STATE OF SOUTH DAKOTA
Richard Kneip, Governor

SOUTH DAKOTA GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Special Report 51

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

by

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Vermillion, South Dakota
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INTRODUCTION

Present Investigation

This report contains the results of a special investigation conducted by the South Dakota Geological Survey from June 4 to July 3, 1969, in and around the City of Volga, Brookings County, South Dakota (fig. 1), for the purpose of assisting the city in locating a future water supply.

Volga now obtains its water from three wells within the city limits. These wells produce from saturated sand and gravel which is less than 15 feet thick, and the combined production of the three wells is approximately 250 gallons per minute.

Included in the survey of the Volga area was: (1) a review and modification of the geology as mapped by Lee (1958), (2) the drilling of 65 auger and six rotary test holes, (3) a well inventory, and (4) a collection and an analysis of 16 water samples.

As a result of this survey, a new area for ground-water development was discovered southwest of the city (fig. 2), and it was recommended that a well be drilled and a pump test conducted in the SW¼NW¼SW¼ of section 22, T. 110 N., R. 51 W. Although the survey indicated a thicker water bearing formation southwest of the recommended site, the distance from the city and the total water requirements for the city dictated the present location of the pump test site.

In December 1969, a pump test was conducted on a new well in the recommended site. The well was constructed by Thorpe Well Company and the test was conducted by the South Dakota Geological Survey. Data from the pump test is on file at the South Dakota Geological Survey. Results of the pump test indicate that the aquifer will sustain more than one well if there is a minimum spacing of 400 feet between wells and a maximum production of 170 gallons per minute from each. If any of the wells exceeds a yield of 170 gallons per minute, the spacing between wells will have to be more than 400 feet.

The cooperation of the residents of Volga, especially the city officials, Mayor E. Wolfe and Superintendent of Water Works Watson Elgie, is greatly appreciated. The assistance of the South Dakota Chemical Laboratory for analyzing the water samples is also acknowledged.

The project was financed by the South Dakota Geological Survey, East Dakota Conservancy Sub-District, and the City of Volga.

Location and Extent of Area

The city of Volga is located in east-central South Dakota in Brookings County which is in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The Volga area covered by this report includes a region that measures four miles north-south by four miles east-west (fig. 2).

Topography and Drainage

Topography of the Volga area ranges from a gently sloping surface of glacial outwash east of the area (fig. 3) to undulating morainic topography toward the west.

All streams in the area form an integrated drainage system that drains into the Big Sioux River.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Volga area are chiefly the result of glaciation late in the Pleistocene Epoch of geologic time. Glacial deposits are collectively termed drift which is divisible into two broad lithologic groups, till and outwash.

Till, commonly called "boulder clay," "blue clay," or "gumbo," consists of unsorted material that ranges in size from boulders to clay and was deposited directly by the ice.

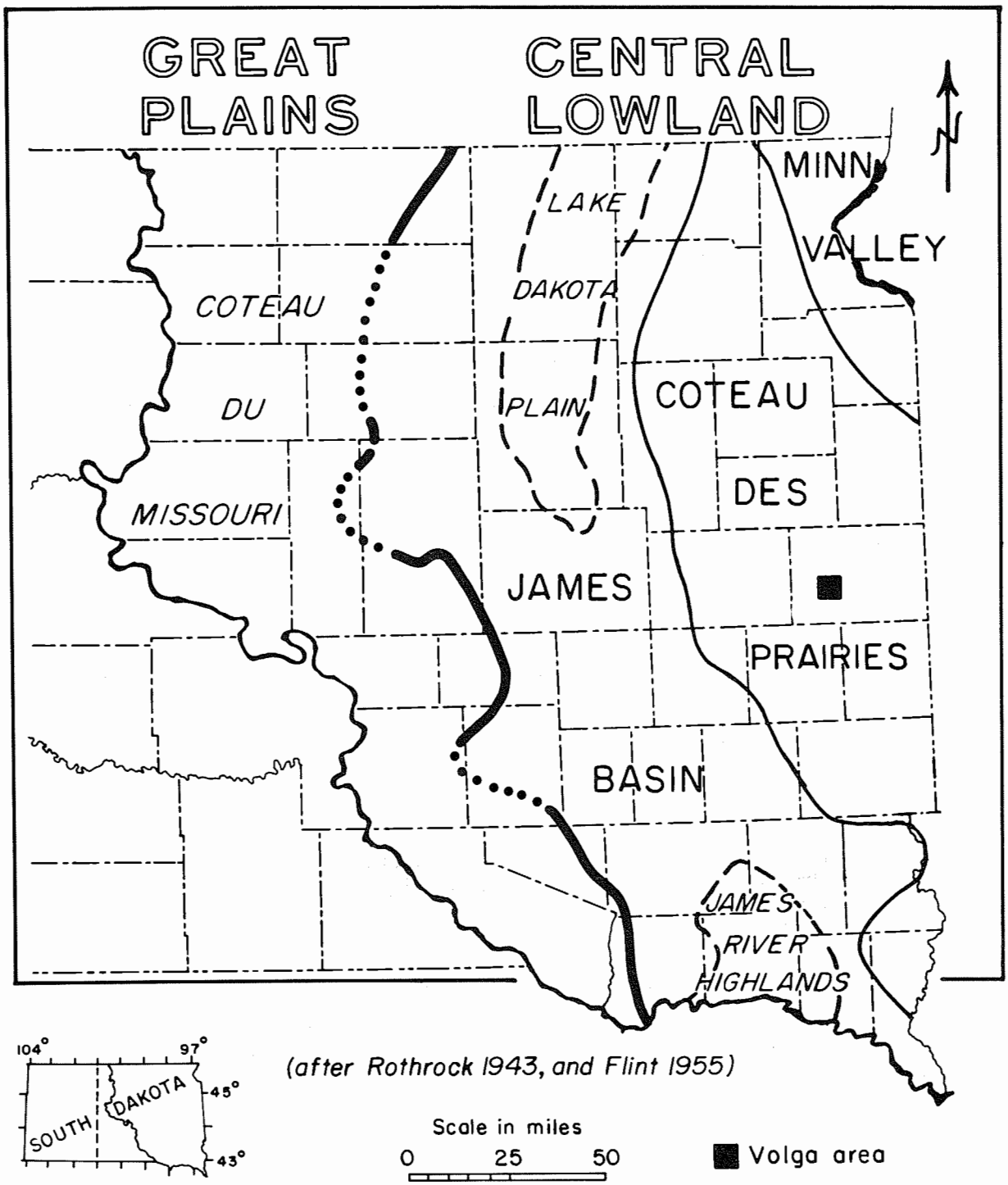
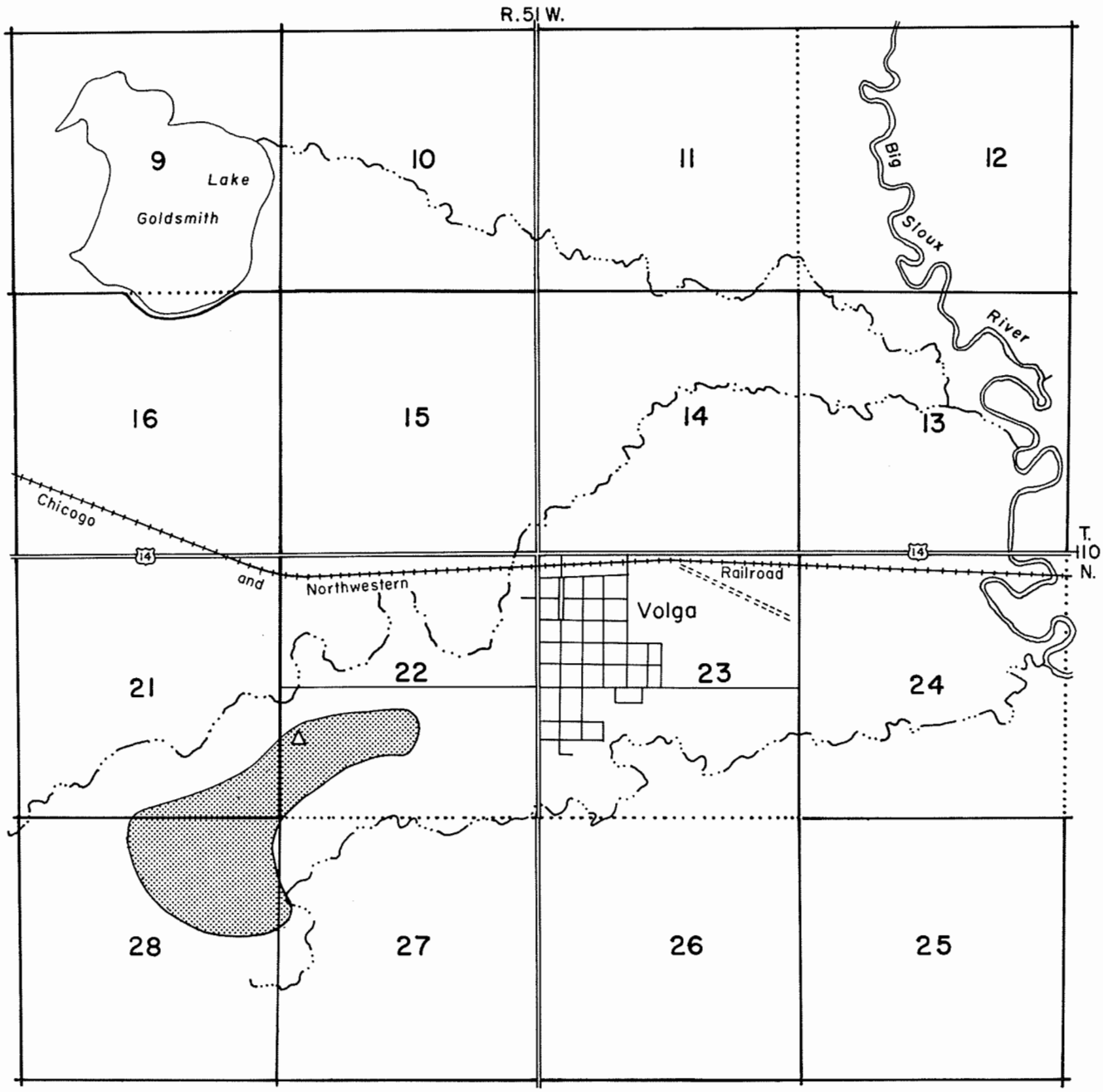


Figure 1. Map of eastern South Dakota showing the major physiographic divisions and location of the Volga area.



EXPLANATION

Recommended area for additional water supplies.

Δ Location of the pump test well.

Intermittent stream

SCALE

0 ¼ ½ 1mile

1000feet 2 3 4 5

Section line roads

Highways

Road or street

Section line

N

by Assad Barari
1970

Figure 2. Map showing location of the recommend area for additional water supplies at Volga.

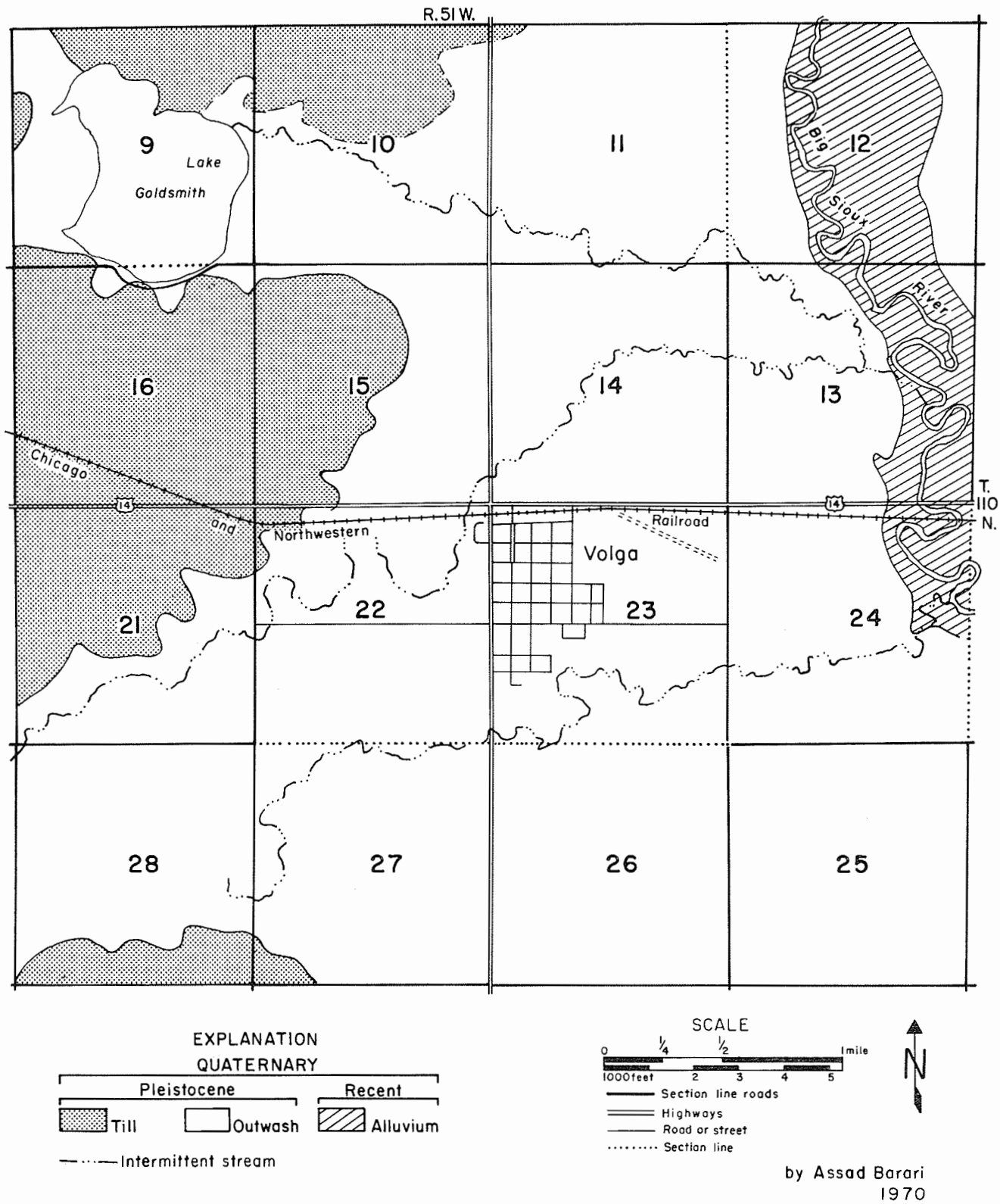


Figure 3. Generalized geologic map of the Volga area. (modified from K.Y. Lee 1958)

Figure 3 shows the distribution of surficial deposits in the Volga area.

Outwash in the Volga area consists of sorted, stratified sand and gravel with minor amounts of clay. The material was deposited by meltwater from an ice sheet and may be present on the surface and under the till (buried outwash) in the Volga study area. Figure 3 reveals that surface outwash covers most of the area.

Alluvium, a deposit generally laid down by modern rivers, is found along the Big Sioux River and its tributaries. The alluvium consists of clay and silt with minor amounts of sand (fig. 3).

Subsurface Bedrock

Subsurface information is extrapolated to the Volga area from a few water wells in Brookings and adjacent counties.

Stratified sedimentary rocks of Cretaceous age are present beneath approximately 350 feet of unconsolidated glacial deposits in the Volga area. These bedrock deposits in descending order are Pierre Shale, Niobrara Marl, Carlile Shale and Codell Member, Greenhorn Limestone, Graneros Shale, and Dakota Formation.

The Pierre Shale consists of light- to dark-gray clayey shale and is approximately 70 feet thick. Beneath the Pierre Shale is approximately 120 feet of the Niobrara Marl, interstratified with shale.

The Carlile Shale underlies the Niobrara Marl and consists of light-gray to black shale interbedded with silt and sand. Data from the Volga area indicates that as much as 70 feet of the Carlile is the Codell Sandstone Member. Total thickness of the Carlile is approximately 130 feet.

The Greenhorn Limestone is composed of hard, light-colored limestone underlain by 150 feet of dark-gray clayey Graneros Shale.

The Dakota Formation is a sequence of alternating sand, sandstone, and shale beds approximately 150 feet thick. Beneath the Dakota are quartzite and granite rocks of Pre-Cambrian age.

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Ground water is defined as water contained in the voids or openings within rocks or sediments below the water table. Practically all open spaces in the rocks that lie below the water table are filled with water; it is called the zone of saturation. The water table is the upper surface of the zone of saturation and is under atmospheric pressure. Rocks (including the soil) that lie above the water table are in the zone of aeration because only some of the open spaces in this zone are filled with water; the remaining portion contains air. This water is either held by molecular attraction, or is moving downward toward the zone of saturation. Water within the ground above the saturated zone moves downward under the influence of gravity, whereas in the saturated zone, it moves in a direction determined by the hydraulic head.

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

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

Recharge is the addition of water to an aquifer (a formation having structures that permit appreciable water to move through it under ordinary field conditions), and is accomplished in four main ways: (1) by 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 into the area, and (4) by artificial recharge, which takes place from excess irrigation, seepage from canals, and water purposely applied to

augment ground-water supplies.

Discharge of ground water from an aquifer is accomplished in four main ways: (1) by evaporation and transpiration by plants, (2) by seepage upward or laterally into surface bodies of water, (3) by lateral movement of water in transient storage out of the area, and (4) by pumping from 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 spaces 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 sorting of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) the removal of mineral matter through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings. Thus, the size of the material has little or no effect on porosity if all other factors are equal.

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

Ground Water in Alluvium

A thin alluvial deposit is present along the Big Sioux River in the Volga area (fig. 3). Because of minimum thickness and high clay and silt content, the alluvium does not readily yield large volumes of water and should not be considered as a water source for the city.

Ground Water in Glacial Deposits

It was stated earlier that glacial deposits are divided into till and outwash. Till does not yield water readily because of its highly unsorted (different sized and shaped particles) nature resulting in low permeability. Locally there are some lenses of sand within the till which provide an adequate supply for farm wells, but these are not important as a possible city water supply.

Outwash, a highly permeable deposit, may make an aquifer. There are two different outwash deposits in the Volga area: surface outwash and buried outwash. Surface outwash deposits (fig. 3) are found in the Big Sioux River and along the present streams. The deposits vary in size from fine to medium sand and gravel with the clay content of deposits varying locally. The thickest water saturated deposit is 35 feet thick, Test Hole 56 (App. A). Figure 4 shows thickness of saturated sand and gravel in the Volga area.

Buried outwash was penetrated by Test Hole 3, 5, and 15 (App. A). These deposits are at a depth of 200 feet or more. Additional information is necessary to define the thickness and areal extent of this aquifer.

Ground Water in Bedrock

The Dakota Formation is the only aquifer other than glacial outwash that could supply significant quantities of water to the City of Volga. However, little data exists as to the availability or quality of the water.

Quality of Ground Water

Ground water always contains dissolved chemical substances in various amounts. Contained chemicals 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 rocks below the water table where the water is moving. In general, the more chemical substances that a water contains, the poorer its quality.

Table 1 shows the quality of water from samples collected in the Volga area. Sample W-1 was collected from the buried sand and gravel a mile northeast of the city. The water from this aquifer has high dissolved chemical substances, especially iron, manganese, and sulfate.

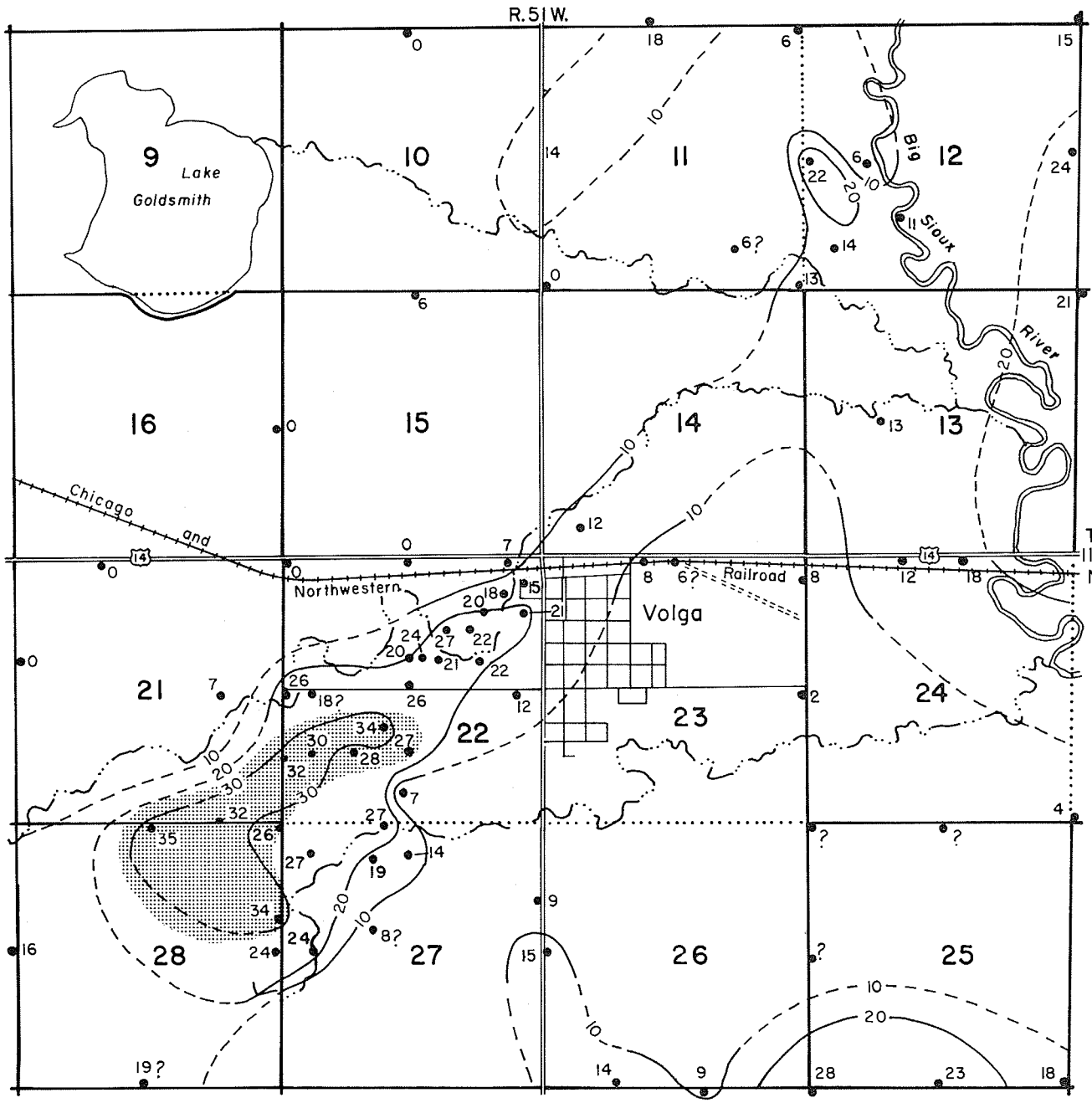


Figure 4. Map showing thickness of saturated surface sand and gravel in the Volga area.

Table 1.–Chemical analyses of water samples from the Volga area

Sample	Parts Per Million											
	Calcium	Sodium	Magnesium	Chlorides	Sulfate	Iron	Manganese	Nitrate Nitrogen	Fluoride	pH	Hardness as $CaCO_3$	Total Solids
A	----	----	----	250	500[1]	0.3	0.005[1]	10.0	0.9-[2] 1.7	—	----	1000[1]
W-1[3]	360	300	125	49	1858	31.6	2.3	4	0.6		1414	3264
W-2	109	12	45	15	204	0.7	0.8	0.5			459	682
W-3	110	15	59	29	100	5.6	2.2	0.1			516	654
W-4	89	14	34	10	130	0.2	0.6	3.4	0.4		360	506
W-5	82	12	34	11	138	1.2	0.2	1.6	0.4		345	534
W-6	109	9	34	7	214	1.2	0.8	0.6	0.4		411	654
W-7	180		45	18	225	.55				7.7	460	655
W-8	80		25	9	80	.18				7.6	300	430
W-9	84		20	5	100	.2				7.8	290	444
W-10	89		37	2	154	0.1	0.9	11	0.2		374	452
W-11	76	8	37	1	128	0	0.06	0.6	0.4		341	436
W-12	67	5	39	1	124	1.9	1.4	0.6	0.2		329	452
W-13	92		25	4.5	123	.3				7.6	330	473
W-14	86	5	64	22	64	0.1	0	28	0.6			604
W-15	124		47	33	145	0.03				7.6	500	767
W-16	100		44	5	130	.08				7.1	430	609

A. Drinking water standards, U. S. Public Health Service (1962).

Samples W-7, W-8, W-9, W-13, W-15, and W-16 were analyzed by the South Dakota Geological Survey. All other samples were analyzed by the South Dakota Chemical Laboratory.

[1] Modified for South Dakota by the Department of Health (written communication, Water Sanitation Section, March 20, 1968).

[2] 1.2 is optimum for South Dakota.

[3] Sample W-1 is from the buried sand and gravel north of the city in the study area. The rest of the samples are from surface outwash in the study area.

Location of Water Samples

(For map location see figure 5)

W-1. NE¼SW¼SW¼SE¼ sec. 11, T. 110 N., R. 51 W., depth of well 286 feet, J. Post

W-2. NW¼SE¼SW¼SW¼ sec. 14, T. 110 N., R. 51 W., City Well No. 5.

W-3. SE¼SW¼SW¼SW¼ sec. 14, T. 110 N., R. 51 W., J. Jones.

W-4. NE¼NW¼NW¼ sec. 23, T. 110 N., R. 51 W., City Well No. 3

W-5. NE¼NW¼NW¼ sec. 23, T. 110 N., R. 51 W., City Well No. 1.

W-6. SW¼NE¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W., City Well No. 2.

W-7. NE¼SW¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W., Test Hole No. 45, water table 9 feet.

W-8. NW¼SE¼NE¼SW¼ sec. 22, T. 110 N., R. 51 W., Test Hole No. 36, water table 15 feet.

W-9. SE¼SE¼NE¼SW¼ sec. 22, T. 110 N., R. 51 W., Test Hole No. 37, water table 16 feet.

W-10. SW¼SW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W., Pump test well, water table 15 feet. Water sample was collected after construction of the well.

W-11. The same location as W-10, water was collected after 40 hours of pumping.

W-12. SW¼SW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W., Rotary Test Hole No. 24, water table 15 feet, water was collected at the beginning of pumping.

W-13. The same location as W-12, water was collected after 5 hours of pumping.

W-14. SW¼NW¼NW¼NW¼ sec. 27, T. 110 N., R. 51 W.

W-15. SE¼SW¼NE¼NE¼ sec. 28, T. 110 N., R. 51 W., depth of well 25 feet.

W-16. SW¼SE¼SW¼SW¼ sec. 21, T. 110 N., R. 51 W., M. Zuiderhaf, water table 12 feet.

Samples W-2, W-4, W-5, and W-6 were collected from City Wells 5, 3, 1, and 2 respectively. Except for iron in sample W-4, these samples have higher manganese and iron than the South Dakota Department of Health limits. Samples W-8, W-9, W-10, W-11, W-12, W-13, and W-15 are from the recommended area (fig. 5). Except for high manganese and low fluoride in all of these samples, and slightly high nitrate in sample W-10, all the other chemicals are within the limits set by the South Dakota Department of Health. Samples W-10 and W-11 were collected from the pump test well. Sample W-10 was collected after the construction of the well and sample W-11 was collected after pumping the well for 40 hours. After pumping, the manganese and iron content was lower and the fluoride content slightly increased. Sample W-11 has less iron and manganese than samples from the present city wells. Samples W-3, W-7, W-14, and W-16 were collected from the surface outwash outside of the recommended area. Sample W-3 has higher iron and manganese, and sample W-7 has higher iron content than the recommended limits. Except for low fluoride in Sample W-14, the rest of the chemicals in W-14 and W-16 are within the limits set by the South Dakota Department of Health.

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

DISCUSSION AND RECOMMENDATIONS

After the completion of the field work in July of 1969, the city council was informed of the following findings: (1) There is a surface aquifer southwest of the city (figs. 2 and 4), which consists of saturated sand and gravel approximately 30 feet thick, at a depth of 15 to 45 feet below the ground surface. The quality of water in this aquifer is comparable or better than the present city water. (2) There is a buried glacial aquifer at a depth of 200 feet below the ground surface, located approximately one mile north of the city. Additional testing is required to define the thickness and areal extent of this aquifer. The water from this aquifer is very high in dissolved chemicals (see table 1).

Based on the saturated thickness, amount of clay, grain size, and the distance from the city, a pump test was recommended in the surface aquifer southwest of Volga at SW¼SW¼NW¼SW¼ Sec. 22, T. 110 N., R. 51 W. (see figs. 2 and 5). The urgency of a satisfactory water supply stimulated the city of Volga to construct this pump test well in the fall of 1969. Following completion of the well by Thorpe Well Company in December of that year, a pump test was conducted by the South Dakota Geological Survey to run at a rate of 170 gallons per minute, a rate nearly double that of each present city well. Results of the pump test indicate that the new well field will provide enough water for the city of Volga. Spacing of the wells should be a minimum of 400 feet with wells yielding 170 gallons per minute. After the construction of a permanent city well, the spacing between future wells should be determined by the new pumping rate.

The city dump ground is located approximately one-fourth mile north of the pump test site. Under the normal pumping rate it is not expected that contaminants from the dump ground will affect the quality of water in the new well field because hydraulic gradient in this area is to the northeast. However, as a precautionary measure it is recommended that two permanent observation wells be constructed (50 feet and 250 feet south of the dump ground), and the elevations surveyed. Water level measurement taken periodically from these observation wells could be used to study possible change in the hydraulic gradient due to pumping the city wells. If pumping produces a hydraulic gradient towards the south, next to the dump ground, the pumping rate should be lowered in the wells to prevent contamination.

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

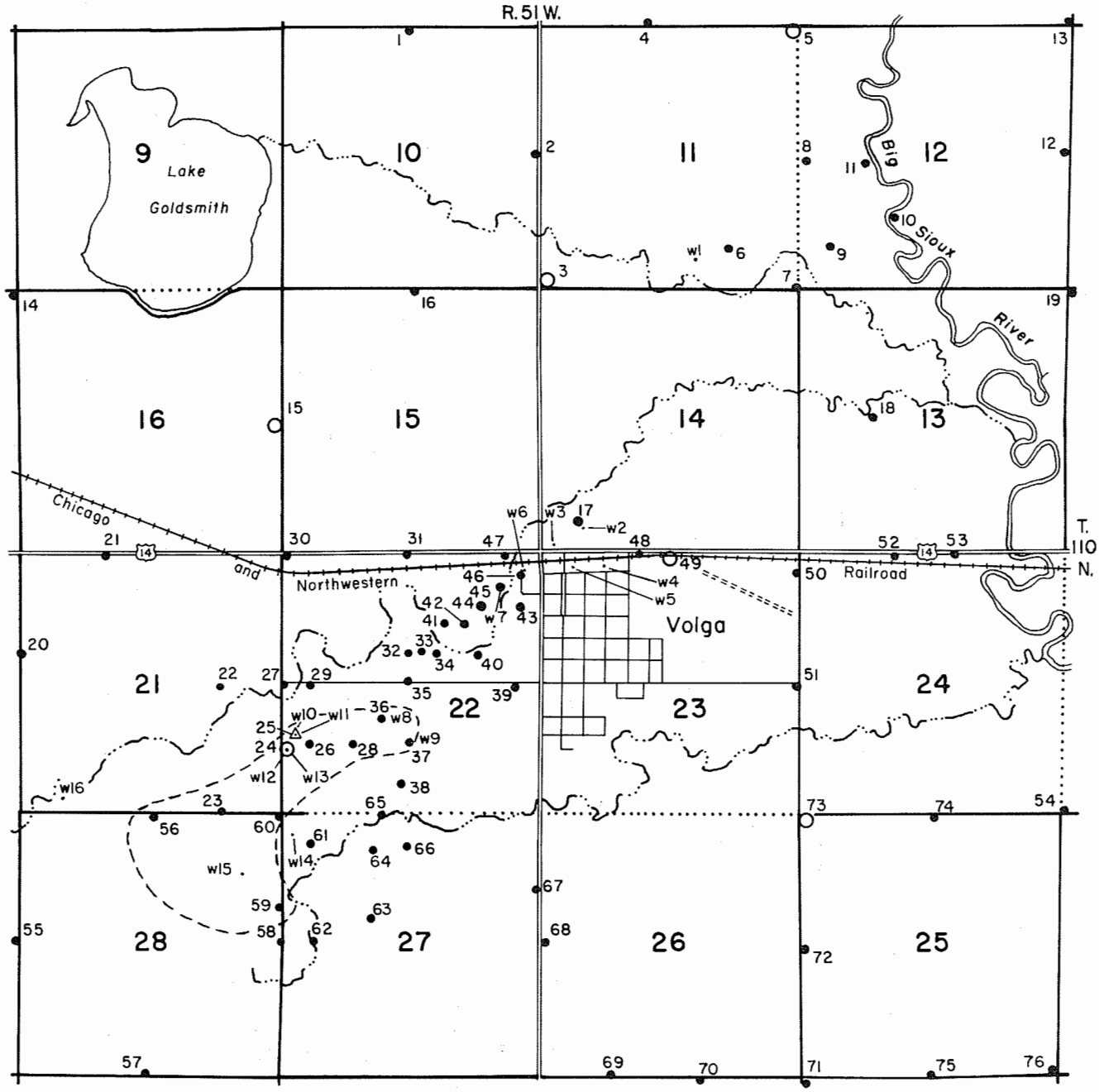


Figure 5. Data map of the Volga area.

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

Chemical Constituents	Significance	Recommended Limits (ppm)[1]
Calcium (Ca) and Magnesium (Mg)	Cause most of the carbonate hardness and scale-forming properties of water by combining with carbonate and bicarbonate present in the water. Seldom can be tasted except in extreme concentrations.	Ca–None Mg–None
Sodium (Na)	Large amounts in combination with chloride will give water a salty taste. Large amounts will limit water for irrigation and industrial use.	None
Chloride (Cl)	Large amounts in combination with sodium give water a salty taste. Large quantities will also increase corrosiveness of water.	250
Sulfate (SO_4)	Large amounts of sulfate in combination with other ions give a bitter taste to water and may act as a laxative to those not used to drinking it. Sulfates of calcium and magnesium will form hard scale. U. S. Public Health Service recommends 250 ppm maximum concentration.	500[2]
Iron (Fe) and Manganese (Mn)	In excess will stain fabrics, utensils, and fixtures and produce objectionable coloration in the water. Both constituents in excess are particularly objectionable.	Fe–0.3 Mn–0.005[2]
Nitrogen (N)	In excess may be injurious when used in infant feeding. The U. S. Public Health Service regards 45 ppm as the safe limit of nitrate (NO_3) or 10 ppm nitrogen (N).	10
Fluoride (F)	Reduces incidence of tooth decay when optimum fluoride content is present in water consumed by children during period of tooth calcification. Excessive fluoride in water may cause mottling of enamel.	0.9-1.7[3]
pH	A measure of the hydrogen ion concentration; pH of 7.0 indicates a neutral solution, pH values lower than 7.0 indicate acidity, pH values higher than 7.0 indicate alkalinity. Alkalinity tends to aid encrustation and acidity tends to aid corrosion.	None
Hardness	Hardness equivalent to carbonate and bicarbonate is called carbonate hardness. Hardness in excess of this amount is noncarbonate hardness. Hardness in water consumes soap and forms soap curd. Will also cause scale in boilers, water heaters, and pipes. Water containing 0-60 ppm hardness considered soft; 61-120 ppm moderately hard; 121-180 ppm hard, and more than 180 ppm very hard. Good drinking water can be very hard.	None
Total Solids	Total of all dissolved constituents. U. S. Public Health Department recommends 500 ppm maximum concentration. Water containing more than 1000 ppm dissolved solids may have a noticeable taste; it may also be unsuitable for irrigation and certain industrial uses.	1000[2]

Modified from Jorgensen (1966).
[1] (ppm) parts per million.
[2] Modified for South Dakota by the South Dakota Department of Health (written communication, Water Sanitation Section, March 20, 1968).
[3] 1.2 is optimum for South Dakota.

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APPENDIX A

Logs of test holes and wells in the Volga area

(For map location see figure 5)

Test Hole No. 1
Location: NE¼NE¼NE¼NW¼ sec. 10, T. 110 N., R. 51 W.
Surface Elevation: 1673 feet
Depth to water: not measured

0- 3	Topsoil
3- 35	Clay, brown, grading to grayish-brown
35- 55	Clay, gray, hard drilling, (till)

* * *

Test Hole No. 2
Location: SE¼SE¼SE¼NE¼ sec. 10, T. 110 N., R. 51 W.
Surface Elevation: 1632 feet
Depth to water: 11 feet

0- 3	Topsoil
3- 25	Sand and gravel, brown, some pebbles
25- 74	Clay, grayish-brown

* * *

Test Hole No. 3 (Rotary Test Hole)
Location: SW¼SW¼SW¼SW¼ sec. 11, T. 110 N., R. 51 W.
Surface Elevation: 1633 feet
Depth to water: not measured

0- 2	Topsoil
2- 18	Gravel and sand
18- 31	Sand, some gravel, little clay
31- 71	Clay, gray, with pebbles, (till)
71- 76	Clay, white-gray
76- 99	Clay, yellow
99-128	Clay, dark-gray
128-194	Clay, some pebbles
194-208	Gravel and clay
208-213	Clay, some pebbles
213-240	Gravel and clay
240-267	Clay, gray, some gravel
267-295	Gravel
295-320	Clay, some pebbles (till)

* * *

Test Hole No. 4
Location: SW¼SE¼SE¼SW¼ sec. 2, T. 110 N., R. 51 W.
Surface Elevation: 1614 feet
Depth to water: 17 feet

0- 3	Topsoil

Test Hole No. 4 (continued)

3- 17	Sand, medium to coarse, some gravel, some clay
17- 21	Sand, light-brown, medium to coarse, some clay
21- 35	Sand and gravel
35- 40	Clay, yellowish-brown
40- 45	Sand, medium to coarse
45- 79	Clay, yellowish-brown, grading to gray, compact

* * *

Test Hole No. 5 (Rotary Test Hole)
Location: NE¼NE¼NE¼NE¼ sec. 11, T. 110 N., R. 51 W.
Surface Elevation: 1605 feet
Depth to water: 5 feet

0- 2	Topsoil
2- 11	Sand and gravel, brown
11- 50	Clay, light-brown, pebbly
50-173	Clay, gray, pebbly
173-175	Gravel
175-228	Clay, light-gray, pebbly
228-265	Sand and gravel and clay layers
265-290	Clay and sand, (till)

* * *

Test Hole No. 6
Location: SE¼NE¼SW¼SE¼ sec. 11, T. 110 N., R. 51 W.
Surface Elevation: 1615 feet
Depth to water: not measured

0- 2	Topsoil
2- 6	Clay, light-brown
6- 16	Sand and gravel, brown
16- 24	Clay, light-gray, compact

* * *

Test Hole No. 7
Location: SE¼SE¼SE¼SE sec. 11, T. 110 N., R. 51 W.
Surface Elevation: 1607 feet
Depth to water: 4 feet

0- 3	Topsoil, sandy
3- 17	Sand and gravel
17- 70	Clay, light-brown, grading to gray, (till)
70- 89	Clay, gray, (till)

* * *

Test Hole No. 8
Location: NW¼NW¼NW¼SW¼ sec. 12, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 4 feet

0- 4	Topsoil

Test Hole No. 8 (continued)

4- 8	Clay, grayish-brown
8- 12	Sand, medium to coarse, grayish-brown
12- 18	Sand and gravel
18- 26	Sand, medium to coarse
26- 39	Clay, light-brown, (till)

* * *

Test Hole No. 9
Location: SE¼NW¼SW¼SW¼ sec. 12, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 4 feet

0- 3	Topsoil
3- 5	Clay, light-brown, sandy
5- 12	Sand and gravel, brown, some clay
12- 14	Sand, medium to coarse, gray
14- 18	Sand and gravel
18- 49	Clay, grayish-brown, pebbly, (till)

* * *

Test Hole No. 10
Location: SE¼SW¼NE¼SW¼ sec. 12, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 4 feet

0- 3	Topsoil
3- 15	Sand and gravel, brown
15- 49	Clay, light-brown, pebbly, compact, (till)

* * *

Test Hole No. 11
Location: NE¼NE¼NW¼SW¼ sec. 12, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 4 feet

0- 3	Topsoil
3- 6	Clay, light-brown
6- 10	Sand and gravel, some clay
10- 39	Clay, light-brown, pebbly, (till)

* * *

Test Hole No. 12
Location: SE¼SE¼SE¼NE¼ sec. 12, T. 110 N., R. 51 W.
Surface Elevation: 1605 feet
Depth to water: 4 feet

0- 2	Topsoil
2- 14	Sand and gravel
14- 28	Sand, bluish-gray
28- 39	Clay, light-brown, fairly compact, (till)
39- 48	Clay, light-brown, very soft, (till)

Test Hole No. 12 (continued)

48- 49	Clay, compact, (till)

* * *

Test Hole No. 13
Location: SE¼SE¼SE¼SE¼ sec. 1, T. 110 N., R. 51 W.
Surface Elevation: 1605 feet
Depth to water: 2 feet

0- 2	Topsoil
2- 8	Sand and gravel, brown, grading to grayish-brown
8- 17	Sand and gravel
17- 49	Clay, grayish-brown, pebbly (till)

* * *

Test Hole No. 14
Location: NE¼NE¼NE¼NE¼ sec. 17, T. 110 N., R. 51 W.
Surface Elevation: 1652 feet
Depth to water: 11 feet

0- 3	Topsoil
3- 21	Clay, light-brown, grading to light-gray
21- 35	Clay, gray, very pebbly, (till)

* * *

Test Hole No. 15
Location: NE¼NE¼NE¼SE¼ sec. 16, T. 110 N., R. 51 W.
Surface Elevation: 1655 feet
Depth to water: not measured

0- 1	Topsoil
1- 35	Clay, yellow, pebbly
35- 40	Sand and gravel
40- 60	Clay, gray
60-149	Clay, yellowish-gray, some pebbles
149-155	Clay, very hard drilling
155-273	Clay, gray, with pebbles
273-320	Gravel, some coal particles
320-335	Clay, gravelly, (till)

* * *

Test Hole No. 16
Location: NW¼NW¼NW¼NE¼ sec. 15, T. 110 N., R. 51 W.
Surface Elevation: 1642 feet
Depth to water: 6 feet

0- 3	Topsoil
3- 12	Sand and gravel, brown
12- 40	Clay, gray, yellow

* * *

Test Hole No. 17
Location: NW¼SE¼SW¼SW¼ sec. 14, T. 110 N., R. 51 W.
Surface Elevation: 1617 feet
Depth to water: 17 feet

0- 3	Topsoil
3- 6	Clay, light-brown
6- 24	Sand and gravel, brown
24- 29	Sand and gravel, light-gray
29- 49	Clay, light-brown, grading to dark-gray, compact, pebbly, (till)

* * *

Test Hole No. 18
Location: SW¼SW¼SE¼NW¼ sec. 13, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 6 feet

0- 3	Topsoil
3- 6	Clay, light-brown
6- 17	Sand and gravel, grayish-brown
17- 19	Sand and gravel, gray
19- 29	Clay, grayish-brown, pebbly, (till)

* * *

Test Hole No. 19 (drilled in 1967)
Location: NW¼NW¼NW¼NW¼ sec. 18, T. 110 N., R. 50 W.
Surface Elevation: 1603 feet
Depth to water: 4 feet

0- 1	Topsoil
1- 4	Sand and gravel
4- 25	Sand, coarse, gravel
25- 39	Clay, dark-gray, pebbly, compact, (till)

* * *

Test Hole No. 20
Location: NW¼SW¼SW¼NW¼ sec. 21, T. 110 N., R. 51 W.
Surface Elevation: 1675 feet
Depth to water: not measured

0- 3	Topsoil
3- 49	Clay, light-brown, grading to dark-brown, compact, pebbly, (till)

* * *

Test Hole No. 21
Location: NE¼NW¼NE¼NW¼ sec. 21, T. 110 N., R. 51 W.
Surface Elevation: 1675 feet
Depth to water: not measured

0- 1	Topsoil
1- 39	Clay, grayish-brown, compact, (till)

* * *

Test Hole No. 22
Location: NW¼NW¼NE¼SE¼ sec. 21, T. 110 N., R. 51 W.
Surface Elevation: 1650 feet
Depth to water: 14 feet

0- 2	Topsoil
2- 10	Sand, tan to brown, fine to medium
10- 21	Sand and gravel, brown
21- 39	Clay, gray, pebbly, (till)

* * *

Test Hole No. 23
Location: SW¼SW¼SE¼SE¼ sec. 21, T. 110 N., R. 51 W.
Surface Elevation: 1655 feet
Depth to water: 20 feet

0- 2	Topsoil
2- 20	Sand and gravel, brown, some clay
20- 34	Sand and gravel, brown, grading to grayish-brown
34- 52	Sand and gravel
52- 59	Clay, grayish-brown, compact, (till)

* * *

Test Hole No. 24
Location: NW¼NW¼SW¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1648 feet
Depth to water: 15 feet

0- 2	Topsoil
2- 25	Gravel and very coarse sand
25- 28	Sand, coarse to very coarse
28- 47	Gravel
47- 49	Clay, some sand, (till)

* * *

Test Hole No. 25 (Pump test well drilled by Thorpe Drilling Co.)
Location: SW¼SW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1645 feet
Depth to water: 15 feet

0- 2	Topsoil
2- 5	Clay, brown
5- 14	Gravel, medium
14- 23	Gravel, fine
23- 45	Gravel, fine to medium
45- 47	Clay

* * *

Test Hole No. 26
Location: SE¼SW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1645 feet
Depth to water: 15 feet

Test Hole No. 26 (continued)

0- 3	Topsoil
3- 31	Sand and gravel
31- 45	Sand, gray, medium-coarse
45- 54	Clay, yellowish-brown, fairly compact, pebbly, (till)

* * *

Test Hole No. 27
Location: NW¼NW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1646 feet
Depth to water: 6 feet

0- 2	Topsoil
2- 6	Sand and gravel, high percent of clay
6- 32	Sand, brown, grading to grayish-brown
32- 44	Clay, grayish-yellow, pebbly, fairly compact, (till)

* * *

Test Hole No. 28
Location: SW¼SW¼NE¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1645 feet
Depth to water: 16 feet

0- 3	Topsoil
3- 16	Sand and gravel, much clay
16- 44	Sand and gravel, brown, grading to light-gray
44- 59	Clay, dark-brown, very pebbly, compact, (till)

* * *

Test Hole No. 29
Location: NE¼NW¼NW¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1643 feet
Depth to water: 11 feet

0- 4	Topsoil, sandy
4- 24	Sand and gravel
24- 29?	Sand, grayish-brown
29?- 94	Clay, light-gray, very pebbly, (till)

* * *

Test Hole No. 30
Location: NW¼NW¼NW¼NW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1670 feet
Depth to water: not measured

0- 3	Topsoil
3- 47	Clay, grayish-brown, pebbly
47- 74	Clay, brownish-gray, pebbly, (till)

* * *

Test Hole No. 31
Location: NE¼NE¼NE¼NW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1647 feet
Depth to water: not measured

0- 4	Topsoil
4- 8	Clay, and gravel
8- 29	Clay, light-brown, pebbly, (till)

* * *

Test Hole No. 32
Location: NE¼SE¼SE¼NW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1648 feet
Depth to water: 17 feet

0- 4	Topsoil
4- 26	Sand and gravel, brown, some clay
26- 37	Sand and gravel
37- 49	Clay, grayish-brown, pebbly, compact, (till)

* * *

Test Hole No. 33
Location: NW¼SW¼SW¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1640 feet
Depth to water: 16 feet

0- 2	Topsoil
2- 4	Clay, light-brown
4- 26	Sand and gravel, brown
26- 40	Sand, light-gray, medium to coarse
40- 54	Clay, light-gray, sandy, (till)

* * *

Test Hole No. 34
Location: NE¼SW¼SW¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1635 feet
Depth to water: 12 feet

0- 3	Topsoil
3- 12	Sand and gravel, brown
12- 20	Sand and gravel, grayish-brown
20- 33	Sand and gravel, brown
33- 49	Clay, pebbly, compact, (till)

* * *

Test Hole No. 35
Location: SE¼SE¼SE¼NW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1641 feet
Depth to water: 14 feet

0- 4	Topsoil
4- 14	Sand and gravel, brown
14- 40	Sand and gravel, much clay

Test Hole No. 35 (continued)

40- 70	Clay, gray, pebbly, compact, (till)

* * *

Test Hole No. 36
Location: NW¼SE¼NE¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1646 feet
Depth to water: 15 feet

0- 2	Topsoil
2- 5	Clay, brown
5- 25	Sand and gravel, brown
25- 30	Sand, light-gray, fine to coarse
30- 39	Sand, dark-brown, medium
39- 44	Clay, grayish-yellow, pebbly, compact, (till)

* * *

Test Hole No. 37
Location: SE¼SE¼NE¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1645 feet
Depth to water: 16 feet

0- 2	Topsoil
2- 6	Clay, light-brown
6- 16	Sand and gravel, brown
16- 43	Sand and gravel, rusty-brown, grading to grayish-brown
43- 54	Clay, pebbly, (till)

* * *

Test Hole No. 38
Location: NE¼SE¼SE¼SW¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1638 feet
Depth to water: 14 feet

0- 2	Topsoil
2- 7	Clay, sandy
7- 21	Sand, grayish-brown, medium to coarse
21- 44	Clay, light-brown, pebbly, very compact, (till)

* * *

Test Hole No. 39
Location: NW¼NE¼NE¼SE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1634 feet
Depth to water: 12 feet

0- 3	Topsoil
3- 12	Sand and gravel, brown
12- 24	Sand and gravel, grayish-brown
24- 44	Clay, light-brown, very pebbly, compact, (till)

* * *

Test Hole No. 40
Location: NW¼SW¼SE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1632 feet
Depth to water: 16 feet

0- 2	Topsoil
2- 5	Clay, light-brown
5- 25	Sand and gravel, brown, some clay
25- 38	Sand, light-gray, medium to coarse
38- 54	Clay, yellowish-brown, pebbly, compact, (till)

* * *

Test Hole No. 41
Location: NW¼NE¼SW¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1632 feet
Depth to water: 4 feet

0- 4	Topsoil
4- 14	Sand, rusty-brown, coarse
14- 31	Sand, light-gray, medium to coarse
31- 44	Clay, dark-brown, few pebbles, (till)

* * *

Test Hole No. 42
Location: NE¼NE¼SW¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1635 feet
Depth to water: 4 feet

0- 4	Topsoil, sandy
4- 15	Sand and gravel, dark-brown
15- 26	Sand and gravel, grayish-brown
26- 39	Clay, gray, easy drilling
39- 54	Clay, gray, pebbly, hard drilling
54- 89	Clay, gray, pebbly, (till)

* * *

Test Hole No. 43
Location: SW¼SE¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1635 feet
Depth to water: 12 feet

0- 4	Topsoil
4- 6	Clay, light-brown
6- 24	Sand and gravel, rusty-brown
24- 33	Sand, gray, little gravel
33- 74	Clay, light-brown, pebbly, (till)

* * *

Test Hole No. 44
Location: SW¼SW¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1632 feet
Depth to water: 8 feet

Test Hole No. 44 (continued)

0- 4	Topsoil
4- 28	Sand and gravel, light-brown, grading to grayish-brown
28- 47	Clay, light-gray, very pebbly, (till)
47- 89	Clay, gray, pebbly, hard drilling, (till)

* * *

Test Hole No. 45
Location: NE¼SW¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1630 feet
Depth to water: 9 feet

0- 3	Topsoil
3- 7	Sand and gravel, brown, some clay
7- 27	Sand and gravel, light-brown
27- 62	Clay, light-brown, pebbly, (till)
62- 82	Clay, hard drilling, (till)
82- 84	Gravel?
84-104	Clay, gray, pebbly, (till)

* * *

Test Hole No. 46
Location: SE¼NE¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1637 feet
Depth to water: 16 feet

0- 2	Topsoil
2- 16	Sand and gravel, brown, much clay
16- 24	Sand and gravel, little clay
24- 31	Sand, medium to coarse
31- 34	Clay, gray, pebbly, compact, (till)

* * *

Test Hole No. 47
Location: NE¼NW¼NE¼NE¼ sec. 22, T. 110 N., R. 51 W.
Surface Elevation: 1632 feet
Depth to water: 6 feet

0- 4	Topsoil
4- 7	Clay and gravel, dark-brown
7- 13	Sand, light-brown, medium
13- 29	Clay, light-brown, pebbly, (till)

* * *

Test Hole No. 48
Location: NW¼NE¼NE¼NW¼ sec. 23, T. 110 N., R. 51 W.
Surface Elevation: 1625 feet
Depth to water: 11 feet

0- 2	Topsoil
2- 11	Sand, medium to coarse
11- 19	Sand and gravel, grayish-brown

Test Hole No. 48 (continued)

19- 69	Clay, light-brown, pebbly, (till)

* * *

Test Hole No. 49 (Rotary test hole)
Location: NW¼NW¼NW¼NE¼ sec. 23, T. 110 N., R. 51 W.
Surface Elevation: 1624 feet
Depth to water: not measured

0- 2	Topsoil
2- 17	Sand and gravel
17- 85	Clay, brown
85- 90	Sand, medium
90-120	Clay, brown
120-183	Clay, grayish-brown
183-195	Clay and gravel
195-225	Gravel
225-255	Clay, light-gray
255-275	Clay, very hard drilling
275-299	Gravel, shale pebbles
299-340	Clay, with gravel
340-410	Shale?, dark-gray
410-560	Marl?, gray

* * *

Test Hole No. 50
Location: SE¼NE¼NE¼NE¼ sec. 23, T. 110 N., R. 51 W.
Surface Elevation: 1622 feet
Depth to water: 11 feet

0- 2	Topsoil
2- 19	Sand and gravel, some clay
19- 74	Clay, grayish-brown, very pebbly, compact, (till)

* * *

Test Hole No. 51
Location: NE¼NE¼NE¼SE¼ sec. 23, T. 110 N., R. 51 W.
Surface Elevation: 1623 feet
Depth to water: 11 feet

0- 3	Topsoil
3- 11	Sand and gravel, brown
11- 13	Sand and gravel, much clay
13- 39	Clay, light-brown, very pebbly, compact, (till)

* * *

Test Hole No. 52
Location: NE¼NW¼NE¼NW¼ sec. 24, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 3 feet

0- 3	Topsoil, sandy

Test Hole No. 52 (continued)

3- 15	Sand and gravel, brown
15- 69	Clay, grayish-brown, pebbly, compact, (till)

* * *

Test Hole No. 53
Location: NE¼NW¼NW¼NE¼ sec. 24, T. 110 N., R. 51 W.
Surface Elevation: 1600 feet
Depth to water: 1 foot

0- 7	Clay, sandy
7- 19	Sand and gravel, brown, grading to gray
19- 49	Clay, light-brown, grading to grayish-brown, pebbly, (till)

* * *

Test Hole No. 54 (drilled in 1967)
Location: SW¼SW¼SW¼SW¼ sec. 19, T. 110 N., R. 50 W.
Surface Elevation: 1598 feet
Depth to water: 3 feet

0- 1	Topsoil
1- 3	Sand
3- 7	Sand, coarse, some gravel
7- 19	Clay, olive-brown, pebbly, (till)

* * *

Test Hole No. 55
Location: SE¼SE¼SE¼NE¼ sec. 29, T. 110 N., R. 51 W.
Surface Elevation: 1674 feet
Depth to water: 35 feet

0- 3	Topsoil
3- 51	Sand and gravel, brown
51- 69	Clay, reddish-brown, pebbly, (till)

* * *

Test Hole No. 56
Location: NW¼NW¼NW¼NE¼ sec. 28, T. 110 N., R. 51 W.
Surface Elevation: 1657 feet
Depth to water: 23 feet

0- 2	Topsoil
2- 35	Sand and gravel, brown
35- 58	Sand, greenish-gray, coarse to very coarse
58- 84	Clay, grayish-brown, very compact, (till)

* * *

Test Hole No. 57
Location: SE¼SE¼SE¼SW¼ sec. 28, T. 110 N., R. 51 W.
Surface Elevation: 1683 feet
Depth to water: 50 feet

Test Hole No. 57 (continued)

0- 12	Clay, light-brown
12- 50	Clay, brownish-gray
50- 69?	Sand and gravel, brown, much clay
69?- 87	Sand, light-gray, very fine, some clay
87- 89	Clay, dark-gray, pebbly, compact, (till)

* * *

Test Hole No. 58
Location: SE¼NE¼SE¼NE¼ sec. 28, T. 110 N., R. 51 W.
Surface Elevation: 1646 feet
Depth to water: 8 feet

0- 3	Topsoil
3- 8	Sand and gravel, much clay
8- 32	Sand, light-brown, medium to very coarse
32- 69	Clay, grayish-brown, pebbly, compact, (till)

* * *

Test Hole No. 59
Location: SE¼NE¼SE¼NE¼ sec. 28, T. 110 N., R. 51 W.
Surface Elevation: 1650 feet
Depth to water: 17 feet

0- 2	Topsoil
2- 14	Sand and gravel, brown, some clay
14- 17	Clay, grayish-brown, pebbly, (till)
17- 24	Sand and gravel, much clay
24- 51	Sand, gray, fine to medium, some clay
51- 59	Clay, yellowish-brown, pebbly, (till)

* * *

Test Hole No. 60
Location: NE¼NE¼NE¼NE¼ sec. 28, T. 110 N., R. 51 W.
Surface Elevation: 1653 feet
Depth to water: 25 feet

0- 2	Topsoil
2- 25	Sand and gravel
25- 44	Sand and gravel, brown, grading to grayish-brown
44- 51	Sand, light-gray, medium to coarse
51- 75	Clay, brown, grading to gray, pebbly, (till)
75- 99	Clay, gray, pebbly, hard drilling, (till)

* * *

Test Hole No. 61
Location: SE¼NW¼NW¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1650 feet
Depth to water: 20 feet

0- 3	Topsoil
3- 6	Clay, with gravel
6- 20	Sand and gravel, brown, much clay

Test Hole No. 61 (continued)

20- 39	Sand and gravel
39- 47	Sand and gravel, brownish-gray
47- 54	Clay, yellowish-brown, pebbly, compact, (till)

* * *

Test Hole No. 62
Location: SE¼SW¼SW¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1640 feet
Depth to water: 5 feet

0- 5	Topsoil
5- 16	Gravel, brown, medium
16- 29	Sand, light-brown, fine to coarse
29- 39	Clay, brown, (till)

* * *

Test Hole No. 63
Location: NE¼SW¼SW¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1645 feet
Depth to water: 21 feet

0- 3	Topsoil
3- 6	Clay, light-brown
6- 16	Sand and gravel, brown
16- 21	Clay, light-brown, grading to dark-gray
21- 29?	Sand and gravel, tan, with clay
29?- 44	Clay, greenish-gray, soft, (till)

* * *

Test Hole No. 64
Location: NE¼SW¼NE¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1640 feet
Depth to water: 7 feet

0- 3	Topsoil
3- 26	Sand, gray, medium to coarse
26- 39	Clay, grayish-brown, compact, (till)

* * *

Test Hole No. 65
Location: NW¼NE¼NE¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1630 feet
Depth to water: 14 feet

0- 1	Topsoil
1- 7	Sand and gravel, light-brown
7- 34	Sand and gravel, brown
34- 41	Sand and gravel
41- 49	Clay, grayish-brown, pebbly, hard drilling, (till)

* * *

Test Hole No. 66
Location: SE¼NE¼NE¼NW¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1640 feet
Depth to water: 4 feet

0- 6	Clay, light-brown
6- 18	Sand, fine to medium, some very coarse
18- 49	Clay, light-brown, (till)

* * *

Test Hole No. 67
Location: NE¼NE¼SE¼NE¼ sec. 27, T. 110 N., R. 51 W.
Surface Elevation: 1644 feet
Depth to water: 12 feet

0- 2	Topsoil
2- 12	Sand and gravel, brown
12- 14	Sand and gravel
14- 21	Sand, brown, medium to very coarse
21- 29	Clay, gray, pebbly, compact, (till)

* * *

Test Hole No. 68
Location: SW¼SW¼SW¼NW¼ sec. 26, T. 110 N., R. 51 W.
Surface Elevation: 1644 feet
Depth to water: 11 feet

0- 3	Topsoil
3- 26	Sand and gravel, brown
26- 75	Clay, light-brown, grading to gray, soft, pebbly, (till)
75- 99	Clay, pebbly, hard drilling, (till)

* * *

Test Hole No. 69
Location: SW¼SW¼SE¼SW¼ sec. 26, T. 110 N., R. 51 W.
Surface Elevation: 1638 feet
Depth to water: 14 feet

0- 6	Roadbed
6- 28	Sand and gravel, brown, much clay
28- 44	Clay, brownish-gray, very pebbly, compact, (till)

* * *

Test Hole No. 70
Location: NE¼NW¼NW¼NE¼ sec. 35, T. 110 N., R. 51 W.
Surface Elevation: 1630 feet
Depth to water: 13 feet

0- 1	Topsoil
1- 13	Sand and gravel, brown
13- 22	Sand and gravel, grayish-brown
22- 39	Clay, grayish-brown, some pebbles, fairly compact, (till)

* * *

Test Hole No. 71 (drilled in 1967)
Location: NW¼NW¼NW¼NW¼ sec. 36, T. 110 N., R. 51 W.
Surface Elevation: 1624 feet
Depth to water: 8 feet

0- 1	Topsoil
1- 8	Sand and gravel
8- 36	Sand, coarse, some gravel
36- 49	Clay, olive-brown, pebbly, (till)

* * *

Test Hole No. 72
Location: NW¼NW¼NW¼SW¼ sec. 25, T. 110 N., R. 51 W.
Surface Elevation: 1625 feet
Depth to water: not measured

0- 1	Topsoil
1- 12	Sand and gravel, brown
12- 39	Clay, yellowish-brown, pebbly, compact, (till)

* * *

Test Hole No. 73 (Rotary Test Hole)
Location: NW¼NW¼NW¼NW¼ sec. 25, T. 110 N., R. 51 W.
Surface Elevation: 1624 feet
Depth to water: not measured

0- 1	Topsoil
1- 16	Sand and gravel
16- 40	Clay, yellowish-gray
40- 45	Gravel
45-185	Clay, gray, some pebbles
185-193	Gravel, some clay
193-195	Clay
195-200	Gravel
200-220	Clay and gravel
220-290	Clay, gray, some pebbles

* * *

Test Hole No. 74
Location: NW¼NW¼NW¼NE¼ sec. 25, T. 110 N., R. 51 W.
Surface Elevation: 1620 feet
Depth to water: not measured

0- 3	Topsoil
3- 10	Sand and gravel, brown
10- 20	Sand, tan, fine to medium
20- 39	Clay, tan, (till)

* * *

Test Hole No. 75
Location: SE¼SE¼SE¼SW¼ sec. 25, T. 110 N., R. 51 W.
Surface Elevation: 1612 feet
Depth to water: 8 feet

Test Hole No. 75 (continued)

0- 3	Topsoil
3- 19	Sand and gravel, brown, little clay
19- 26	Sand, tan, fine to medium
26- 31	Sand, light-gray
31- 49	Clay, gray, pebbly, soft, (till)

* * *

Test Hole No. 76 (drilled in 1967)
Location: SE¼SE¼SE¼SE¼ sec. 25, T. 110 N., R. 51 W.
Surface Elevation: 1603 feet
Depth to water: 5 feet

0- 2	Topsoil
2- 5	Sand and gravel
5- 23	Sand, fine to coarse
23- 34	Clay, light-gray, (till)

* * *

APPENDIX B

Well Records in the Volga Area

Source: O, Surface outwash; Ob, buried sand lenses and outwash

Use: D, domestic; S, stock

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Jorenby, O.	SW¼SW¼SW¼SE¼ sec. 2, T. 110 N., R. 51 W.	8		O	D, S
Vanderberg, M.	SW¼NW¼NW¼ sec. 2, T. 110 N., R. 51 W.	35		O	D, S
Van Hoepen, M.	SE¼SE¼SE¼SE¼ sec. 3, T. 110 N., R. 51 W.	50		O	D, S
Meyer, B.	SE¼SE¼SW¼SW¼ sec. 3, T. 110 N., R. 51 W.	70	60	Ob	D, S
Hoogwerf, G.	NE¼NE¼NE¼SE¼ sec. 4, T. 110 N., R. 51 W.	80	55	Ob	D, S
Leslie, R.	SE¼SE¼NE¼ sec. 4, T. 110 N., R. 51 W.	65		Ob	D, S
Jensen, M.	SE¼SE¼SW¼SW¼ sec. 4, T. 110 N., R. 51 W.	84	54	Ob	D, S
Raabe, W.	NW¼SE¼NE¼ sec. 5, T. 110 N., R. 51 W.	75		Ob	D, S
Knudsen, C.	SW¼SW¼SW¼SW¼ sec. 8, T. 110 N., R. 51 W.	132		Ob	D, S
Nelsen, D.	SE¼SE¼SE¼SW¼ sec. 8, T. 110 N., R. 51 W.	130		Ob	D, S
Jurgens, L.	SW¼SW¼SW¼SE¼ sec. 8, T. 110 N., R. 51 W.	90		Ob	D
Statema, J.	SE¼SE¼SE¼NE¼ sec. 8, T. 110 N., R. 51 W.	40	30	Ob	
Lengkeek, G.	SE¼NW¼NW¼ sec. 10, T. 110 N., R. 51 W.	82	75	Ob	D, S
Vandenberg, J.	NE¼SE¼SE¼ sec. 10, T. 110 N., R. 51 W.	20		O	D, S

Name	Location	Depth of Well (feet)	Depth to Water (feet)	Source	Use
Olson, M.	NE¼SE¼NE¼ sec. 10, T. 110 N., R. 51 W.	40	25	O	D, S
Starkenburg, D.	SE¼SW¼NW¼ sec. 11, T. 110 N., R. 51 W.	30	20	O	D, S
Post, J.	NE¼SW¼SW¼SE¼ sec. 11, T. 110 N., R. 51 W.	286	34	Ob	- S
VanderWall, W.	SE¼SE¼NE¼SE¼ sec. 15, T. 110 N., R. 51 W.	20	8	O	D, S
Vermeulen, J.	NE¼NE¼SE¼SE¼ sec. 15, T. 110 N., R. 51 W.	12		O	D, S
Santeana, G.	NW¼NW¼NE¼NW¼ sec. 15, T. 110 N., R. 51 W.	25		O	D, S
Warnas, H.	NE¼NE¼SE¼NE¼ sec. 17, T. 110 N., R. 51 W.	90		Ob	D, S
Vostad, T.	SE¼NW¼NW¼NW¼ sec. 20, T. 110 N., R. 51 W.	30	20	Ob	D, S
Vandenberg, L.	NE¼NE¼SW¼NE¼ sec. 20, T. 110 N., R. 51 W.	80	50	Ob	D, S
Zuiderhaf, M.	SW¼SE¼SW¼SW¼ sec. 21, T. 110 N., R. 51 W.	20	12	O	D, S
Olson, L.	SE¼SE¼SW¼SE¼ sec. 21, T. 110 N., R. 51 W.	30		O	D, S
Nissen, H.	NW¼NE¼NW¼SE¼ sec. 22, T. 110 N., R. 51 W.	16	12	O	D, S
Schlimmer, L.	SE¼SE¼SE¼SW¼ sec. 24, T. 110 N., R. 51 W.	35	20	O	D, S
Jorenby, J.	NE¼NE¼SW¼NW¼ sec. 25, T. 110 N., R. 51 W.	25	16	O	D, S
Nelson, A.	NW¼SE¼SE¼SW¼ sec. 27, T. 110 N., R. 51 W.	39	32	O	D, S
Anderson, A.	NW¼NW¼SE¼NE¼ sec. 28, T. 110 N., R. 51 W.	25		O	D, S
Mans, W.	SE¼NW¼SE¼NW¼ sec. 29, T. 110 N., R. 51 W.	50	40	O	D, S