen, Leslie	NW¼NE¼NE¼SW¼-29-97-53	60	sand	S
Larsen, Duane	NE¼NE¼NE¼SE¼-29-97-53	140	sand	S
Flint, Ole	NE¼SE¼NE¼NE¼-30-97-53	85	sand	S, D
Danielson, Dan	SW¼SW¼NW¼SW¼-32-97-53	50	chalk	S
Peterson, Wayne	NW¼NW¼NW¼SW¼-33-97-53	72	chalk	S
Peterson, Harvey	NE¼NE¼NE¼NE¼-33-97-53	90	sand	S
Nelson, Silas	NW¼NW¼NW¼NE¼-33-97-53	110	sand	S, D
Lauritzen, Holger	SE¼SE¼SE¼SE¼-33-97-53	125	chalk	S, I
Peterson, Melby	SE¼NE¼NE¼NE¼-34-97-53	80	sand	S

Name	Location	Depth of Well (ft)	Geologic Source	Use
Paul's Hatchery	SE¼NE¼NE¼SE¼-34-97-53	120	gravel	S, D
Nielson, Stanley	SW¼SW¼SW¼SE¼-34-97-53	96	chalk	S, D
Frier, Lloyd	SE¼SE¼SE¼SE¼-35-97-53	70	chalk	S, D
Ness, Norman	SE¼SE¼NW¼NW¼-35-97-53	80	sand	S
Sorenson, Leonard	SW¼SW¼NE¼NE¼-35-97-53	75	sand	S