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

by

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Vermillion, South Dakota
1972
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INTRODUCTION

Present Investigation

This report contains the results of a special ground-water investigation conducted by the South Dakota Geological Survey from July 25 to August 16, 1968, in and around the city of Howard, Miner County, South Dakota (fig. 1). The purpose of this investigation was to assist the city in locating an additional water supply.

In the spring of 1968 pumping from three municipal wells located within the city limits could not adequately satisfy the demands for water; consequently, the city hired Minnebaha Waters to drill a new well. A well was drilled north of Highway 34 within the city limits and a layer of gravel approximately 20 feet thick was penetrated at a depth of 175 feet. Following this, the South Dakota Geological Survey installed an observation well 75 feet east of the well to test the aquifer as a potential water supply. On June 18, 1968, a pump test was conducted at a rate of 180 gallons per minute for 24 hours. After finding favorable results, the well was completed and water from the well has been used since the installation of a pump.

In addition to the pump test this study included (1) the mapping of the geology of 72 square miles, (2) the drilling of 29 rotary and 62 auger test holes, (3) the surveying of the elevation of rotary test holes, (4) a well inventory, and (5) a collection and analyses of 18 water samples.

Results from the investigation indicate that the city could obtain additional water from a buried sand and gravel deposits approximately 170 feet below the land surface. Other shallow and deep potential sources of water have also been found, which require additional testing.

Cooperation of the residents of Howard, especially former Mayor R. D. Sherman, Ray Callanan, former General Superintendent of Municipal Utilities, and Berhard Mengenhauser, Water Superintendent, was greatly appreciated. Assistance of the Minnebaha Water Co. during the pump test, and of the State Chemical Laboratory for analyzing the water samples is acknowledged.

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

Location and Extent of Area

The Howard area as used in this report includes a region that measures nine miles north-south and eight miles east-west. The city lies within the James Basin, a part of the Central Lowlands physiographic province (fig. 1).

GENERAL GEOLOGY

Surficial Deposits

Surficial deposits of the Howard area are chiefly the results of glaciation late in the Pleistocene Epoch of geologic time. Glacial deposit are collectively called drift, and are divided into till and outwash deposits. Till consists of a heterogeneous mixture of boulders, pebbles and sand in matrix of clay directly deposited by the ice. Outwash material, on the other hand, is a sorted deposit consisting of mostly sand and gravel with minor amounts of clay deposited by meltwater streams issuing from the ice. The thickness of the glacial drift is approximately 200 feet in this area. Alluvium is deposited in the present streams (fig. 2). Alluvium consists of silt, clay and small amounts of sand and gravel.

Subsurface Bedrock

Beneath the glacial deposits lie sedimentary rocks of Cretaceous age. In the Howard area these
Figure 4. Major physiographic divisions of eastern South Dakota and location of the Howard area.
Figure 2. Generalized geologic map of the Howard area.
rock formations in descending order are: Pierre Shale, Niobrara Marl, and Carlile Shale.

The Pierre consists of dark-gray noncalcareous shale. Although this formation was penetrated by most of the deep test holes in the area, it was not present in the new well field nor was it indicated in the log of the well drilled next to the standpipe. The Niobrara consists of light-gray dark-gray marl or chalk. It is up to 90 feet thick, and is located at a depth of approximately 200 feet below the surface. The Carlile consists of medium- to dark-gray bentonitic shale interbedded with silt or sand layers.

The well inventory from northwest of the study area indicates that the Dakota Formation consisting mostly of sandstone is present, but more information is needed to identify the depth and the thickness of this formation.

The Sioux Quartzite which consists predominantly of fine grains of iron-coated quartz cemented with silica. The “Wash” which consists of a mixture of sand-to pebble-size fragments of Sioux Quartzite is present above the cemented quartzite (Jorgenson, 1960). This formation is at a depth of approximately 400 feet below the city. The well inventory from northwest of the study area indicates that it is deeper than 1,000 feet.

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. The water table is the upper surface of the zone of saturation which is under atmospheric pressure. Practically all open spaces in the rocks that lie below the water table are filled with water. Rocks (including the soil), that lie above the water table are in the zone of aeration. Some of the interstices in this zone are also filled with water, but the 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 into 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 of 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.

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. Porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of assortment of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) removal of mineral matter through solution by percolating waters, 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. 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

Alluvium is found along the West Fork of the Vermillion River and small amount along the Little Vermillion River (fig. 2). Because of high clay and silt content the alluvium does not readily yield large volumes of water. It 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 nature and low permeability; whereas, outwash deposits generally do exhibit good permeability and therefore if they are extensive enough make good aquifers.

Surface outwash, found along present streams (fig. 2), and buried outwash are present in the Howard area. Thickness of saturated surface sand and gravel outwash is shown on figure 3. Buried sand lenses and outwash were penetrated at varying depths by test holes in this area. Figure 4 shows the elevations of the test hole sites, depth to each layer of sand and gravel, and the thickness of each sand and gravel deposit. Because of rapid changes in the thickness of these deposits and the varying depths to each layer contours are not shown.

Ground Water in Bedrock

Sandstones of the Dakota Formation, where they are present, yield water to artesian wells in roost parts of the State. Artesian wells which have higher hydraulic head than the ground surface produces flowing wells. Well inventory from the area indicates that the Dakota Formation is present 4 miles north of the city; however, well logs from within the city indicate that the Dakota Formation is absent beneath the city. More information is required to define the areal extent and water yielding capacity of this aquifer in the Howard area.

The "Wash" which is a porous and permeable deposit overlies the Silous Quartzite. Some of the city wells produce water from the "Wash" and quartzite which are hydraulically connected.

Quality of Ground Water

Ground water always contains dissolved chemical substances in various amounts. Cationic 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 chemical analyses of water samples collected from the Howard area (for location of samples, see fig. 5).

Samples W-1, W-2, W-5, W-8, W-17, and W-18 were collected from the surface outwash in the area. Samples W-2, W-17, and W-18 have higher sulfate; samples W-17 and W-18 have high iron content; and sample W-1 has higher nitrogen than the recommended limits. Except for total solids in sample W-5, all samples in this group have higher total solids and manganese and less fluoride content than the recommended limits set by the South Dakota Department of Health.

Samples W-15 to W-16 were collected in different periods from the new city well which obtains water from the buried outwash. All samples in this group have higher sulfate, manganese,
EXPLANATION

by A. Barari 1969

*12 Test hole showing thickness of saturated sand and gravel.
Contour interval = 10 feet.

Figure 3. Map showing the thickness of saturated surface and shallow sand and gravel along the present streams in the Howard area.
EXPLANATION

E = Elevation
S 110-125 = Sand from depth of 110 to 125 feet. Test hole drilled by S. D. G. S. Rotary rig

A = E-S similar data as above. Test hole or well drilled by drilling companies.

Figure 4. Map showing thickness of saturated buried sand and gravel in the Howard area.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Source</th>
<th>Calcium</th>
<th>Sodium</th>
<th>Magnesium</th>
<th>Chloride</th>
<th>Sulphate</th>
<th>Iron</th>
<th>Manganese</th>
<th>Nitrate</th>
<th>Nitrogen</th>
<th>Fluoride</th>
<th>pH</th>
<th>Hardness</th>
<th>Total Solids</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Parts Per Million</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>S</td>
<td>250</td>
<td>500²</td>
<td>0.3</td>
<td>0.05</td>
<td>10⁻¹</td>
<td>0.92⁻¹</td>
<td>1.7</td>
<td>1000²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>W-1</td>
<td>S</td>
<td>376</td>
<td>91</td>
<td>94</td>
<td>475</td>
<td>0.81</td>
<td>3</td>
<td>60.5</td>
<td>0.60</td>
<td>7.4</td>
<td>1065</td>
<td>1365</td>
<td></td>
<td></td>
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<td>W-2</td>
<td>S</td>
<td>208</td>
<td>106</td>
<td>42</td>
<td>670</td>
<td>0.12</td>
<td>0.7</td>
<td>0</td>
<td>0.40</td>
<td>7.5</td>
<td>900</td>
<td>1250</td>
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<td>W-5</td>
<td>S</td>
<td>200</td>
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<td>32</td>
<td>332</td>
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<td>10.0</td>
<td>0.24</td>
<td>7.5</td>
<td>700</td>
<td>940</td>
<td>940</td>
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<td>W-8</td>
<td>S</td>
<td>192</td>
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<td>76</td>
<td>462</td>
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<td>8.25</td>
<td>0.43</td>
<td>7.6</td>
<td>790</td>
<td>1220</td>
<td>1220</td>
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<td></td>
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<tr>
<td>W-17</td>
<td>S</td>
<td>256</td>
<td>122</td>
<td>440</td>
<td>1500</td>
<td>0.75</td>
<td>2.8</td>
<td>0</td>
<td>7.6</td>
<td>1140</td>
<td>3000</td>
<td>3000</td>
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<tr>
<td>W-18</td>
<td>S</td>
<td>252</td>
<td>45</td>
<td>0</td>
<td>600</td>
<td>1.5</td>
<td>0.6</td>
<td>0</td>
<td>7.2</td>
<td>820</td>
<td>1015</td>
<td>1015</td>
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<td>W-11</td>
<td>B</td>
<td>171</td>
<td>254</td>
<td>28</td>
<td>22</td>
<td>1008</td>
<td>0.1</td>
<td>1.28</td>
<td>4</td>
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<td>542</td>
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<tr>
<td>W-12</td>
<td>B</td>
<td>178</td>
<td>37</td>
<td>22</td>
<td>1010</td>
<td>1.6</td>
<td>9.4</td>
<td>0.6</td>
<td>598</td>
<td>1872</td>
<td>576</td>
<td>1914</td>
<td></td>
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<tr>
<td>W-13</td>
<td>B</td>
<td>164</td>
<td>310</td>
<td>41</td>
<td>20</td>
<td>1016</td>
<td>0.3</td>
<td>1.6</td>
<td>16</td>
<td>0.8</td>
<td>576</td>
<td>1914</td>
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<tr>
<td>W-14</td>
<td>B</td>
<td>166</td>
<td>303</td>
<td>47</td>
<td>18</td>
<td>1008</td>
<td>0.7</td>
<td>1.82</td>
<td>22</td>
<td>0.8</td>
<td>608</td>
<td>1830</td>
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<tr>
<td>W-15</td>
<td>B</td>
<td>172</td>
<td>300</td>
<td>51</td>
<td>19</td>
<td>1070</td>
<td>2.3</td>
<td>1.7</td>
<td>0.6</td>
<td>640</td>
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<tr>
<td>W-16</td>
<td>N</td>
<td>268</td>
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<td>24</td>
<td>1320</td>
<td>4.85</td>
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<td>0</td>
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<td>7.3</td>
<td>850</td>
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<tr>
<td>W-3</td>
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<td>12</td>
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<td>8.3</td>
<td>30</td>
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<tr>
<td>W-4</td>
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<td>8</td>
<td>222</td>
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<td>7.7</td>
<td>110</td>
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<tr>
<td>W-6</td>
<td>D</td>
<td>30</td>
<td>2</td>
<td>234</td>
<td>950</td>
<td>4.90</td>
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<td>8.2</td>
<td>85</td>
<td>2560</td>
<td></td>
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</tr>
<tr>
<td>W-7</td>
<td>Q</td>
<td>196</td>
<td>37.5</td>
<td>135</td>
<td>1050</td>
<td>0.11</td>
<td>0</td>
<td>0</td>
<td>7.3</td>
<td>640</td>
<td>2030</td>
<td>2030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W-9</td>
<td>Q</td>
<td>203</td>
<td>255</td>
<td>46</td>
<td>124</td>
<td>1125</td>
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<td>0</td>
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<td>3</td>
<td>695</td>
<td>2116</td>
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<tr>
<td>W-10</td>
<td>Q</td>
<td>179</td>
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<td>50</td>
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<td>1072</td>
<td>4.1</td>
<td>0.12</td>
<td>1</td>
<td>3</td>
<td>651</td>
<td>2090</td>
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1 Modified for South Dakota by Department of Health (Written Communication Water Sanitation Section, March 20, 1968).
2 2.7 is optimum for South Dakota. Samples W-11, W-13, W-14, and W-15 were analyzed by the South Dakota Chemical Laboratory. All other samples were analyzed by the South Dakota Geological Survey.
Source  S – Surface outwash  B – Buried sand lenses and outwash  N – Niobrara Marl  Q – Sioux Quartzite  D – Dakota Formation
Location of Water Samples in the Bowdoin area

(For map location, see fig. 5.)


W. 1 SW NW NW NW sec. 8, T. 107 N., R. 55 W., A. Bergheim, 19 feet deep, water table 3 feet

W. 2 SW SW SW SW sec. 8, T. 107 N., R. 55 W., H. Hegdahl, 24 feet deep, water table 17 feet

W. 3 SW NW NW NW sec. 14, T. 107 N., R. 56 W., A. Sherman, 5867 feet deep, water table 4007 feet

W. 4 NE NE NE NE sec. 14, T. 107 N., R. 56 W., E. Hauge, 1,000 feet deep

W. 5 SW NW SE NE NW sec. 17, T. 107 N., R. 55 W., L. Eide, 20 feet deep

W. 6 SE SE NE NE sec. 22, T. 107 N., R. 56 W., P. Collin, 800 feet deep

W. 7 NE NE sec. 3, T. 106 N., R. 56 W., City well, 575 feet deep

W. 8 NE SE SW NE sec. 2, T. 106 N., R. 56 W., 18 feet deep

W. 9 SW NE sec. 2, T. 106 N., R. 56 W., City Well (golf course), 412 feet deep

W. 10 SW NW sec. 2, T. 106 N., R. 56 W., City Well, 410 feet deep

W. 11, 12, 13, 14, and 15 SE SW sec. 2, T. 106 N., R. 56 W., City new well,

W. 11 After 1½ hours pumping
W. 12 After 5 hours pumping
W. 13 September 6, 1968
W. 14 September 14, 1968
W. 15 February 12, 1970

W. 16 NE NE NE NE sec. 10, T. 106 N., R. 56 W., L. Scott, 240 feet deep

W. 17 NE NE SE SW NW sec. 14, T. 106 N., R. 56 W., Test hole 97, water table 7 feet

W. 18 NE NE SE SW SW sec. 24, T. 106 N., R. 56 W., Test hole 107, water table 8 feet
Figure 5. Data map of the Howard area.

- 44 Auger test hole
- 56 Rotary test hole
- ▲ Test hole or well by drilling company
- ● New city well
- W-II Water sample

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total solids, lower fluoride and samples W-13 and W-14 have higher nitrate (nitrate nitrogen) than the recommended limits. Also samples W-14 and W-15 have higher iron than the recommended limits. Generally water samples from the surface outwash are harder than water from other sources in the area.

Samples W-16 is from the Niobrara Marl. This sample has higher sulfate, iron, fluoride, and total solids than the recommended limits.

Samples W-7, W-9, and W-10 are from the Dakota Formation. These samples have less hardness than the rest of the samples collected in the area, but they are higher in sulfate, iron, fluoride, and the total solids than the recommended limits.

Samples W-7, W-9, and W-10 are taken from wells producing from the Sioux Quartzite. These samples have higher sulfate and total solids than the recommended limits set by the U. S. Department of Health. Also samples W-9 and W-10 have higher iron, fluoride and sample W-9 has higher nitrate (nitrate nitrogen) than the recommended limits. The quality of water samples from the Sioux Quartzite and the buried outwash are comparable.

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

**CONCLUSIONS AND RECOMMENDATIONS**

There are four potential sources of water for the city of Howard. These sources are:

1. **Layers of buried glacial sand and gravel deposits.** Thickness and depth to each sand and gravel layer varies in different locations. Figure 4 shows the elevation of test hole sites and the depth and thickness of each sand layer penetrated by the drill. Beneath the city, at a depth of approximately 1/20 feet, there is a sand and gravel layer with an approximate thickness of 20 feet. The new city well is producing water from this sand and gravel layer. The logs from test holes and the results of the pump test indicate that this deposit will sustain additional wells with a minimum spacing of 600 feet between the wells with a pumping rate not to exceed 200 gallons per minute. Water from this deposit has lower chloride and fluoride than the water from the Sioux Quartzite, whereas the rest of the chemicals are comparable with the water from the Sioux Quartzite (table 1).

Water samples from all sources, except some samples from the surface outwash, have higher sulfate content than the limit set by the South Dakota Department of Health. Water samples W-14 and W-15 have higher iron than recommended limits. It appears that buried glacial sand and gravel deposits are the most favorable source of water for the city of Howard.

If the city should decide to drill additional wells in the buried sand and gravel, it is recommended that the well location be chosen by considering the thickness of the deposit penetrated by the test hole (fig. 4). It is also recommended that the city of Howard consult an engineering firm with regard to the cost of removing some of the chemicals from the water.

2. **Sioux Quartzite and the “Wash,”** which is located, at a depth of approximately 400 feet below the city, could produce additional water similar in quality to water samples W-7, W-9, and W-10 which are from the old city well (table 1).

3. **Surface Outwash deposits are present along the present streams in the area.** Two locations where the sand has maximum thickness, could be considered; these locations are 2½ miles north of the city along the West Fork of the Vermilion River, and 7½ miles northeast of the city. No sample was collected from the first location, but samples W-1, W-2, and W-5 were collected from the second location. Samples from this surface outwash indicated a higher degree of hardness than any other source in the area. If the city decides to test this aquifer, it is recommended that they hire a well drilling company to construct a pump test well. This test should be conducted by a qualified hydrologist or engineer and run for a minimum of 72 hours.

4. **The Dakota Formation** from analyses of well inventory information indicates that the Dakota is present approximately 4 miles north and northwest of the city. Water samples W-3, W-4, and W-6 collected from this formation indicate that this water has the lowest hardness of any other water in the study area, but has higher sulfate, iron, and fluoride than the
| Chemical Constituents | Significance | Recommended Limits (ppm)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca) and Magnesium (Mg)</td>
<td>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.</td>
<td>Ca—None Mg—None</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>Large amounts in combination with chloride will give water a salty taste. Large amounts will limit water for irrigation and industrial use.</td>
<td>None</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>Large amounts in combination with sodium give water a salty taste. Large quantities will also increase corrosiveness of water.</td>
<td>250</td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>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.</td>
<td>500²</td>
</tr>
<tr>
<td>Iron (Fe) and Manganese (Mn)</td>
<td>In excess will stain fabrics, utensils, and fixtures and produce objectionable coloration in the water. Both constituents in excess are particularly objectionable.</td>
<td>Fe—0.3 Mn—0.05</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>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 (NO₃) or 10 ppm nitrogen (N).</td>
<td>10</td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>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.</td>
<td>0.9-1.7³</td>
</tr>
<tr>
<td>pH</td>
<td>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.</td>
<td>None</td>
</tr>
<tr>
<td>Hardness</td>
<td>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.</td>
<td>None</td>
</tr>
<tr>
<td>Total Solids</td>
<td>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.</td>
<td>1000⁴</td>
</tr>
</tbody>
</table>

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.
recommended limits. If the city should decide to test this aquifer, it is recommended that the city follow the same procedure as was recommended for testing the surface outwash.

Before a permanent well is drilled the city officials should consult with the South Dakota Water Resources Commission to obtain water rights and a permit to drill a city well, and with the South Dakota Department of Health to determine the biological and chemical suitability of the water.
REFERENCES CITED


APPENDIX A

Logs of test holes and wells in the Howard area

(For map location see fig. 5)
Test Hole 5 – continued.

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-17</td>
<td>Clay, blue-gray, pebbly</td>
</tr>
<tr>
<td>17-41?</td>
<td>Sand, coarse</td>
</tr>
<tr>
<td>41-74</td>
<td>Clay, gray, pebbly</td>
</tr>
</tbody>
</table>

Test Hole 6
Location: NW NW NW NW sec. 8, T. 107 N., R. 55 W.
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1-5</td>
<td>Sand and gravel, brown</td>
</tr>
<tr>
<td>5-45</td>
<td>Clay, brown grading to gray, pebbly</td>
</tr>
<tr>
<td>45-74</td>
<td>Clay, gray, pebbly</td>
</tr>
</tbody>
</table>

Test Hole 7
Location: NE NE SW NW sec. 8, T. 107 N., R. 55 W.
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Topsoil, light-brown; few pebbles</td>
</tr>
<tr>
<td>1-16</td>
<td>Clay; some pebbles and boulders, (till)</td>
</tr>
</tbody>
</table>

Test Hole 8
Location: NE NE NW SW sec. 8, T. 107 N., R. 55 W.
Depth to water: approximately 10 feet

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2-4</td>
<td>Clay, light-brown, sandy</td>
</tr>
<tr>
<td>4-30?</td>
<td>Sand and gravel, brown</td>
</tr>
<tr>
<td>30-74</td>
<td>Clay, gray, pebbly</td>
</tr>
</tbody>
</table>

Test Hole 9
Location: SE SW SW SW sec. 8, T. 107 N., R. 55 W.
Depth to water: 8 feet

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1-8</td>
<td>Clay, dark-brown, sandy</td>
</tr>
<tr>
<td>8-20?</td>
<td>Sand, brown, coarse</td>
</tr>
<tr>
<td>20-53</td>
<td>Clay, sandy</td>
</tr>
<tr>
<td>53-74</td>
<td>Clay, pebbly, (till)</td>
</tr>
</tbody>
</table>

Test Hole 10
Location: SW SE SE SW sec. 8, T. 107 N., R. 55 W.
Depth to water: 31 feet

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-31</td>
<td>Clay, light-brown, sandy</td>
</tr>
</tbody>
</table>
Test Hole 10 -- continued.

31- 74 Clay, gray, pebbly, (till)

* * *

Test Hole 11
Location: SE%SW%NW%NE% sec. 8, T. 107 N., R. 55 W.
Depth to water: dry

0- 3 Topsoil
3- 15 Clay, light-brown; few pebbles
15- 74 Clay, brown to dark-gray, sandy, (till)

* * *

Test Hole 12
Location: NE%NE%NE%NW% sec. 8, T. 107 N., R. 55 W.
Depth to water: dry

0- 2 Topsoil
2- 74 Clay, light-brown grading to gray, pebbly

* * *

Test Hole 13
Location: SE%SE%SW%SW% sec. 9, T. 107 N., R. 55 W.
Depth to water: dry

0- 3 Topsoil, dark-gray
3- 13 Clay, light-brown; some pebbles, (till)
13- 65 Clay, gray; some pebbles, (till)

* * *

Test Hole 14
Location: SW%SW%SW%SW% sec. 9, T. 107 N., R. 55 W.
Depth to water: 5 feet

0- 1 Topsoil
1- 13 Clay, brown, pebbly
13- 46 Clay, gray, pebbly, (till)
46- 74 Clay, gray-brown, pebbly, (till)

* * *

Test Hole 15 (Rotary Test Hole)
Location: NW%NW%NW%NW% sec. 15, T. 101 N., R. 56 W.
Surface elevation: 1570 feet
Depth to water: not measured

0- 17 Clay, yellowish-brown, pebbly, (till)
17- 50 Clay, gray, gravelly
50- 65 Clay, very sandy and gravelly, (till)
65- 80 Clay, gray, pebbly
80- 84 Sand
84-440 Clay, gravel, (till)
Test Hole 15 – continued.
140-155 Clay, (till)
155-170 Shale, dark-gray

Test Hole 16
Location: SE1/4 SE1/4 SE1/4 sec. 15, T. 107 N., R. 56 W.
Depth to water: 13 feet

0-3 Gravel, brown
3-7 Clay, dark-brown, pebbly
7-12 Clay, gray
12-70 Clay, dark-gray, sand, (till)

Test Hole 17
Location: NE1/4 NW1/4 SW1/4 sec. 14, T. 107 N., R. 56 W.
Depth to water: 13 feet

0-13 Sand and gravel; much clay
13-15 Clay, gray; gravel
15-33 Gravel, gray; some sand
33-40 Sand, very coarse; much clay
40-74 Clay, dark-gray, sandy, (till)

Test Hole 18
Location: NE1/4 SE1/4 SW1/4 sec. 14, T. 107 N., R. 56 W.
Depth to water: not measured

0-3 Topsoil
3-6 Clay, dark-gray
6-40 Clay, sandy
40-52 Sand, clay
52-74 Clay, dark-gray; few pebbles

Test Hole 19 (Rotary Test Hole)
Location: SE1/4 SE1/4 SE1/4 SW1/4 sec. 14, T. 107 N., R. 56 W.
Surface elevation: 1575 feet
Depth to water: not measured

0-2 Topsoil
2-20 Clay, yellow, pebbly
20-46 Clay, yellow, sandy
46-48 Gravel
48-110 Clay, gray, pebbly, (till)
110-118 Gravel, some clay stringers; some coal
118-154 Clay, very gravelly, (till)
154-170 Chalk, dark-gray
Test Hole 20  
Location: SW\%SW\%NE\%NW\% sec. 14, T. 107 N., R. 56 W.  
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1- 6</td>
<td>Sand and gravel, dark-brown; much clay</td>
</tr>
<tr>
<td>6- 16</td>
<td>Clay, brown, sandy, (till)</td>
</tr>
<tr>
<td>16- 49</td>
<td>Clay, dark-gray, sandy, (till)</td>
</tr>
</tbody>
</table>

****

Test Hole 21  
Location: NE\%NE\%NE\%NW\% sec. 14, T. 107 N., R. 56 W.  
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-</td>
<td>Topsoil</td>
</tr>
<tr>
<td>3- 25</td>
<td>Clay, brown, sandy</td>
</tr>
<tr>
<td>25- 74</td>
<td>Clay, gray, sandy, (till)</td>
</tr>
</tbody>
</table>

****

Test Hole 22  
Location: SW\%SW\%NE\%SW\% sec. 17, T. 107 N., R. 55 W.  
Depth to water: 18 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1- 6</td>
<td>Clay, brown to gray, pebbly, (till)</td>
</tr>
<tr>
<td>66- 74</td>
<td>Clay, gray-brown; pebbles, (till)</td>
</tr>
</tbody>
</table>

****

Test Hole 23  
Location: NE\%SE\%NE\%SW\% sec. 17, T. 107 N., R. 55 W.  
Depth to water: 6 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2- 6</td>
<td>Clay, dark-brown, sandy</td>
</tr>
<tr>
<td>6- 12</td>
<td>Sand, gray, coarse; some gravel; clay</td>
</tr>
<tr>
<td>12- 46</td>
<td>Clay, gray sandy</td>
</tr>
<tr>
<td>46- 74</td>
<td>Clay, gray-brown, sandy</td>
</tr>
</tbody>
</table>

****

Test Hole 24  
Location: NE\%NW\%SE\%NW\% sec. 17, T. 107 N., R. 55 W.  
Depth to water: 3 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1- 3</td>
<td>Clay, dark-brown, sandy</td>
</tr>
<tr>
<td>3- 31</td>
<td>Sand, coarse; gravel; increasing clay content toward the bottom of the interval</td>
</tr>
<tr>
<td>31- 74</td>
<td>Clay, gray, pebbly, (till)</td>
</tr>
</tbody>
</table>

****
Test Hole 25 (Rotary Test Hole)
Location: SE¼SW¼SW¼SE¼ sec. 17, T. 107 N., R. 55 W.
Surface elevation: 1635 feet
Depth to water: not measured

0-  2  Topsoil
2-  6  Gravel, coarse
6- 95  Clay, gray, pebbly
95-110 Clay, gravel
110-125 Gravel, grading to gravelly till
125-170 Clay, gravel, (till)
170-174 Gravel, course
174-190 Clay, sandy, (till)
190-200 Chalk, dark-gray

* * * *

Test Hole 26
Location: NW¼NW¼NW¼SW¼ sec. 16, T. 107 N., R. 55 W.
Depth to water: not measured

0- 3  Roadbed
3- 15 Clay, brown; some sand
15- 74 Clay, dark-gray; some sand, (till)

* * * *

Test Hole 27
Location: NE¼NW¼SE¼SE¼ sec. 16, T. 107 N., R. 55 W.
Depth to water: not measured

0- 2  Topsoil, sandy
2- 22 Clay, dark-brown, sandy, (till)
22- 74 Clay, dark-gray, sandy, (till)

* * * *

Test Hole 28 (Rotary Test Hole)
Location: SW¼SW¼SW¼SW¼ sec. 20, T. 107 N., R. 56 W.
Surface elevation: 1512 feet
Depth to water: not measured

0-  3  Topsoil, dark-gray
3-  5  Clay, yellow, pebbly, (till)
5-103 Clay, gray, pebbly, (till)
103-110 Sand and gravel
110-112 Clay, gray, very sandy
112-180 Clay, dark-gray, (shale)
180-385 Chalk, dark-gray

* * * *

Test Hole 29
Location: NW¼NW¼NW¼NW¼ sec. 22, T. 107 N., R. 56 W.
Depth to water: 39 feet

0-  1  Topsoil
Test Hole 29 – continued.

1. 37 Clay, light-brown, sand; some pebbles
37. 48 Clay, gray, pebbly

* * *

Test Hole 30
Location: NE%NE%NE%NW% sec. 22, T. 107 N., R. 56 W.
Depth to water: 26 feet

0- 2 Topsoil
2- 13 Clay, light-brown
13- 26 Clay, dark-brown, (till)
26- 66 Clay, dark-brown, sandy, (till)

* * *

Test Hole 31
Location: SE%SE%SE%NE% sec. 22, T. 107 N., R. 56 W.
Depth to water: 357 feet

0- 2 Topsoil
2- 38 Clay, brown grading to gray, sandy, (till)
38- 41 Gravel, clay
41- 89 Clay, gray; some gravel, (till)

* * *

Test Hole 32 (S.D.G.S. Test Hole, 1959)
Location: NW%SW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1622 feet
Depth to water: not measured

0- 24 Clay, brown

* * *

Test Hole 33 (S.D.G.S. Test Hole, 1959)
Location: SW%SW% sec. 25, T. 107 N., R. 55 W.
Surface elevation: 1585 feet
Depth to water: not measured

0- 36 Clay, brown

* * *

Test Hole 34 (S.D.G.S. Test Hole, 1959)
Location: SW%SW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1573 feet
Depth to water: not measured

0- 5 Clay, brown
5- 9 Gravel and clay
9- 29 Clay, gray; pebbles

* * *
Test Hole 35
Location: NE%SE%SE%SW% sec. 23, T. 107 N., R. 56 W.
Depth to water: 11 feet

0- 3 Topsoil
3- 6 Clay, dark-brown
6- 14 Sand and gravel; some clay
14- 32 Gravel and sand, brownish-gray; some clay
32- 74 Clay, dark-gray, sandy; (till)

***

Test Hole 36 (S.D.G.S. Test Hole, 1959)
Location: NE%SW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1558 feet
Depth to water: 6 feet

0- 15 Clay, dark-gray
15- 19 Gravel and clay
19- 50 Clay and pebbles

***

Test Hole 37 (S.D.G.S. Test Hole, 1959)
Location: NW%SW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1567 feet
Depth to water: 10 feet

0- 2 Clay, dark-gray
2- 11 Gravel and sand
11- 21 Clay, medium gray; pebbles
21- 49 Sand, fine to medium
49- 54 Sand, fine-medium; clay
54- 64 Clay; sand, fine

***

Test Hole 38 (S.D.G.S. Test Hole, 1959)
Location: NW%SW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1568 feet
Depth to water: 13 feet

0- 3 Clay, dark-gray
3- 11 Gravel
11- 17 Clay and gravel
17- 44 Sand, medium
44- 64 Sand and clay

***

Test Hole 39 (S.D.G.S. Test Hole, 1959)
Location: SE%NW% sec. 23, T. 107 N., R. 56 W.
Surface elevation: 1559 feet
Depth to water: 12 feet

0- 4 Clay, dark-gray; pebbles
4- 5 Clay and gravel
Test Hole 39 – continued.

5- 9 Clay; sand, coarse
9- 49 Clay

Test Hole 40
Location: SW¼SW¼SW¼sec. 24, T. 107 N., R. 56 W.
Depth to water: not measured

0- 1 Topsoil
1- 7 Clay, dark-brown
7- 54 Clay, gray, pebbly, (till)

Test Hole 41
Location: NE¼NE¼NE¼sec. 24, T. 107 N., R. 56 W.
Depth to water: 31 feet

0- 1 Topsoil
1- 7 Clay, light-brown; some pebbles
7- 74 Clay, dark-gray, sandy, (till)

Test Hole 42 (Rotary Test Hole)
Location: NE¼NE¼NE¼sec. 24, T. 107 N., R. 56 W.
Surface elevation: 1697 feet
Depth to water: not measured

0- 24 Clay, yellow, pebbly
24- 48 Clay, gray, pebbly, (till)
48- 60 Sand, coarse
60-170 Clay, gravel, (till)
170-184 Gravel, coarse
184-200? Clay; gravel, (till)
2007-215 Shale, dark-gray

Test Hole 43
Location: SW¼SW¼SW¼sec. 19, T. 107 N., R. 55 W.
Depth to water: not measured

0- 30 Clay, brown, grading to gray; some pebbles
30- 74 Clay, dark-gray; pebbles, (till)

Test Hole 44
Location: NE¼NE¼NE¼sec. 19, T. 107 N., R. 55 W.
Depth to water: not measured

0- 2 Topsoil
2- 36 Clay, dark-brown, sandy
Test Hole 44 – continued.

36- 74 Clay, dark-gray, sandy, (till)

** * * *

Test Hole 45 (Rotary Test Hole)
Location: SW¼ SW¼ SW¼ sec. 28, T. 107 N., R. 56 W.
Surface elevation: 1530 feet
Depth to water: not measured

0- 35 Clay, yellow, pebbly
35-120 Clay, gray, sandy
120-130 Gravel, coarse, well sorted
130-155 Shale, dark-gray

** * * *

Test Hole 46
Location: SW¼ SW¼ SW¼ sec. 27, T. 107 N., R. 56 W.
Depth to water: not measured

0-  2 Topsoil
2- 16 Clay, pebbly
16- 28 Clay, gravelly
28- 74 Clay, dark-gray, sandy and gravelly

** * * *

Test Hole 47 (Rotary Test Hole)
Location: SW¼ SW¼ SW¼ sec. 27, T. 107 N., R. 56 W.
Surface elevation: 1555 feet
Depth to water: not measured

0-  25 Clay, yellow, pebbly
25- 28 Gravel and sand
28- 32 Clay, dark-brown
32- 95 Clay, gray, sandy
95-100 Gravel, coarse
100-129 Clay, gray, sandy
129- Boulder
129-155 Shale, dark-gray

** * * *

Test Hole 48
Location: NW¼ NW¼ NW¼ NW¼ sec. 27, T. 107 N., R. 56 W.
Depth to water: 30 feet

0-  3 Topsoil
3- 18 Clay, dark-brown, pebbly
18- 43 Clay, dark-gray, sandy
43- 52 Sand, dark-gray, fine
52- 79 Clay, dark-gray, gravelly

** * * *
Test Hole 49
Location: NW%NW%NW%NW sec. 26, T. 107 N., R. 56 W.
Depth to water: 25 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2-14</td>
<td>Clay, light-brown, pebbly</td>
</tr>
<tr>
<td>14-25</td>
<td>Clay, pebbly</td>
</tr>
<tr>
<td>25-29</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>29-54</td>
<td>Clay, dark-brown grading to deep-gray, sandy</td>
</tr>
</tbody>
</table>

Test Hole 50
Location: SW%SE%SW%NW sec. 26, T. 107 N., R. 56 W.
Depth to water: 28 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2-28</td>
<td>Clay, red-brown, sandy</td>
</tr>
<tr>
<td>28-47</td>
<td>Clay, light-brown, sandy</td>
</tr>
<tr>
<td>47-58</td>
<td>Sand, light-brown, coarse</td>
</tr>
<tr>
<td>58-79</td>
<td>Clay, dark-gray, pebbly</td>
</tr>
</tbody>
</table>

Test Hole 51 (S.D.G.S. Test Hole, 1959)
Location: SW%SE sec. 26, T. 107 N., R. 56 W.
Surface elevation: 1550 feet
Depth to water: 8 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>Clay, dark-gray</td>
</tr>
<tr>
<td>4-9</td>
<td>Clay, sandy</td>
</tr>
<tr>
<td>9-14</td>
<td>Clay and gravel</td>
</tr>
<tr>
<td>14-19</td>
<td>Gravel</td>
</tr>
<tr>
<td>19-24</td>
<td>Clay; sand and gravel</td>
</tr>
<tr>
<td>24-29</td>
<td>Sand</td>
</tr>
<tr>
<td>29-49</td>
<td>Clay, sandy</td>
</tr>
</tbody>
</table>

Test Hole 52
Location: SE%SE%SE%SE sec. 26, T. 107 N., R. 56 W.
Depth to water: 19 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2-28</td>
<td>Clay, red-brown, pebbly</td>
</tr>
<tr>
<td>28-487</td>
<td>Sand and gravel, dark-gray</td>
</tr>
<tr>
<td>487-94</td>
<td>Clay, dark-gray; boulders</td>
</tr>
</tbody>
</table>

Test Hole 53
Location: NE%NW%NE%NW sec. 25, T. 107 N., R. 56 W.
Depth to water: 6 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1-5</td>
<td>Clay, dark-brown, sandy</td>
</tr>
<tr>
<td>6-9</td>
<td>Sand, dark-brown, coarse</td>
</tr>
</tbody>
</table>
Test Hole 53 – continued.

9- 62 Clay, brown, sandy
62- 79 Clay, gray, pebbly

* * * *

Test Hole 54 (Rotary Test Hole)
Location: NE%NE%NE%NE% sec. 25, T. 107 N., R. 56 W.
Surface elevation: 1600 feet
Depth to water: not measured

0- 29 Clay, yellow, pebbly
20- 65 Clay, gray, pebbly
65-140 Clay, gravelly
140-170 Clay, some shale gravel
170-192 Clay, gray, pebbly
192-200 Shale, black

* * * *

Test Hole 55 (Rotary Test Hole)
Location: NE%NE%NE%SE% sec. 31, T. 107 N., R. 56 W.
Surface elevation: 1499 feet
Depth to water: not measured

0- 45 Clay, yellow to dark-brown, pebbly
45- 57 Clay, gray, pebbly
57- 63 Gravel, coarse
61-110 Clay, gray, pebbly
110-125 Shale; bentonite

* * * *

Test Hole 56 (Rotary Test Hole)
Location: NE%NE%NE%NE% sec. 34, T. 107 N., R. 56 W.
Surface elevation: 1382 feet
Depth to water: not measured

0- 28 Clay, yellow, pebbly
28-107 Clay, gray, pebbly
107-109 Gravel
109-144 Clay, gray, gravelly
144-155 Gravel; coal
155-170 Clay, gravelly
170-185 Gravel, coarse
185-195 Clay, gravelly
195-203 Gravel, coarse
203-215 Shale, calcareous

* * * *

Test Hole 57
Location: SW%SE%SW%SE% sec. 35, T. 107 N., R. 56 W.
Depth to water: 6 feet

0- 9 Sand and gravel, brown; some clay
Test Hole 57 – continued.

9- 54 Clay, blue-gray, grades to brown, pebbly

Test Hole 58 (Rotary Test Hole)
Location: SW%SW%SW%NW% sec. 32, T. 107 N., R. 55 W.
Surface elevation: 1608 feet
Depth to water: not measured

0- 70 Clay, yellow, pebbly
26- 80 Clay, gray, pebbly
80-160 Clay, gray, gravelly
160-170 Shale, dark-gray
170-185 Chalk, dark-gray

Test Hole 59
Location: SE%SE%SW%SW% sec. 33, T. 107 N., R. 55 W.
Depth to water: 7 feet

0- 2 Sand, dark-brown
2- 9 Gravel, brown, coarse
9- 25 Clay, dark-gray, gravelly
25- 74 Clay, dark-gray, sandy

Test Hole 60
Location: NE%SE%NE%NW% sec. 33, T. 107 N., R. 55 W.
Depth to water: not measured

0- 1 Topsoil
1- 17 Clay, light-brown, pebbly
17- 74 Clay, dark-gray, pebbly

Test Hole 61
Location: SE%SE%SE%NE% sec. 33, T. 107 N., R. 55 W.
Depth to water: 16 feet

0- 1 Topsoil
1- 11 Clay, light-brown, sandy
11- 24? Clay, dark-gray, sandy
24?- 34? Sand and gravel
34?- 94 Clay, dark-gray, pebbly

Test Hole 62
Location: NW%SW%NW%NW% sec. 34, T. 107 N., R. 55 W.
Depth to water: 8 feet

0- 5 Clay; sand and gravel
Test Hole 62 – continued.

5- 8  Clay, dark-brown, sandy
8- 24  Sand, brown, medium to coarse
24- 47  Clay, gray
47- 74  Clay, dark-gray, pebbly, (till)

Test Hole 63 (Rotary Test Hole)
Location: SE1/4SE1/4SE1/4 sec. 4, T. 106 N., R. 56 W.
Surface elevation: 1521 feet
Depth to water: not measured

0- 13  Clay, yellowish-brown, pebbly
13- 31  Clay, brown, pebbly
31- 34  Sand, medium to coarse
34- 60  Clay, gray, pebbly
60- 62  Gravel, coarse
62-155  Clay, gray, pebbly
155-163  Gravel, very coarse
163-180  Shale; bentonite

Test Hole 64 (Rotary Test Hole)
Location: NW1/4NW1/4NW1/4 sec. 3, T. 106 N. R. 56 W.
Surface elevation: 1534 feet
Depth to water: not measured

0- 20  Clay, right-gray, pebbly
20-137  Clay, gray, sandy
137-150  Gravel; clay
150-168  Clay, gray, gravelly
168-179  Gravel, coarse
179-200  Shale, dark-gray

Test Hole 65 (Rotary Test Hole)
Location: NE1/4NE1/4NE1/4 sec. 3, T. 106 N. R. 56 W.
Surface elevation: 1564 feet
Depth to water: not measured

0- 15  Clay, yellow, pebbly
15- 34  Clay, reddish-brown, pebbly
34-155  Clay, gray, pebbly
155-168  Gravel, medium to coarse
168-228  Clay?
228-245  Chalk, dark-gray, (marl)

Test Hole 66 (Test Hole was drilled by Fredrickson’s Inc. and reported by DeWild & Grant, Engineers to the city)
Location: SW1/4NW1/4 sec. 2, T. 106 N., R. 56 W.
Surface elevation: not measured
Depth to water: not measured
Test Hole 66 – continued.

0-  2  Topsoil, black
2-  70  Clay, brown
70-  85  Sand, coarse, colored
85-152  Clay, blue
152-154  Sand, colored
154-158  Clay, blue
158-161  Sand, yellow
161-175  Sand, dirty, colored
175-200  Clay, blue
200-244  Shale, black
244-252  Shale, soft, gray
252-278  Shale, hard, gray
278-300  Sand, gray
480-500  Shale lensed with sand
500-  

* * *

Test Hole 67
Location: SE1/4SW1/4NE1/4NW1/4 sec. 2, T. 106 N., R. 56 W.
Depth to water: 33 feet

0-  3  Topsoil
3-  33  Clay, dark-brown, sandy
33- 39  Clay, gray
39- 51  Clay, gray-brown, sandy
51-  74  Clay, dark-gray, sandy

* * *

Test Hole 68
Location: SW1/4NE1/4NW1/4NE1/4 sec. 2, T. 106 N., R. 56 W.
Depth to water: 22 feet

0-  4  Topsoil
4-  16  Sand and gravel, dark-brown
10- 22  Clay, dark-gray, sandy
22- 34  Sand and gravel; much clay
34- 59  Clay, dark-gray, sandy
52- 69  Clay, dark-gray, hard drilling

* * *

Test Hole 69
Location: SE1/4SE1/4NW1/4NE1/4 sec. 2, T. 106 N., R. 56 W.
Depth to water: 32 feet

0-  8  Clay, dark-brown, sandy
8-  69  Clay, dark-gray, pebbly
69- 73  Gravel, dark-gray, coarse
73-  79  Clay, dark-gray, sandy

* * *
Test Hole 70
Location: SW%SW%SW%NE% sec. 2, T. 106 N., R. 56 W.
Depth to water: 27 feet

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 3</td>
<td>Topsoil</td>
</tr>
<tr>
<td>3- 12</td>
<td>Clay, brown</td>
</tr>
<tr>
<td>12- 25</td>
<td>Clay, dark-brown</td>
</tr>
<tr>
<td>25- 33</td>
<td>Sand and gravel, dark-gray</td>
</tr>
<tr>
<td>33- 38</td>
<td>Clay, gray, gravelly</td>
</tr>
<tr>
<td>38- 42</td>
<td>Sand and gravel, dark-gray</td>
</tr>
<tr>
<td>42- 94</td>
<td>Clay, pebbly</td>
</tr>
</tbody>
</table>

***

Test Hole 71
Location: SE%SE%SW%NE% sec. 2, T. 106 N., R. 56 W.
Depth to water: 7 feet

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 1</td>
<td>Topsoil</td>
</tr>
<tr>
<td>1- 18</td>
<td>Sand and gravel, dark-brown</td>
</tr>
<tr>
<td>18- 74</td>
<td>Clay, dark-gray, pebbly</td>
</tr>
</tbody>
</table>

***

Test Hole 72 (Rotary Test Hole)
Location: NE%SW%NE% sec. 2, T. 106 N., R. 56 W.
Surface elevation: 1557 feet
Depth to water: 91.7 feet (buried sand and gravel)

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 3</td>
<td>Topsoil</td>
</tr>
<tr>
<td>3- 20</td>
<td>Clay, yellow, pebbly</td>
</tr>
<tr>
<td>20- 90</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>90- 92</td>
<td>Gravel</td>
</tr>
<tr>
<td>92-125</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>125-140</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>140-144</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>144-154</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>154-155</td>
<td>Clay</td>
</tr>
</tbody>
</table>

***

Test Hole 73 (Test Hole was drilled by Fredrickson's Inc. and reported by DeWild & Grant, Engineers to the city)
Location: SW%NE% sec. 2, T. 106 N., R. 56 W.
Surface elevation: 1562 feet
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 3</td>
<td>Topsoil, black</td>
</tr>
<tr>
<td>3- 18</td>
<td>Sand, brown, coarse; clay</td>
</tr>
<tr>
<td>18-170</td>
<td>Clay, dark-gray; sand</td>
</tr>
<tr>
<td>170-182</td>
<td>Sand</td>
</tr>
<tr>
<td>182-184</td>
<td>Clay, dark-gray</td>
</tr>
<tr>
<td>184-198</td>
<td>Sand, coarse; clay</td>
</tr>
<tr>
<td>198-226</td>
<td>Shale (?)</td>
</tr>
<tr>
<td>226-274</td>
<td>Clay, sandy</td>
</tr>
<tr>
<td>274-344</td>
<td>Shale, gray</td>
</tr>
<tr>
<td>344-380</td>
<td>Shale, gray, hard</td>
</tr>
</tbody>
</table>
Test Hole 73 – continued.

380-405  Shale, gray and dark-gray
405  Sioux Quartzite

* * * *

Test Hole 74 (Rotary Test Hole)
Location: SW1/4 NE1/4 SW1/4 sec. 2, T. 106 N., R. 56 W.
Depth to water: not measured

0- 6  Gravel
6- 17  Clay, brown, gravelly
17- 20  Gravel, coarse
20- 30  Clay, grayish-tan, sandy
30- 37  Gravel, fine to medium
37- 53  Clay, brown, sandy
53- 57  Sand, coarse
57- 67  Clay, dark-gray, pebbly
67- 73  Gravel, coarse
73-142  Clay, dark-gray, gravelly
142-148  Gravel, medium
148-151  Clay, sandy
151-160  Gravel, coarse
160-170  Clay, dark-gray
170-195  Sand, fine; much clay
195-208  Shale; bentonite
208-215  Chalk, gray, (marl)

* * * *

Test Hole 75 (New city well drilled by Grimshaw Drilling Co.)
Location: SE1/4 SW1/4 sec. 2, T. 106 N., R. 56 W.
Surface elevation: not measured
Depth to water: 133 feet

0- 17  Gravel, coarse
17- 25  Clay, gray
25- 60  Sand, gray, fine
60-121  Clay, gray; sandy
121-130  Sand and gravel
130-150  Clay, gray
150-153  Sand
153-175  Clay; some fine sand
175-185  Clay with boulders
185-200  Gravel; some clay

* * * *

Test Hole 76 (Observation Well)
Location: SE1/4 SW1/4 sec. 2, T. 106 N., R. 56 W.
Surface elevation: 1565 feet
Depth to water: 133 feet

0- 15  Sand and gravel
15- 25  Clay, dark-gray; sandy
25- 67  Clay, dark-gray; drills hard; sandy
Test Hole 76 -- continued.

67-72  Sand stringers; easy drilling
72-113  Clay, dark-gray; pebbles
113-124  Gravel, very coarse
124-173  Clay, dark-gray, pebbly
173-192  Gravel, coarse
192-197  Chalk, light to dark-gray

***

Test Hole 77 (Rotary Test Hole)
Location: SW\%SW\%SW\%SW\% sec. 1, T. 106 N., R. 56 W.
Surface elevation: 1565.3 feet
Depth to water: 130 feet

0-25  Clay, yellow, pebbly
25-50  Clay, gray, pebbly, (till)
150-175  Shale, dark-gray
175-200  Chalk, gray

***

Test Hole 78 (Rotary Test Hole)
Location: SW\%SW\%SW\%NW\% sec. 1, T. 106 N., R. 56 W.
Surface elevation: 1559 feet
Depth of water: not measured

0-18  Clay, yellowish-brown, pebbly
18-23  Clay, dark-gray, pebbly
23-31  Sand, coarse
31-55  Clay, dark-gray, pebbly
55-80  Clay, very gravelly
80-133  Clay, dark-gray, pebbly
133-137  Gravel, fine to coarse
137-147  Clay, gravelly
147-155  Shale, dark-gray

***

Test Hole 79 (Rotary Test Hole)
Location: NW\%NW\%NW\%NW\% sec. 1, T. 106 N., R. 56 W.
Surface elevation: 1561 feet
Depth to water: not measured

0-2  Topsoil
2-30  Clay, yellow, pebbly
30-32  Gravel, coarse
32-145  Clay, gray, pebbly
145-170  Shale, dark-gray

***

Test Hole 80 (Rotary Test Hole)
Location: SE\%SE\%SE\%SW\% sec. 6, T. 106 N., R. 55 W.
Surface elevation: 1599 feet
Depth to water: not measured
Test Hole 80 -- continued.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-33</td>
<td>Clay, yellow, pebbly</td>
</tr>
<tr>
<td>33-62</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>62-69</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>69-95</td>
<td>Clay, gray, gravelly</td>
</tr>
<tr>
<td>95-110</td>
<td>Gravel, clay stringers</td>
</tr>
<tr>
<td>110-145</td>
<td>Clay, sandy</td>
</tr>
<tr>
<td>145-155</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>155-165</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>165-170</td>
<td>Shale, gray</td>
</tr>
</tbody>
</table>

***

Test Hole 81 (Rotary Test Hole)
Location: NE¼NE¼NE¼NE¼ sec. 8, T. 106 N., R. 56 W.
Surface elevation: 1485 feet
Depth of water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>Clay, yellow, pebbly</td>
</tr>
<tr>
<td>20-30</td>
<td>Clay, brown, pebbly</td>
</tr>
<tr>
<td>30-47</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>47-50</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>50-65</td>
<td>Clay; gravel stringers</td>
</tr>
<tr>
<td>65-128</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>128-136</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>136-140</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>140-144</td>
<td>Gravel, very coarse</td>
</tr>
<tr>
<td>144-155</td>
<td>Chalk, gray</td>
</tr>
</tbody>
</table>

***

Test Hole 82 (Rotary Test Hole)
Location: SE¼SE¼SE¼SE¼ sec. 9, T. 106 N., R. 56 W.
Surface elevation: 1522 feet
Depth of water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>Clay, yellowish-gray, pebbly</td>
</tr>
<tr>
<td>20-30</td>
<td>Clay, reddish-brown</td>
</tr>
<tr>
<td>30-45</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>45-48</td>
<td>Clay, brown</td>
</tr>
<tr>
<td>48-50</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>50-132</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>132-140</td>
<td>Shale, dark-gray</td>
</tr>
</tbody>
</table>

***

Test Hole 83
Location: SE¼SE¼SE¼NE¼ sec. 10, T. 106 N., R. 56 W.
Surface elevation: 1567 feet
Depth of water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Topsoil</td>
</tr>
<tr>
<td>3-10</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>10-20</td>
<td>Clay, brown, pebbly</td>
</tr>
<tr>
<td>20-50</td>
<td>Clay, brown, gravelly</td>
</tr>
<tr>
<td>50-60</td>
<td>Gravel</td>
</tr>
<tr>
<td>60-65</td>
<td>Clay, gravelly</td>
</tr>
</tbody>
</table>
Test Hole 83 -- continued.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-80</td>
<td>Sand?; clay</td>
</tr>
<tr>
<td>80-170</td>
<td>Clay, gray; hard drilling</td>
</tr>
<tr>
<td>170-190</td>
<td>Shale?</td>
</tr>
<tr>
<td>190-196</td>
<td>Chalk, gray</td>
</tr>
</tbody>
</table>

** Test Hole No. 84 (Source of data, Special Report No. 6, S.D.G.S.)
Location: NSECNE sec. 11, T. 106 N., R. 56 W. (at standpipe)
Surface elevation: 1572 feet
Depth to water: 158 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-20</td>
<td>Till, poorly sorted yellow sand, calcareous sandy clay with gypsum fragments</td>
</tr>
<tr>
<td>20-50</td>
<td>Sand, poorly sorted; with clay</td>
</tr>
<tr>
<td>50-60</td>
<td>Sand; with medium gray clay and sandy clay</td>
</tr>
<tr>
<td>60-150</td>
<td>Sand and gravel, poorly sorted with clay as above</td>
</tr>
<tr>
<td>150-170</td>
<td>As above, but with much lignite</td>
</tr>
<tr>
<td>170-180</td>
<td>Gravel, pebble and granule size</td>
</tr>
<tr>
<td>180-190</td>
<td>Gravel and sand; with much lignite</td>
</tr>
<tr>
<td>190-200</td>
<td>Niobrara Formation, marl, light gray; with abundant small white chalk spots; also lignite which may be cavings</td>
</tr>
<tr>
<td>200-260</td>
<td>Chalk; spotted marl as above</td>
</tr>
<tr>
<td>260-270</td>
<td>Same as above with scattered Inoceramus prisms and shell fragments</td>
</tr>
<tr>
<td>270-280</td>
<td>Chalk; spotted marl as above; some lignite</td>
</tr>
<tr>
<td>280-290</td>
<td>Same as above</td>
</tr>
<tr>
<td>294</td>
<td>(Carille Formation top E. L. *)</td>
</tr>
<tr>
<td>290-300</td>
<td>Sand, fine to very coarse-grained, angular to subrounded, poorly sorted, loose and calcareous argillaceous sandstone</td>
</tr>
<tr>
<td>300-320</td>
<td>Sand and sandstone as above; shale, medium dark-gray bentonitic; pyrite</td>
</tr>
<tr>
<td>320-340</td>
<td>Siltstone, yellow-brown; siltstone concretions, sandy, some slightly calcareous</td>
</tr>
<tr>
<td>340-350</td>
<td>Shale, micaceous, sandy, medium dark-gray; some fine-grained sandstone</td>
</tr>
<tr>
<td>350-360</td>
<td>Sandstone, white, fine-grained, calcareous, micaceous, glauconitic; lignite</td>
</tr>
<tr>
<td>360-370</td>
<td>Shale, medium dark-gray</td>
</tr>
<tr>
<td>370-380</td>
<td>Shale, dark-gray</td>
</tr>
<tr>
<td>380-400</td>
<td>Sand, fine-grained with bentonite</td>
</tr>
<tr>
<td>400-402</td>
<td>Sioux Formation, well cemented, siliceous quartze sandstone</td>
</tr>
</tbody>
</table>

* Formation Tops picked by Electric Logs

** Test Hole 85 (S.D.G.S. Test Hole, 1959)
Location: NW¼NE¼ sec. 11, T. 106 N., R. 56 W.
Depth to water: 12 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>Clay and sand</td>
</tr>
</tbody>
</table>
Test Hole 85 — continued.

4-  8  Sand and gravel
8-  22 Clay and gravel
22- 39 Sand, medium
39- 40 Clay, gray

Test Hole 86 (S.D.G.S. Test Hole, 1959)
Location: SW 1/4 NE 1/4 sec. 11, T. 106 N., R. 56 W.
Depth to water: 267 feet

0-  4  Clay, dark-gray
4-  6  Gravel and sand
6-  9  Sand and clay
9- 10  Sand and gravel
10- 19  Gravel, medium
19- 29  Gravel, medium, and clay
29- 34  Sand and clay
34- 39  Silt, sand, and clay
39- 44  Silt, sand, clay, and gravel
44- 54  Clay and gravel

Test Hole 87
Location: SW 1/4 NE 1/4 sec. 11, T. 106 N., R. 56 W.
Depth to water: 10 feet

0-  1  Topsoil
1-  6  Sand and gravel, brown
6- 10  Clay, brown, sandy
10- 17  Sand, light-brown; much clay
17- 24  Clay, gray-brown, sandy

Test Hole 88 (S.D.G.S. Test Hole, 1959)
Location: SE 1/4 NE 1/4 sec. 11, T. 106 N., R. 56 W.
Surface elevation: 1527 feet
Depth to water: not measured

0-  7  Gravel and clay
7- 19  Clay, brown, and pebbles

Test Hole 89 (S.D.G.S. Test Hole, 1959)
Location: SE 1/4 SE 1/4 sec. 11, T. 106 N., R. 56 W.
Surface elevation: 1519 feet
Depth to water: 4 feet

0-  5  Clay, brown
5- 24  Clay and sand
Test Hole 90
Location: SE\%SW\%SE\%SE sec. 7, T. 106 N., R. 55 W.
Depth to water: not measured

0-  1  Topsoil
1-  42  Clay, dark-brown
42- 74  Clay, dark-gray, sandy

Test Hole 91 (Rotary Test Hole)
Location: SE\%SE\%SE\%SE sec. 8, T. 106 N., R. 55 W.
Surface elevation: 1615 feet
Depth to water: not measured

0-  14  Clay, yellow
14-  40  Gravel, grading to sand
40-  58  Clay, gray, pebbly
58-170  Clay, gray, sandy and pebbly
170-181  Gravel, coarse
181-190  Shale, dark-gray

Test Hole 92
Location: SW\%SW\%SE\%SW\% sec. 9, T. 106 N., R. 55 W.
Depth to water: not measured

0-   9  Clay, light-brown, sandy
9-  65  Clay, gray, sandy

Test Hole 93 (Rotary Test Hole)
Location: SEN\%SE\%SEN\%SE sec. 15, T. 106 N., R. 56 W.
Surface elevation: 1555 feet
Depth to water: not measured

0-   2  Topsoil, black
2-  30  Clay, yellow, grading to dark-brown
30-  80  Clay, gray, sandy
80-  95  Clay, gray, gravelly
95-138  Clay, gray, sandy
138-150  Gravel; some clay stringers
150-170  Chalk, gray

Test Hole 94 (S.D.G.S. Test Hole, 1959)
Location: NW\%NW\% sec. 14, T. 106 N., R. 56 W.
Surface elevation: 1516 feet
Depth to water: 8 feet

0-   4  Clay, dark-gray; gravel
4-   9  Clay, sandy
9-  14  Clay
14-  39  Clay, sandy
Test Hole 95 (S.D.G.S. Test Hole, 1959)
Location: NE\%NW\% sec. 14, T. 106 N., R. 56 W.
Surface elevation: 1539 feet
Depth to water: 7 feet

0-  9  Clay and gravel
  9- 24  Clay, sandy
 24- 39  Gravel, fine; clay
 39- 49  Sand, fine; clay, gray

Test Hole 96
Location: NE\%NW\%NW\%NE\% sec. 14, T. 106 N., R. 56 W.
Depth to water: 8 feet

0-   6  Clay, brown; pebbles
  6- 12  Sand, dark-brown, coarse; much clay
 21- 54  Clay, dark-gray, pebbly

Test Hole 97
Location: NE\%NE\%SE\%NW\% sec. 14, T. 106 N., R. 56 W.
Depth to water: 11 feet

0-   2  Topsoil
  2-  7  Clay, gray
  7- 18  Sand, coarse; clay
 18- 39  Clay, dark-gray, sandy

Test Hole 98
Location: SW\%NW\%NE\%SE\% sec. 14, T. 106 N., R. 56 W.
Depth to water: 7 feet

0-   7  Clay, dark-gray, sandy
  7- 22  Sand, coarse; some clay
 22- 54  Clay, dark-gray, pebbly

Test Hole 99 (Rotary Test Hole)
Location: NE\%NE\%NE\%NW\% sec. 14, T. 106 N., R. 56 W.
Surface elevation: 1551 feet
Depth to water: not measured

0-  15  Clay, yellow, pebbly
 15-  60  Clay, gray, pebbly
 60-  62  Sand
 62-150  Clay, gray, gravelly
150-158  Gravel, coarse
158-170  Chalk, gray

* * *
Test Hole 100
Location: NW¼NW¼NW¼NE¼ sec. 13, T. 106 N., R. 56 W.
Depth to water: not measured

0-  7  Sand, dark-brown, clayey
7-  34?  Clay, brown
34?-  64  Clay, dark-gray; some pebbles

Test Hole 101
Location: SW¼SE¼SE¼SW¼ sec. 16, T. 106 N., R. 55 W.
Depth to water: 37 feet

0- 10  Clay, brown; some pebbles
10-  25  Clay, gray, sandy
25-  37  Clay, gray; much sand
37-  74  Clay, dark-gray, sandy

Test Hole 102 (Rotary Test Hole)
Location: NE¼NE¼NE¼NE¼ sec. 20, T. 106 N., R. 56 W.
Surface elevation: 1492 feet
Depth to water: not measured

0-  20  Clay, brown
20-  35  Clay, dark-brown; a gravel stringer
35-100  Clay, gray
100-112  Gravel, coarse
112-155  Chalk, gray

Test Hole 103
Location: SW¼NW¼NW¼ sec. 21, T. 106 N., R. 56 W.
Depth to water: not measured

0-   2  Topsoil
2-  28  Clay; pebbles

Test Hole 104 (Rotary Test Hole)
Location: SE¼SE¼SE¼SE¼ sec. 21, T. 106 N., R. 56 W.
Surface elevation: 1506 feet
Depth to water: not measured

0-  32  Clay, yellowish-brown
32-  42  Clay, gravelly
42-  45  Gravel
45-122  Clay, gray, gravelly
122-140  Chalk, gray
Test Hole 105
Location: NE1/4NE1/4NW1/4 sec. 27, T. 106 N., R. 56 W.
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil</td>
</tr>
<tr>
<td>2-29</td>
<td>Clay, pebbles, (till)</td>
</tr>
</tbody>
</table>

Test Hole 106
Location: SW1/4NW1/4SW1/4NW1/4 sec. 24, T. 106 N., R. 56 W.
Depth to water: 11 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Sand and gravel, brown</td>
</tr>
<tr>
<td>5-11</td>
<td>Clay, sandy and gravelly</td>
</tr>
<tr>
<td>11-23</td>
<td>Sand and gravel; boulders</td>
</tr>
<tr>
<td>23-74</td>
<td>Clay, gray, sandy</td>
</tr>
</tbody>
</table>

Test Hole 107
Location: SE1/4SE1/4NW1/4SW1/4 sec. 24, T. 106 N., R. 56 W.
Depth to water: 8 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material</th>
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<tbody>
<tr>
<td>0-4</td>
<td>Clay, brown, sandy</td>
</tr>
<tr>
<td>4-11</td>
<td>Clay; some gravel</td>
</tr>
<tr>
<td>11-19</td>
<td>Sand, coarse to very coarse</td>
</tr>
<tr>
<td>19-21</td>
<td>Clay, gray; pebbly</td>
</tr>
<tr>
<td>21-29</td>
<td>Sand, gray; clay</td>
</tr>
<tr>
<td>29-39</td>
<td>Clay, gray</td>
</tr>
</tbody>
</table>

Test Hole 108
Location: NW1/4NE1/4NW1/4 sec. 25, T. 106 N., R. 56 W.
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>6-26</td>
<td>Clay, blue-gray, sandy</td>
</tr>
<tr>
<td>26-38</td>
<td>Sand and gravel; some clay</td>
</tr>
<tr>
<td>38-74</td>
<td>Clay, blue-gray, gravelly</td>
</tr>
</tbody>
</table>

Test Hole 109 (Rotary Test Hole)
Location: NE1/4NE1/4NE1/4 sec. 25, T. 106 N., R. 56 W.
Surface elevation: 1569 feet
Depth to water: not measured

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Gravel, coarse</td>
</tr>
<tr>
<td>5-20</td>
<td>Clay, yellow, pebbly</td>
</tr>
<tr>
<td>20-150</td>
<td>Clay, gray, pebbly</td>
</tr>
<tr>
<td>150-152</td>
<td>Boulders</td>
</tr>
<tr>
<td>152-164</td>
<td>Shale, dark-gray, noncalcareous</td>
</tr>
<tr>
<td>164-170</td>
<td>Chalk, light-gray, calcareous</td>
</tr>
</tbody>
</table>

* * * *
Test Hole 110
Location: NE\%NW\%NE\%NE\% sec. 30, T. 106 N., R. 55 W.
Depth to water: 41 feet

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Topsoil, brown</td>
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<tr>
<td>2-19</td>
<td>Clay, brown, sandy</td>
</tr>
<tr>
<td>19-52</td>
<td>Clay, gray, sandy</td>
</tr>
<tr>
<td>52-62</td>
<td>Sand, dark-gray; clay</td>
</tr>
<tr>
<td>62-94</td>
<td>Clay, gray to dark-gray</td>
</tr>
</tbody>
</table>

* * *
# APPENDIX B

Well Records in the Howard Area

Source: O, Surface outwash; B, Buried sand lenses and outwash; N, Niobrara (Chalk-Marl); D, Dakota Formation

Use: D, domestic; S, stock

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Depth of Well (feet)</th>
<th>Depth to Water (feet)</th>
<th>Source</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haine, M.</td>
<td>NE 44 SEC 15 SW 46 SEC 4, T. 106 N., R. 55 W.</td>
<td>385</td>
<td>100</td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Seswer, E.</td>
<td>NW 44 NW 46 NW 46 SEC 5, T. 106 N., R. 55 W.</td>
<td>160</td>
<td>60</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Litterick, J.</td>
<td>NE 44 NW 46 NW 46 SEC 7, T. 106 N., R. 55 W.</td>
<td>96</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Laibb, W.</td>
<td>NW 44 NW 46 NW 46 SEC 8, T. 106 N., R. 55 W.</td>
<td>200</td>
<td>N</td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Wolff, E.</td>
<td>SE 44 SW 46 SE 46 SEC 17, T. 106 N., R. 55 W.</td>
<td>183</td>
<td>60</td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Feldhaus, T.</td>
<td>NE 44 NE 46 NE 46 SEC 18, T. 106 N., R. 55 W.</td>
<td>340</td>
<td></td>
<td>N?</td>
<td>D</td>
</tr>
<tr>
<td>Weidler, V.</td>
<td>NE 44 NW 46 NW 46 SEC 19, T. 106 N., R. 55 W.</td>
<td>165</td>
<td></td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Neiese, L.</td>
<td>SW 44 NW 46 SE 46 SEC 20, T. 106 N., R. 55 W.</td>
<td>225</td>
<td></td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Terman, R.</td>
<td>NW 44 NW 46 SE 46 SEC 20, T. 106 N., R. 55 W.</td>
<td>150</td>
<td>65</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Shomaker, C.</td>
<td>SE 44 SE 46 NE 46 SEC 21, T. 106 N., R. 55 W.</td>
<td>160</td>
<td></td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Grant, J.</td>
<td>SW 44 SW 46 SW 46 SEC 21, T. 106 N., R. 56 W.</td>
<td>250</td>
<td></td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Butts, W.</td>
<td>SW 44 SW 46 SW 46 SEC 3, T. 106 N., R. 56 W.</td>
<td>214</td>
<td>160</td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Name</td>
<td>Location</td>
<td>Depth of Well (feet)</td>
<td>Depth to Water (feet)</td>
<td>Source</td>
<td>Use</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------</td>
<td>---------------------</td>
<td>-----------------------</td>
<td>--------</td>
<td>-----</td>
</tr>
<tr>
<td>Noonan, W.</td>
<td>SE%SW%SE%SE% sec. 4, T. 106 N., R. 56 W.</td>
<td>255</td>
<td>237</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Anderson, L.</td>
<td>SE%SE%SE%NE% sec. 4, T. 106 N., R. 56 W.</td>
<td>256</td>
<td>146</td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>Rasmussen, A.</td>
<td>NE%NE%NE%NW% sec. 9, T. 106 N., R. 56 W.</td>
<td>180</td>
<td>90</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Miller, J.</td>
<td>SE%SE%SE%SE% sec. 9, T. 106 N., R. 56 W.</td>
<td>210</td>
<td>90</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Schnader, J.</td>
<td>NE%NE%NE%NE% sec. 9, T. 106 N., R. 56 W.</td>
<td>215</td>
<td></td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Calmus, G.</td>
<td>NW%NW%NW%SW% sec. 9, T. 106 N., R. 56 W.</td>
<td>210</td>
<td></td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Scott, L.</td>
<td>NE%NE%NE%SE% sec. 10, T. 106 N., R. 56 W.</td>
<td>240</td>
<td></td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Weishoof, T.</td>
<td>SW%SW%NW%NW% sec. 12, T. 106 N., R. 56 W.</td>
<td>200</td>
<td></td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Thompson, R.</td>
<td>NW%NW%NW%SW% sec. 12, T. 106 N., R. 56 W.</td>
<td>200</td>
<td></td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>McCain, E.</td>
<td>SW%SW%SW%SW% sec. 13, T. 106 N., R. 56 W.</td>
<td>155</td>
<td></td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>Reich, M.</td>
<td>SW%SW%SE%SE% sec. 14, T. 106 N., R. 56 W.</td>
<td>234</td>
<td></td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Rasmussen, C.</td>
<td>NW%NW%NW%NW% sec. 15, T. 106 N., R. 56 W.</td>
<td>200</td>
<td>70</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Rasmussen, A.</td>
<td>NE%NE%NE%NE% sec. 15, T. 106 N., R. 56 W.</td>
<td>200</td>
<td>70</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Hafner, W.</td>
<td>SE%NE%NE%SE% sec. 17, T. 106 N., R. 56 W.</td>
<td>170</td>
<td>60</td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>Stangoh, R.</td>
<td>SE%SW%SE%SW% sec. 22, T. 106 N., R. 56 W.</td>
<td>206</td>
<td>90</td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>Denponpolf, P.</td>
<td>NE%NW%NE%NW% sec. 28, T. 106 N., R. 56 W.</td>
<td>106</td>
<td>60</td>
<td>B</td>
<td>D,S</td>
</tr>
<tr>
<td>Feldhaus, L.</td>
<td>NE%NE%NE%NW% sec. 36, T. 106 N., R. 56 W.</td>
<td>7</td>
<td></td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>Name</td>
<td>Location</td>
<td>Depth of Well (feet)</td>
<td>Depth to Water (feet)</td>
<td>Source</td>
<td>Use</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------</td>
<td>---------------------</td>
<td>-----------------------</td>
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</tr>
<tr>
<td>Bloem, J.</td>
<td>NW%NW%SW%SW% sec. 6, T. 107 N., R. 55 W.</td>
<td>507</td>
<td>B</td>
<td>D,S</td>
<td></td>
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<tr>
<td>Corey, H.</td>
<td>NW%NW%SE%SW% sec. 6, T. 107 N., R. 55 W.</td>
<td>100</td>
<td>70</td>
<td>B</td>
<td>D,S</td>
</tr>
<tr>
<td>Bengheim, A.</td>
<td>SE%SE%SE%SE% sec. 6, T. 107 N., R. 55 W.</td>
<td>19</td>
<td>O</td>
<td>D,S</td>
<td></td>
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<tr>
<td>Roseo, A.</td>
<td>NE%NE%NE%NW% sec. 7, T. 107 N., R. 55 W.</td>
<td>900</td>
<td>700</td>
<td>D</td>
<td>D,S</td>
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<tr>
<td>Bergheter, A.</td>
<td>NW%NW%NW%NW% sec. 8, T. 107 N., R. 55 W.</td>
<td>19</td>
<td>3</td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>Hegdahl, H.</td>
<td>SE%SW%SW%SW% sec. 8, T. 107 N., R. 55 W.</td>
<td>24</td>
<td>17</td>
<td>O</td>
<td>D</td>
</tr>
<tr>
<td>Hegdahl, H.</td>
<td>SE%SW%SW%SW% sec. 8, T. 107 N., R. 55 W.</td>
<td>16</td>
<td>13</td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>Jukam, J.</td>
<td>SW%SE%SW%SE% sec. 8, T. 107 N., R. 55 W.</td>
<td>160</td>
<td>90</td>
<td>B</td>
<td>S</td>
</tr>
<tr>
<td>Almaas, N.</td>
<td>SW%SE%SE%SW% sec. 9, T. 107 N., R. 55 W.</td>
<td>240</td>
<td>90</td>
<td>N</td>
<td>D,S</td>
</tr>
<tr>
<td>Eide, L.</td>
<td>SE%NW%SE%NW% sec. 17, T. 107 N., R. 55 W.</td>
<td>27</td>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>Schwader, R.</td>
<td>SW%SE%SE%SW% sec. 17, T. 107 N., R. 55 W.</td>
<td>90</td>
<td>B</td>
<td>D,S</td>
<td></td>
</tr>
<tr>
<td>Road, L.</td>
<td>NE%NE%NE%SE% sec. 18, T. 107 N., R. 55 W.</td>
<td>150</td>
<td>70</td>
<td>B</td>
<td>D,S</td>
</tr>
<tr>
<td>Voltz, J.</td>
<td>NE%NE%SW%NW% sec. 18, T. 107 N., R. 55 W.</td>
<td>750</td>
<td>10</td>
<td>D</td>
<td>D,S</td>
</tr>
<tr>
<td>Henden, A.</td>
<td>NE%SE%SE%NE% sec. 19, T. 107 N., R. 55 W.</td>
<td>16</td>
<td>9</td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>Fjellstad, H.</td>
<td>NW%NW%NE%NW% sec. 20, T. 107 N., R. 55 W.</td>
<td>100</td>
<td>B</td>
<td>D,S</td>
<td></td>
</tr>
<tr>
<td>Olsen, L.</td>
<td>NE%NE%NW%SW% sec. 20, T. 107 N., R. 55 W.</td>
<td>55</td>
<td>B</td>
<td>D,S</td>
<td></td>
</tr>
<tr>
<td>Bradford, R.</td>
<td>SW%SW%NW%SW% sec. 21, T. 107 N., R. 55 W.</td>
<td>427</td>
<td>50</td>
<td>N?</td>
<td>D,S</td>
</tr>
<tr>
<td>Name</td>
<td>Location</td>
<td>Depth of Well (feet)</td>
<td>Depth to Water (feet)</td>
<td>Source</td>
<td>Use</td>
</tr>
<tr>
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<td>Remacle, P.</td>
<td>NW%SW%SW%SW%NW% sec. 21, T. 107 N., R. 55 W.</td>
<td>100</td>
<td>B</td>
<td>D,S</td>
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<td>Erikson, A.</td>
<td>SW%NW%NW%NW%NW% sec. 27, T. 107 N., R. 55 W.</td>
<td>265</td>
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<tr>
<td>Jacobson, K.</td>
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<td>220</td>
<td>100</td>
<td>N</td>
<td>D,S</td>
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<tr>
<td>Hardick, C.</td>
<td>NE%NW%NW%NW%NW% sec. 28, T. 107 N., R. 55 W.</td>
<td>25</td>
<td>8</td>
<td>O</td>
<td>D,S</td>
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<tr>
<td>Jacobson, W.</td>
<td>NW%NW%NW%SW%SW% sec. 28, T. 107 N., R. 55 W.</td>
<td>140</td>
<td>30</td>
<td>B</td>
<td>D,S</td>
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<tr>
<td>Bender, M.</td>
<td>SW%SW%NW%NW%NW% sec. 30, T. 107 N., R. 55 W.</td>
<td>180</td>
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<td>168</td>
<td>88</td>
<td>N?</td>
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<td>Haak, G.</td>
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<td>120</td>
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<td>282</td>
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<td>Wombacker, C.</td>
<td>SW%NW%SW%SW%SW% sec. 34, T. 107 N., R. 55 W.</td>
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<td>30</td>
<td>N</td>
<td>D,S</td>
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<td>Hardick, B.</td>
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<td>220</td>
<td>90</td>
<td>N</td>
<td>D,S</td>
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<td>Worder, R.</td>
<td>SW%SW%SW%SW%SW% sec. 12, T. 107 N., R. 56 W.</td>
<td>612</td>
<td>412</td>
<td>D?</td>
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<td>Hauge, M.</td>
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<td>90</td>
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<td>Craner, R.</td>
<td>SE%SE%SE%SE%SE% sec. 13, T. 107 N., R. 56 W.</td>
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<td>Coviglioni, J.</td>
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<td>Name</td>
<td>Location</td>
<td>Depth of Well (feet)</td>
<td>Depth to Water (feet)</td>
<td>Source</td>
<td>Use</td>
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<td>70</td>
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