State of South Dakota

Harlan J. Bushfield, Governor

STATE GEOLOGICAL SURVEY

E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 40

SOURCES OF WATER SUPPLY FOR THE CITY OF MILLER, SOUTH DAKOTA

by

E. P. Rothrock

University of South Dakota
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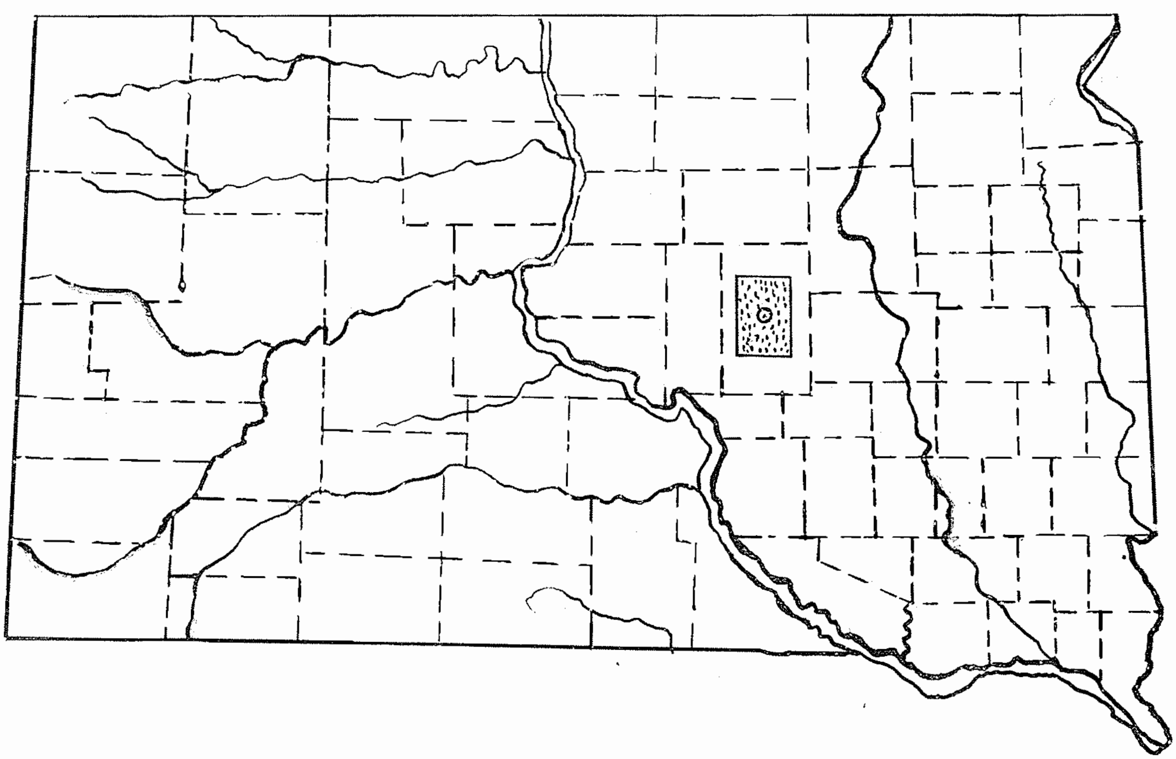


Area covered by this report

SOURCES OF WATER SUPPLY

FOR THE

CITY OF MILLER, SOUTH DAKOTA

INTRODUCTION

Purpose of Investigation: The need for adequate information on possible sources of water supply was forcibly brought home to many cities in South Dakota during the drouth of 1934 when water shortage not only killed vegetation, but caused near epidemics and water famine in many communities. In order to forestall another such catastrophe and enable the various communities to use their water supplies efficiently, the State Geological Survey inaugurated a program of water investigation which it is hoped can be extended to each city in the State.

Investigations of this nature had previously been carried on at Watertown and Huron, but were not comprehensive enough to cover all possible sources of supply. The investigation here reported, therefore, is the first attempt to assemble the available information on all possible sources of supply for a single city. The City of Miller was chosen because several requests for assistance with their water problems had been received from city officials.

It is hoped that this work will not only be of material benefit to the City of Miller, but will be the first of a series of such investigations which will enable our cities to improve their present supplies and provide for emergencies which are sure to come in the future.

Methods of Work and Acknowledgements: The information contained herein was gathered from the files of the Geological Survey and supplemented by a week's study of the area by a Survey field party. Three lines of investigation were followed.

1. A study of the deep well or artesian supplies was made by collecting data from deep wells in the vicinity and from the available information on the stratigraphy of this part of the State.

2. A search for shallow aquifers such as outwash bodies at or near the surface.

3. A search for buried aquifers made from observations on the locations of springs, by well records, and electric soundings.

The surface geology was done by the State Geologist and Mr. Edward Ries. The electrical soundings were made by a party consisting of Dr. Wayne W. Marshall, and Messrs. Richard Aroner and Dorian Lavier. The author wishes to acknowledge the work of the other members of the party without whose enthusiastic and painstaking help this report would have been impossible.

Thanks are also due to Mayor W. E. Burke and the citizens of Miller and vicinity, who not only provided comfortable quarters for the party but assisted greatly in supplying information and offering many courtesies which made the work proceed smoothly.

GEOLOGY

The ground water supplies of any region depend on geological factors which control not only the distribution of water, but the ease with which it can be extracted. The position of the water table, the porosity and permeability of the rocks in which the water is carried are therefore of prime importance. A brief discussion of the geology of the Miller area, therefore, will not be amiss, since it may explain the location or lack of aquifers with which the water prospector will have to deal.

<u>The pre-Cambrian Basement</u>: Pre-Cambrian rocks are a group of very dense, hard rocks which underlie the entire region and form the foundation on which some 1500 feet of younger rocks lie. They are volcanic and metamorphic rocks, and therefore hopeless as water bearers for any city project. Their porosity is low and what water is obtained from them comes from cracks which are not sufficiently abundant to supply it in great quantity.

At Huron the pre-Cambrian rocks consist of a white granite. At Woolsey a little pink quartzite overlies a granite gneiss. None of these are good aquifers. What kind of rock comprises the pre-Cambrian in the Miller area is not known since no wells have penetrated to its depth in the immediate vicinity. The general character of the pre-Cambrian rocks of the State, however, is sufficiently well known to condemn it as a source of water for city supplies in this region.

The depth to the pre-Cambrian at Miller should not exceed 1500 feet. At Huron it lies at a depth of 1175 feet; at Woolsey it was encountered at 1191 feet. At Miller it has not been encountered in drilling 1145 feet, and 12 miles southwest a well 1422 feet deep failed to reach it. Others more distant show that the pre-Cambrian surface slopes gently westward, and indicate 1500 feet as the approximate depth at which it will lie in Miller.

<u>Mesozoic Rocks</u>: The bedrock which lies on top of the pre-Cambrian belongs to a group of sediments formed during the Cretaceous period of the Mesozoic era. These formations are soft, poorly cemented sands and

LOG OF MILLER CITY WELL 1941

Corre-lation	Section	Depth	Thick-ness	Character of rocks
Pierre		150	220	Reported as boulder clay in city well drilled during 1910.
Pierre		300 450	?????	Blue shale---Gumbo.
Niobrara			80	Speckled gray shale and chalk.
Carlile		600 750	170	Shale; Some concretionary limestone. Contains some pyrite.
Greenhorn			80	Limestone. Much speckled limey pieces and shells.
Graneros		900 1050	270	Black shale. Contains abundant pyrite. A few concretionary limestones.
Dakota Group				Fine, clear, angular pieces of white quartz. Sandstone, 18 feet of shale
		1200 1245	?	Water bearing sandstone.

shales, for the most part, and offer easy drilling. In general the section consists of a zone of sand covered with a series of thick, dark shales. The sands offer excellent water prospecting, but the shales are too impervious to yield a usable supply.

The sands apparently belong to the Dakota-Lakota group of formations and were formed as beaches on the pre-Cambrian foundation. Records of wells drilled in the vicinity of Miller show 50 to 100 feet of this sand, but do not penetrate its entire thickness. A well twelve miles southwest of Miller (Puffer Well, Sec. 1, T. 109 N., R. 70 W.) reported nearly 300 feet of sand in two zones which were separated by a rock listed as "granite." As this was underlain by sand it is probable that the granite of the driller was really a section of sand which has been cemented to a quartzite. The upper 200 feet apparently contained some shale beds in this well, but the record does not indicate how thick or how numerous these are. There has been some suggestion that the lower part of these sands belongs to the Jurassic Sundance formation, which is older than the Lakota. The evidence available, however, does not indicate that the Sundance reaches this far east, though it was separated from the overlying Lakota sand as close as Pierre, 70 miles to the west.

Overlying the sands are eleven hundred feet of dark colored shales belonging to the Benton group and the Pierre formation. In the Benton group there are representatives of the Graneros, Greenhorn, Carlile and Niobrara formations, as is shown in the accompanying log made from cuttings of the well at Miller. These shaley formations, however, are not of interest in this investigation except that they indicate the depth of bedrock which will have to be penetrated before any possibility of a water bearing horizon can be encountered.

Mantle Rock: The surface of the entire region is mantled with glacial deposits formed during the last ice age (the Pleistocene epoc). During this time continental glaciers spread westward from the James Valley over this portion of the State, leaving deposits of unconsolidated boulder clays, dropped by the melting ice, and sands, gravels and clays sorted from the debris by streams of ice water and deposited as outwash in sheets and channels in the boulder clay. These deposits vary greatly in thickness and no single figure can be given for them. It is probable, however, that at no place are they less than fifty feet with the possible exception of the base of the Wessington Hills escarpment It is known that they are more than one or two hundred feet thick in others These deposits are of considerable interest as a source of shallow water and will be discussed in greater detail later in the report

Aquifers: From the foregoing sketch of the geology it is evident that prospecting will have to be confined to the Cretaceous bedrock and the glacial deposits, as these are the only rocks carrying sands coarse enough to allow the development of sufficient water to supply the city Glacial clays sometimes furnish ample water for farm use, but can easily be pumped dry These wells often mislead the prospector, for a sandy clay will many times furnish an abundant water supply for farm use, but will not permit the passage of water fast enough to supply the quantity needed for a city Two things must be considered before attempting to develop a source of ground water, therefore First, it must be below the water table during dry years Second, the rocks must be sufficiently permeable to supply the volume of water necessary

The water table is the surface of the underground water below which the pores of all rocks are saturated As the position of this surface is determined by the amount of water which reaches it by soaking into the earth, it fluctuates with wet and dry years A little observation will usually determine the lowest depth to which it is likely to go in dry weather The position of the water table is not of much interest for deep wells since the water table rarely falls below the depth of a score or two of feet In the use of shallow wells, however, it is very important since the best water sands will fail in times of drouth if the water table falls below their level

The permeability of an aquifer is determined primarily by the size of the grains Gravels will yield water faster than sands because the pores the holes between the pebbles, are larger Mixtures of coarse and fine grains, however, often have low permeability because the finer grains fill the pores between the larger, thus increasing the friction and making them "tight". Most sands have sufficient permeability to make them good aquifers if they are saturated with water, however.

DEEP WELL SUPPLIES

Artesian supplies have been used by the city to date, and should prove a permanent and reliable source of water if properly developed and maintained. The only source of artesian water is the sandy zone which has been designated above as the Dakota-Lakota sandstones. These sands cannot be easily separated into formations, as the records available are not sufficiently detailed. Flows appear, however, to occur in certain horizons and to be absent at others. This is the characteristic effect of clean sand layers separated by beds of shale or by sand made "tight" by its fineness or by the addition of large percentages of clays.

The depth to the top of the sand zone indicated by the various wells that have been drilled in and near Miller is about 1100 feet. The first flow is encountered at 1130 feet and another one at 1160 feet. Still lower flows can be obtained, though there are no records of their depths in the immediate vicinity. The water prospector, however, is not through until he has penetrated the sand zone to the pre-Cambrian "granite". Thus a total of some 400 feet of sands are available to the prospector for deep well water.

The character of the upper waters is such that it makes a very usable water for domestic purposes. Some of the objectionable features of artesian water, to be sure, are there, such as the slightly bitter taste due to iron sulphates and a low concentration of fluorides. The water, however, is not saline. An analysis of the water from the upper flows was obtained from the State Chemical Laboratory, and showed the following:

Analysis of Water[1]
City of Miller
June, 1938

Total Solids	2120
Silica SiO_2	16
Sulphate SO_4	1214
Chloride Cl	99
Fluoride Fl	2.4
Calcium Ca	192
Magnesium Mg	58
Hardness as $CaCO_3$	721
Iron Fe	1.0
Manganese Mn	0.0
Alkalinity Methyl Orange	134
Alkalinity Phenolphthalein	0.0

The character of the lower waters has not been determined, since they are not used in the vicinity. Without actual drilling into these waters, however, it is not possible to tell what their character would be. There is no geological reason, however, why they should not be as usable as those in the upper flows.

1. Guy G. Frary, "Public Water Supplies in South Dakota", State Chemical Laboratory, University of South Dakota, Vermillion, South Dakota, January 1939.

CHANNEL GRAVELS

Aside from the artesian sands which have just been described, there are no available water supplies in the bedrock. Other sources, therefore, must be sought in the mantle of glacial drift which covers the surface. The boulder clay, which makes the largest portion of the drift, is too nearly impervious to yield sufficient quantities of water for city supply, but bodies of sand and gravel lying in it may make excellent aquifers where they lie beneath the water table.

The most obvious of these aquifers are sand and gravel fills of the small valleys which traverse the region. These are forks of Wolf Creek, Little Turtle, Turtle and Pearl Creeks. These creeks flow in shallow, flat-bottomed valleys approximately a half mile across. An examination of them shows that they are really small, round-bottomed troughs cut in the boulder clays which have been partly re-filled with sands and gravels washed into them, in part by glacial waters from melting ice and in part by floods of more recent origin. These fills vary from a couple of yards to a score of feet in depth. Ten feet was measured in a well on Little Turtle Creek south of Miller and six or eight feet were exposed in constructing a bridge on Wolf Creek. Gravel bars were noted on Little Turtle and other creeks south of Miller, but the fill on Wolf Creek was composed of a dirty, fine sand.

It is apparent from the outcrops available that there is considerable variation in the material of the fills. That they are fairly efficient aquifers, however, is attested by the lake at the northern end of Miller and the farm well noted above on Little Turtle Creek two miles south of the city. This well has furnished ample supplies of water for as high as 100 head of stock, failing in only one very dry summer since it was drilled. Enough water was encountered in the Turtle Creek fill at St. Lawrence to cause considerable inconvenience in building abutments for the highway bridge across it.

These channels make excellent farm wells but are probably too small to supply the needs of a community the size of Miller. They are also too shallow to be relied on in times of continued drouth. As a supplementary supply, however, they might prove useful and a considerable supply could be developed by building a series of dams to prevent the run off of flood water and a series of shallow wells or sumps, from which the water could be pumped.

SPRINGS

A third possible source of water is offered in the springs at the base of Ree Heights. Eight of these were located between Miller and the village of Ree Heights. They lie near the base of this highland and all occur in sharp valleys cutting the escarpment. The seepage occurs anywhere from a few hundred feet to a quarter mile up the gully from the mouth. Their location is indicated on the map accompanying this report.

It will be noted that five of these springs lie in a two mile stretch, on the northeast portion of the escarpment facing Miller. One more occurs about a mile farther south and two additional lie to the west separated by distances of about three miles.

According to reports, these springs have never gone dry, which indicates that they are seepages from a considerable reservoir and therefore are worth serious consideration as a source of supply for the city of Miller.

They are issuing at the contact of the glacial drift and the shale bedrock, and evidently are fed by a layer of gravel or sand which marks the base of the drift. In other words they are seeps from a buried outwash. The number and disposition of these springs indicates that the sheet of gravel outwash is extensive, but the size of the flow from the springs suggests that it is not very thick. Around some of the springs, gravels are in evidence, but in most of them overlying boulder clay has slumped and washed over them covering them completely.

Measurements made on these springs show that the total amount of water flowing from seven of them during the summer of 1941 was 24.8 gallons per minute. The five springs nearest the city of Miller gave a total

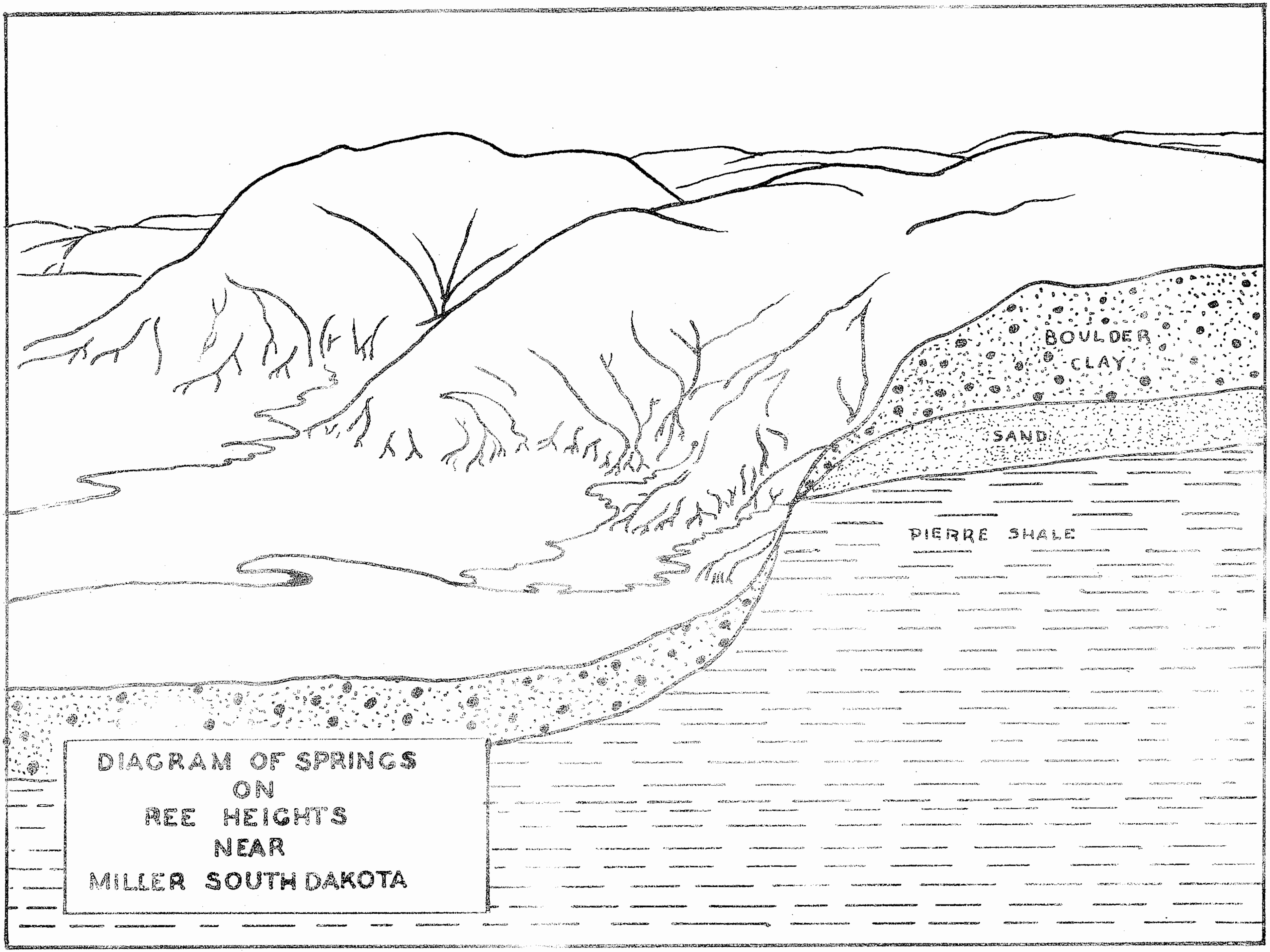


DIAGRAM OF SPRINGS
ON
REE HEIGHTS
NEAR
MILLER SOUTH DAKOTA

flow of 13.1 gallons per minute. No individual spring exceeded 10 gallons a minute, most of them giving about one or two. The 10 gallon figure was reported for the spring which furnishes the water supply at Ree Heights. The highest rate of flow actually measured was found in a spring at the southwest corner of Sec. 5, T. 112 N., R. 69 E. It measured 4.8 gallons. This measurement was made from a pipe which was flowing into a watering trough. It was not possible to obtain an accurate figure for the water which was leaking outside this pipe, but from the size of the stream it was estimated that about the same amount of water escaped as flowed through the pipe. Thus this spring would discharge about nine or ten gallons per minute. A four gallon flow was measured from the spring at the Boy Scout Camp in the northwest quarter of Sec. 2, T. 111 N., R. 69 W. So far as could be ascertained there was no leakage from this spring. Other springs gave lower readings as follows:

	Owner	Location	Discharge in Gallons Per Minute
1.	Percy Nicholas	NW$\frac{1}{4}$,Sec.12,T.112N,R.69 W.	1.02
2.	Unknown	SE$\frac{1}{4}$,Sec.22,T.112N,R.69 W.	2.00
3.	Unknown	SW$\frac{1}{4}$,Sec.22,T.112N,R.69 W.	0.5

From the foregoing figures it is evident that these springs in their present condition will not supply a sufficient quantity of water for the city of Miller. If the total flow of the five springs nearest the city were used, the total discharge would amount to only 18,000 or 20,000 gallons per day.

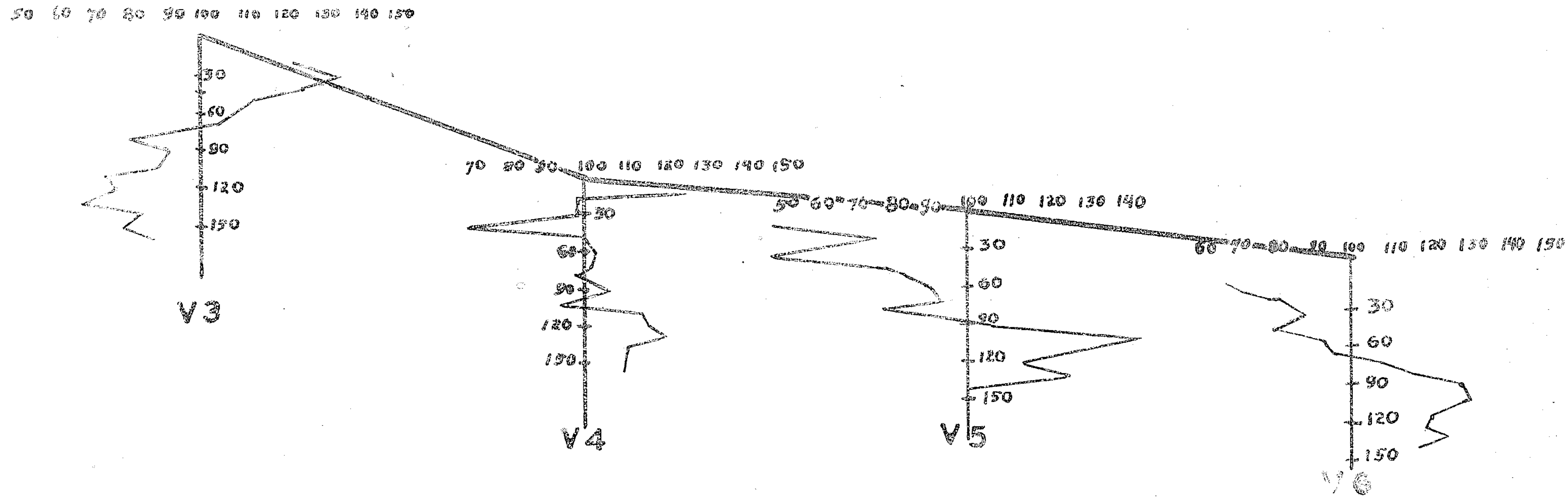
This is hardly sufficient to supply a city the size of Miller, but it is possible that a considerably larger supply could be developed. As was stated above, these springs are seeps from a large reservoir. It should be possible, therefore, by drilling wells on the highland at a proper distance back from the edge of the bluff, or by cleaning and cementing the springs, or driving tunnels into the sand from the outcrop to materially increase the water flow It is impossible to state from this investigation just how much water could be developed, but with the sand extending six miles around the outcrop and an undetermined distance under the highland, it might be possible to produce as much water as is needed, if the situation warranted the expense. It must be borne in mind, however, that a simple harnessing of an individual spring will not serve the purpose. Water will have to be collected from a number of springs or wells covering a considerable area.

BURIED OUTWASH

The area in front of the Ree Heights is the sort of place where gravels often are formed during glaciation. An effort was made, therefore, to determine whether a body of outwash gravels of sufficient size to furnish the necessary water was buried in the vicinity. Shallow farm wells threw little light on the question since they were too widely scattered. A small net of electric soundings, however, indicated the presence of such a deposit just west of the city. A cross section drawn from the southwest corner of section 19 to the southwest corner of section 4 indicated a gravel or sand bed at a depth of approximately 70 or 80 feet. Soundings a mile east showed nothing whatsoever and still other soundings, a mile west, indicated gravels at a similar depth.

A well in the southwest corner of Sec. 19, T. 112 N., R. 68 W. reported water at seventy feet which checks fairly well with the sounding made at this point. Wells drilled one half mile west and one half mile south of a sounding made in the southwest corner of Sec. 7 of the same township, however, did not check so well. These were drilled to depths of 225 feet and 132 feet, respectively, and while they had water there was no large body of sand. The sounding, however, was in a different topographic location and one half mile away and therefore may have recorded the presence of gravel accurately.

It should be remembered that electric soundings are not always accurate indicators. They should, therefore, be carefully checked with drilling records before any development is attempted. Time did not permit following up the electrical soundings on this survey and therefore the presence of buried outwash was indicated only as a possibility. If a further investigation should reveal a sand body of sufficient thickness and porosity to allow pumping of large volumes of water, a very excellent supply would be available, since it is deep enough to



RESISTIVITY PROFILE IN VICINITY OF MILLER SOUTH DAKOTA

HORIZONTAL SCALE ⟵⟶ 1 MILE

HORIZONTAL LINES OF FIGURES GIVE RESISTIVITY VALUES

VERTICAL LINES OF FIGURES GIVE DEPTHS IN FEET be below the dry weather water table, extensive enough to furnish a large supply of water, and close enough to Miller to make long pipe lines unnecessary.

It should again be emphasized that the evidence of the electric soundings must be checked by drilling before considering any development of this sort of supply. One or two wells, placed near the location where the soundings were made, will be sufficient. These wells, however, must be carefully drilled and logged. If these preliminary wells check the electrical soundings then development can be carried on wherever the soundings indicate gravel or sand beds. The area in which this prospecting might be profitable is shown on the accompanying map

RECOMMENDATIONS

Artesian Supplies: The artesian supply is probably the most easily obtained and the surest supply available. In developing it, however, it must be remembered that the entire thickness of the sand to the top of the "granite" (pre Cambrian rocks) can supply water. Any prospect well short of this depth will give only a partial test. The quality of the lower water cannot be inferred from wells thirty or forty miles distant as the character is considerably different within that distance, especially in a north and south direction. The water encountered at Miller probably comes from the east and should resemble waters found at Wolsey more than those found in Orient or farther west.

It should also be remembered that increase in the size of the hole makes only a small change in the volume of water that can be discharged by the well. If greater volumes are needed, additional wells must be drilled. These, however, must be spaced far enough apart to prevent interfering with each other when pumping is in progress. This spacing will depend on the rate of pumping and the volume of water which is discharged, but distances of 600 to 1000 feet are not too much. With proper well spacing and proper control and care of the wells to prevent leaking, corrosion and similar difficulties, an unlimited supply of water is available from this source.

Springs: The springs in the northeast face of Ree Heights probably offer the next best supply. Their water is hard, but very usable and does not have the corrosive properties of the artesian water. They apparently come from a continuous sand body which can be developed to supply a fair amount of water and which can be depended upon in times of drouth. They contain no such volume of water as the artesian sands, however. The engineering problems of such development cannot be discussed in this report. One possibility, however, might be collecting of water from wells scattered along the escarpment and high enough on the hills to reach the sands back of the face of the escarpment. Another alternative would be to clean out the existing springs and construct such basins and retaining walls as would be necessary to collect all the water they are discharging, and if possible increase their present discharge. Sufficient water could be collected from several springs in this manner to make an important addition to the city's supplies

Other methods of development may be recommended by competent engineers, but these two will suffice to show the sort of operations that will have to be undertaken if these supplies are to be developed.

Buried Outwash: If the buried outwash indicated by the electric soundings is as extensive as appears and contains any thickness it might be a very usable supply. Its main advantage would lie in the fact that it is near the city of Miller and would require less transportation than water from the springs. It is apparently deep enough to insure a supply in dry weather and will contain hard water very much like the spring water.

This, however, is a much more questionable source than either of the two which have been mentioned. If the other sources do not prove adequate, however, this one should be investigated.

Gravel Channels: The gravel channels described above in which Turtle, Little Turtle, and Wolf Creeks flow could be used as a last resort, or as a supplement to other water supplies. The water in the channels is hard, but not corrosive. The small size of the fills and the fineness of much of the material will not allow sufficient volume of water to supply a city the size of Miller. Moreover the fills are at the surface and less than ten feet in depth which allows them to go dry in times of continued drouth. These channels are also subject to pollution since surface sewage can be washed into the shallow sands easily. For this reason they would have to be carefully safeguarded if they are to be used for city ice supplies or for drinking water.

The development of these channel fills should include the construction of low dams to prevent the run-off of storm water thus allowing it to sink into the gravels and sands of the fill. Water could then be pumped from a series of well spaced shallow wells or sumps. In case of extreme necessity it might be possible to develop a sufficient water supply from several of these channels. However, this would be an expensive and unsatisfactory source at best. Its main use probably will be as an adjunct to the other supplies described and as such its possibilities should be kept in mind in any consideration of water for the city.

The development of a satisfactory water supply for a community the size of Miller in a country where the rainfall is light is a problem under any conditions. This community, however, is fortunate in having adequate supplies providing they are properly used. There is no single development that will solve the entire difficulty but the intelligent use of the sources described in this report should give an ample supply of good water at all times.